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Land use affects the turnover of organic carbon in roots and respired CO_2

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Land use has been shown to determine the quantity and quality of litter entering soils and thereby affecting the chemical composition of labile soil organic matter. Much less is known about the turnover of soil organic carbon (SOC) and its relation to land use. Here, we studied the turnover of OC in roots, bulk soils and respired CO_2 in a high number of differently managed forest and grassland soils using a new turnover model. We hypothesized that OC turnover in roots and respired CO_2 is more sensitive to land use (forest vs. grassland) and certain land use practices (e.g. fertilization, grazing, harvesting) than the turnover of SOC and thus can be used as an early indicator of management related effects.

We collected soil samples (0-10 cm) from 54 grassland and forest plots in three different German regions (Schorfheide-Chorin, Hainich-Dün, Schwäbische Alb) and determined the SOC stocks. An aliquot of each sample was incubated (20˚C, 60% WHC) for 14 days. Radiocarbon contents in roots, SOC and respired CO_2 were determined with accelerator mass spectrometry (AMS). We set up a comprehensive root and SOC turnover model (RootSOC) with a 2-pool root litter model and a 2-pool SOC model. The turnover times of roots and SOC in the RootSOC model were calibrated using the Δ^{14}C value of roots, SOC and respired CO_2, and SOC stocks as joint constraints. In the RootSOC model root litter inputs to the soil are modeled as the mortality of two root litter pools, which are assumed to be in steady-state. Root litter inputs enter a fast cycling SOC pool which is decomposed according to first-order kinetics with the decomposition rate k_Y. A part h of the outflow from the fast cycling pool is not directly mineralized to CO_2 but transferred into a slowly cycling pool with the decomposition rate k_0.

In our study areas, SOC stocks and the rate of respiration were higher in grasslands (5.5$\pm$2.4 kg m^{-2}; 127$\pm$50 μg C-CO_2 per g dry soil per day) compared to forest soils (3.2$\pm$1.1 kg m^{-2}, 53$\pm$25 μg C-CO_2 per g dry soil per day). The SOC stock and the respiration rates were mainly controlled by abiotic conditions such as parent material and associated soil texture and SOC concentrations. The SOC turnover time was in most soils $>$100 yrs and not different in grasslands and forests. The OC turnover in roots and respired CO_2 was instead fast ($<$10 yrs) and therefore largely affected by land use with significantly longer OC turnover in roots and respired CO_2 of forest compared to grassland soils. This indicates a slower C cycling in forest compared to grassland soils.