Lariviere D., Djupström L., Nilsson O. (2025). Impact of varying retention proportions on Scots pine (*Pinus sylvestris*) establishment across planting, direct seeding, and natural regeneration. Silva Fennica vol. 59 no. 3 article id 25007. https://doi.org/10.14214/sf.25007

Supplementary file S3 – Growth (Mean Height Difference between the first and last inventories) by Regeneration method

Total seedling growth, defined as the difference in mean sample plot height between the first and final inventories, was analysed using linear mixed-effects models (LMER) for each regeneration method separately (*Growth*). The objective was not to compare regeneration methods with one another, but to assess the effects of tree retention level and site preparation on growth within each method, recognising that each method has inherent characteristics such as initial biases, differences in starting seedling size, and temporal lags in development. Fixed effects included tree retention level (*ret_lvl*), mechanical site preparation (*MSP*), and initial mean height (*mean_H1*) as a covariate to account for potential differences in growth due to initial seedling size. The forest stand identifier (*Stand ID*) and block were included as random effects (*1|StandID/Block*). P-values for fixed effects were derived using the Satterthwaite method. The general model form was:

Equation 1 in R

$$(Growth) \sim ret\_lvl + Markb\ + mean\_H1 + (1 \mid StandID\ /Block)$$

```
mod_G_planted <- lmer(Mean_H_diff~ ret_lvl + Markb + mean_H1 + (1 | BeID/Block), data= PLANTED_df, weights = weights)
mod_G_seeded <- lmer(Mean_H_diff~ ret_lvl + Markb + mean_H1 + (1 | BeID/Block), data= SEEDED_df, weights = sum_ANTAL5)
mod_G_NR <- lmer(Mean_H_diff ~ ret_lvl + Markb + mean_H1 + (1 | BeID/Block), data= NATURALR_df, weights = sum_ANTAL5)
```

Mathematical Equation 3

$$Growth_{ijk} \sim \beta_0 + \beta_1 \cdot ret\_lvl_{ijk} + \beta_2 \cdot MSP_{ijk} + \beta_3 \cdot mean\_H1_{ijk} + u_j + v_{k(j)} + \varepsilon_{ijk}$$

Where β_0 is the intercept, β_1 to β_3 are fixed effect coefficients, $u_j \sim \mathcal{N}(0, \sigma_u^2)$ is the random effect for stand, $v_{k(j)} \sim \mathcal{N}(0, \sigma_v^2)$ is the random effect for block nested within stand, and $\varepsilon_{ijk} \sim \mathcal{N}(0, \sigma^2)$ is the residual error.

Supplementary S3 Table 1. Results from repeated measures ANOVA examining the effects of Retention Level, Site Preparation, and their interaction (Retention × Site) on the mean growth of the different regeneration types (*Planted Seedlings*, *Direct Seeded*, and *Naturally Regenerated*). Each cell reports the F-statistic from a Type II Wald F test, with degrees of freedom estimated using the Kenward–Roger approximation (reported as *F*(numerator df, denominator df)), and the associated p-value.

Regeneration method	Factor	F-value (NumDF, DenDF)	p-value	Direction (if significant)
Planted Seedlings	Retention Level	F = 0.96 (4, 10.06)	0.470	–
	Site Preparation	F = 31.81 (1, 40.37)	**<0.001 *****	↑ (higher growth with site preparation)
	Initial Height	F = 6.74 (1, 52.56)	**0.012 ***	↑ (taller seedlings grew more)
Direct Seeded	Retention Level	F = 3.44 (4, 9.45)	0.054 .	(trend ↑ for 3%)

Regeneration method	Factor	F-value (NumDF, DenDF)	p-value	Direction (if significant)
	Site Preparation	F = 20.86 (1, 41.27)	**<0.001 *** **	↑ (higher growth with site preparation)
	Initial Height	F = 13.45 (1, 52.83)	**<0.001 *** **	↑ (taller seedlings grew more)
Naturally Regenerated	Retention Level	F = 0.21 (4, 9.63)	0.926	–
	Site Preparation	F = 4.96 (1, 33.58)	**0.033 ***	↓ (growth lower on prepared sites)
	Initial Height	F = 10.42 (1, 38.49)	**0.003 ****	↓ (taller seedlings grew less)

Notes: * p < 0.05, ** p < 0.01, *** p < 0.001, . p < 0.1.
F-values are from Type II Wald F-tests with Satterthwaite degrees of freedom.
Direction (↑/↓) is based on the sign of the fixed-effect estimates in the corresponding mixed model.
“Retention level” refers to the tree retention category (five levels: 3, 10, 30, 50 % or Burn 50).
“Site preparation” = mechanical site-preparation treatment (0 = without, 1 = with).
“Growth (Mean Height Difference)” is the change in mean sample-plot height between the first and last inventories.