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VULNERABILITY OF FORESTS TO STORM DAMAGE IN A FOREST DISTRICT OF SOUTH-WESTERN GERMANY SITUATED IN THE PERIPHERY OF THE 1999 STORM (LOTHAR)

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Abstract

The paper attempts to evaluate the impact of the storm (called Lothar) of December 1999 on a forest district in the periphery of the area of major damage in south-western Germany. Sites within the district are generally considered suitable for stable rooting of the district's major tree species - Norway spruce, beech, ash, sycamore and oak. The evaluation was based on timber salvage data of four publicly owned forests, on inventory data gathered for all stands during a survey in the summer of 1999, and for selected stands in spring 2000. Based on the growing stock prior to the storm and the volume of salvage (post the storm), the vulnerability of spruce was ranked highest followed by beech, oak and ash/sycamore. Apparently, species composition of stands did not mediate vulnerability of spruce: the proportion of standing volume of spruce removed by the storm did not differ significantly between stands of almost pure spruce and mixed stands of spruce and deciduous trees.

Introduction

In the central area of storm damage in Baden-Württemberg (south-western Germany) wind gust velocities exceeded 200 km/h (Mayer & Schindler 2002). Such extreme wind velocities are considered to generally exceed the stability of trees almost independent from forest structures (lit. in Mason 2002). In contrast, in peripheral areas with less severe wind velocities, forest structures (e.g. species composition, vertical structure) can be expected to significantly influence the potential impact and extent of storm damage.
Drawing from inventory data in conjunction with data on salvage we attempted to analyse factors influencing vulnerability of forests in a forest district situated in eastern Baden-Württemberg in the periphery of the area that suffered major damage from the 1999 storm (see Kronauer 2000): the storm affected a volume of approximately double the normal annual cut in the district. Such an analysis appeared promising, as the most recent inventory had been carried out during the summer of 1999 yielding current data on the district's forests.

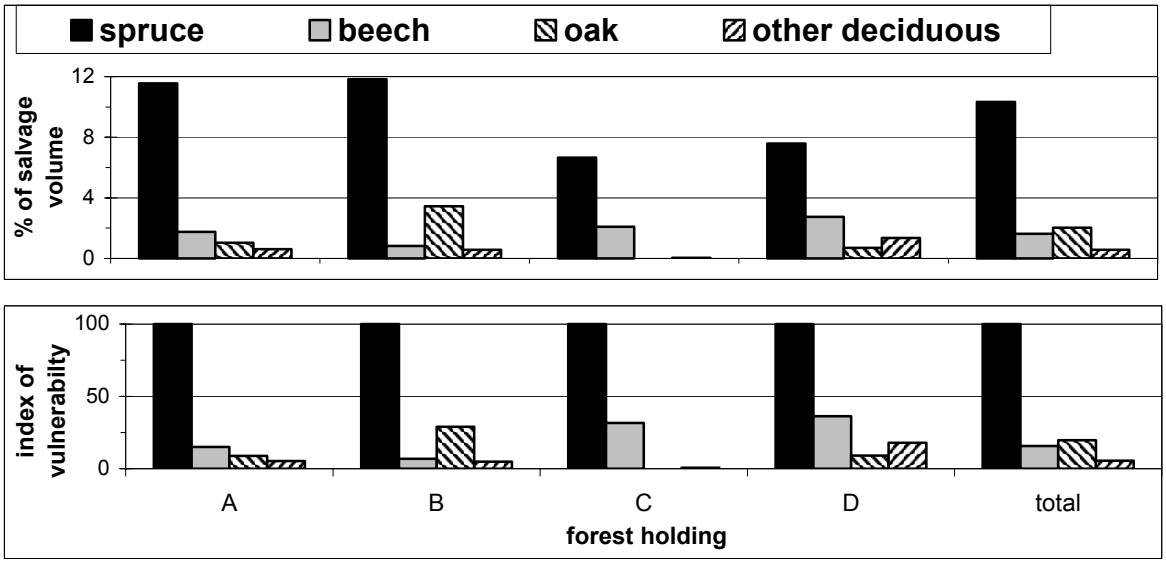
Methods and material

The forest district of Blaustein is situated on the limestone plateau of the Schwäbische Alb in eastern Baden-Württemberg in the vicinity of the city of Ulm. In general, the sites are considered suitable for stable rooting of the districts major tree species - Norway spruce (*Picea abies*), beech (*Fagus sylvatica*), ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*) and oaks (*Quercus robur* and *Q. petraea*).

Four publicly owned forests (approx. 4,000 ha) had been subject to an inventory in the summer of 1999 (plot density: 1 plot per 2 ha) yielding current data on composition and structure of the growing stock almost immediately prior to the storm in December. These data on growing stock prior to the storm were compared to volume and species composition of storm damage as deduced from the forest owners' data on salvage in the aftermath of the storm.
In selected stands dominated by spruce (> 85 %), mixed stands of spruce and deciduous trees or stands dominated by deciduous trees (> 95 %) inventory plots were revisited in spring 2000 and checked for trees that had survived the storm. Storm impact on the stands was inferred by comparing inventory data calculated for trees existing on the plots prior to the storm and trees that had survived the storm (for further detail see Kohnle et al. 2003).

Species composition of salvage

Fig. 1: Volume of salvage and volume of growing stock prior to the 1999 storm of the major tree species in four publicly owned forests of the Blaustein forest district.



		publicly owned forests:				
		A	B	C	D	**total**
total volume of salvage (m³)		*33,959*	*15,500*	*4,400*	*8,280*	***62,139***
% of total salvage volume	spruce	85	86	87	88	**86**
	other conifers	1	1	1	0	**1**
	beech	12	5	12	11	**10**
	oaks	1	7	0	1	**2**
	ash, sycamore (other deciduous)	1	1	0	1	**1**
salvage volume in % of growing stock prior to the storm	spruce	12	12	7	8	**10**
	beech	2	1	2	3	**2**
	oaks	1	3	0	1	**2**
	ash, sycamore (other deciduous)	1	1	0	1	**1**
	total	*6*	*6*	*4*	*6*	***6***
index of vulnerability*	spruce	100	100	100	100	**100**
	beech	15	7	32	36	**16**
	oaks	9	29	0	9	**20**
	ash, sycamore (other deciduous)	5	5	1	18	**6**

* reference value: salvage volume of spruce in % of growing stock of spruce = 100

In all four forests, salvage in Norway spruce reached the highest values by far. This was true for the absolute volume of salvage as well as for the proportion of the volume of growing

stock removed by the storm. To compare the vulnerability of the different tree species to storm damage an index of vulnerability was calculated using the percentage of spruce growing stock removed as a reference value.
In comparison with spruce, vulnerability indices for beech generally ranked second followed by oaks; ash/sycamore showing the lowest vulnerability indices. This ranking corresponds with earlier findings for the 1990 storm (Weidenbach 1991, Aldinger et al. 1996).
However, our results with beech and oaks were inconsistant: although in tendency index values for beech were considerably higher than for oaks (three out of four forests) while recognizing that in one forest this ranking was reversed (figure 1). We made a similar observation for the ash/sycamore group where - with the exception of one forest - indices indicated a comparatively low level of vulnerability. However, judging from known site composition, forest structure, or stand exposition we couldn't readily identify obvious reasons that convincingly explained these inconsistencies.

Correlation bewteen height, diameter and vulnerability of spruce

Diameter. For analysis of dbh (diameter at breast height; 1.30 m) of spruce lost by storm we selected the sample plots where spruce had partially vanished from the plots in spring 2000. Plots without spruce prior to storm or total loss of spruce were omitted. Spruce trees vanished from the plots showed slightly smaller average dbh if compared to spruce trees remaining on the plots (figure 2). Although not pronounced dbh differences were statistically significant ($p<0.05$; t-test).

Fig. 2: Average dbh of spruce remaining on plots in comparison to spruce disappearing from plots from 1999-2000 and average relation of dbh of disappearing trees in relation to remaining trees (analysis of plots where spruce had only partially disappeared).

	spruce			
	trees remaining on plot 1999-2000		trees disappearing from plots 1999-2000	
	mean	*SE*	mean	*SE*
dbh (in cm)	40.4*	*0.44*	39.1*	*0.67*
[number of trees]	*[308]*		*[190]*	
[number of plots]	[50]			

**: difference between means significant (t-test; p<0.05)*

Height. For analysis of the influence of stand height on vulnerability of spruce, losses of volume of spruce growing stock were calculated for all plots containing spruce prior to storm and were grouped according to the tallest spruce present on the plot ("top height"). The scatterplot seems to suggest that volume losses increase in tendency with top height of the plots (figure 3). However, our data showed a tremendous amount of variation resulting in an inacceptably poor correlation coefficient for a polynomic regression explaining approximately 20 % of the total variation. Correlation clearly improved, if only the plots with the highest volume losses (5 plots per 5 m hight class) were included in the regression analysis (R^2=0.78).

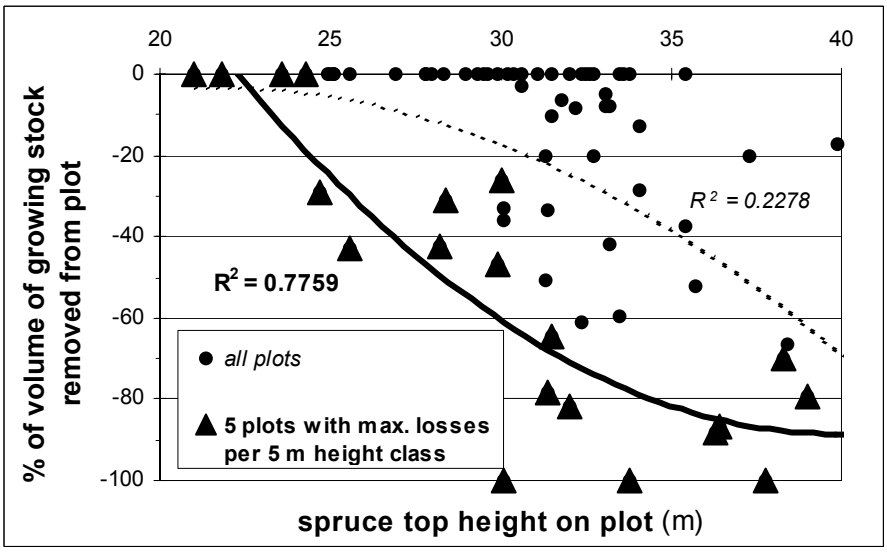


Fig. 3: Top height of spruce on plots and percentage of volume of spruce growing stock removed by the 1999 storm.

Vulnerability of spruce in pure and mixed stands

As is the rule on suitable sites, in the Blaustein district spruce outgrows deciduous trees in hight. For example, within the mixed spruce/deciduous stands height of spruce had reached average values up to approx. 4 m higher prior to storm 1999 than those of beech as the major deciduous species (figure 4).

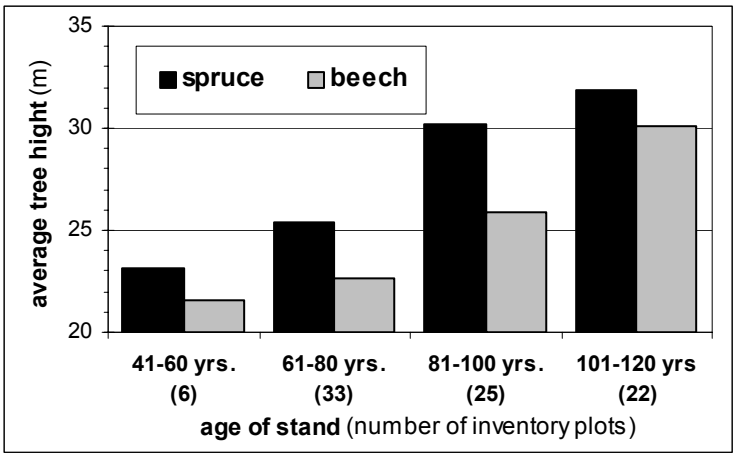


Fig. 4: Average height of spruce and beech in mixed stands of spruce and deciduous trees prior to the 1999 storm.

Therefore, it appeared of interest to analyse if vulnerability of spruce had increased in mixtures with deciduous trees of inferior height. However, we did not find apparent differences of losses in spruce between almost pure spruce stands or mixed spruce/deciduous stands, respectively. This finding was true for losses of volume of growing stock as well as for tree numbers (figure 5). It appears reasonable to assume, that within the mixed stands analysed mixture with deciduous trees of inferior height either had not resulted in an increased “wind load” of the relatively heigher spruce or had been compensated by other factors, respectively.

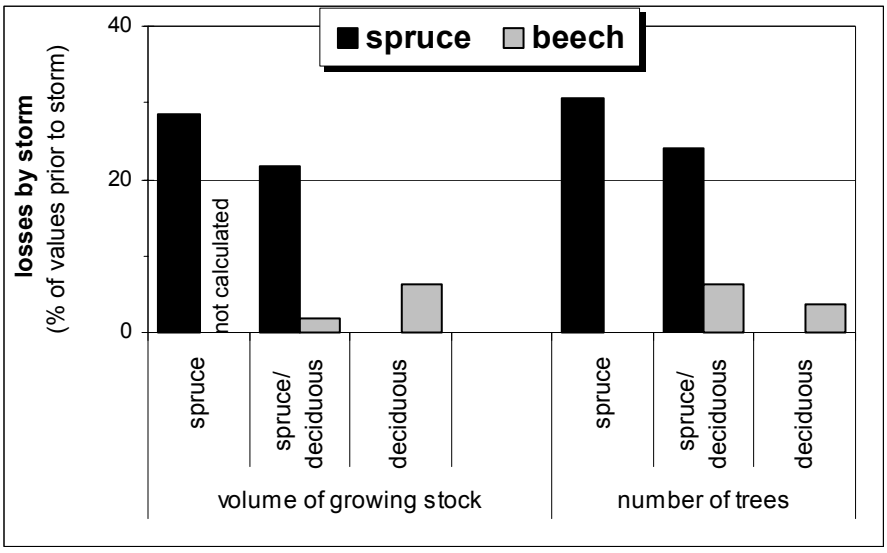


Fig. 5: Losses in tree number and volume of growing stock of spruce and beech in different mixture types of stands.

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