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D4.2 Review of existing CSF management, their potential impacts on soils and critical knowledge gaps

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How management affects soil C-sequestration and greenhouse gas fluxes in boreal and temperate forests? – a review

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Abstract

The global forest carbon (C) stock is estimated at 662 Gt of which 45% is in soil organic matter. To maintain or strengthen the soil C stock, a comprehensive understanding of the effects of forest management practices on forest soil C stock and greenhouse gas (GHG) fluxes is needed for the development of effective forest-based climate change mitigation strategies. For this purpose, we reviewed peer-reviewed literature on forest management practices that affect soil C stocks and GHG fluxes and identified soil processes that affect soil GHG balance. Furthermore, we analyzed and discussed how forest management effects

on soil are represented by models that can be used in GHG inventories and scenario analyses that address forest climate change mitigation potential.

Our extensive review clarified that intensive timber harvesting with removal of harvest residues/stumps results in a reduction in soil C stock, while high stocking density and enhanced productivity by fertilization or favorable tree species selection increase soil C stock. In general, soils under coniferous tree species have higher overall C stock than those of deciduous trees. However, while deciduous species store more C in mineral soils, coniferous trees accumulate C in the organic layer. Nitrogen fertilization increases the soil C stock by increasing litter input and it may also decrease decomposition rate. Furthermore, N fertilization decreases the CH_4 sink and increases N_2O emissions. Wood ash fertilization of peatland forests has a minor effect on soil GHG fluxes in the short term and long-term effects need further studies. Peatland hydrology management is a major driver of the GHG emissions of the peatland forests, with lower water level corresponding to higher CO_2 emissions. Furthermore, global warming potential of all GHG emissions (CO_2, CH_4 and N_2O) together can be ten-fold higher after clear-cutting than in peatlands with standing trees.

The climate change mitigation potential of forest soils, as estimated by modelling approaches, accounts for stand biomass driven effects and climate factors that affect the decomposition rate. Future challenge is to account the effects of soil preparation and other management that affects soil processes by changing soil temperature, soil moisture, soil nutrient balance, microbial processes, hydrology and soil oxygen concentration in the models that are applied in GHG inventories and forest scenario analyses. Current work on soil monitoring and modelling should focus on soil C stabilization processes and integration of the functioning of the soil microbiota on soil models.

Keywords: forest fertilization; forest fire management; forest soil carbon management; greenhouse gas; harvesting practices; peatland hydrology management