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DIEBACK ENVIRONMENT FROM A FOREST SOIL PERSPECTIVE – 2nd year project report

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INTRODUCTION In Central Europe, disturbance to Norway spruce (Picea abies (L.)) stands has largely been attributed to droughts in 2018 and 2019 (Hari et al. 2020; Kornhuber et al. 2019). However, our understanding of forest soil responses to drought-induced tree mortality is far from complete (Allen et al. 2015). For example, while tree canopy removal can cause increased air and surface temperatures, forest floor and topsoil moisture levels often increase (Špulák et al. 2021). In this study, we assess the significance of different post-disturbance management conditions on forest regeneration and parallel effects linked with soil condition in three representative forest types, i.e. clear-cut sites, disturbed forest with dead trees and living (healthy) uncut forest. The study was realised under four "work packages". Owing to the large dataset obtained for soil properties, this study focuses on soil enzymatic activity and soil moisture dynamics.

WP1 SOIL TYPOLOGY

WP2 SOIL BIOCHEMISTRY AND BIOLOGY

WP3 HUMUS CONDITIONS AND SOIL CARBON

WP4 PHYSICAL AND HYDROPHYSICAL PROPERTIES

MATERIAL AND METHODS The design strategy ensured that each study locality included three treatments (living forest, disturbed forest and clear-cut sites) with similar soil and meteorological conditions, the plots being established using the design of Fidler et al. (2021). In 2021, study sites were established in two Bohemian (Benešov, Vilémov) and three Moravian (Vranov, Velká Bíteš, Černá Hora I) spruce monocultures, the site list being expanded to include three new Moravian spruce monocultures (Černá Hora II, Vír, Letovice) and repeat sampling at Vilémov in 2022. A more detailed description of the study localities is provided in Vichta (2022). At each plot, soil samples were obtained using two sampling protocols. The first focused on vertical differences in soil enzymatic activity in the forest floor and topsoil, with soil enzyme activity from C-hydrolases (C-cycle) and N-hydrolases (N-cycle) being determined using fluorogenic substrates, according to Bárta et al. (2014), and labile carbon levels in the soil determined by measuring POxC, according to Weil et al. (2003). The second protocol established the vertical dynamics of soil water in the soil column and individual soil layers, the soil water regime being measured using TDR or TDT sensors (EMS Kučera, Brno) at three depth profiles (10, 30 and 60 cm). The resulting time series' covered the period of rainwater replenishment (October to December 2021) and period of intensive vegetation growth (May to July 2022). All tests were performed at a significance level of 5 % (i.e. $p < 0.05$) using the Statistica software package v.14.

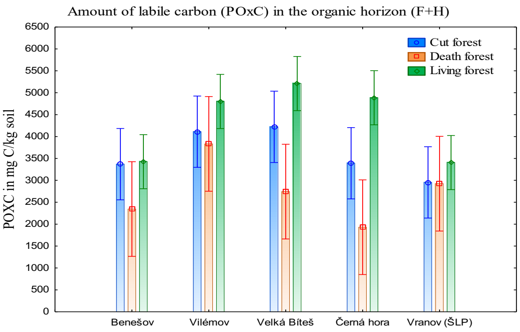

Figure 1. Amount of labile carbon in the organic horizon for all stand treatments at all localities in 2021.

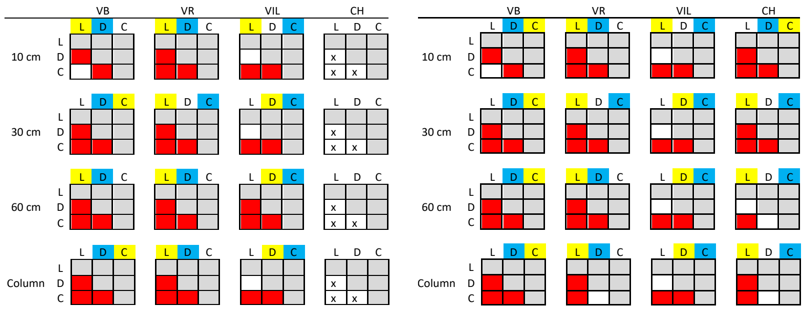

Figure 2. Results of the Kruskal-Wallis test across all stand treatments, period of rainwater replenishment (left), period of intensive vegetation growth (right) and depths using soil moisture values (L = living forest, D = disturbed forest with dead trees, C = clear-cut sites; VB = Velká Bíteš, VR = Vranov, VIL = Vilémov, CH = Černá Hora). Blue squares indicate wetness treatment for depth, yellow squares indicate driest treatment for depth. Red squares indicate significantly different means (at the 5% significance level) and white squares indicate not confirmed differences in means. Squares with black cross are no-data periods.

RESULTS AND DISCUSSION There was a significant difference between the living and disturbed forests and the clear-cut site at Vranov, with N-hydrolase activity being higher in the living and disturbed forest. At Černá hora and Velká Bíteš, the amount of labile carbon was highest in the living forest. For all other localities, there was no significant difference in C-hydrolase and N-hydrolase activity and the amount of labile carbon between different forest stand sites. All sites showed a similar soil water content (SWC) distribution within the soil column, with sites at the disturbed site having the highest SWC, followed by clear-cut sites and living forest sites. Overall SWC values for the entire column were significantly different between clear-cut and living forest sites, however, with SWC being higher in the living forest at Velká Bíteš and clear-cut sites at Vranov and Černá Hora. According to Kopáček et al. (2020), the impacts of forest disturbance on SWC are particularly significant in the upper forest soil layer, a finding confirmed in our own study, with significant differences in SWC at 10 cm depth at all localities.

CONCLUSIONS Our results confirm the general assumption of disturbed forests with dead trees being 'wetter' than clear-cut sites, followed by living forests. While we found similar results with the amount of labile soil carbon, there were no clear differences between stands in C-hydrolase and N-hydrolase activity. As such, we suggest that deeper layers are primarily influenced by soil substrate properties and not by disturbance to forest cover. Further phases of this research will focus on the organic and organic-mineral soil layers (to a max. depth of 30 cm).

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REFERENCES

Allen, C. D., Breshears, D. D., & McDowell, N. G. (2015). On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. Ecosphere, 6(8), 1-55.
Bárta, J., Šlajsová, P., Tahovská, K., Picek, T., & Šantrůčková, H. (2014). Different temperature sensitivity and kinetics of soil enzymes indicate seasonal shifts in C, N and P nutrient stoichiometry in acid forest soil. Biogeochemistry, 117(2), 525-537.
Fidler, O., Holík, L.,Kučera, A., Neubauer, Š., Samec, P., Šlachetka, M.,-- Tomášová, G., Valtera, M., Vichta, T., -Volánek, J., Žižlavská, N., Balková, M. (2021). Dieback environment from the forest soil perspective - 1st year project report. In SilvaNet – WoodNet 2021: Proceedings Abstracts of Student Scientific Conference. Brno: Mendel university in Brno, 2021, s. 25--26. ISBN 978-80-7509-814-6.
Hari, V., Rakovec, O., Markonis, Y., Hanel, M., & Kumar, R. (2020). Increased future occurrences of the exceptional 2018–2019 Central European drought under global warming. Scientific reports, 10(1), 1-10.
Kornhuber, K., Osprey, S., Coumou, D., Petri, S., Petoukhov, V., Rahmstorf, S., & Gray, L. (2019). Extreme weather events in early summer 2018 connected by a recurrent hemispheric wave-7 pattern. Environmental Research Letters, 14(5), 054002.
Kopáček, J., Bače, R., Hejzlar, J., Kaňa, J., Kučera, T., Matějka, K., ... & Turek, J. (2020). Changes in microclimate and hydrology in an unmanaged mountain forest catchment after insect-induced tree dieback. Science of the Total Environment, 720, 137518.
Špulák, O., Šach, F., & Kacálek, D. (2021). Topsoil moisture depletion and recharge below young Norway spruce, white birch, and treeless gaps at a mountain-summit site. Forests, 12(7), 828.
Vichta, T., Neubauer, Š., Valtera, M., Holík, L., Fidler, O., Samec, P., Tomášová, G., Volánek, J., Kučera, A., Šlachetka, M., Žižlavská, N., Balková, M. (2022). Effect of Norway spruce forest dieback on soil water balance: the examples from upland areas of the Czech Republic. In Veda mladých 2022: Proceedings
Weil, R. R., Islam, K. R., Stine, M. A., Gruver, J. B., & Samson-Liebig, S. E. (2003). Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. American Journal of Alternative Agriculture, 18(1), 3-17.