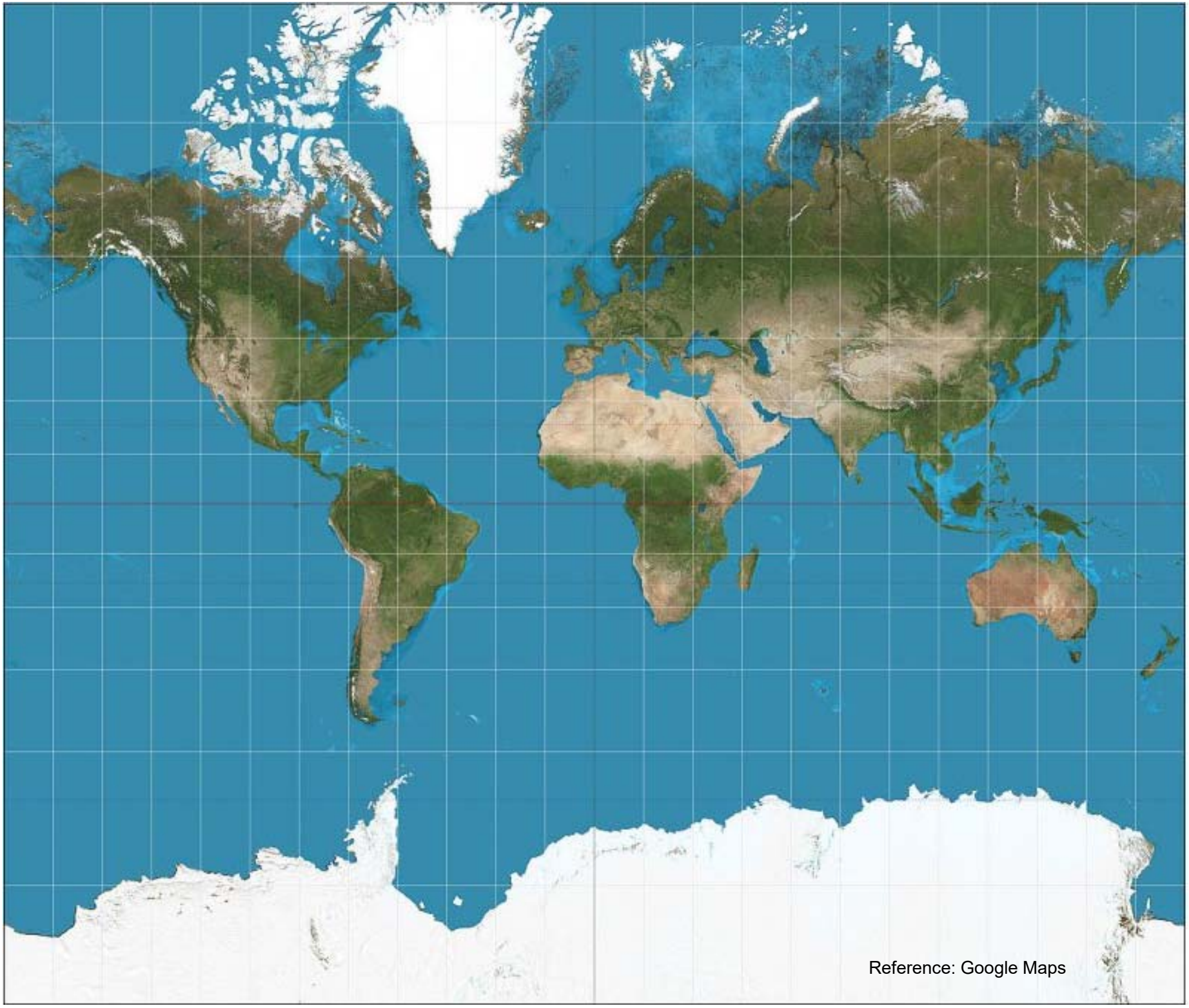
New values to the bio-based industry by precision wood characterisation and delivery

$$Y_{iljk} = \mu + f(A, B, C, \ldots) + Site_i + Tree_{j(il)} + \varepsilon_{iljk}$$

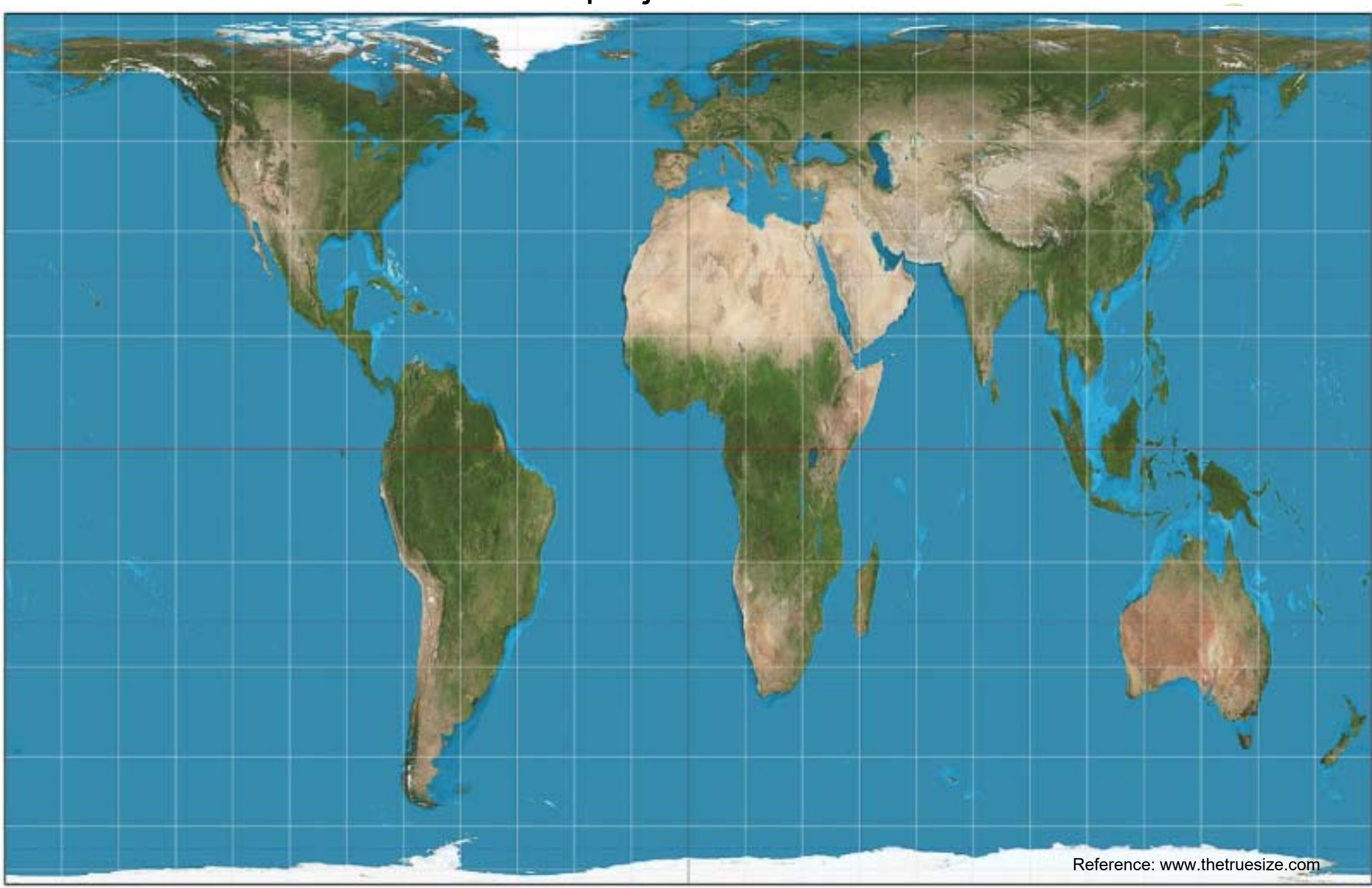
Background picture from:
The Swedish Forest Sector Research Agenda (2017)

Lars Wilhelmsson & John Arlinger

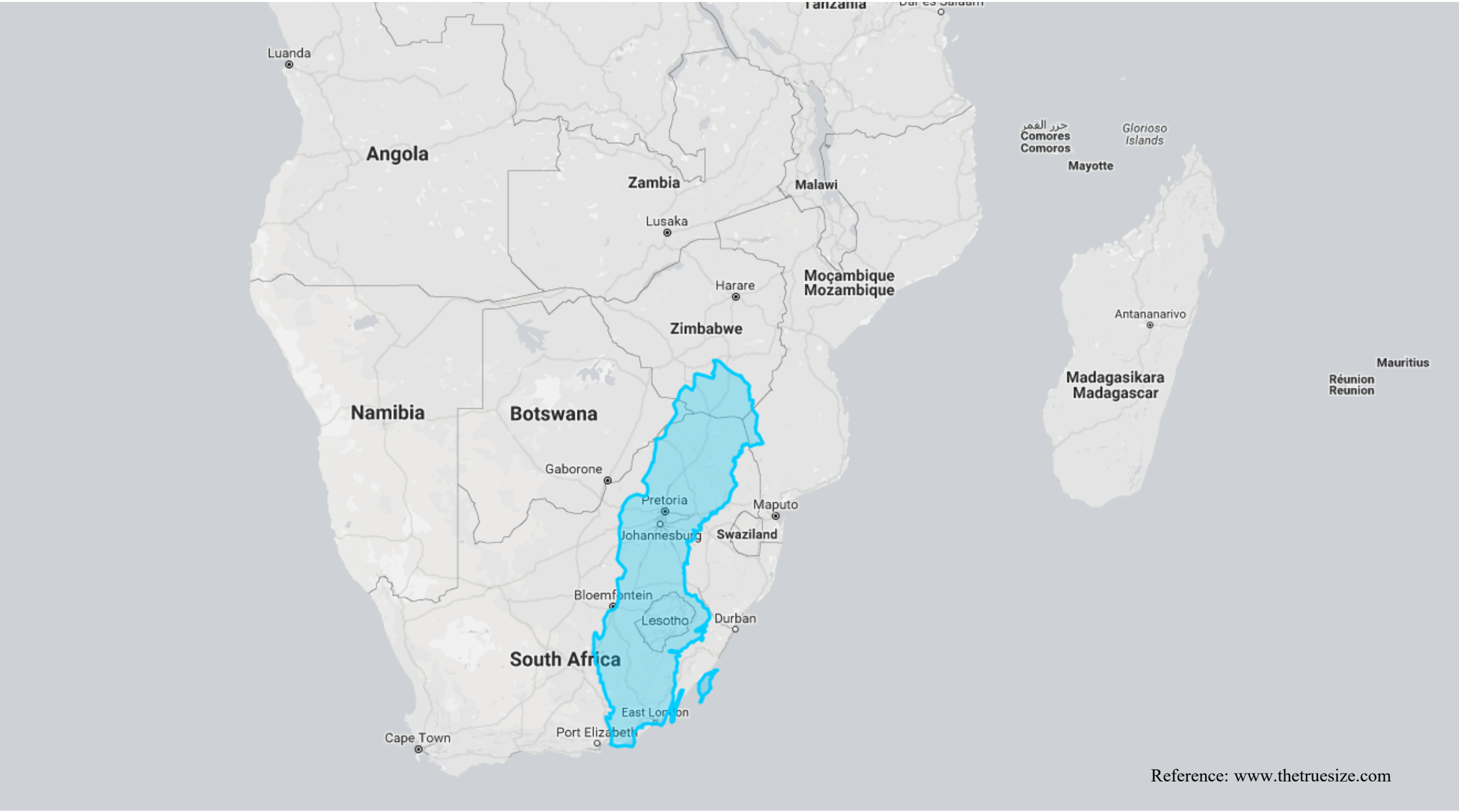


The world in Mercator projection e.g. Google Maps

”True size” projection



”True size” of Sweden



Reference: www.thetruesize.com

Sweden = forest

73 %
forest

80 %
cultivated forest

The forest Sweden's most important raw material

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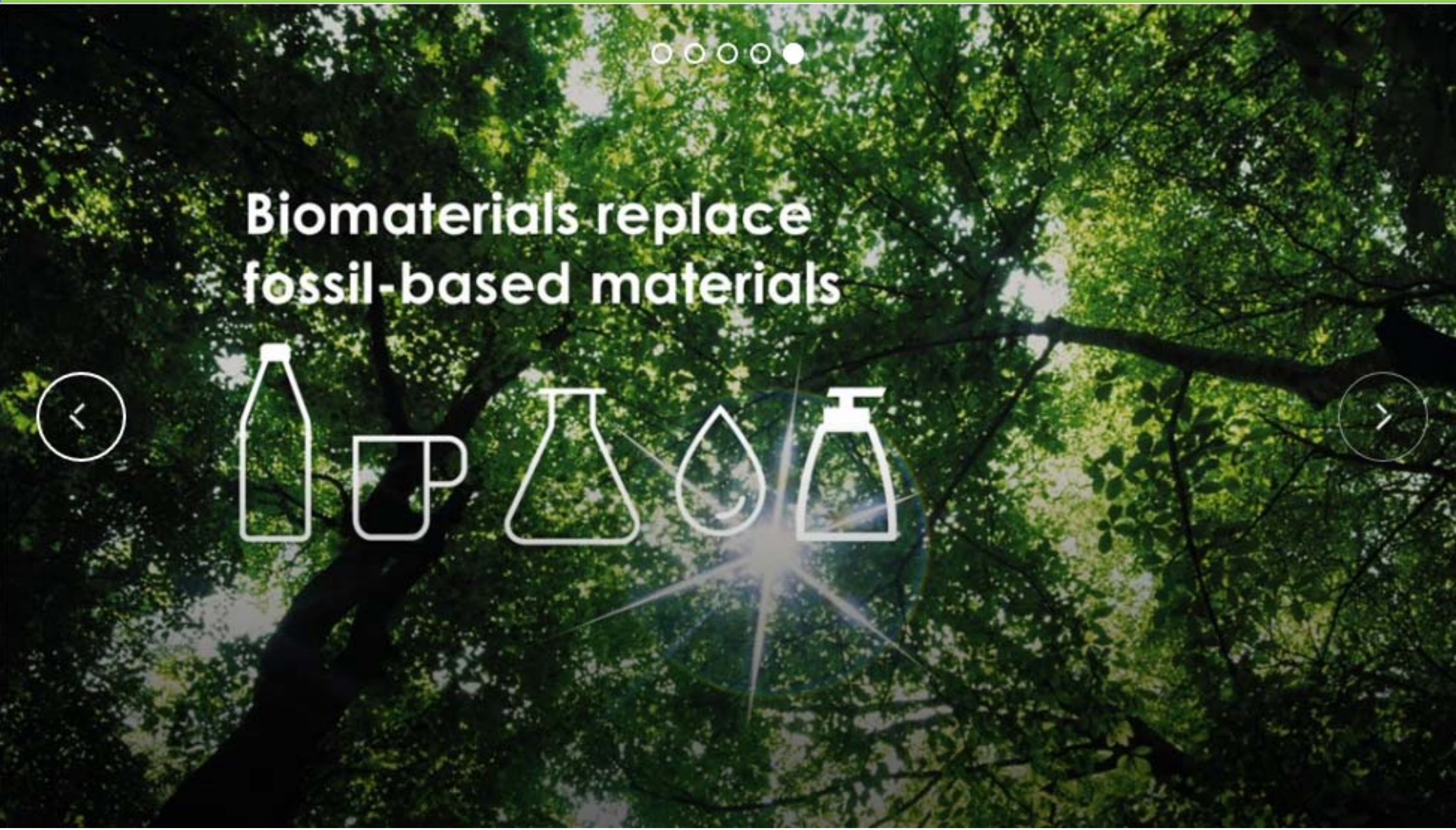

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Forestry and the forest branch contributes to solutions!

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Forestry and the forest branch contributes to solutions!

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Production value of Swedish forest based products
€ 12,000,000,000

Market value of sustainably produced roundwood
€ 3,000,000,000

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Forests and forestry

- *Sustainability*
- *More forest based materials*
- *Value chains*
- *Right from initiation*
- *Other ecosystem services*

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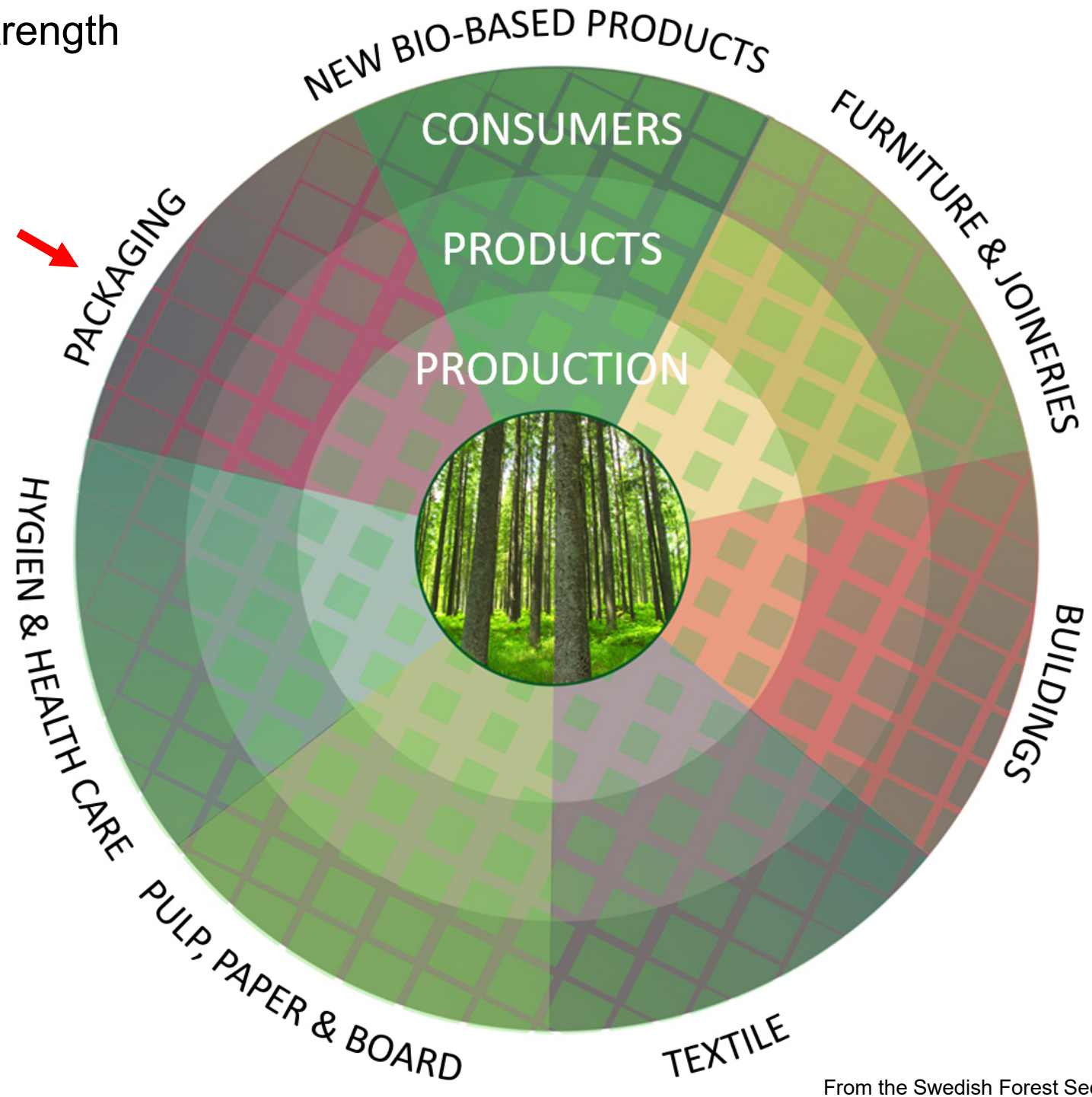
Background picture from:
The Swedish Forest Sector Research Agenda (2017)

Stiffness, bending strength
Shape stability
Durability
Surface properties
Visual properties



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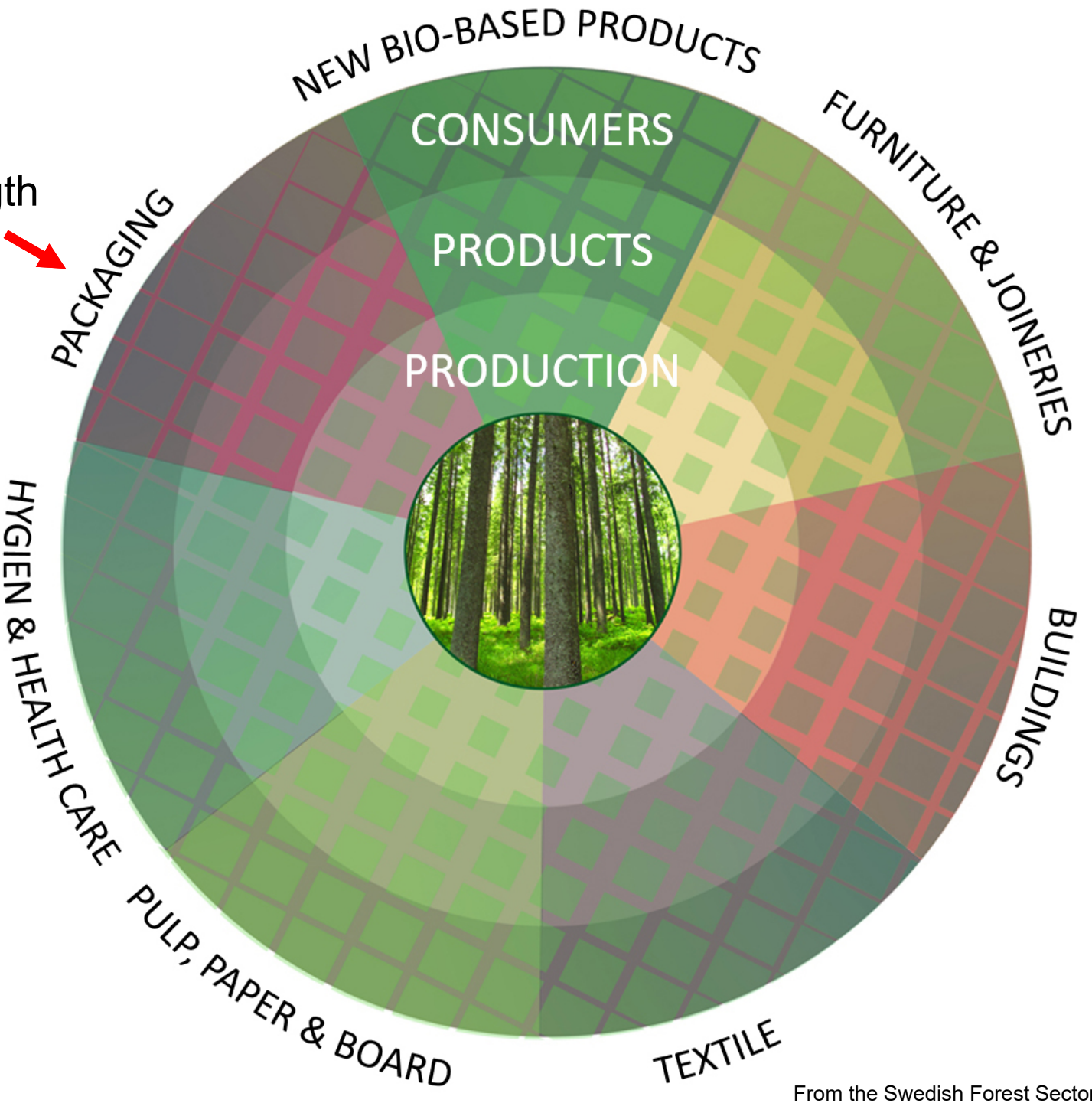
From the Swedish Forest Sector Research Agenda

Fibre properties
(length, cell-wall thickness etc)
Tear, tensile strength
Porosity
Extractives
…..



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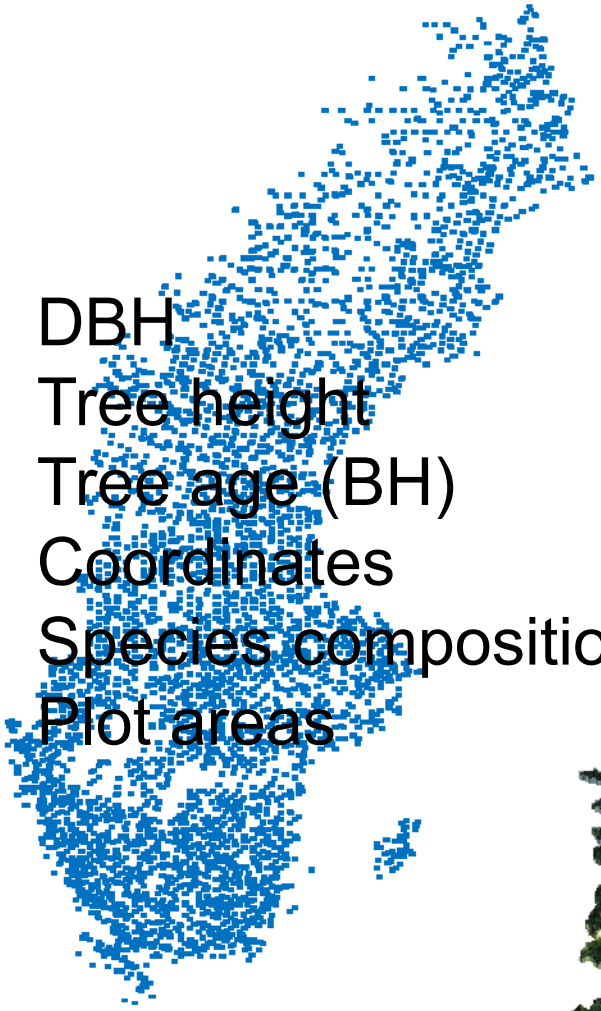
From the Swedish Forest Sector Research Agenda

Material: Sample plots from the Swedish National Forest Inventory

~ 45000 Scots pine trees



- DBH
- Tree height
- Tree age (BH)
- Coordinates
- Species composition
- Plot areas

~ 70 000 Norway spruce trees

- DBH
- Tree height
- Age (BH)
- Coordinates
- Species
- Plot areas

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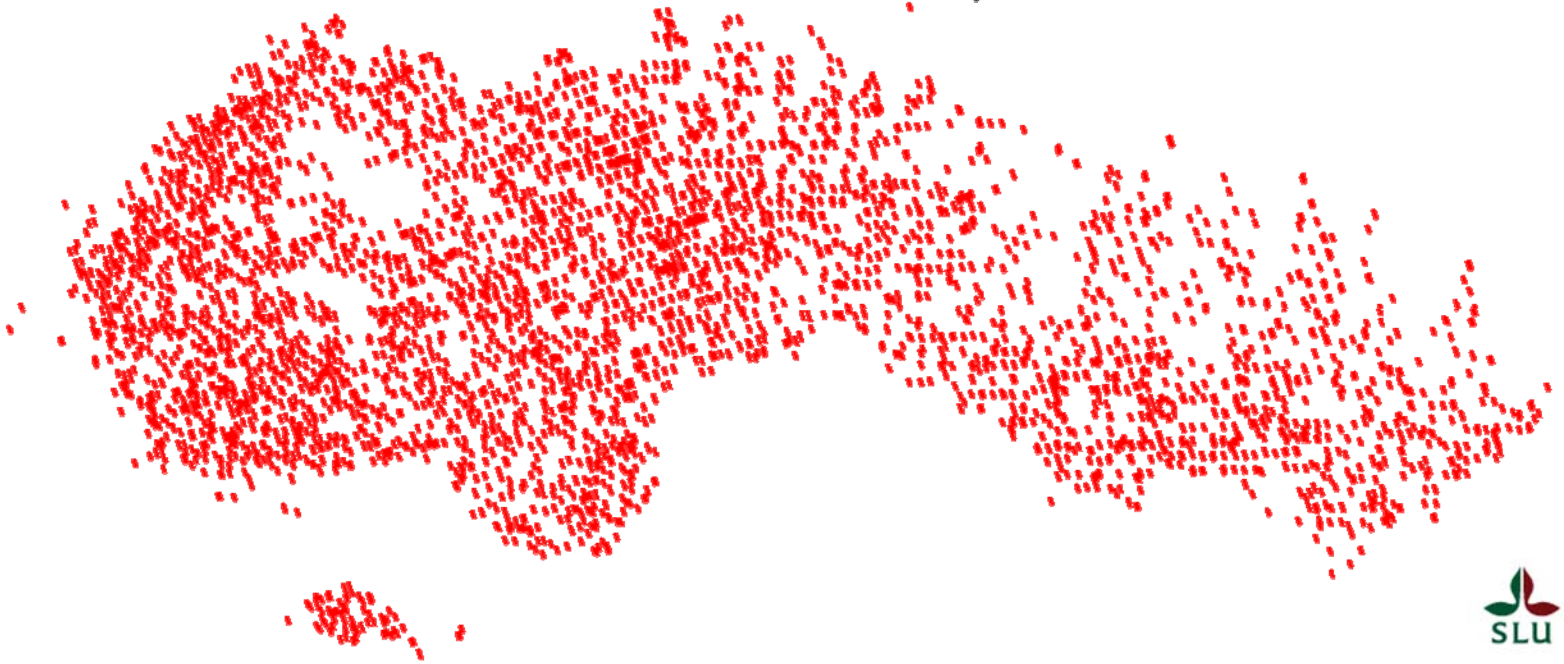
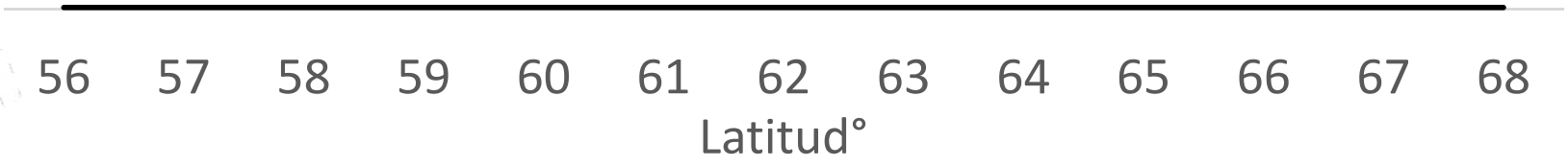
Simulated harvesting



SLU



Some wood properties harder to measure during operation, but possible to predict

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- **Basic density**
  - Bending strength- & stiffness, C-class
  - Surface hardness
  - Chip and fiber properties,
  - Yield (material) & Combustion value

- **Thickest branch/whorl**

  + Distance between whorles

- **Heartwood**
  - durability

Scots pine all sawlogs, small end diameter > 140 mm

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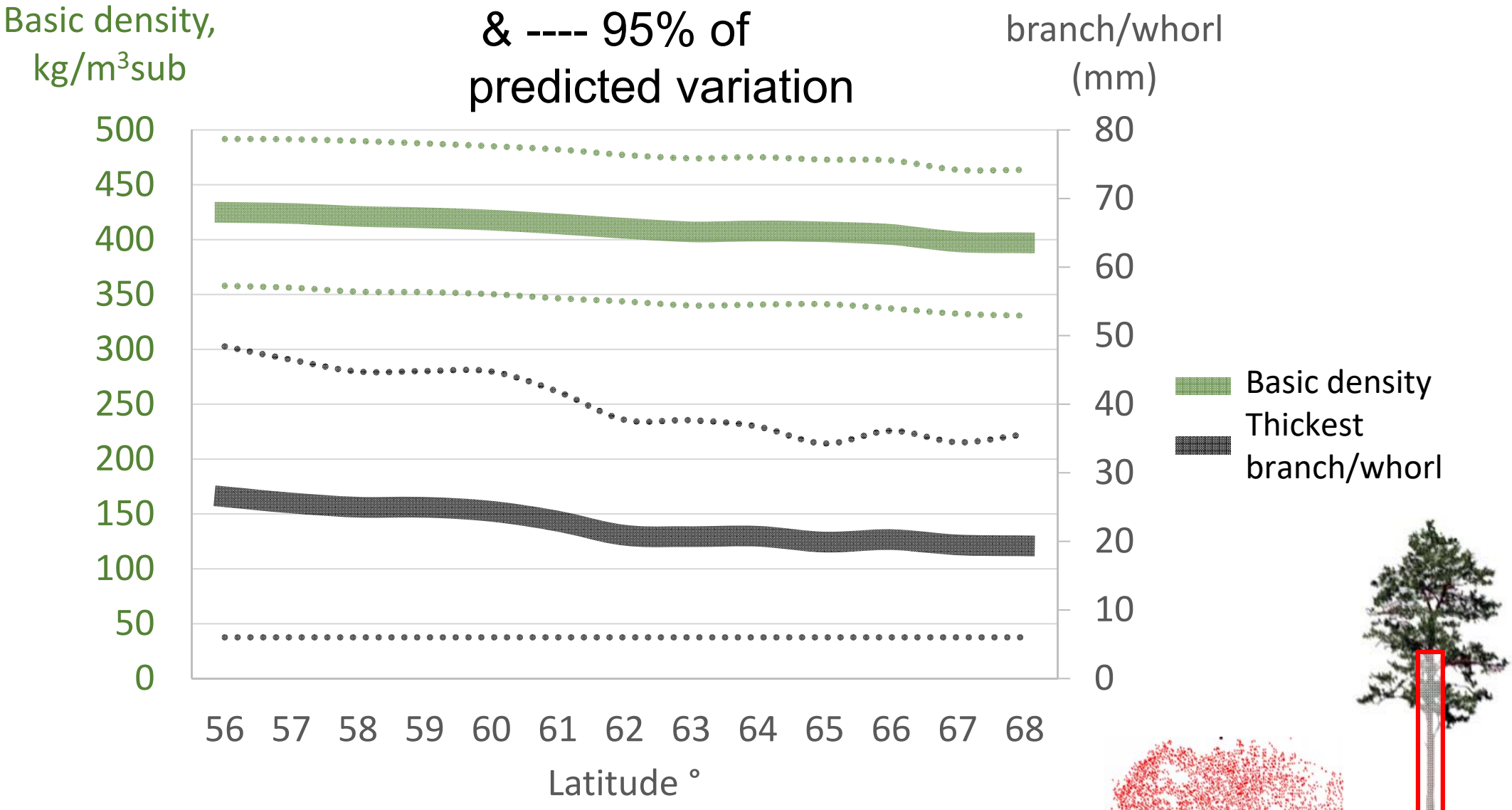
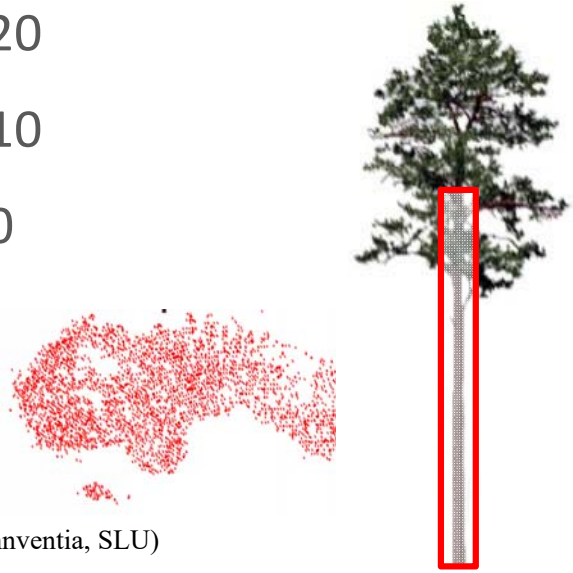
Mean values
& ---- 95% of
predicted variation



52699 logs



Results from simulated harvesting of plots from
The Swedish National Forest Inventory, Bucking simulations by TimAn (Skogforsk) and models for predicting wood properties (Skogforsk, Innventia, SLU)

Scots pine all butt logs > 140 mm

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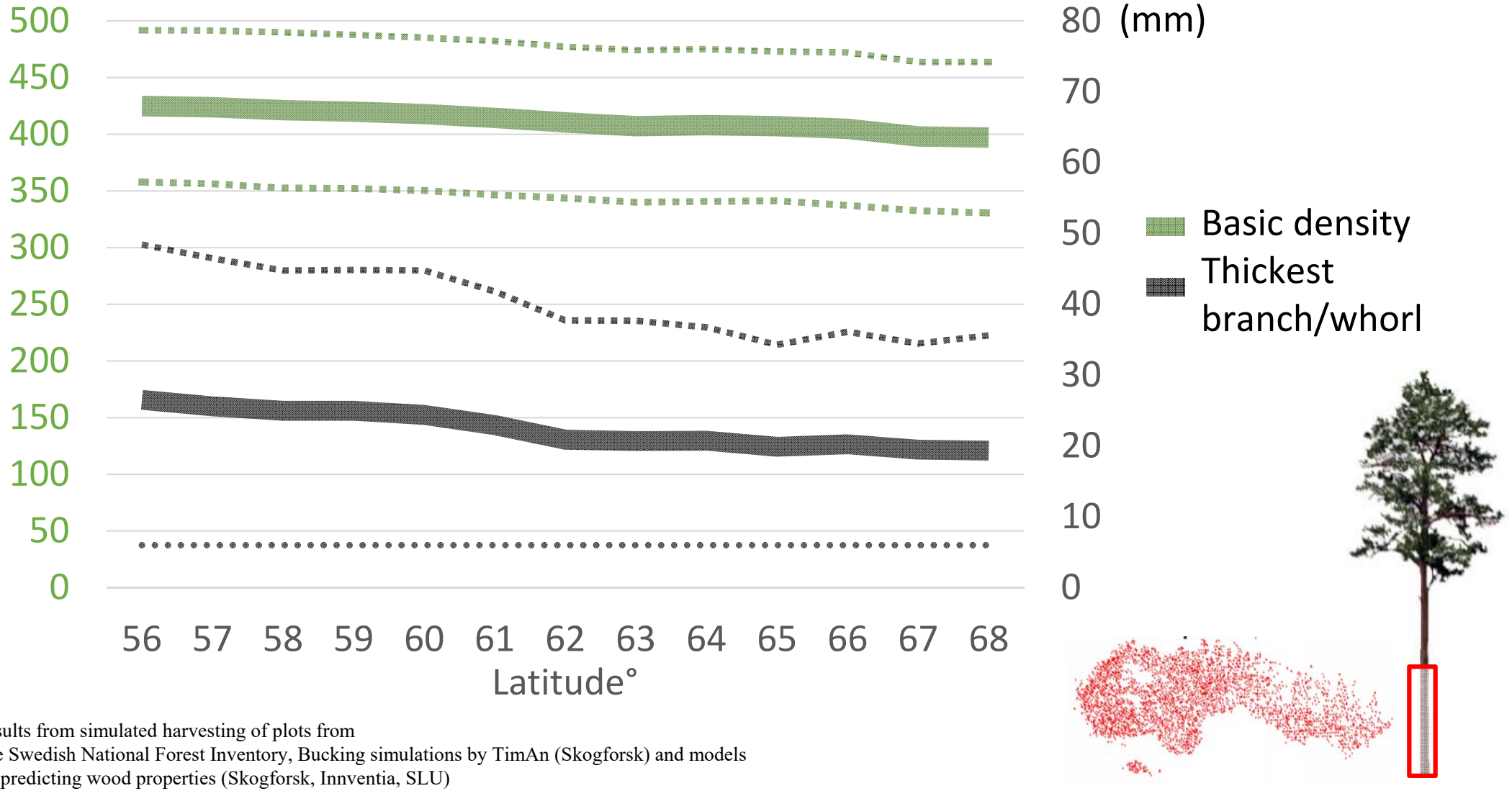
Mean values
& ---- 95% of
predicted variation

Basic density,
kg/m³sub

Thickest
branch/whorl
(mm)



Results from simulated harvesting of plots from
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Example Butt logs Scots pine
Small end diameters **220 -239** mm (ub)

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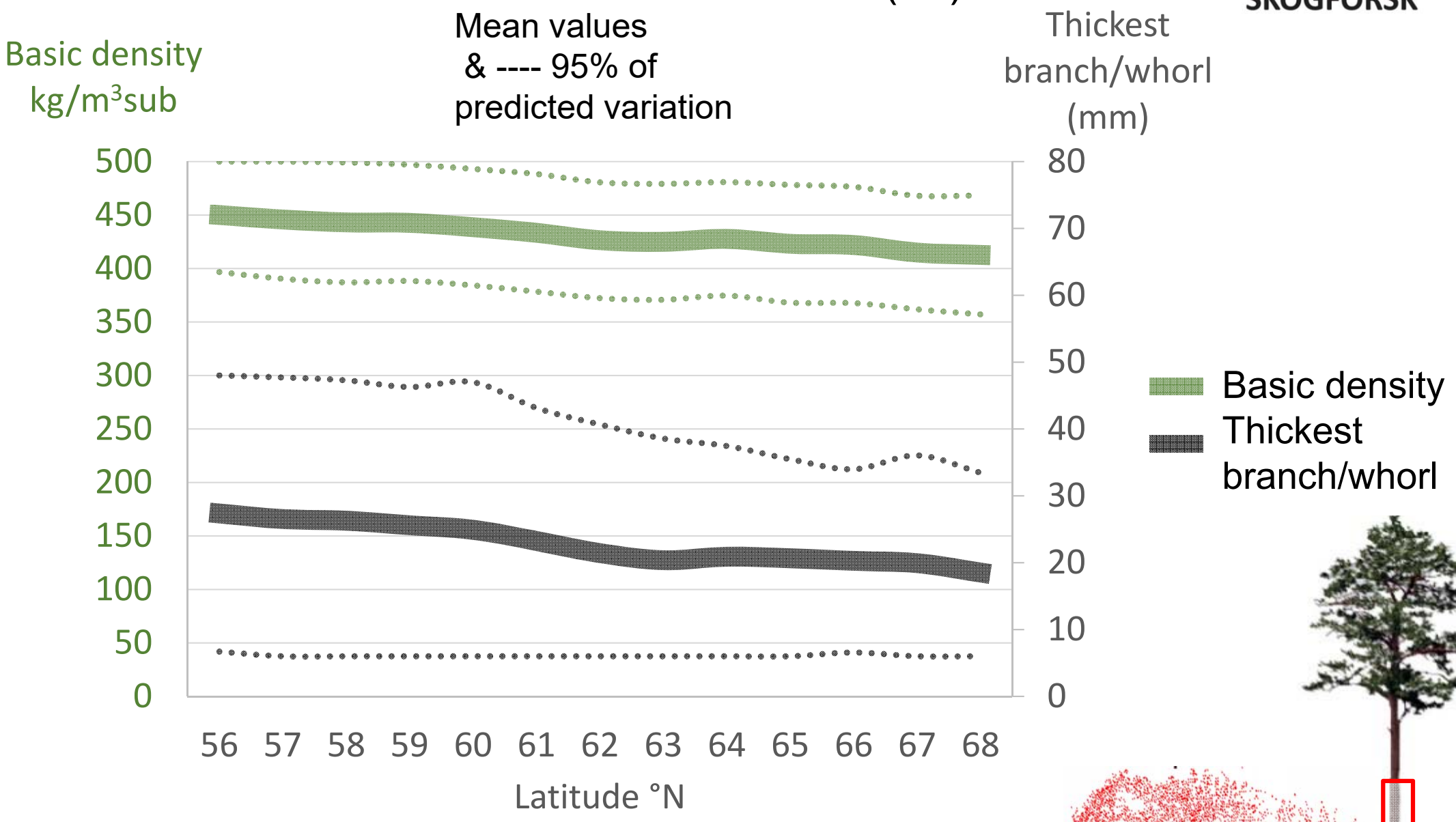
Mean values
& ---- 95% of
predicted variation



3269 logs

Results from simulated harvesting of plots from
The Swedish National Forest Inventory, Bucking simulations by TimAn (Skogforsk) and models
for predicting wood properties (Skogforsk, Innventia, SLU)

Example 2:nd logs Scots pine
Small end diameters 220 -239 mm (ub)

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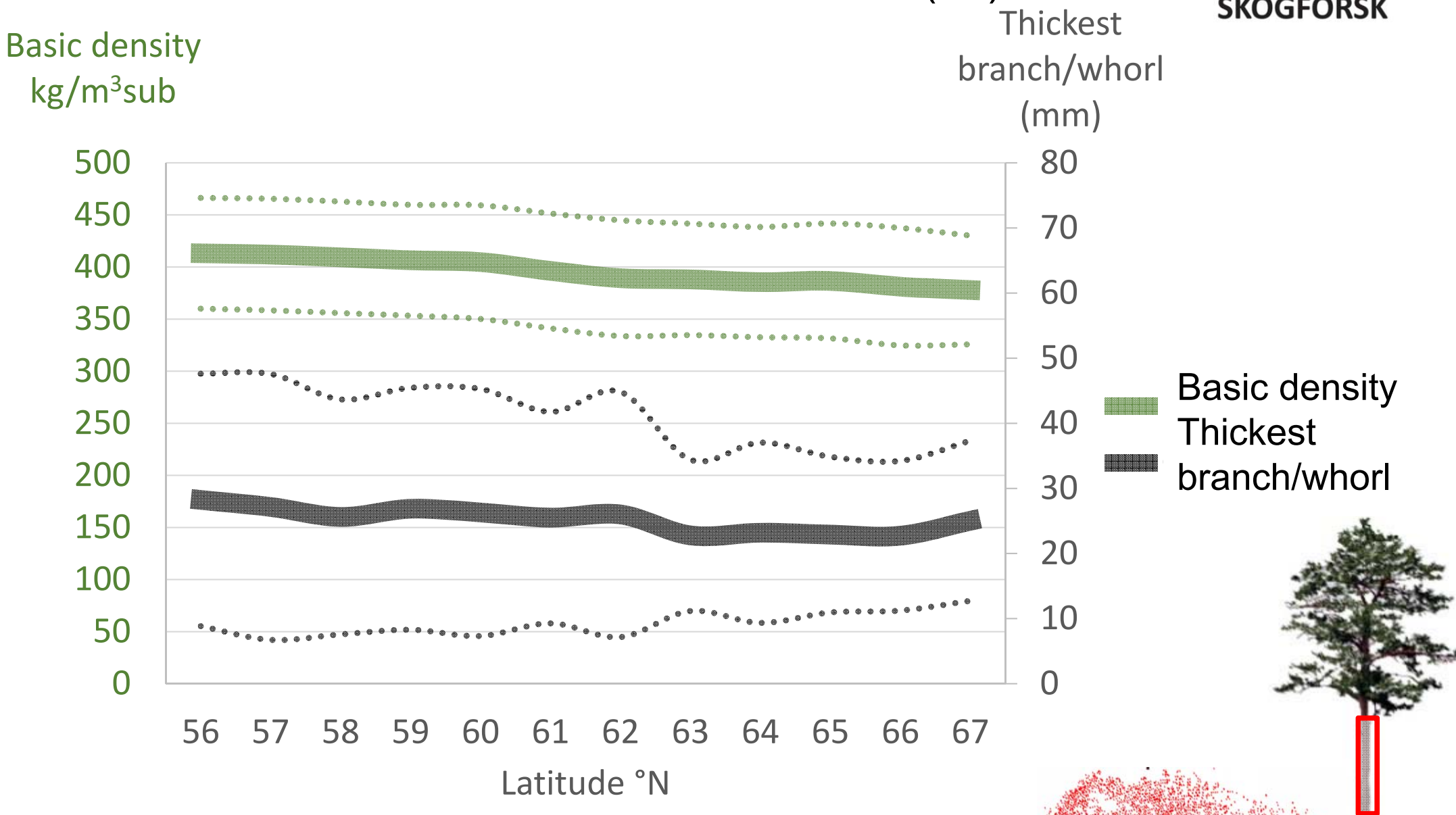
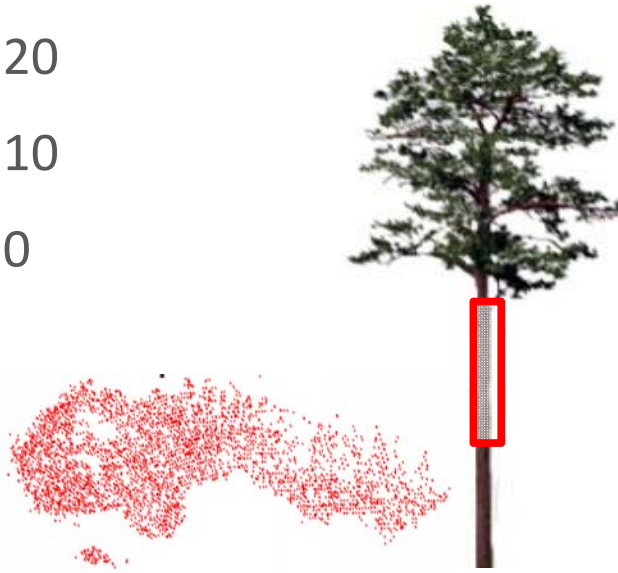


1370 logs



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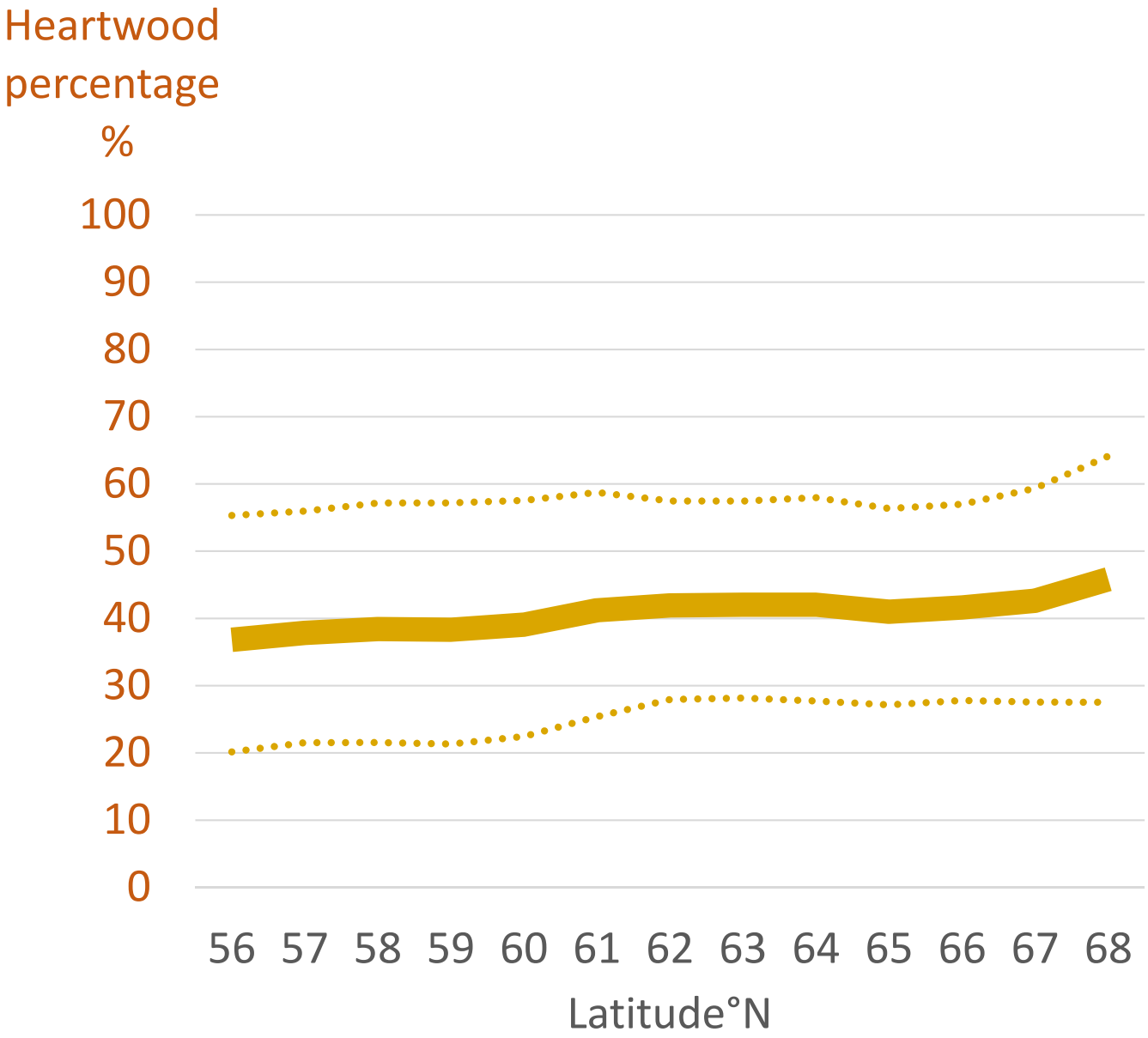
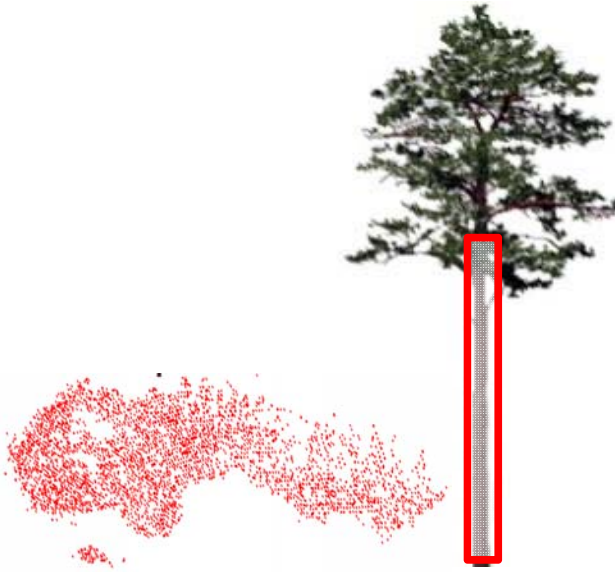
Scots pine, all sawlogs > 140 mm



Heartwood %



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Example Buttlogs Scots pine, Toppdiameter 220 -239 mm (ub)

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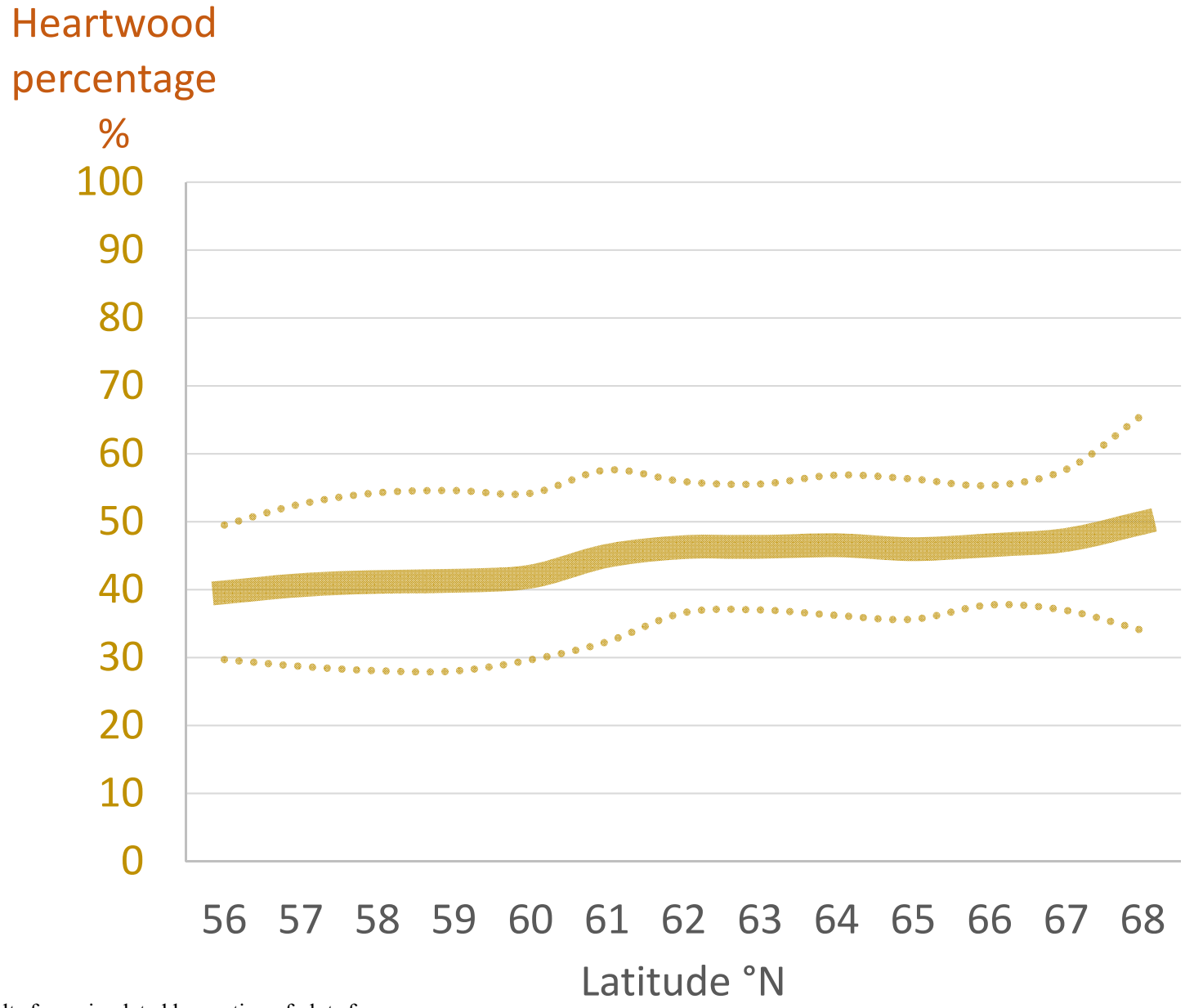

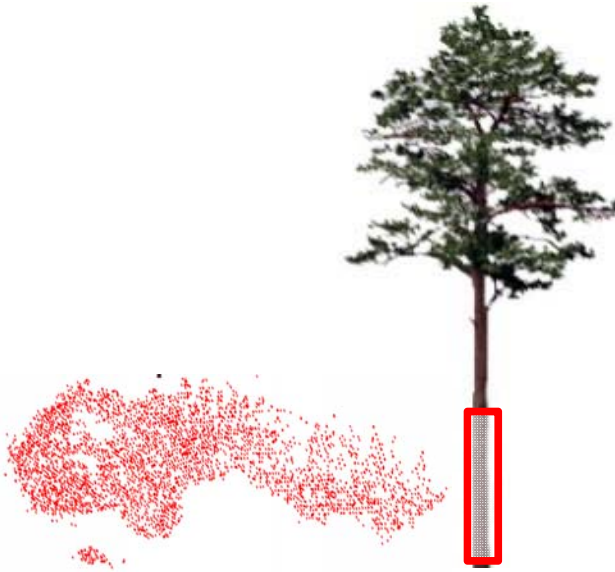

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Example: 2:nd logs Scots pine
Small end diameter 220 -239 mm (ub)

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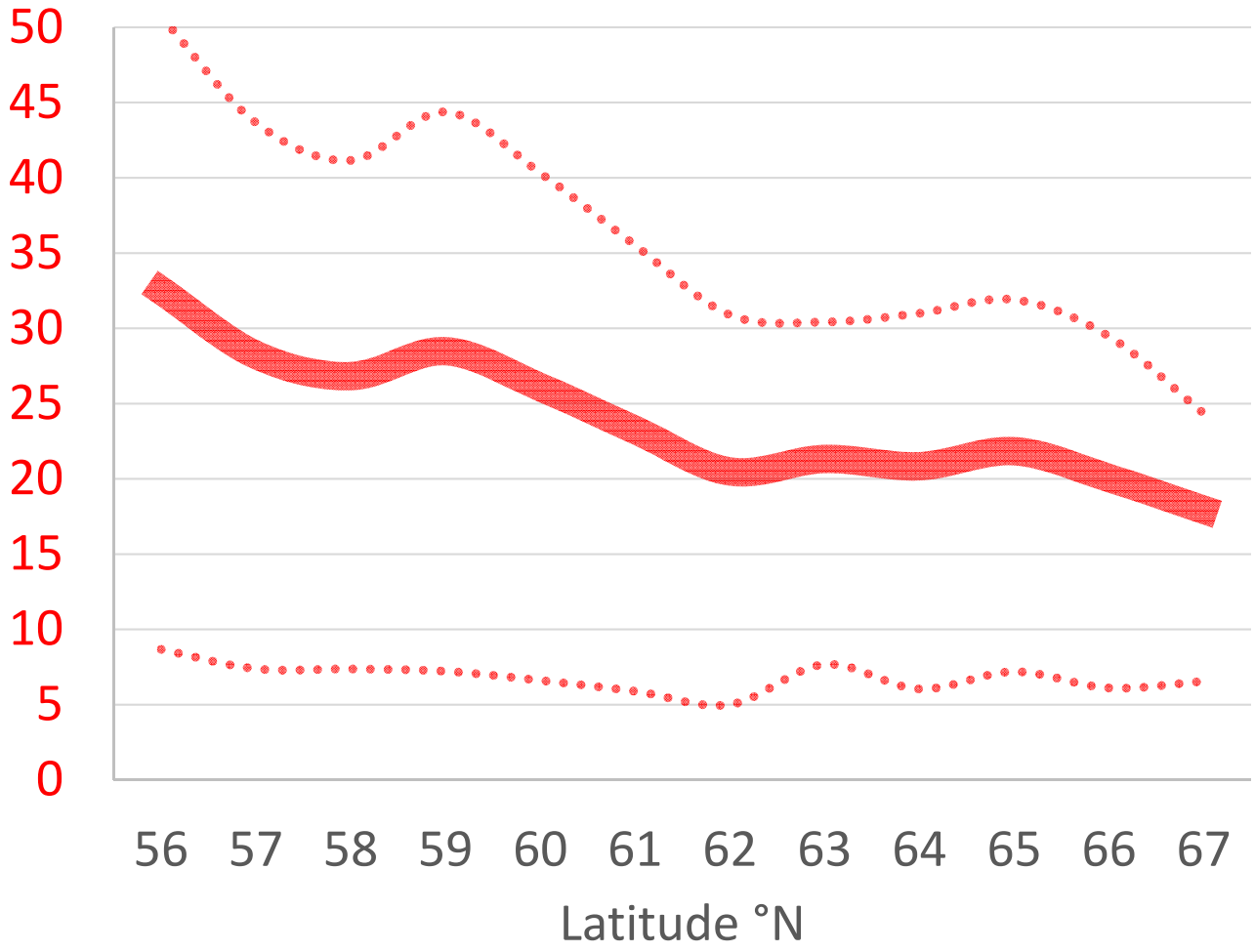
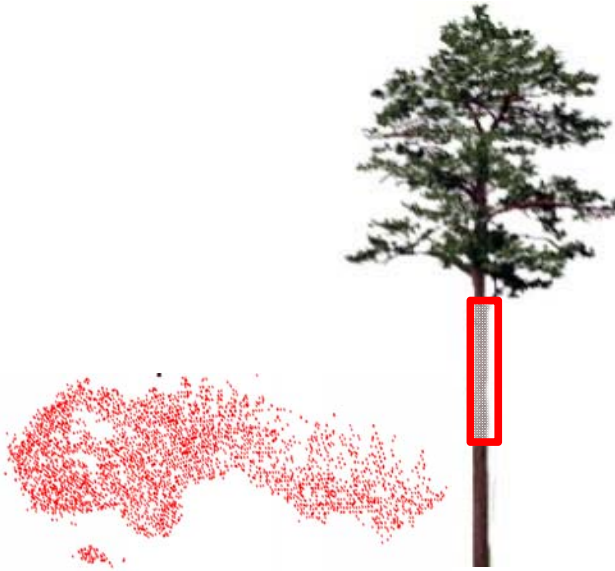
Distance between branch whorls, cm



Distance between whorls



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Results based on analysis of the Swedish National Forest Inventory 2005-2009 (Wilhelmsson 2017 unpubl.)

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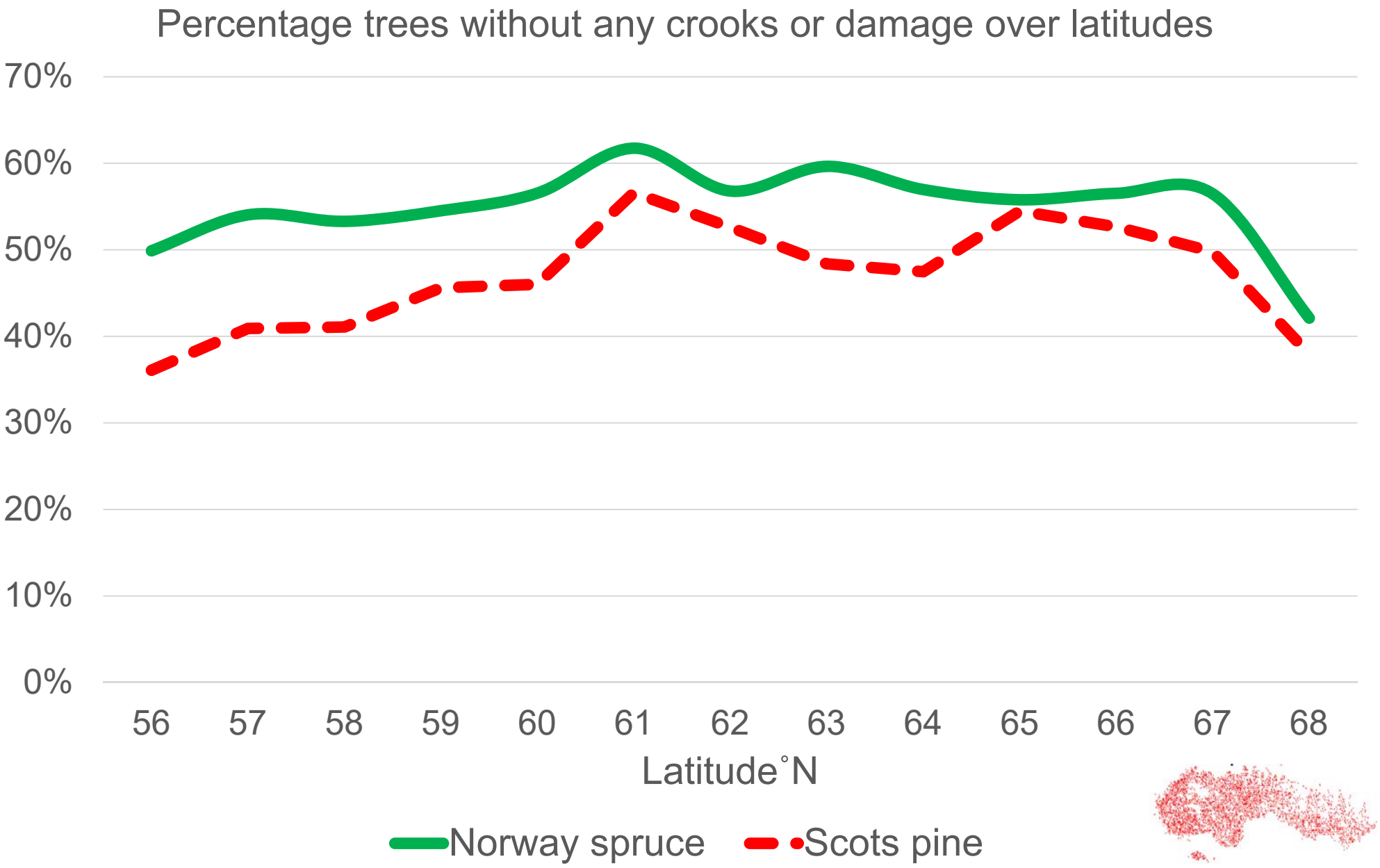

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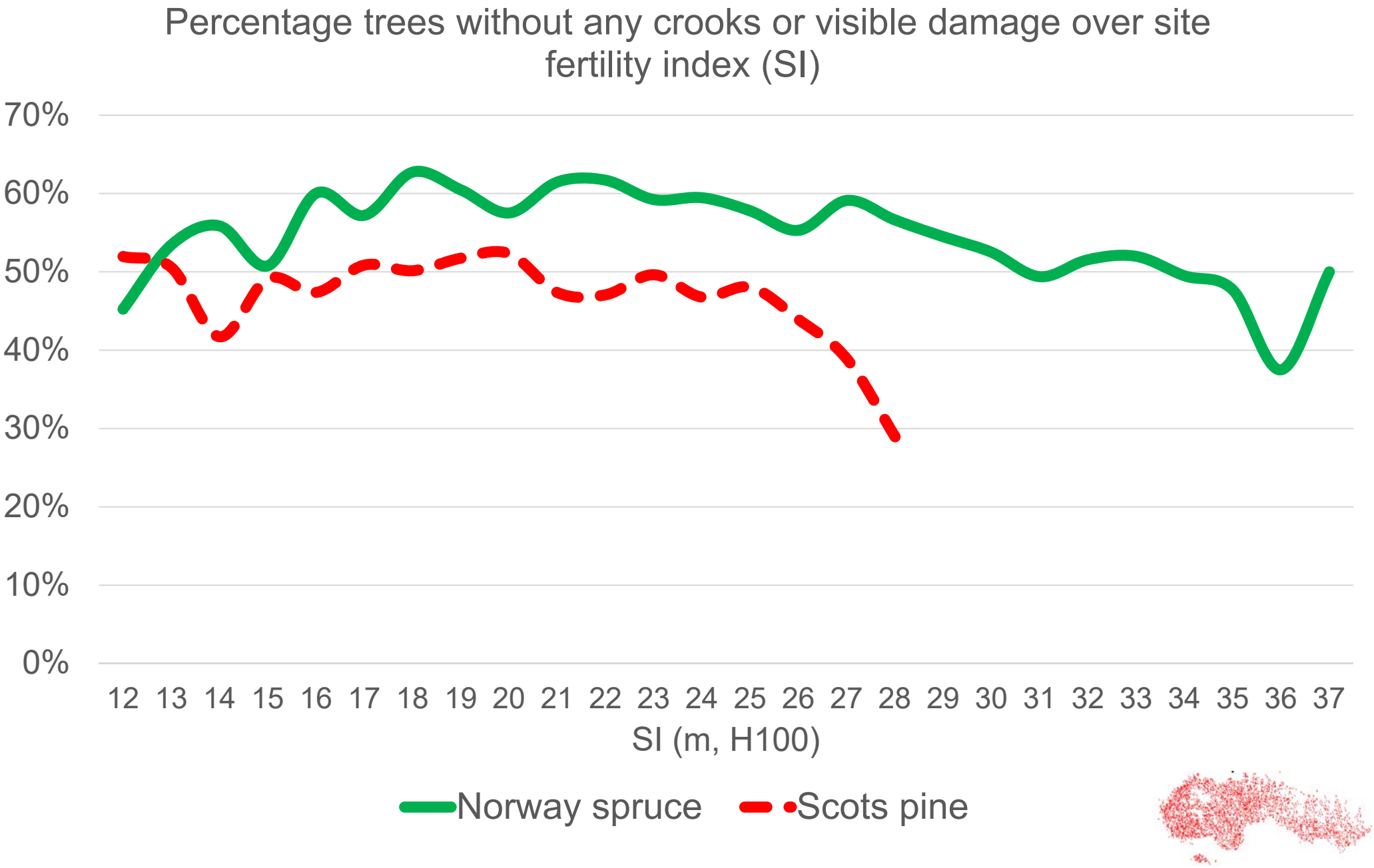

Mapping of stem properties by harvester production files (StanForD)

- Data on individual logs/stems reported from all harvested objects
  - Log diameters, length and longitudinal positions in stems
  - Species
  - Coordinates
  - Stem faults (operator's forced cuts)
- Stems can be "reconstructed" to analyse alternative bucking regimes
- Skogforsk has established a nationwide database of harvester production files. More results coming……

Example from a randomly picked harvesting object ”Labbo” ~ latitude 60°

BERGVIK SKOG

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Labbo, Örbyhus
ex. Ala pine quality 3

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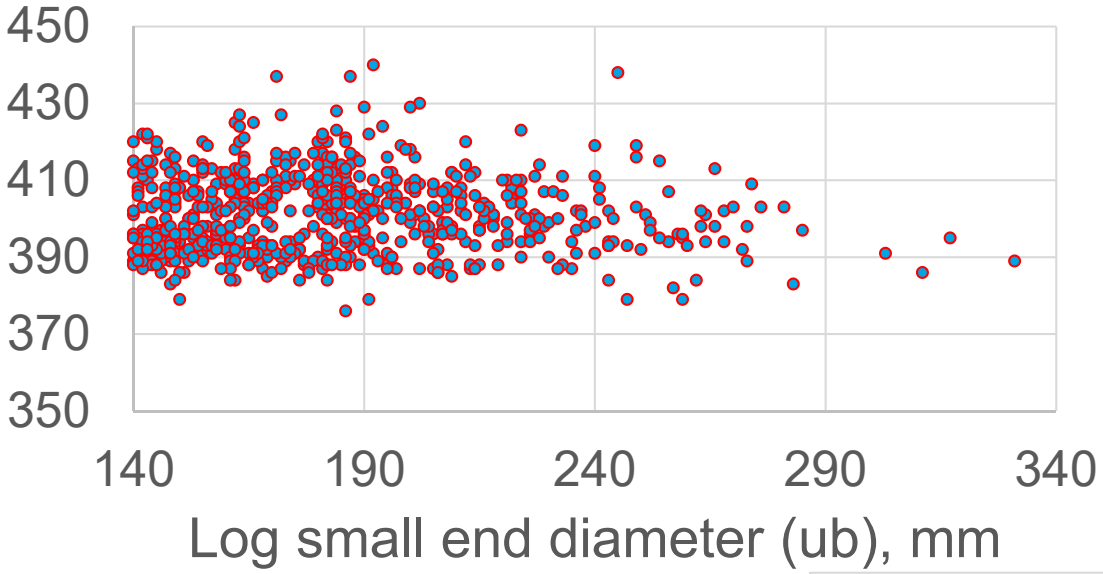
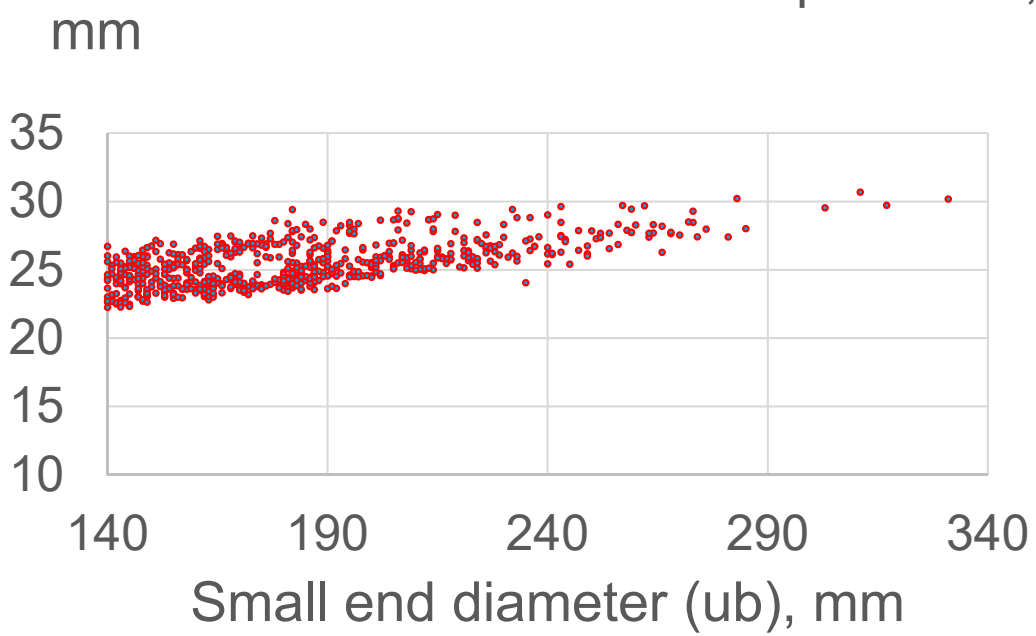
Basic density



Thickest branch per whorl, mm



WOOD GAME HOUSE

Reference: amaozon.com

Mastering the variations
opens new opportunities

Conclusions

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- Large variation in wood properties – turn problem to opportunity!
- The variation pattern is similar for pine and spruce

- Internal properties of logs can be calculated and partly predicted by tree height, diameter (along stem) tree age (bh) coordinates + models of wood properties

- All this can be utilized for
  - improving utilization of the variability of forest raw materials
  - improving planning and yield calculations

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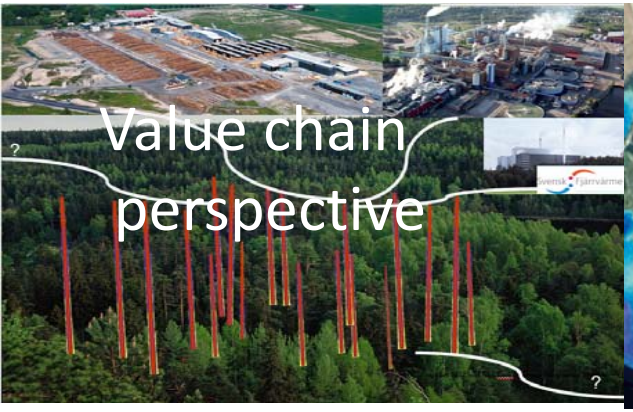

General aim - EFFORTE

to develop and adopt novel technology and tools that improve:

- **efficiency and sustainability of forestry**
- **throughout the entire forest based value chain within the EU**

EFFORTE

EFFORTE

BIO-BASED INDUSTRIES
Public-Private Partnership

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