Modelling the Variation in Latewood Proportion of Scots Pine Wood from Finland and Sweden

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Introduction

- Latewood (LW) proportion along with annual ring width explains major part of the variation in wood density
- Basic density affects a variety of physical, mechanical, tooling, etc. properties of wood related to performance in wood processing and end-uses
- LW proportion is highly related to the length of growing period and the rhythm of annual diameter growth
- In this paper, sources of variation in LW proportion of Scots pine (*Pinus sylvestris* L.) wood were analysed with linear mixed models

Empirical material (Figs. 1&2)

- Sampling was designed to cover the geographic spread and to represent different forest sites and age classes of mature pine stands in Finland and Sweden
- A total of 180 felled sample trees from five regions
- Sample discs from the sections of butt, middle, and top logs
- Two series of measurements along the south-north diagonal were averaged

Mixed model analysis

- Longitudinal linear model with AR(1) covariance structure
- Only readily available variables on stand and tree characteristics as independents
- Cubic relationship between ring number (cambium age) and LW proportion
- Separate models for the most northerly region and the other four regions
- Due to missing observations data was reduced to a total of 516 positions in 173 trees

$$LW_{xijkl} = \sum_{h=0}^{3} (b_h + v_{hkl}) n_{xijkl}^h + b_4 hr_{ijkl} + b_5 SI_{kl} + u_{0\,jkl} + e_{xijkl}$$

LW_{xijkl} = latewood proportion of ring x at height position i in tree j in stand k in region l

n_{xijkl} = serial number of ring x from the pith at height position i in tree j in stand k in region l

hr_{ijkl} = relative height of position i in tree j in stand k in region l

SI_{kl} = site index of stand k in region l

$b_0 \ldots b_5$ = parameters of fixed effects

u_{0jkl} = parameter of tree level random effect; $u_{0jkl} \sim N(0, \sigma^2_{tr0})$

$v_{0kl} \ldots v_{3kl}$ = parameters of stand level random effect; $v_{hkl} \sim N(0, \sigma^2_{sth})$

e_{xijkl} = residual variance; $e_{xijkl} \sim N(0, \sigma^2_{e0})$, $Cov(e_{xijkl}, e_{x'ijkl}) = \rho^{|x-x'|}\sigma^2_{e0}$

Results

- Highly significant cubic effect of cambium age ($b_1 \ldots b_3$) (Table 1)
- Negative effect of relative height position within a tree (b_4)
- Negative effect of site index (b_5), insignificant in northern Finland
- In northern Finland, the avegare pith-to-bark curves for LW proportion did not differ between stands, contrary to the other four regions ($\sigma^2_{st1} \ldots \sigma^2_{st3}$)
- Approx. 20% of the total variation was explained by fixed factors and 50–60% by fixed and random factors both
- Residual accounted for approx. 70–80% of the total random variation

Conclusions

Latewood proportion

- increased from the pith outward
- decreased from the butt upward
- was the lowest in northern Finland
- decreased toward high site indices in the other four regions

Only one fifth of the total variation could be covered by available background variables

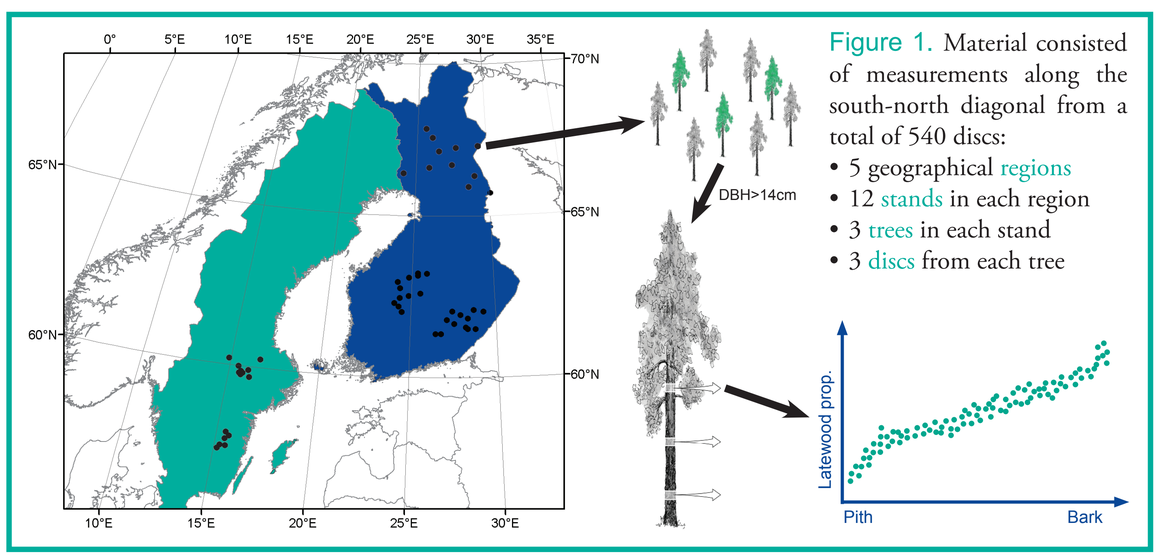

Figure 1. Material consisted of measurements along the south-north diagonal from a total of 540 discs:
- 5 geographical regions
- 12 stands in each region
- 3 trees in each stand
- 3 discs from each tree

Table 1. Estimates of fixed parameters and predicted variance components of the linear mixed models for northern Finland and the other four regions.

Fixed parameters

	b_0	b_1	b_2	b_3	b_4	b_5
NF	23.6 *	1.45 **	-.0764 **	.0023 *	-7.41 **	-.349
Others	25.0 *	7.34 **	-1.23 **	.0728 **	-11.9 **	-.542 **

Variance components

	σ^2_{tr0}	σ^2_{st0}	σ^2_{st1}	σ^2_{st2}	σ^2_{st3}	σ^2_{e0}	ρ
NF	7.26 *	3.93	.110	.0001	.0000	26.4 **	.383 **
Others	5.76 **	.0000	6.04 **	.308 **	.001 **	22.7 **	.299 **

* Significant at the 0.01 level, ** Significant at the 0.001 level

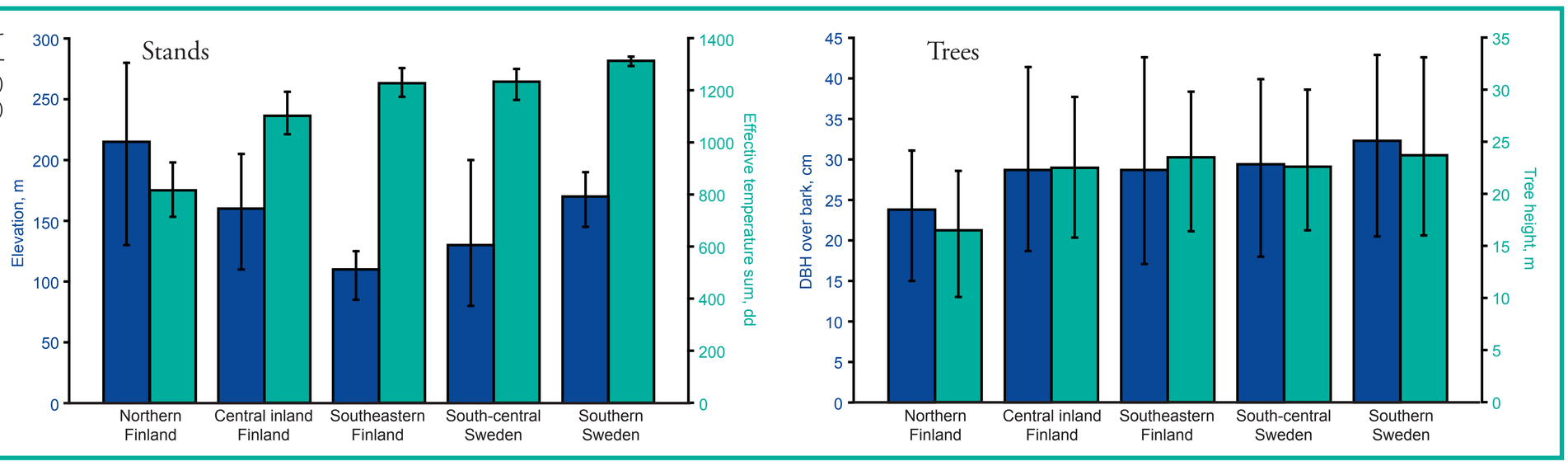

Figure 2. Basic characteristics (min–average–max) of stands (left) and sample trees (right) in different regions.

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