



***Lēmumu pieņemšanas atbalsta instruments meža ražības paaugstināšanai, nodrošinot efektīvu un klimatam piemērotu selekcijas efekta pārnesi***  
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**Provenance-specific dynamic height growth model for lodgepole pine in Eastern Baltic region**

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**Abstract**

Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia*) is a native species of North America, which has been successfully introduced in the Baltic sea region and elsewhere in Europe, with the largest economic importance in Sweden due to fast initial growth, resistance to harsh environmental conditions, and potentially higher productivity compared to Scots pine. In Latvia, experimental trials of lodgepole pine have been established since the early 1980s, and the available data from remeasured trees after four decades now allow to develop growth models up to at least mid-rotation, hence assessing the performance of the tested provenances. In context of climate change adaptation, farsighted decisions regarding assisted migration at both inter- and intra- species level can be informed by analyzing and choosing well-performing origins of native and introduced species.

We used the generalized algebraic difference approach (GADA) to model individual tree height growth of lodgepole pine provenances. The modelling was based on data from provenance trials in Latvia with an age range of up to 40 years, comprising study material of 33 origins from North America. We used mixed-effect modelling approach, applying the provenance as a random effect on the parameters of commonly used dynamic height growth derivatives.

Dynamic form of Hossfeld equation derived by Cieszewski had the best fit. The model coefficient  $\beta_1$  showed a significant variation between provenances, reflected by distinct differences in provenance-specific growth trajectories, especially asymptote. The differences were consistent over presented site quality range. The best performance was shown by the origins of Babine Lake and Summit Lake, while provenances from Alberta and Bonaparte Lake had the slowest height growth.

The developed model with provenance-specific coefficient  $\beta_1$  reasonably reflected the actual growth of the studied provenances and could be used to support decisions regarding selection of well-adapted provenances for climate-smart utilization in the Eastern Baltic region.

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### Introduction

Lodgepole pine (*Pinus contorta* Dougl. var. *latifolia*) is a native species of North America, which has been successfully introduced in the Baltic sea region and elsewhere in Europe, with the largest economic importance in Sweden due to fast initial growth, resistance to harsh environmental conditions, and potentially higher productivity compared to Scots pine. In Latvia, experimental trials of lodgepole pine have been established since the early 1980s, and the available data from re-measured trees after four decades now allow to develop growth models up to at least mid-rotation, hence assessing the performance of the tested provenances. In context of climate change adaptation, farsighted decisions regarding assisted migration at both inter- and intra-species level can be informed by analysing and choosing well-performing origins of native and introduced species.

Therefore, we aimed to develop provenance-specific individual tree height growth model for lodgepole pine in Latvia.



Figure 1. Lodgepole pine progeny trial in Latvia at the age of 40 years.

### Materials and Methods

We used the generalized algebraic difference approach (GADA) to model individual tree height growth of lodgepole pine provenances. The modelling was based on data from 6 provenance trials in Latvia with an age range of up to 40 years, comprising study material of 33 origins from North America (in total, 1428 height-age series). We used mixed-effect modelling approach, applying the provenance as a random effect on the parameters of commonly used dynamic height growth derivatives. A preliminary analysis showed that GADA form of Hossfeld equation derived by Cieszewski (2002) had the best fit:

$$h = \frac{b_1 + \frac{h_0 - b_1}{1 - b_2 h_0 t_0^{-b_3}}}{1 + b_2 \frac{h_0 - b_1}{1 - b_2 h_0 t_0^{-b_3}} t_1^{-b_3}}$$

where  $h_0$  is the height at the beginning of the forecast period,  $m$ ;  $h_1$  is the height at the end of the forecast period,  $m$ ;  $a_0$  is age at the beginning of the forecast period, years;  $a_1$  is age at the end of the forecast period, years; and  $b_1, b_2, b_3$  are empirical coefficients.

### Results

The dynamic form of Hossfeld equation with provenance-specific coefficient  $b_1$  showed the best fit, reflected by distinct differences in provenance-specific growth trajectories, especially asymptote (Figure 2). Mean residual and root mean square error of the final fitted model was -0.02 and 1.37 m, respectively; the distribution of the residuals over predicted height were scattered around zero without distinct trends. The differences among the provenances were consistent over presented site quality range. The best performance was shown by the origins of Babine Lake and Summit Lake, while provenances from Alberta and Bonaparte Lake were the lowest.

### Conclusions

The developed model with provenance-specific coefficient  $b_1$  reasonably reflected the actual growth of the studied provenances and could be used to support decisions regarding selection of well-adapted provenances for utilization in the Eastern Baltic region.

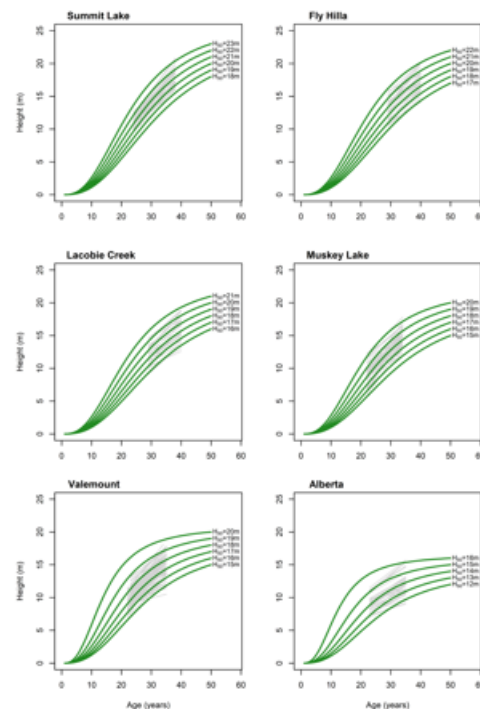


Figure 2. Lodgepole pine height growth curves applying Hossfeld dynamic model. Six provenances with distinct growth patterns are shown. Light grey colour in the background denote observed height - age series.