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Changes in soil organic carbon stocks and fractions following forest expansion on subalpine grasslands

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The abandonment of grasslands represents the dominant land-use change (LUC) and the main driver for the establishment of new forest areas in many regions of the European Alps. Fractions sensitive to LUC can be indicative of changes in soil organic carbon (SOC) and they can allow a better understanding of OC stabilization processes. Despite the key role played by physical OC fractions, it is still unclear how they respond to forest expansion on abandoned grasslands. Our aim was therefore to explore the impact of LUC on SOC storage, focusing on the effect of grassland abandonment and forest expansion on physical OC fractions.

In a subalpine area of the Trentino region, Italy, four land use types were investigated: i) managed grassland, mown and fertilized for more than 100 years; ii) grassland abandoned around 10 years ago, with shrubs and Picea abies saplings; iii) early-stage forest, dominated by P. abies and established on a grassland abandoned around 1970; iv) old forest, dominated by Fagus sylvatica and P. abies. For each land use type, three subplots were sampled with eight soil cores to 30 cm depth. SOC stocks were calculated after determination of bulk density, stoniness, root biomass and organic carbon content. Aggregate size fractions were obtained through wet-sieving using a series of sieves (2000, 250, 53 μm mesh size). In size-density fractionation, a silt and clay fraction <50 μm was separated from a fraction >50 μm, after physical dispersion of aggregates. The fraction >50 μm was further separated at a density of 1.6 g cm-3 in sodium polytungstate, for the estimation of particulate organic matter (POM) and stable aggregates.

Especially in the top 10 cm, mineral soil OC stocks were lower in early-stage and old forest (-28%) than in managed and abandoned grasslands. Despite a tendency toward increasing mean size of aggregates according to aggregate size fractionation, size-density fractionation revealed a significant decline in OC allocation to stable aggregates from grassland to forest. In 0-10 cm, the fraction of SOC stored in stable aggregates shifted from 78% in managed grassland to 59% in the old forest. Size-density fractionation also showed that a greater fraction of SOC was stored in POM in the old forest (18% of SOC stock) compared with the managed grassland (5%), but it did not compensate for the decreased OC accumulation in stable aggregates. The OC allocation to silt and clay fractions remained unchanged, thus showing lower response to LUC.

The decline in SOC storage in stable aggregate fractions was indicative of the decreasing total mineral SOC stocks after forest expansion on subalpine grasslands. Higher OC allocation to POM fraction in the mineral soil and changed carbon distribution between mineral and organic soil layers suggest an overall decrease in SOC stability and a concomitant shift to more labile OC fractions.