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Soil organic carbon stocks and stability in maritime pine forests under contrasted pedoclimates and management practices

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The Landes forest (southwest France) is the largest man-made maritime pine (Pinus pinaster ait) forest in Europe and presents a large diversity of Podzols, which are acidic and nutrient poor soils by nature. In this cultivated forest system, three types of heathland are found: wet, humid (i.e. intermediate between wet and dry) and dry and each is associated with specific Podzols (Umbric, Umbric-Ortsteinic or Ortsteinic Albic, and Haplic, respectively). In this study, we considered ten sites, five located in wet or humid and five located in dry heathland over the Landes forest. In each site, soil pits were dug, described and sampled in two adjacent plots, each characterized by low or high stand density. Soil organic carbon (SOC) stocks were calculated for each pedological horizon and the whole profile (0–100 cm) using bulk density and C concentration (elemental analysis) measurements. SOC stability was assessed using Rock-Eval thermal analysis. We studied the influence of soil type, heathland type and forest stand density as well as depth on SOC stocks and stability.

In the studied soils, pedogenesis is very affected by the soil water regime. Results showed that different Podzols store various amount of carbon with Humic Podzols having significantly greater SOC stocks (233 t C/ha) than Ortsteinic Podzols (108 t C/ha) and Haplic Podzols (58 t C/ha). On average, almost half the total mineral SOC stocks (0–100 cm) was found in the first 30 cm. SOC stocks did not decrease linearly with depth, with the deep indurated B horizon storing 29.4 t C/ha. SOC was more thermally stable in the deep soil horizons.

Contrasted forest stand density over two decades had no significant effect on SOC stocks or thermal stability in the first 30 cm or up to 1 m depth. Heathland type was however very significant for SOC stocks, with humid sites storing twice as dry sites (149 t C/ha vs. 60 t C/ha, respectively) and stability, with humid sites having more thermally stable SOC than dry sites. Differences between the two heathland types were significant in the first 50 cm for SOC stocks but limited to the topsoil (0–30 cm) for SOC stability.

In the studied maritime pine forest, humid heathland and their Humic Podzols stored the most carbon and this carbon was also the most thermally stable overall. Our study showed that topsoil (0–30 cm) in these forest soils contained on average a lot of carbon that is not very stable that could be vulnerable in a context of global changes, and specifically land-use change, or the intensification of the production systems (e.g., more tillage). This is particularly the case of the Eh horizon of Humic Podzols in wet heathland, where large amounts of unstable carbon can be found.