The temperature and moisture regime of charcoal-enriched land use legacy soils

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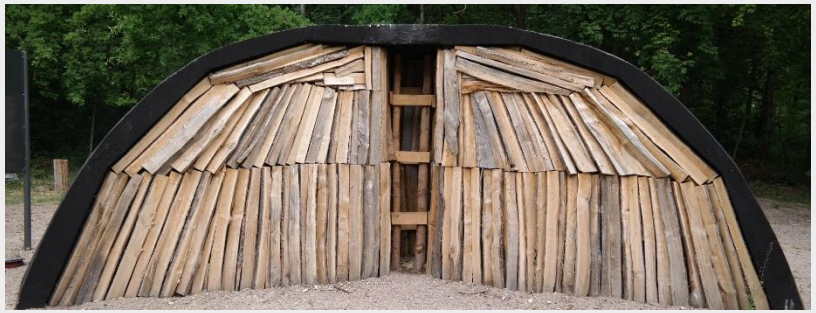

Relicts of historic charcoal hearths (RCH) are a widespread legacy of historic land use. RCH have been documented in high spatial densities and can cover a significant proportion of the surface in RCH landscapes, so that their soil properties can also affect ecological site conditions of woodlands today.

We characterized soil physical properties of RCH in Brandenburg, Germany; and monitored the moisture and temperature regime of two sites under field conditions, for at least one year for each site.

The study sites are RCH shaped as slightly elevated platforms in flat terrain in the Tauersche Forst, north of Cottbus, Germany. Soils are developed on sandy substrates. Large-scale mapping based on LIDAR Digital Elevation Models showed that RCH occur in very high spatial densities in areas with such conditions in the Northern German Lowland and also within the German Lower Mountain Ranges (Schneider et al. 2020, Geoarchaeology).

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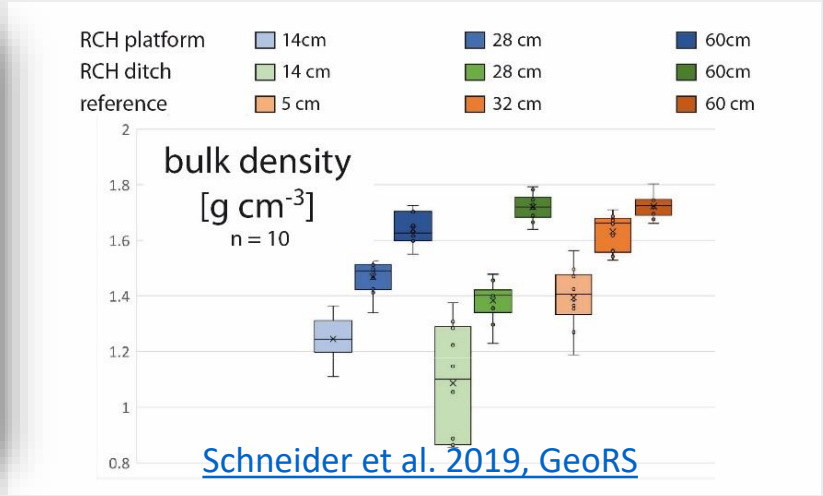
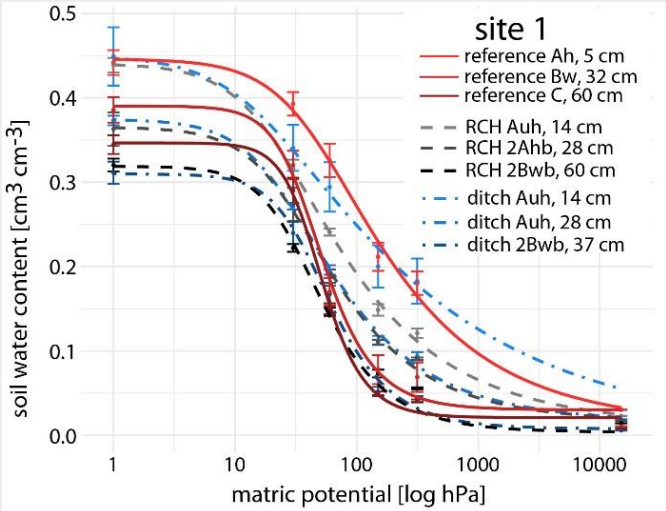
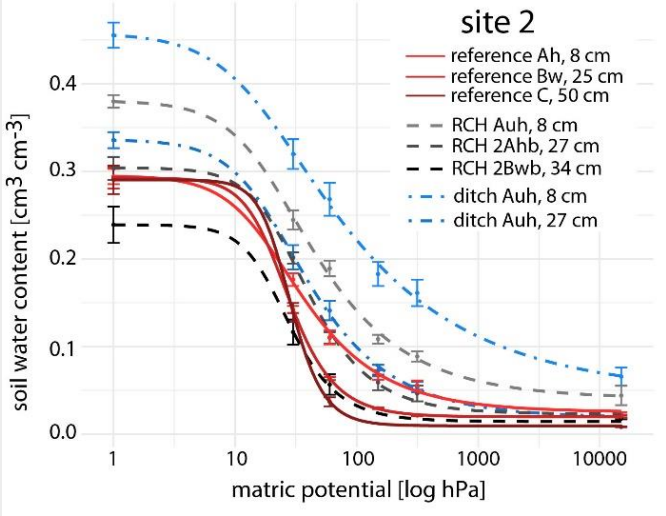
The soils at RCH platforms are most prominently characterized by a 20 to 40 cm thick substrate layer, which is rich in charcoal fragments of various sizes and has a very low bulk density. Soil profiles in former ditches around the platforms often show a multi-layered stratigraphy.

The laboratory analyses reveal that the low bulk density and high porosity of the RCH substrates is mainly related to larger volumes of coarse and fine pores. Therefore, the high porosity of charcoal-enriched substrates is not necessarily associated with higher water retention and plant-available water contents, and the pore size distribution and water retention in RCHs differ from those characteristically found for biochar-amended soils.



Schneider et al. 2019, GeoRS





Schneider et al. 2020, Geoderma

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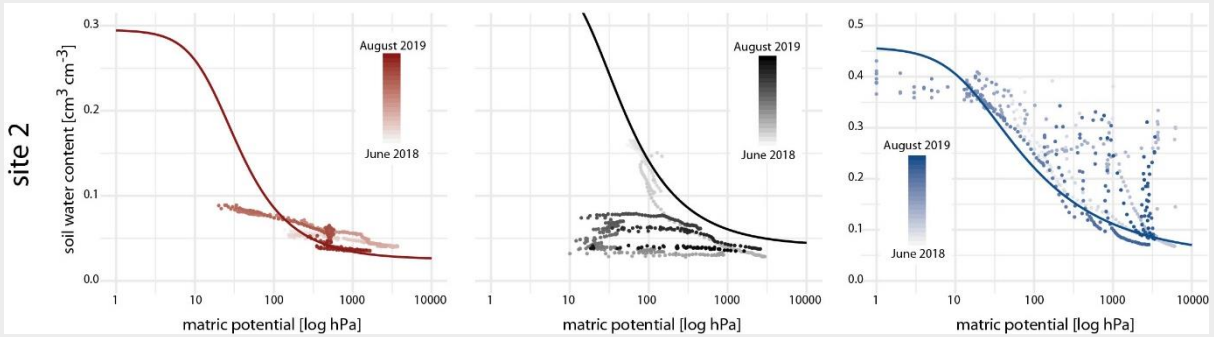
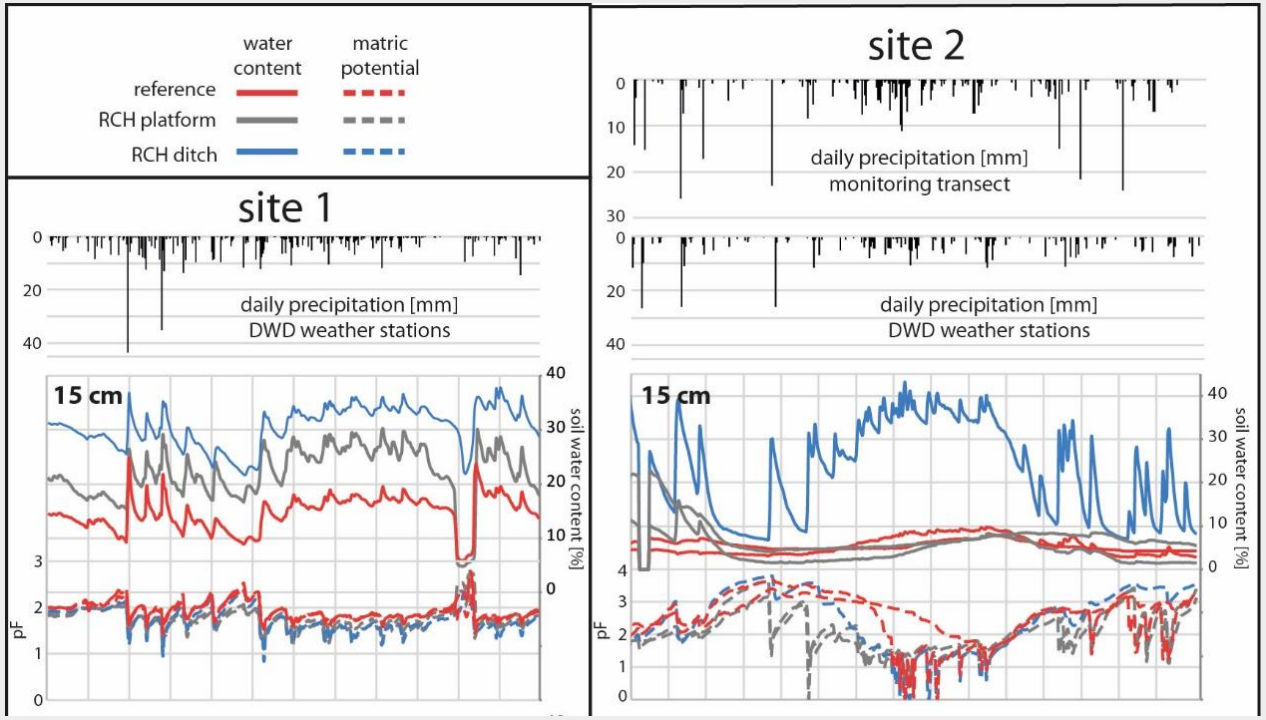
Soil moisture monitoring shows higher water contents in RCH soils under relatively wet conditions and lower water contents under dry conditions. Considerably high water contents were found for the ditch profiles. The increased spatial and temporal variability in soil moisture in RCH soils is most likely related to the larger volumes of coarse pores and more rapid desorption during dry phases.

The relationships between soil water contents and matric potentials measured at the monitoring sites also reflect strong hysteresis effects, especially after dry periods. The results suggest that high proportions of the pore space, both in RCH soils and in the reference forest soils, are not saturated under field conditions, which shows that laboratory-based SWRCs might only poorly reflect the dynamics of soil water retention in the field.

Overall, the results affirm that the legacies of charcoal production increase spatial and temporal variations in soil moisture, which in turn can cause increased variability in ecological site conditions in charcoal production areas.





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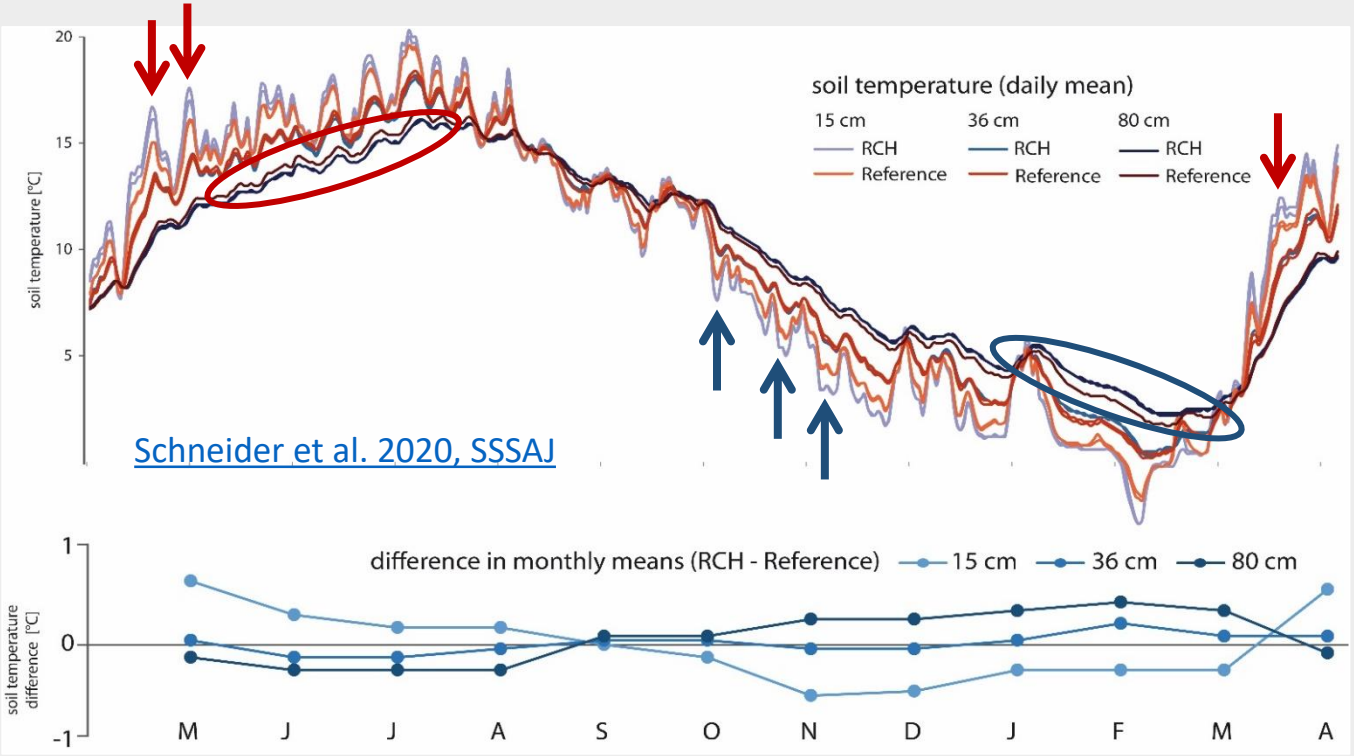

Soil temperature monitoring showed differences between the temperature regimes of RCH and reference forest soil profiles. RCH soil exhibit higher daily and seasonal temperature variations in the topmost horizons, i.e., within the charcoal-rich substrate layers. In deeper parts of the profiles, temperature variations are lower.

The results of a laboratory characterization of soil thermal conductivity show that these differences are related to a clearly lower thermal conductivity in the RCH soil, which is associated with the low bulk density and high contents of SOM. The results show that the effects of the physical properties of RCH substrate can propagate beyond the charcoal-enriched soil horizons. These modifications in the soil temperature regime might contribute to several poorly understood effects of charcoal addition on biogeochemical processes in soils.

References

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