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Exploring functional relationships between post-fire soil water repellency, soil structure and physico-chemical properties

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Soil water repellency (WR) and aggregate stability (AS) are two soil properties that are typically modified after burning and impose significant influence on subsequent hydrological and geomorphological dynamics. The response of AS and soil WR to fire depends upon how fire has influenced other key soil properties (e.g. soil OM, mineralogy). Meanwhile, routine thinning of trees and woody vegetation may alter soil properties (e.g. structure and porosity, wettability) by use of heavy machinery and species selection.
The study area is situated along a north-facing slope of Mount Carmel national park (Israel). The selected sites are presented as a continuum of management intensity and fire histories. To date, the natural baseline of soil WR has yet to be thoroughly assessed and must be investigated alongside associated soil aggregating parameters in order to understand its overall impact.
This study examines (i) the natural baseline of soil WR and physical properties compared to those of disturbed sites in the immediate (controlled burn) and long-term (10-years), and (ii) the interactions of soil properties with different control factors (management, surface cover, seasonal-temporal, burn temperature, soil organic carbon (OC) and mineralogy) in Mediterranean calcareous soils. Analysis of surface soil samples before and after destruction of WR by heating (200-600°C) was implemented using a combination of traditional methods and infrared (IR) spectroscopy.
Management and surface cover type conditioned the wettability, soil structure and porosity of soils in the field, although this largely did not affect the heat-induced changes observed in the lab. A positive correlation was observed along an increasing temperature gradient, with relative maxima of MWD and BD reached by most soils at the threshold of 400-500°C. Preliminary analyses of soil OC (MIR) and mineralogical composition (VIS-NIR) support existing research regarding: (i) the importance of soil OC quality and composition in determining wettability rather than quantity, as evidenced both by the high variation observed in the field and the strong presence of aliphatic functional groups in the absence of WR; and (ii) commonly proposed mechanisms affecting soil aggregate properties—albeit with differing temperature thresholds and longer exposure times employed in this study. Namely, these mechanisms tend to involve: (i) soil OM and WR reduction at low to moderate temperatures, and (ii) thermal fusion of particles within moderate to high temperatures.
Overall, results suggest a positive influence of management on soil properties as well as high soil resilience to moderate severity fire disturbance in the studied areas. However, the specific changes in soil OM and mineral composition that are responsible for destruction of WR and subsequent changes in AS remain poorly understood. Based on these results, a key next step within this study will entail a closer examination of OC ratios and their potential links with certain mineral species known to influence soil aggregation and soil WR. Noting the importance of soil OM-mineralogical interactions on run-off and erosion processes, results may contribute to better prediction of post-fire responses in the future and improve the ability to fine-tune site specific management approaches accordingly.