DIEBACK ENVIRONMENT FROM A FOREST SOIL PERSPECTIVE

3rd year project report

Holík Ladislav, Kučera Aleš, Kostka Matěj, Neubauer Štěpán, Nikitina Tatiana, Samec Pavel, Tomášová Gabriela, Valtera Martin, Vichta Tomáš, Volánek Jiří, Zapletal Petr, Balková Marie

Mendel university in Brno / Faculty of Forestry and Wood Technology
e-mail: marie.balkova@mendelu.cz

KEYWORDS

bark beetle
Norway spruce
soil biochemistry
soil DNA
soil moisture

INTRODUCTION

Major and the most interesting outcomes of the final project phase are presented in this contribution. The project was centred around forest soil property changes after the Norway spruce (*Picea abies* (L.) H. Karst) disturbances caused by the drought and bark beetle infestation during the last decade. The research took place on eight research plots (Fig. 1) with the following treatment triplets: (1) clear-cut, (2) declined with standing trees and (3) healthy stand. The study and particular hypothesis were carried out within four work packages: WP1 – Soil typology; WP2 – Soil biochemistry and biology; WP3 – Humus conditions and soil carbon; WP4 – Physical and hydrophysical properties.

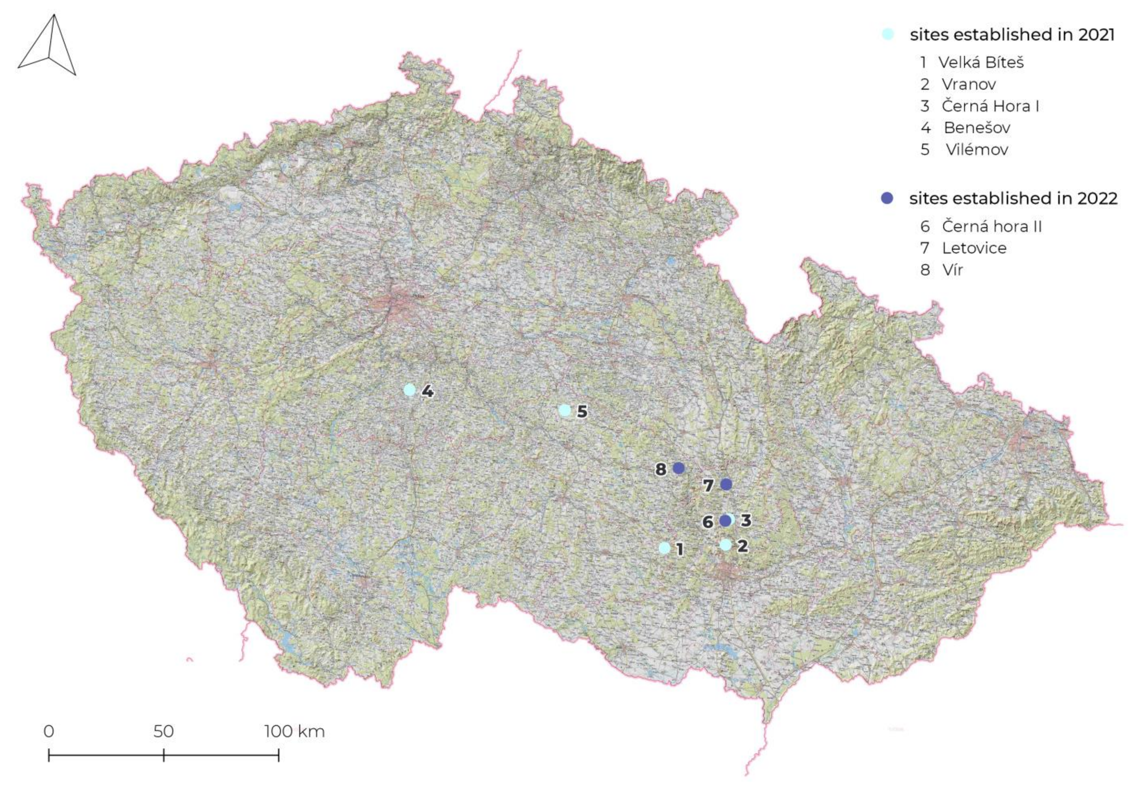

Figure 1: Research sites established during the project solution in 2021 and 2022

RESULTS

WP1

Within the system of examined Norway spruce stands in the Bohemian-Moravian Highland (with the area of 16.792 km^2 and 36.3% forestation), 35 soil types were classified in total. They represent 0.63% of mapped forest soils. The major detected soil reference groups were Cambisols (Fig. 2) with the following units: Haplic (37.1%), Luvic (26.9%), Skeletic (8.8%) and Dystric (4.7%). The soils were classified into six hydric groups, with the majority of anhydromorphic light sandy soils (93.6%). Redoximorphic (2.9%) and heavy clay soils (1.9%) represented units of percentage only.
All the hydric groups were characteristic by the highest retention capacity in top-soil horizons beside the lower diagnostic horizons. The retention water capacity corresponded with the hydrolimits variability of the light sandy soils across the whole Czech Republic and indicated the regional differences of the soils under influence by water within the particular forest areas.

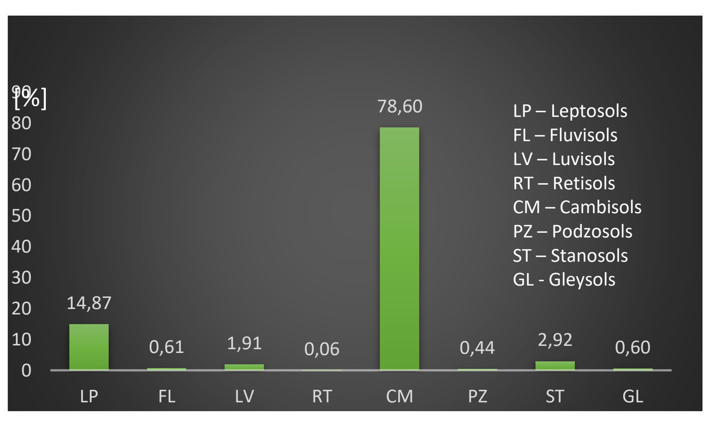

Figure 2: Forest soil reference groups determined during the project within the research plots

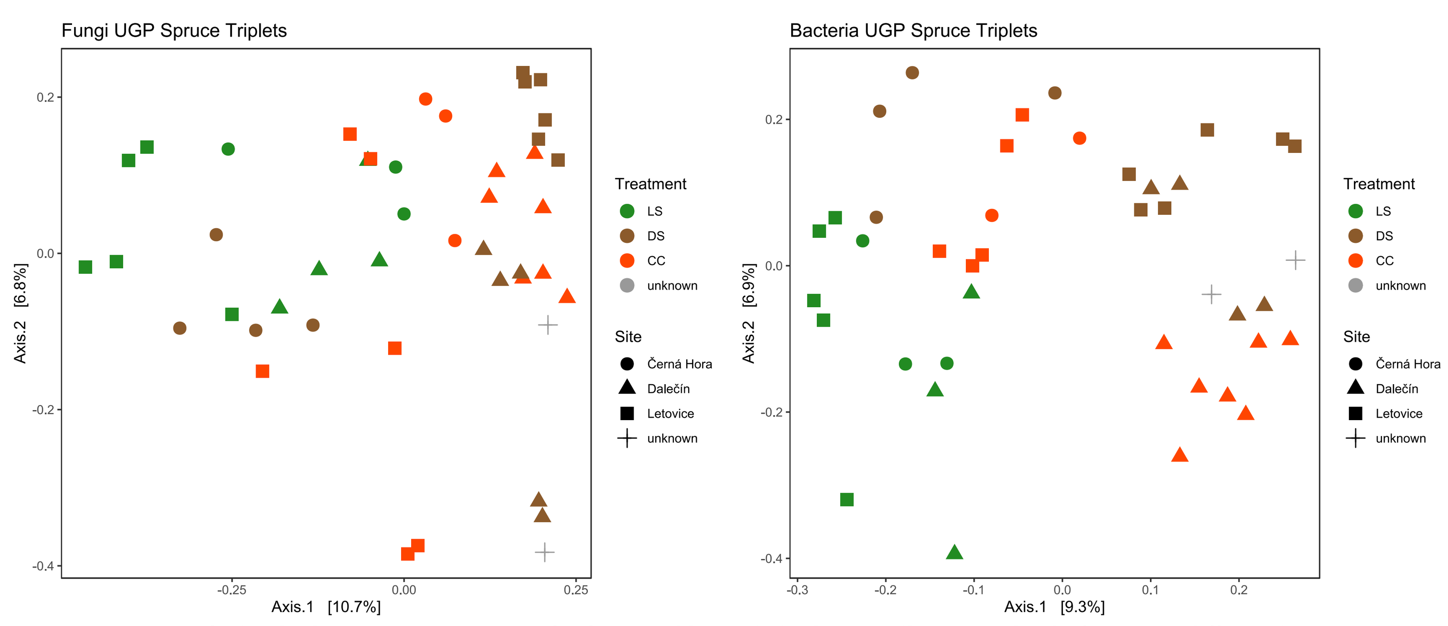

Figure 3: PCA of microbial community structure for fungi and bacteria in the topsoil (0–5 cm depth) from sites differing in treatment (living, dead standing, clear cut) and locality (Letovice, Vír and Černá hora II)

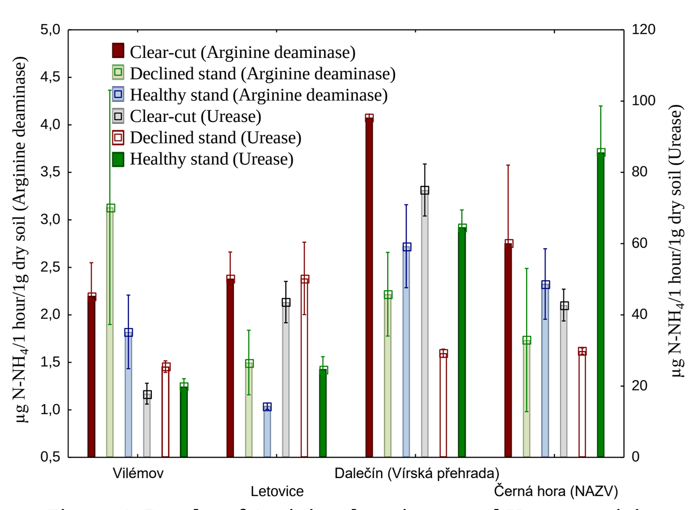

Figure 4: Results of Arginine deaminase and Urease activity in the 0–5 cm depth

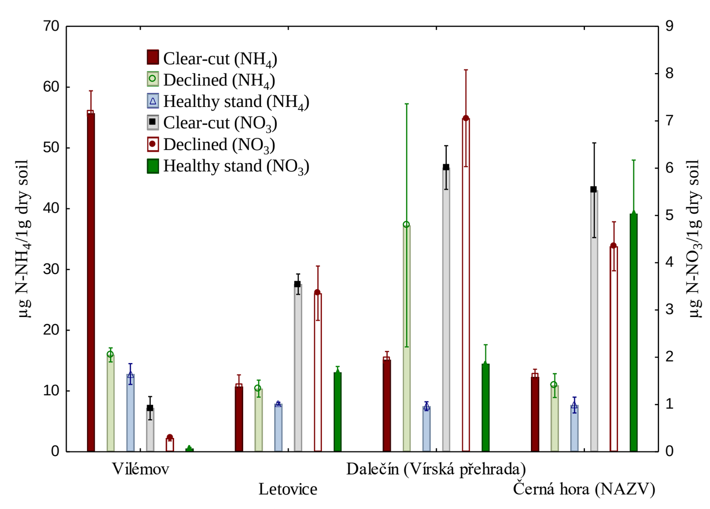

Figure 5: Amount of NH_4 and NO_3 in the 0–5 cm depth

WP2 & WP3

For the plots established in 2022 (Letovice, Vír and Černá hora II), DNA sequencing was performed to determine the bacterial and fungal community composition. Interim results indicate some apparent trends. Interrelationships were explained by PCA and descriptive statistics with respect to treatment and locality. Graphical representation of fungal data shows that the fungal community separation is mainly due to the treatment, whereas the bacterial data are distinctly separated by both the treatment and the locality (Fig. 3). Fungal and bacterial abundances were evaluated on the level of kingdom, phyla, and genera. Regarding the archaeal and bacterial ratio, a rapid increase in declined stands with standing trees was observed. Such shift can be explained by the site's hydric and nitrogen cycle-related changes. On the other hand, the clearcuts show no preliminary obvious change. Detailed descriptive bioinformatics at the phyla and genus level requires further analysis with the background knowledge of each group's specificities and behaviour, e.g., mycorrhizal symbiosis and site conditions can be well demonstrated on the example of the *Archaeorhizomyces* and *Russula genera*, which show apparent abundance differences within the treatments and rapid decreases after the stand decline. Concerning the enzymatic and microbial activity analyses across all research plots, the most interesting results comprise concentration measurements of ammonia nitrogen – NH_4 (for depths of 0–5 cm and 0–10 cm), nitrate nitrogen – NO_3 (for the F+H layer) (Fig. 4) and the urease enzyme activity (Fig. 5). The results are surprisingly contradictive in the sense that the highest amount of NH_4 is linked to the lowest urease activity in declined stands. This result is, however, logical since soil microbial communities are not always able to produce sufficient amount of nitrogen compound degrading enzymes, helping to obtain organic matter-contained ammoniacal nitrogen contradicting the relative site abundance. Surprisingly, the activity of arginine deaminase enzyme (also producing NH_4) is statistically significant only in the fermented and humus layers, where its activity is the lowest on the clearcut compared to declined and healthy stands.

WP4

The example of an initial assessment of water-holding capacity included soils on the locality in Vilémov that are strongly to very strongly water-holding. In general, clearcut was the wettest site, followed by declined and healthy stands. The clearcut was more than 32% wetter than the healthy stand and 17% wetter than the declined stand. The largest relative differences in moisture were found in the topsoil, at 10 and 30 cm.
During the study period, soil moisture values at all depths were within the range of available water capacity, excepting the summer period June to August 2022, when at 10 and 30 cm the moisture values for helthy and dead stands approached or exceeded the wilting point. Early in this period, the declined stand gradually died back and was eventually harvested in late July and August.
When the microclimatic conditions changed, in the period July/August 2022, after the removal of the dead stand, a leapfrog in soil moisture was observed in this plot, with a growth of more than 13% in the whole soil column and at most 18% in the spruce root zone (i.e. 30 cm). The most significant difference between the two variants is that the original clearcut site is compactly grassed, whereas the new one's top organic horizons are without vegetation cover and are exposed to the weather conditions. Therefore, in particular, the role of the creation of grass tuf on the site in terms of soil water retention, and its potential negative impact on soil chemistry by excess water, should be a major focus of future research.

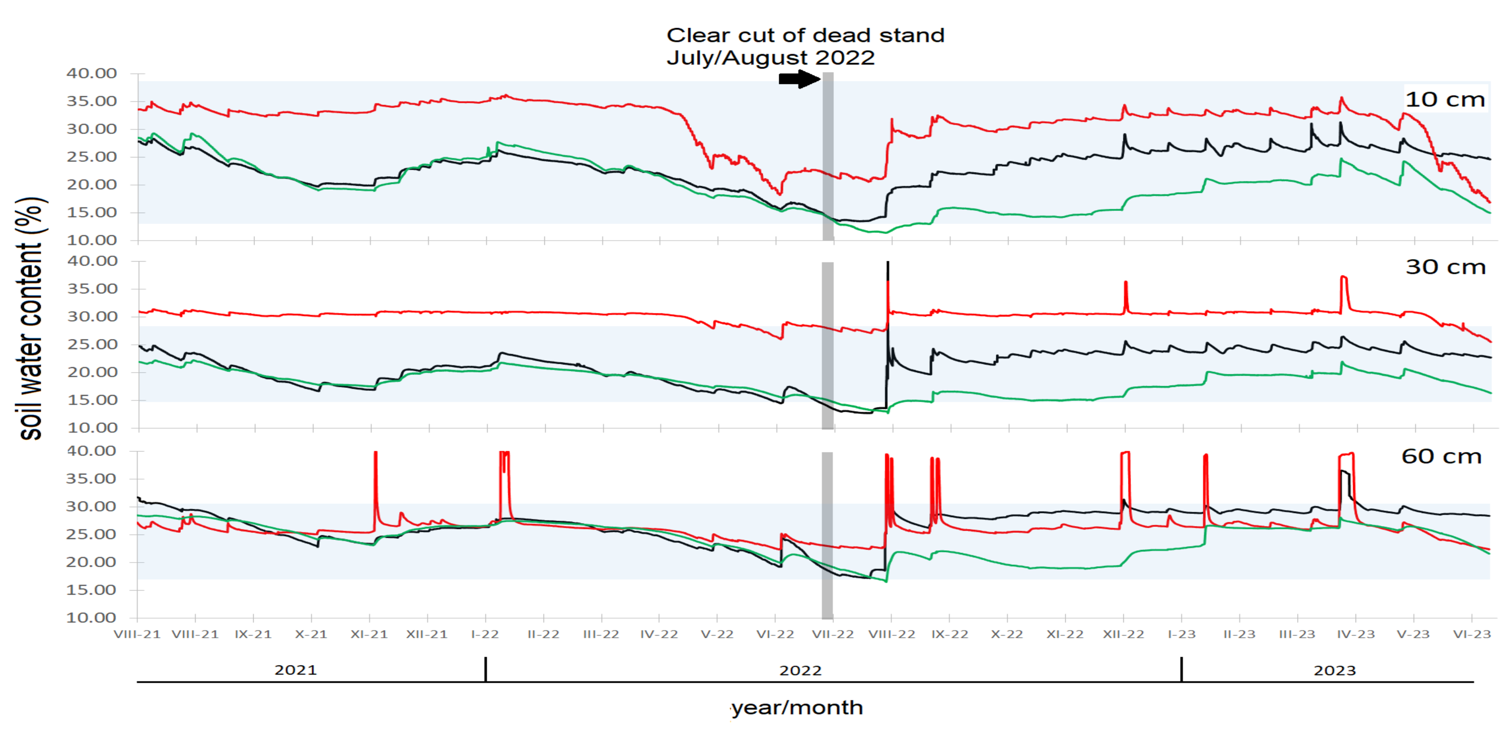

Figure 6: Course of soil moisture at the depths of 10, 30 and 60 cm; green line = healthy stand, red line = clear-cut, black line = declined stand with standing trees, blue range = available water capacity by plants.

CONCLUSION

This contribution summarizes only the most interesting results of each WP because it is not possible to describe all of them in detail. However, several articles in scientific journals have been published and other manuscripts are being prepared for publication in following year.

ACKNOWLEDGEMENT: This contribution was founded by Internal Grant Agency MENDELU, LDF_TP_2021006 Soil environment response at Norway spruce dieback stands.

ldf.mendelu.cz

MENDELU
Faculty of Forestry and Wood Technology