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Does mixing tree species enhance stand resistance against natural hazards? A case study for spruce

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ABSTRACT

In this study, survival of spruce (*Picea abies* [L.] Karst.) trees in mixed- and mono-species stands was analyzed using the database of Rhineland-Palatinate's forest damage survey (FDS). The influence of species mixture on tree survival probability was analyzed using data from 9864 trees, of which 2866 spruce trees have been analysed in detail. Data was collected on 495 research plots in a series of continuous measurements taken since 1984.

For estimating survival probability, the Kaplan–Meier method was applied to achieve a first overview about possible effects. The analysis was then extended using Accelerated Failure Time (AFT) models to estimate the parameters of a Weibull function, used to describe survival times. The resulting models were used to simultaneously analyze the effects of intensity of mixture (represented by Shannon–Weaver-Index and, alternatively, by species proportion), time since harvest and site characteristics.

Results obtained indicate positive effects of species mixture on resistance of spruce trees: survival probabilities increase with increasing intensity of mixture, regardless whether mixture is characterised by Shannon–Weaver-Index or species proportion.

Spruce trees in monocultures on average site conditions will reach age 100 with a probability of 80%. Spruce trees growing in a moderately mixed stand (average Shannon–Weaver-Index 0.4) show a slight increase in survival probability to a 83% probability of reaching age 100 whilst spruce trees in a more diverse stand (average Shannon–Weaver-Index 1.2) have a 97% probability of reaching age 100. An admixture of 50% thus leads to an increase in survival probability of 17 percentage points. Site variables even show a stronger impact on survival than tree species mixture. From these variables wet soils had the strongest negative influence on spruce survival, while orographic conditions of saddles, anticlines, valleys, trenches or dells showed the strongest positive influence on survival. However, the strongest influence on spruce survival was recent harvest activity. The more time had passed since the harvest operation, the less likely residual trees were to succumb to stresses.

1. Introduction

The use of simple models for the evaluation of management options in ecosystem management is very common amongst economists (Armstrong, 2007). However, many of the models used suffer from a lack of biological accuracy (Bulte and van Kooten, 1999), which originates from their deterministic nature, as well as from their focus on single-species situations (Knoke and Seifert, 2008). Modelling deterministically means to implicitly provide the existence of genuine information about the future and ignore the numerous uncertainties in forest management (Palma and Nelson, 2010). This practice may lead to very optimistic financial assessments of economically-optimised silvicultural decisions (Lucas and Andres, 1978; Möhring, 1986; Knoke et al., 2008), which in turn precludes the possibility of integration of the precautionary approach into economic modelling (Figge and Hahn, 2004; Knoke and Mosandl, 2004; Knoke and Moog, 2005; Weber-Blaschke et al., 2005 or Krysiak, 2006). However, precaution is a central component of modern sustainability concepts (Hahn and Knoke, 2010), and becomes particularly important if climate change scenarios are to be considered.

This lack of biological accuracy as described is particularly true for the modelling of mixed-species stands. Here, models often not only ignore relevant factors like a possible compensation of financial risks between tree species (Clasen et al., 2011; Knoke and Wurm, 2006), they also regularly exclude the ecological effects of mixing tree species and the resulting biophysical consequences (Knoke et al., 2008; Pretzsch, 2009).

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