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Full-drained peatland forests as nitrous oxide sources

Ülo Mander (1), Martin Maddison (1), Marika Truu (1), Jaak Truu (1), Mikk Espenerg (1), Alar Teemusk (1), Raili Torga (1), Kaido Soosaar (1), and Veiko Uri (2)

(1) University of Tartu, Tartu, Estonia (ulo.mander@ut.ee), (2) Estonian University of Life Sciences, Tartu, Estonia (veiko.uri@emu.ee)

From November 2013 until March 2016, we measured nitrous oxide (N2O) fluxes (using the static chamber method) and analysed the nitrogen (N) balance in three full-drained peatland forest types in Eastern Estonia – a Scots pine forest on Myrtillus-drained peatland, a Norway spruce forest and a Downy birch forest both on Oxalis-drained peatland with three replicate plots of 50x100 m each. In all 9 study plots, drainage work had been carried out in the early 1970s. We also measured N storage in aboveground and belowground biomass, the understory and soils, as well as gaseous N fluxes from soils. A metagenomic analysis of soil microbial community abundance and related genes was carried out. In both birch and spruce forests, high N2O emissions were measured: the annual average was 4.0 and 5.2 kg N2O-N ha-1 yr-1 respectively; with maximum values reaching 1.44 mg N2O-N m-2 h-1. In spruce forests, the highest emission values were registered in autumn and winter. In pine forests the average annual flux was 1.31 kg N2O-N ha-1 yr-1, with maximum values in spring (up to 0.05 mg N2O-N m-2 h-1). Groundwater table depth (from 0 to >100cm) was the main predictor of N2O emission, although the relationship was non-linear – the highest fluxes were measured at a water depth of from -10 to -40 cm. The assimilation in biomass and N2 emission (measured in intact soil cores using the He-O method) were the main fluxes in the N budget. The N2O flux in birch forests correlated with the abundance of soil denitrifying microbes. There was a strong positive relationship between N2O emission and nosZII gene abundance in the soils of birch and pine forests. In birch forests, high values of both N2 and N2O emission show that the consumption of N2O by microbes possessing nitrous oxide reductase genes (nosZI&II) cannot compensate N2O production. In pine and spruce forests the N2O flux was positively correlated to the abundance of soil archaea.
Although most of the studied forest sites were climate coolers (due to the high annual production), the remarkably high N2O in birch and spruce stands demonstrates the need for sustainable management and smart water table regulation in forests grown on drained Histosols.