Evaluation of changes in chemical soil properties and assessment of silvicultural site use after a forest fire

Pötter Krouse, Katharina, & Hannemann, Jens

Landeskompetenzzentrum Forst Eberswalde (LFE)

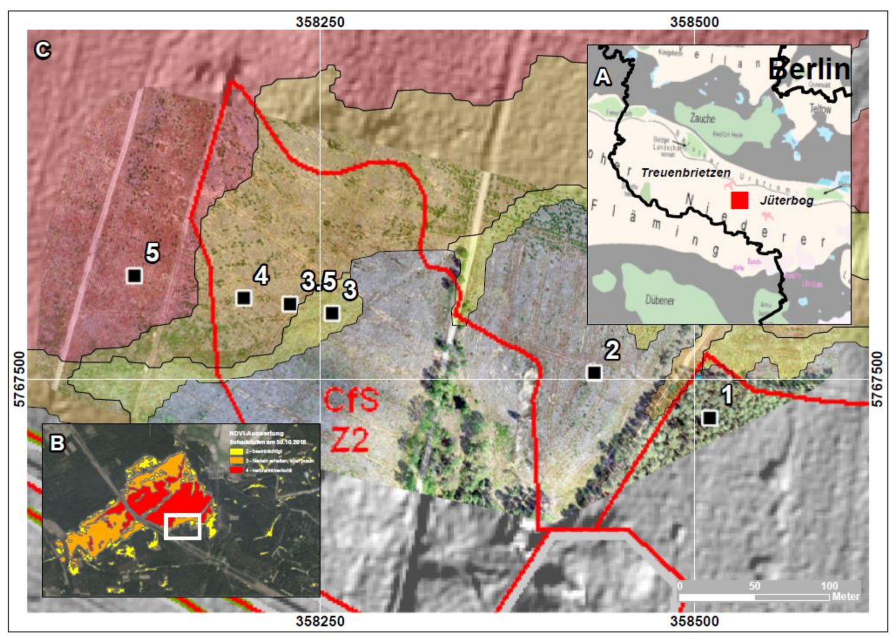
WALDWIRTSCHAFT ABER NATÜRLICH

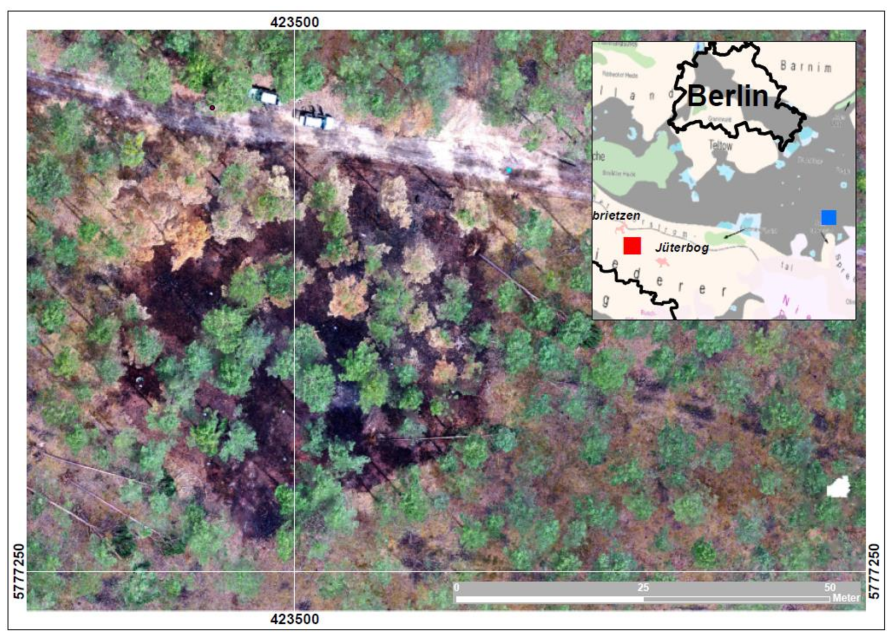
Introduction

As of September 16th, 500 forest fires were recorded for the state of Brandenburg in 2022. There were seven larger fires ranging from 30 to 422 ha [1]. Warmer and drier summers will increase the risk of these more severe forest fires in Germany. Despite this challenge, there is a lack of expertise for dealing with this risk in the forestry and hazard control community. The research collaboration ErWiN (Enhancement of the ecological, silvicultural and technical expertise concerning forest fires) aims to produce an important foundation for a knowledge-based handling of forest fires in the areas of silviculture and firefighting. The research presented here analyzes changes in soil characteristics. The goal is to identify the altered water and nutrient supply for the regenerating forest stands.

Left: research plot in Treuenbrietzen which burnt again in June 2022 (original fire in August 2018); *Right*: research plot in Groß Eichholz (fire in May 2022)

Materials and Methods





Left: research plots in Treuenbrietzen with burn severities (figure B: © A. MARX, Eogreen Analytics GmbH) and orthographic photo (© F. Becker); *Right*: research plots in Groß Eichholz with orthographic photo (© F. Becker)

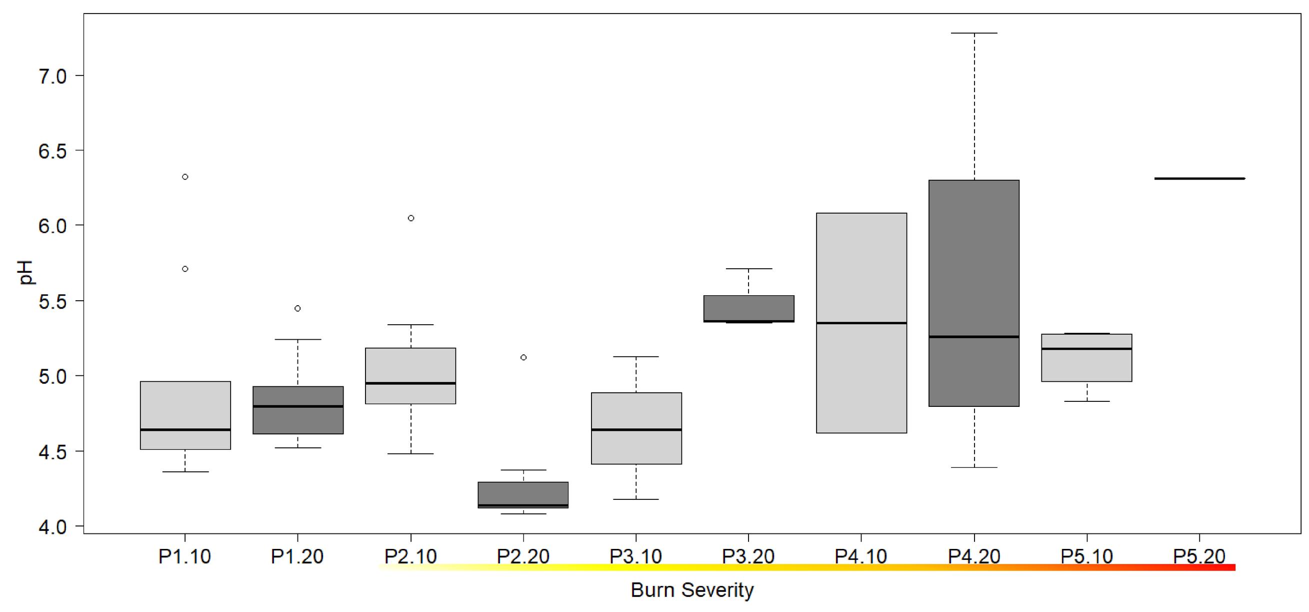
	Treuenbrietzen	**Groß Eichholz**
Date of forest fire [1]	23.08.2018	10.05.2022
Area burnt (in ha) [1]	334	0,25
Management after fire	salvage logging (in research area)	no management intervention
Installation of research plots	May 2021 (3 years after fire)	within 2 weeks after fire
Number of research plots	5 (2 controls and 1 in each of the three burn severity areas)	4 (1 control and 3 in burnt area)
Frequency of soil samples taken	yearly	monthly
Chemical analysis soil	total C, total N, pH, cation exchange, aqua regia digestion	
Frequency of soil solution taken	every 2 to 3 weeks	initially weekly and since July bi-weekly
Chemical analysis soil solution	pH, EC, DOC, macro and micro nutrients, heavy metals	
Analysis of hydrophobicity	"molarity of an ethanol droplet test" [2] in the field on undisturbed soil sample	
Environmental Data	data logging for air temperature and humidity and soil temperature and soil moisture (in 15 cm depth); precipitation monitoring according to G. Hellmann method	
Statistical analysis	software R Studio version 1.2.5033; t-Test/ Wilcoxon-Test and ANOVA/ Kruskal-Wallis-Test (figures in Results and Discussion)	

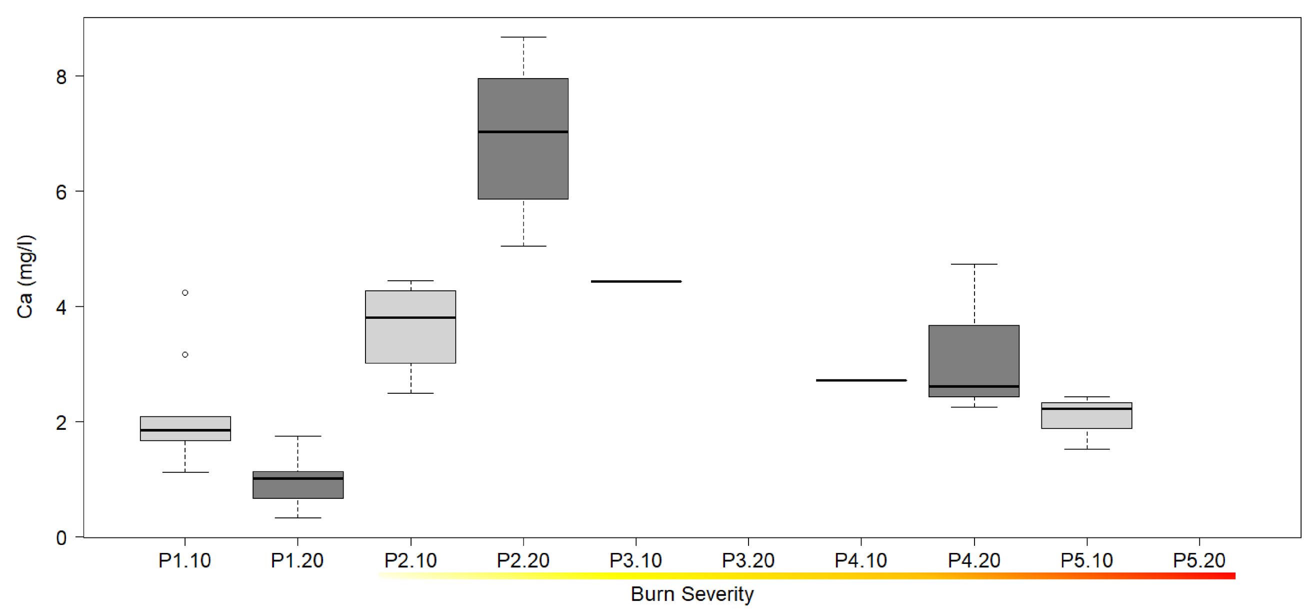
Left: soil solution sampling with suction cups in 10 and 20 cm depth (0,6 bar suction applied by hand pump); *Right*: soil sampling with soil corer up to a depth of 60 cm at all research plots in Treuenbrietzen

Results and Discussion

Even three years after the fire in Treuenbrietzen, the **pH** is still higher for all burn severities compared to the control (P1). For the suction cups in 10 cm depth, these differences are statistically not significant. However, for suction cups in 20 cm depth, there are statistically significant differences between the plots P1.20 and P2.20 as well as P2.20 and P4.20. A few other publications confirm these results ([3], [4]) whereas others found no changes up to ten months after a prescribed burn [5].

For the suctions cups in 10 cm depth, the **Ca** concentrations are significantly higher for all burn severities compared to the control (P1). For the suction cups in 20 cm depth, there are statistically significant differences between P1.20 and P2.20, P1.20 and P4.20 as well as P2.20 and P4.20. The results are similar for Mg (data not shown here). Many other studies also found an increase in Ca and Mg concentrations in the soil solution of burnt soils ([3], [6], [7], [8], [9], [10]). The findings differ though concerning the time span of these effects ranging from three months [6] up to three years ([3], [4], [7], [10]). As with the pH, there are some researchers who found no changes up to ten months after a prescribed burn [5].





Top: pH values of soil solution along the burn severity gradient in Treuenbrietzen; *Bottom*: Calcium concentrations of soil solution along burn severity gradient in Treuenbrietzen; Data collection from June 2021 until January 2022

Legend: P1 (control plot in forest), P2 (control plot on burnt site), P3 (plot low burn severity), P4 (plot medium burn severity), P5 (plot high burn severity), .10 (suction cups in 10 cm depth), .20 (suction cups in 20 cm depth)

Conclusion and Outlook

The data collected in Treuenbrietzen in 2021 indicates that forest fires can have long-lasting effects on the chemical properties of soils. Nevertheless, it is impossible to know whether the current state is a result of the forest fire because soil data from before the fire is not available. Using an adjacent unburnt site for comparison is only an approximation to pre-fire conditions due to the small-scale heterogeneity of soils.

This raises the question of whether controlled burns of different severities are more adequate alternatives for understanding how soils change after a forest fire and how this information can help identify suitable tree species for reforestation.

[1] Landesbetrieb Forst Brandenburg: Forest Fire Statistic for Brandenburg (unpublished data).
[2] Doerr, S. H. (1998). On standardizing the 'water drop penetration time' and the 'molarity of an ethanol droplet' techniques to classify soil hydrophobicity: a case study using medium textured soils. *Earth Surface Processes and Landforms: The Journal of the British Geomorphological Group*, 23(7), 663-668.
[3] Riek, W., Strohbach, B. & Siewert, C. (2002). Untersuchungen zur Veränderung chemischer Eigenschaften von Waldböden durch Feuereinwirkung - Ergebnisse eines Wadbrandexperiments in der Lausitz.
[4] Van Cleve, K., & Dyrness, C. T. (1983). Effects of forest-floor disturbance on soil-solution nutrient composition in a black spruce ecosystem. *Canadian Journal of Forest Research*, *13*(5), 894-902.
[5] Elliott, K. J., & Vose, J. M. (2005). Initial effects of prescribed fire on quality of soil solution and streamwater in the southern Appalachian Mountains. *Southern Journal of Applied Forestry*, *29*(1), 5-15.
[6] Näthe, K., Levia, D. F., Tischer, A., Potthast, K., & Michalzik, B. (2018). Spatiotemporal variation of aluminium and micro-and macronutrients in the soil solution of a coniferous forest after low-intensity prescribed surface fires. *International Journal of Wildland Fire*, *27*(7), 471-489.
[7] Chorover, J., Vitousek, P. M., Everson, D. A., Esperanza, A. M., & Turner, D. (1994). Solution chemistry profiles of mixed-conifer forests before and after fire. *Biogeochemistry*, *26*(2), 115-144.
[8] Stark, N. M. (1977). Fire and nutrient cycling in a Douglas-Fir/Larch forest. *Ecology*, *58*(1), 16-30.
[9] Grier, C. C. (1975). Wildfire effects on nutrient distribution and leaching in a coniferous ecosystem. *Canadian Journal of Forest Research*, *5*(4), 599-607.
[10] Lewis Jr, W. M. (1974). Effects of fire on nutrient movement in a South Carolina pine forest. *Ecology*, *55*(5), 1120-1127.

Contact:

Katharina Pötter Krouse
Katharina.PoetterKrouse@LFB.brandenburg.de

Jens Hannemann
Jens.Hannemann@LFB.Brandenburg.de

https://erwin.thuenen.de/

Funded by:

FNR Fachagentur Nachwachsende Rohstoffe e.V.

Waldklimafonds