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Impact of forest management and soil compaction on soil GHG fluxes of a temperate forest

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Temperate forests are a considerable sink for methane (CH_4), carbon dioxide (CO_2) and the emissions of nitrous oxide (N_2O) and nitric oxide (NO) are low. Apart from the tree species composition, forest management itself can have a significant long-term influence and act as a driver on the GHG budget, particularly through soil compaction.

To assess the impact of tree species composition, thinning and soil compaction on the GHG budget, we measured GHG soil fluxes in a one-year campaign in a forest located in the catchment of the "Münichbach", south-west to Vienna, Austria (N 48°07'16", E 16°02'52", 510 m MASL). The soil is classified as Dystric cambisol over sandstone which is known to be sensitive for compaction and has a low recovery capacity. The mean air temperature in the campaign year (2019) was 9.7 °C and the annual precipitation was 820 mm. The experimental setup consisted of four treatments reflecting the heterogeneity of the catchment: a mixed stand (F) which was not thinned since 1913 consisting of beech, spruce, and larch; a pure beech stand last thinned in 2002 (L); a pure beech stand last thinned in 2013 (M), and the skid trails (R) that pass through the area of treatment M. For each treatment, five randomly distributed plots were selected, each equipped with three static chambers. The gas sampling was conducted manually at intervals of 3 weeks. Methane and N_2O in the gas samples were analysed by gas chromatography, those of NO by a soil core incubation approach using a chemiluminescence detector. Fluxes of CO_2 were measured in-situ with an EGM-4 environmental gas monitor (PP Systems).

The regularly wet skid trails (R) showed a significant reduction in CH_4 uptake, and increased CO_2 and N_2O emissions. N deposition was considerably higher at F than at the beech stands (L and M), which affected GHG fluxes, resulting in significantly highest NO emissions of 0.65 ±0.07 kg N ha^{-1} y^{-1}, and N_2O emissions of 0.42 ±0.04 kg N ha^{-1} y^{-1}, comparable to those at R, while CH_4 fluxes did not differ from those of beech stands. The results of the study show lower emissions of beech sites in terms of NO and N_2O. However, in terms of CH_4 uptake beech stands revealed no significant difference compared to mixed stand (F). The treatments F and M showed comparable CH_4 fluxes, while L tended toward a lower uptake. The greatest long-term effect of forest management was apparent at the skid trails (R), with significantly highest CO_2 and N_2O emissions, and lowest CH_4 uptake. Compared to the other treatments, annual GWP_{100} was significantly

highest at R with 10.41 ±0.37 t ha^{-1}, which was 30, 28, and 58% higher than the means of F, L, and M.