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Fire-induced decoupling of water and carbon cycling in Andean páramo soils: implications for long-term carbon storage

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Páramo ecosystems are globally significant carbon reservoirs, storing approximately 150–300 Mg C ha^{-1} in their organic-rich soils (Hofstede et al., 2014; Mosquera et al., 2023). Beyond carbon sequestration, páramo soils provide essential ecosystem services, particularly water regulation and purification. Their high organic matter content, low bulk density, and strong aggregation promote exceptional water retention and gradual release, sustaining downstream baseflow and buffering hydrological extremes (Buytaert et al., 2006; Mosquera et al., 2023). Paramo soils also function as natural filters, regulating nutrient fluxes and improving water quality before water reaches headwaters, although disturbance can impair this function (Rey-Romero et al., 2022). In these high-mountain systems, low temperatures and persistent soil moisture slow decomposition, promoting peat accumulation and long-term carbon storage within an integrated soil–water–carbon system (Hribljan et al., 2017). We investigated fire-induced changes in soil carbon storage and quality in the Berlín–Santurbán (Picacho) páramo, Colombia, following the 2024 fires. Soil samples from burned and adjacent non-burned areas were subjected to sequential loss-on-ignition (LOI) analysis to quantify fresh organic matter (FOM) and thermally stable recalcitrant organic matter (ROM) fractions. Non-burned soils showed strong correlations among texture, water content, FOM, and ROM, indicating a tightly coupled system that supports biologically mediated carbon sequestration and hydrological regulation. In contrast, burned soils exhibited reduced water content and diminished texture-controlled water retention. Although burned soils contained higher recalcitrant organic matter, this reflected enrichment in fire-derived pyrogenic carbon rather than enhanced ecosystem carbon capture. Our findings demonstrate that wildfire alters not only soil carbon quantity and quality but also affect other paramo soil ecosystem services.

References

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