Thinning effects on genetic variation in Scots pine and implications for sustainable breeding and forestry

Pauls Zeltiņš[1+], Andis Adamovičs[1], Āris Jansons[1], Roberts Matisons[1]
[1]Latvian State Forest Research Institute "Silava", Salaspils, Latvia
[+]pauls.zeltins@silava.lv

Introduction

- Boreal and temperate conifer forests face increasing climate-related stressors that threaten productivity and resilience.
- Sustainable forest management must balance timber production with long-term genetic diversity, which supports adaptability.
- Commercial thinning reduces competition, enhances growth, and improves stand stability.
- However, genetic implications of thinning are less understood:
  - May increase heritability by reducing environmental noise.
  - But may reduce genetic diversity if genotypes are removed.
- Scots pine (*Pinus sylvestris* L.) is a key species for Northern European forestry and a focus of systematic tree breeding programs in the region.

Objectives

- Quantify commercial thinning effects on growth.
- Assess changes in heritability (h^2) and additive genetic variance (CV_a).
- Evaluate genotypic diversity retention (family survival after thinning).

Materials and methods

Study sites: 4 Scots pine progeny trials in eastern Latvia.

- Material: 49–122 open-pollinated families per trial from first-generation seed orchards.
- Design: 1 × 2 m spacing, 8–15 trees per family-plot, 4 or 8 replications.
- Commercial thinning of various intensity (remaining basal area 8&12 and 15&20 m^2 ha^{-1}, removed up to 58%) at the age of ~ 30-40 y. From below, without regard to family identity.
- Measurements before (height (H), diameter at breast height (DBH)) and 5 years after thinning (only DBH).
- Analysis: Linear mixed-effects models
  - Tested main effects and interactions (family, DBH_{before}, DBH_{before} × thinning).
  - Estimated h^2 and CV_a.
  - Calculated Spearman rank correlations for family means between treatments and inventories.

Figure 1. Progeny trial No. 41, 10 years after thinning (age 45 years).

Results

- **Growth response** (Fig. 2):
  - Pre-thinning DBH strongly predicted post-thinning DBH (F = 386–2336, p < 0.001).
  - Thinning intensity showed no significant main effect, but trends indicated slightly higher DBH growth for bigger trees under heavier thinning.
- Heritability (h^2) and genetic variance (CV_a) increased after thinning:
  - Trial 41: DBH h^2 rose from 0.15 to 0.24; CV_a from 13.5% to 15.7%.
  - Trial 39: DBH h^2 increased from 0.06 to 0.10; ΔDBH h^2 = 0.38.
  - Trial 43: DBH h^2 increase (0.03 → 0.19).
  - Trial 34: consistently low h^2 (0.08–0.09).
- **Family representation**: nearly all families remained after thinning (Tab.1).
- **Family ranking stability** limited between thinning intensities (r = 0.02–0.35), moderate across inventories (r up to 0.67).
- Substantial genetic variation in DBH persisted post-thinning (Fig. 3).

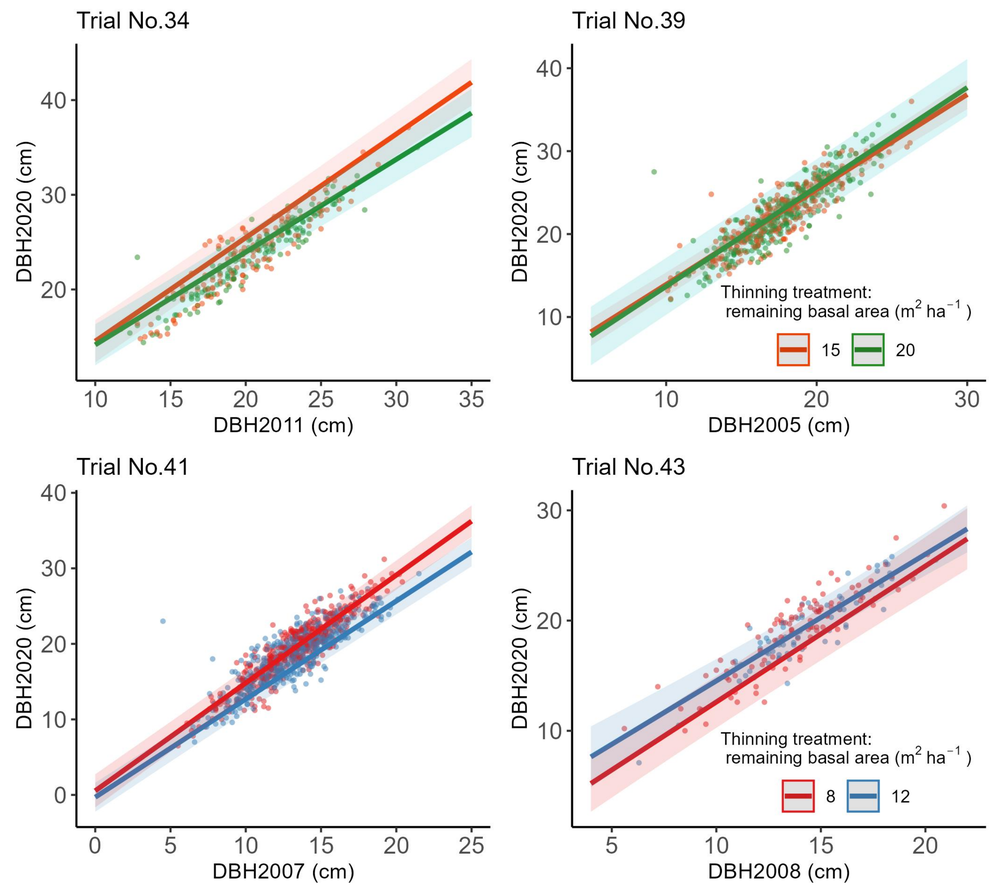

Figure 2. Relationship between pre-thinning and post-thinning diameter at breast height.

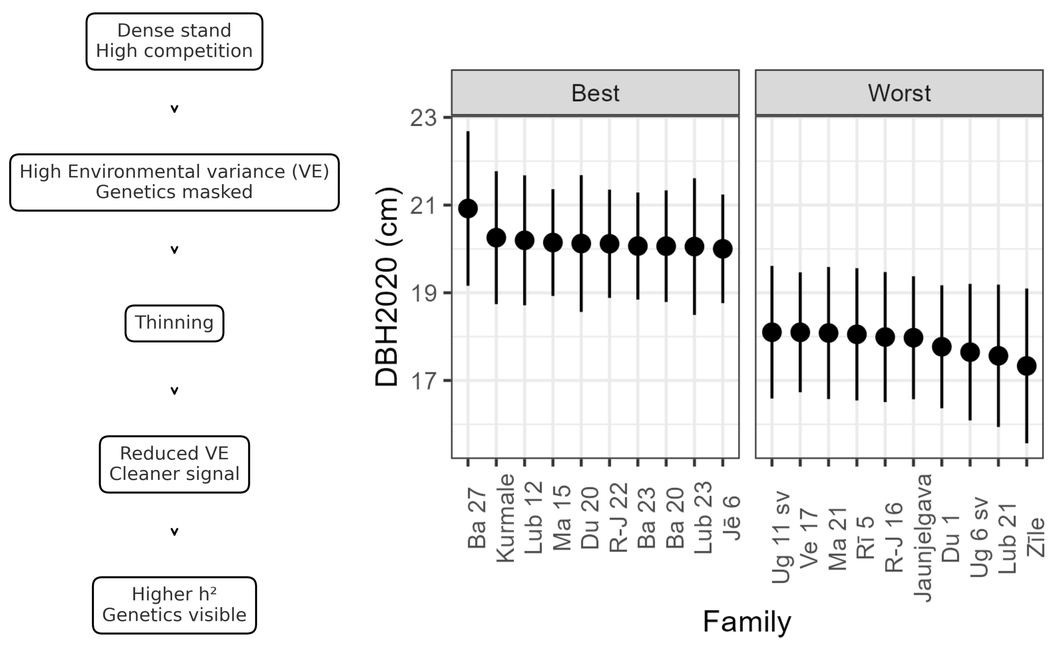

Figure 3. Comparison of the best and worst families based on diameter growth in the trial *41*.

Table 1. Family representation in the studied trials.

Trial No.	Number of families		
	Initially planted	Before thinning	After thinning
34	49	47	47
39	103	103	100
41	122	122	120
43	49	49	48

Conclusions

- Commercial thinning did not erode genetic base → support adaptation capacity for uncertain future
- This retention of genotypes also underlines the role of progeny trials as *ex situ* genetic conservation units, supporting long-term adaptability.
- Commercial thinning does not deplete genetic differences in Scots pine → importance of tree breeding in long-term.
- By reducing competition, thinning led to a higher expression of genetic variance, reflected in increased heritability of DBH.

Overall, the selection of the best genotypes, combined with an appropriate management regime (thinning), indicated to enhance stand productivity by allowing the genetically determined fast growth of selected genotypes to be expressed without narrowing the genetic base.

Innovation in Forest Management and Value Chain for Latvia's Growth: New Forest Services, Products and Technologies (Forest4LV), Project No. - VPP-ZM-VRIIILA-2024/2-0002