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Woody plant encroachment effect on soil organic carbon dynamics: results from a latitudinal gradient in Italy

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Woody plant encroachment into pastures and grasslands represents a significant land cover change phenomenon, with a considerable impact on carbon dynamics at an ecosystem level. It was estimated that 7.64% of the Southern Europe land was subject to that process between 1950 to 2010. As a result of woody encroachment, changes in vegetation composition can produce substantial changes to the soil organic carbon (SOC) cycle. Despite the numerous papers published on land-use change, an evaluation of the IPCC terrestrial carbon pools changes occurring during woody encroachment on abandoned pastures and grasslands is still lacking, particularly for the Italian territory. Therefore, the aim of this study was to investigate the role of woody encroachment on carbon sequestration over abandoned pastures and grasslands in Alpine and Apennine ecosystems, with a particular focus on the SOC.
We applied a chronosequence approach to seven selected sites located along a latitudinal gradient in Italy. Each chronosequence consisted of a pasture currently managed, three sites abandoned at different times in the past and, finally, a mature forest stand representing the last phase of the succession. The European Commission sampling protocols to certify SOC changes was adopted to estimate the variations following woody encroachment. Soil samples were collected at different depths in the topsoil (0-30 cm) and subsoil (30-70 cm), despite the original protocol formulation being limited to the topsoil only. In addition, aboveground living biomass (AGB), dead wood and litter were also measured following international protocols.
Considering all C pools together, woody plant encroachment leads to a progressive C stock accumulation in all the chronosequences. The total C stock of mature forest stands ranges from 1.78 ± 0.11 times (Eastern Alps) to 2.48 ± 0.31 times (central Apennine) the initial value on pastures. Unsurprisingly, the C stocks of AGB, dead wood and litter all increase during the process of woody encroachment. Instead, the SOC dynamics are more complex, as previous studies suggest they are strongly affected by precipitation and temperature. Accordingly, we found that in the Apennine sites, characterised by a Mediterranean mountainous climate, the SOC increased more than 50% from pasture to forest stages. Conversely, the increment appears not or barely statistically significant in the two colder and more humid Eastern Alps sites. Our results also indicate a substantial amount of SOC is stored in the subsoil, despite many existing sampling protocols (including the original form of the one we adopted) typically restrict measurements only to the topsoil. Therefore, it is recommended to measure the SOC along the whole profile to avoid overlooking the significant amount of C that can accumulate in the subsoil during the process of woody encroachment.
In conclusion, this study reveals a positive impact of woody encroachment in increasing the C at an ecosystem level and suggests that SOC measurements are extremely important when precise emission-removal estimates due to land use change are required.