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Forest clear-cutting effects on greenhouse gas dynamics in riparian buffer zones

Marcus Klaus[1], Katerina Machacova[2], Alice Falk[1], Marcus Wallin[3], Kaidoo Soosaar[2,4], and Mats Öquist[1]

[1]Department of Forest Ecology and Management, Swedish University of Agricultural Sciences, Umeå, Sweden
[2]Global Change Research Institute of the Czech Academy of Sciences, Brno, Czech Republic
[3]Department of Aquatic Sciences and Assessment, Swedish University of Agricultural Sciences, Uppsala, Sweden
[4]Department of Geography, University of Tartu, Estonia

Soils play an important role in the Earth's greenhouse gas cycle. The gas dynamics in soils are tightly coupled to gas dynamics in plants, trees, and surface waters. Riparian soils receive and process solutes leaching from upland areas and act as crucial buffers of land-use effects on various ecological and biogeochemical properties of surface waters. However, their role in greenhouse gas cycling is poorly understood. Forest clear-cutting often increases the leaching of organic carbon, nutrients and greenhouse gases in groundwater. Unfortunately, the fate of these substances on their way from upland clear-cut areas through riparian forest buffer zones left along streams after clear-cutting is unknown, but highly relevant for watershed-scale greenhouse gas budgets. Here, we performed a watershed-scale experiment to investigate the effect of clear-cutting on greenhouse gas dynamics in riparian forest buffer zones in a Swedish boreal headwater catchment. The experiment included weekly to monthly sampling during April-October before (2020) and after (2021) forest clear-cutting performed in February 2021, and included a treatment watershed and an untreated reference watershed. We measured concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) in soils using gas probes installed at various depths within the zone of groundwater level fluctuations along four transects from the clear-cut area through riparian forest buffer zones to near-stream sites. We also measured fluxes of these gases between the atmosphere and the forest floor, as well as tree stems, using flux chamber techniques. Initial results suggest that the clear-cutting increased CO_2 and CH_4 concentrations in clear-cut soils and the center of riparian buffer zones, but not in near-stream sites. In contrast, the concentrations of N_2O in soils were not affected by forest clear-cutting across the full transects. In terms of greenhouse gas exchange with the atmosphere, the clear-cutting did not affect CO_2, CH_4 and N_2O fluxes at the forest floor. Tree stems were consistent emitters of CO_2 and CH_4 in 2021, but the clear-cut effect remains unclear due to missing reference data before the clear-cut. Together, these results suggest that the clear-cut induced excess of CO_2 and CH_4 in upland groundwater was likely consumed in riparian soils or emitted through tree stems, assuming that upland and riparian soils were hydrologically connected. Our results stress the potential importance of riparian buffer zones in mediating clear-cut effects on catchment-scale greenhouse gas budgets.