DRIVERS OF WIND MORTALITY ASSOCIATED WITH SEVERE WINDSTORMS IN PRIMEVAL MOUNTAIN FOREST

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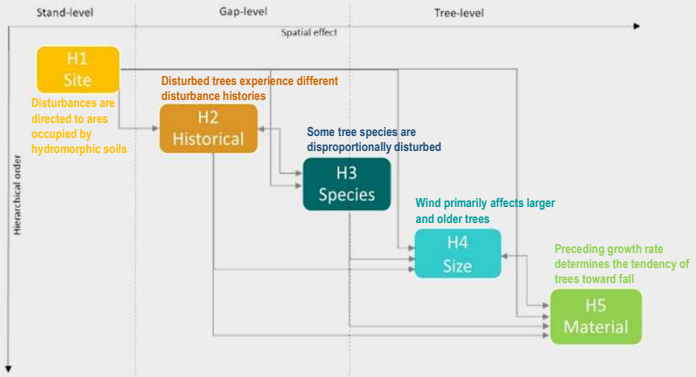
1 Introduction

The driving forces of tree mortality following wind disturbances of mountain mixed European temperate forests belongs among issues not comprehensively resolved. Hence, we aimed to elucidate the key factors of tree resistance to historical severe disturbance events in the Boubínský Primeval forest (Šumava Mts.,CZE). Specifically, we formulated the following hypotheses:



2 Methods and Materials

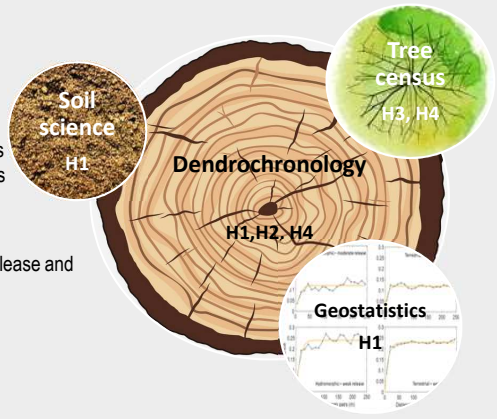
We interconnected several data sets and different approaches for particular hypotheses and statistically compared selected characteristics of 271 pairs of neighbouring trees that were disturbed by Herwart storm in 2017 and those that survived. Using pair tests we evaluated following characteristics:

Soil science
soil hydromorphism

Geostatistics
spatial pattern of disturbance events on terrestrial and hydromorphic soils

Dendrochronology
tree age, frequency and intensity of past disturbances as revealed by release and gap origin

Tree census
tree species, DBH



3 Results

The results demonstrate that the susceptibility of trees to treefall is primarily driven edaphically, limiting severe events non-randomly to sites occupied by hydromorphic soils, promoting the existence of a spatially-explicit, edaphically-determined mixed disturbance regime. The non-random spatial distribution of treefall events, largely limited to previously disturbed sites, indicates the extraordinary significance of windthrow dynamics in biogeomorphic processes. While gap-phase dynamics dominated terrestrial soils, hydromorphic sites rather experienced extremely strong, but less frequent events, such as Herwart or the series of windstorms in the 1870s (Fig. 1-2).

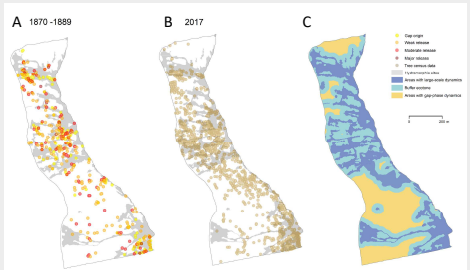


Figure 1. Maps of the spatial pattern of severe disturbances in Boubin, based on dendrochronological (A) and tree census (B) data, and a map of the spatially-explicit mixed disturbance regime (C), derived on the basis of the soil hydromorphism map plus dendrochronological and tree census data.

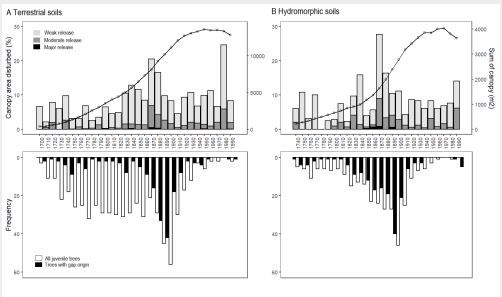


Figure 2. Summary disturbance histories of Boubin, developed separately for: (A) terrestrial and (B) hydromorphic soils. Upper charts represent the proportion of disturbed canopy area (%) from the total sum of exposed canopy (sample depth, m²) in the examined decade. Bottom charts depict the number of trees indicating gap origin.

Our study supports the hypothesis that tree stability is related to previous tree growth and disturbance history in the vicinity. While disturbed trees usually recruited in open canopy gaps and experienced only one severe release event, surviving trees characteristically regenerated under the canopy and were repeatedly released. On average, tree survivors showed 40% more releases by number per tree and created nearly three times more total sum of disturbed canopy area than trees killed in 2017 (Fig. 3). While our study revealed that individuals with accelerated growth rates were more vulnerable to the Herwart storm, it does not support the size hypothesis that windstorms primarily select larger and older trees. Instead, trees killed by the Herwart storm had lower age and dimension than surviving neighbours.

The distribution of tree populations along a gradient of soil moisture resulted in a selective impact of the Herwart storm, primarily affecting Norway spruce, indicating a tight soil-species-disturbance interaction. On the other hand, we did not detect any interspecific variation for most of studied characteristics (Fig. 3).

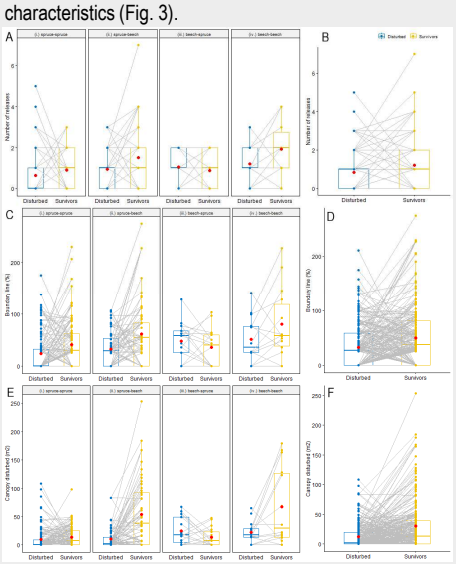


Figure 3. Paired boxplots of characteristics of disturbance frequency and intensity for both dendrochronological datasets for: (A,C,E) the characteristics sorted by species pairs; (B,D,F) the characteristics for all species. The hinges correspond to the 25th and 75th percentiles, with the thick solid line showing the median and red circles the mean values. Grey lines connect individual trees within the pairs.

4 Conclusions

The results indicate that severe events do not affect the forest randomly, but instead hit the same places repeatedly, i.e. patches with a predominance of hydromorphic soils, in turn affecting disturbance regime, species composition as well as tree growth. The functional trait of slow initial growth, with several periods of suppression, provides a tree mechanical advantage in wind firmness as well as delayed canopy accession. In contrast, trees with rapid growth rates are connected with accelerated life cycle, and thus earlier predisposition to root pathogens as well as exposure to disturbance.

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