Biogeomorphic and pedogenic impact of trees in three soil regions

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1. Objectives

Forest soils are under constant direct and indirect influence of trees and their root systems. Additionally, soil microbes and mycorrhizas form several complex symbiosis with tree roots and together act as a powerful **"weathering engine".**

Geomorphology, soil science, and forest ecology have already recognized several processes which impact weathering processes, forest dynamics and forest soil evolution (e.g. tree uprooting). However, there is another important **hotspot of biotic impact** of trees which is space, soil material and associated processes under trees and tree stumps. In spite of the needs which we think are tremendous and can add to our understanding of weathering and soil production processes this narrow part of the **Critical Zone** has not been adequately studied so far. Such studies were seriously limited in the past mainly due to difficulties in soil profile excavation and a priori assumptions that effects of individual trees are not significant and that such soils do not generally differ from soils in places currently not occupied by living and decaying trees.

Here we propose a novel approach to the study of forest soils through **soil regions**.

Research questions:

1) Do trees through stem flow and root systems influence soil physical and chemical properties?

2) Do root systems impact biochemical and biomechanical weathering in soils and regolith?

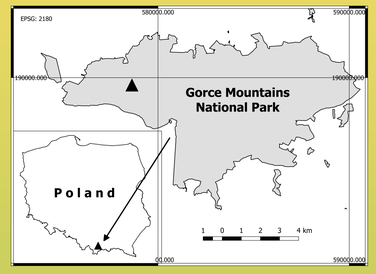
3) What kind of long-term effects detected in soils can be attributed to tree roots?

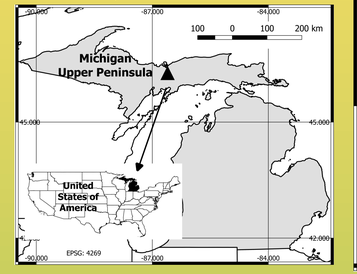
2. Methods

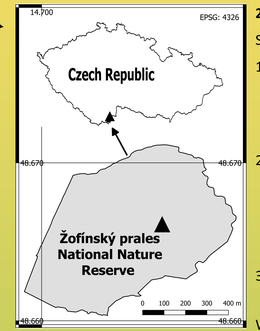
2.1. Study sites

Because of our attempt to test general rules of soil development under trees for this study we chose tree individuals in three different soil regions:

- **Haplic Cambisols** on flysch (Turbacz Reserve in Gorce Mountains National Park, Poland)
- **Entic Podzols** on granites (Zofin Reserve in Novohradske Mountains in the Czech Republic)
- **Albic Podzols** on a glacial outwash (Upper Peninsula, Michigan, USA).







2.2. Soil analyses

We conducted numerous chemical analysis which allowed us to evaluate main soil forming processes in soils affected (control) and unaffected by trees. We focused on **soil weathering** and leaching processes, formation of secondary minerals, clay translocation, podzolization, melanization, and hydromorphic processes.

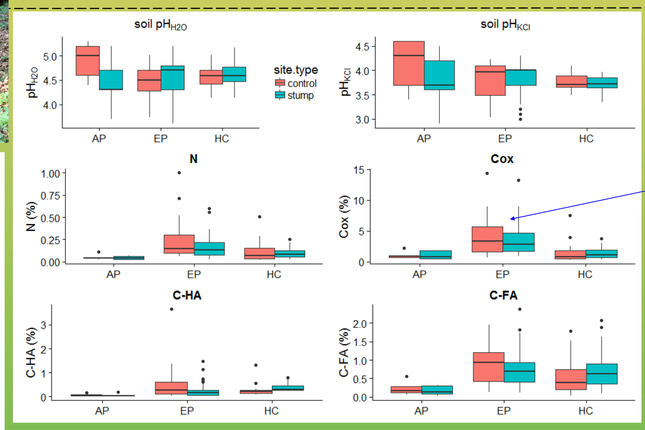
We followed standard procedures tested previously by Šamonil (2010). In total 10 samples were taken in Michigan, 55 in Zofin and 69 in Turbacz which were analyzed for 20 chemical and physical properties.

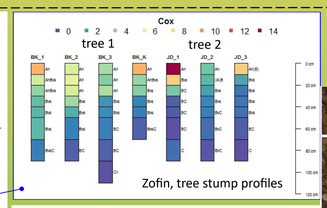
2.3. Data processing

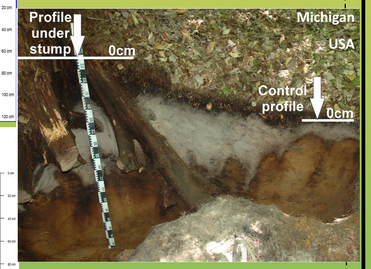
Statistical tests:

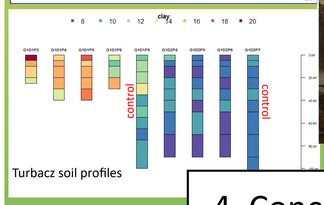
1. non-parametric Kruskal-Wallis rank sum test we tested whether the mean ranks were the same in all the groups defined by the main soil regions (nominal variable).
2. results of Kruskal-Wallis test were confirmed by means of two-sided Dunn test for multiple comparison (p-values = 0.05; p-values adjusted according to Bonferroni method, Dunn, 1964).
3. Pearson correlation coefficients at p-values = 0.0001.

We used the following R libraries: *stats*, *aqp* (Beaudette et al., 2013), *corrplot* (Wei, Simko, 2016), *FSA* (Ogle, 2016) and *ggplot2* (Wickham, Chang, 2016).









3. Results

Biomechanical effects include:

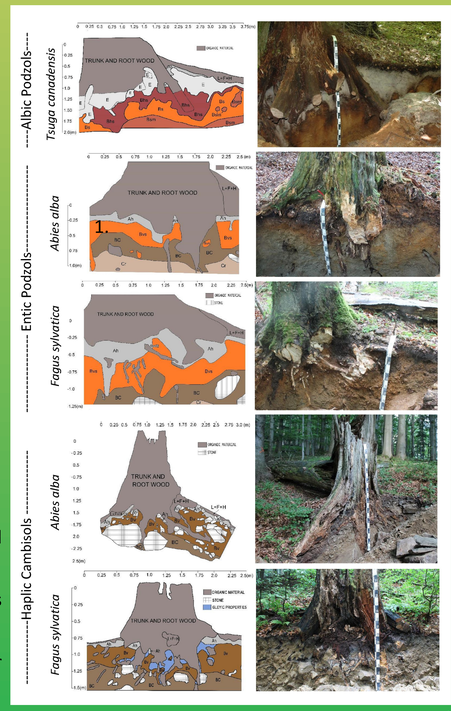
1. empty and infilled relict **root channels**
2. volumetric changes of soil body within the root zone (large roots pushed the soil while they grow)
3. structural changes in the soil horizons configuration marked by chemical processes and their visible and detectable effects (color, balk density, moisture content).

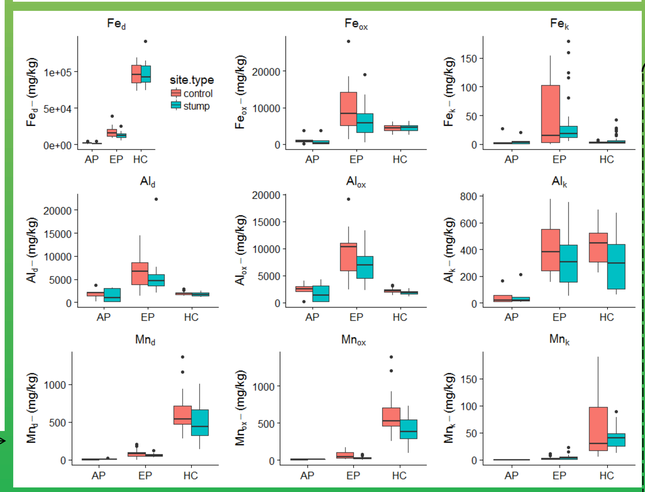
Biochemical effects include:

1. **hydromorphic** changes along large roots in Haplic Cambisols (at Turbacz site) caused by permanent higher moisture content and water translocation along the roots.
2. differences were considerable between Zofin and Turbacz soil regions which were characterized by contrastic soil type: Entic Podzols and Haplic Cambisols.

Evaluation of soil properties differentiation between control profiles and soils under tree stumps:

1. there were no significant differences between control and stump soils for the same soil region
2. in the majority of cases control soil profiles had higher values (higher means) of the analyzed chemical compounds.





4. Conclusions

The current study is still ongoing but based on the presented set of data we can conclude that:

- in spite of clearly visible alteration of the soil profiles under tree stumps caused by biomechanical effects, in most cases, in term of chemical properties, no significant differences exist between control profiles and soils from the root zone.
- most often the analyzed chemical properties had mean values higher at control sites. This feature could be partly caused by stem flowing and translocation of chemical compounds into deeper horizons with water.
- surprisingly there were no significant differences between soil regions in terms of soil pH, N, Cox and C-HA. However, the content of Fe$_d$ and different forms of Mn were much higher in HC (Turbacz).

So far we have assumed equal age between tree stump sites but this issue will be revealed in the future by application of dendrochronology and radiocarbon dating of tree wood samples.

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