Fire regime effects on soil habitat and carbon balance in Mediterranean landscapes

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Wildfire severity and frequency in European Mediterranean regions are projected to intensify under climate change, exacerbating soil degradation and disrupting carbon sequestration. Moreover, these events pose serious risks to human life, infrastructure, and local economies. Although prescribed burns are advocated to mitigate wildfire risk, EU fire policies remain reactive, prioritizing short-term social stability over long-term forest resilience—a critical gap given conflicting evidence on fire impacts. While some studies suggest wildfires reduce carbon stocks, others argue they create more stable carbon forms. Additionally, some researchers suggest impacts on soil carbon dynamics are highly dependent on fire regime (severity and frequency).

This PhD project seeks to align fire management with broader climate mitigation goals, by comparing fire regime effects (high vs. low severity; high vs. low frequency) on Mediterranean soil: 1) habitats, through laboratory-based assays to assess plant development and microbiota, and 2) carbon balance, through field analysis of carbon stocks/forms (Total Organic Carbon, Thermogravimetry) and carbon flux measurements, using a Trace Gas Analyzer.

Preliminary results showed that the fire residues (char+ashes) produced from high-severity wildfires are more water-repellent than those from low-severity wildfires and prescribed burns - a factor that is positively correlated with runoff and soil erosion. Residues from high-severity wildfires showed higher pH (8.79±0.76) but lower organic-matter content (5±2%) compared to residues from low-severity wildfires and prescribed burns (pH = 7.83±0.66 and organic-matter = 60±10%). High-severity, high-frequency wildfires exhibited the highest pH values (9.44±0.45), whereas high-severity, low-frequency wildfires showed the lowest organic-matter contents (4±2%). This increased soil alkalinity and lower organic-matter content are factors that may contribute to phytotoxicity. Ongoing pot assays with *Lolium perenne* and germination/root elongation tests using *Lactuca sativa* are evaluating the effects of the residues produced from different fire regimes on soil habitat (plant development, soil and leachate phytotoxicity, water retention capacity and microbial community). Ultimately, this research will clarify how contrasting fire regimes reshape the functional capacity of Mediterranean soils, providing the scientific basis for fire management strategies that safeguard both ecosystem resilience and the net carbon balance of Mediterranean landscapes.

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