Predicting regeneration establishment in Norway spruce plantations using a multivariate multilevel model

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Abstract. This study predicts the regeneration establishment on 3-year-old Norway spruce *(Picea abies (L.)* Karst) plantations is southern Finland using regeneration survey data. Regeneration establishment was described by seven response variables: number of planted spruces, natural Scots Pines (*Pinus sylvestris L.).* natural spruces, natural seed-origin birches *(Betula pubescenes Ehrh.* and *R. pendula* Roth.) and other broadleaves (i.e. sprout-origin birches and other broadleaves than birch). as well as height of crop-tree spruce and dominant height of broadleaves. lie to the multivariate (several responses for each plot) and multilevel (plot stand municipality forest centre) structure. regeneration establishment was modeled by fitting a multivariate multilevel model with explanatory variables such as temperature sum, site fertility, soil quality and method of site preparation. In the model, the numbers of tree seedlings were modeled using over-dispersed Poisson distributed equations, and the tree heights were modeled using normally distributed linear equations, The estimated fixed and random parameters of the equations were logical, and there was no serious bias in predicting the regeneration establishment in the independent test data set. This modeling approach can he used to predict the regeneration establishment stochastically by taking into account the large unexplained variation in regeneration models.

Introduction

In forest management planning, mathematical models are commonly used to predict forest development over time. One of the most difficult tasks of forest modelling is to predict the regeneration of new trees in the stand. The processes of forest regeneration are highly variable due to many random factors that affect the germination, survivability and growth of seedlings. The number and early development of natural seedlings are closely connected to the regenerative biology of overstory trees, the prevailing soil and climatic factors, competition by overstory trees and ground vegetation (e.g. Kozlowski 2002). There arc also many factors controlling the success of artificial regeneration. Even though direct sowing would guarantee a sufficient amount of seed and good seed dispersal, site and weather conditions may be unfavourable for the germination