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The annual budget of CH4 and N2O from a riparian forest: balances between the forest floor, tree stems and canopy

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Forests can be considered as sources and sinks of various greenhouse gases, including methane (CH4) and nitrous oxide (N2O), due to both natural processes and human actions. Further, they are important carbon (C) and nitrogen (N) pools. Determining forests contribution to the greenhouse effect requires deeper understanding of nutrient cycles within ecosystem at different levels: soil, vegetation(trees), and atmosphere. Stands of grey alder (Alnus incana), a fast-growing deciduous tree species in Northern Europe, are contemplated as ecosystems with high C sink capacity. Additionally, N cycling in alder forests is recognized as intensive due to atmospheric N fixation by symbiotic bacteria.

From September 2017 to October 2018, we investigated a 40-yrs old hemiboreal grey alder forest stand on a former agricultural land (Gleysol) in Estonia. We measured CH4 and N2O budgets, considering fluxes from the forest floor (12 x dynamic automatic soil chambers), tree stems (static tree stem chambers, gas samples taken from 12 trees at level 0.1, 0.8 and 1.8 m above ground) and the whole ecosystem (eddy covariance technique). Automatic sampling of water level, soil temperature, and soil moisture (10 cm depth), precipitation, air temperature and humidity, global radiation and PAR were carried out.

The forest was a net annual source of CH4 and N2O: 6.33 $\pm$ 0.29 and 3.42 $\pm$ 0.12 kg ha-1 (mean $\pm$ SE), respectively. Soil and stem fluxes of CH4 correlated positively and showed similar seasonal dynamics being the highest in autumn (flood) and spring (thaw). In contrast, CH4 was mainly consumed either in the topsoil or in the stems during summer season. Furthermore, CH4 flux derived significantly in wet and dry periods. Stem flux was the main source for ecosystem exchange in the wet period in contrast to the dry period, when ecosystem flux was significantly higher than fluxes from soil and tree stems. Hereby, it may be assumed, canopy was the main emitter. N2O fluxes from the soil and stem remained on a very low level during the summer drought but peaked during the wet autumn season and freezing-thawing events, respectively. N2O fluxes from the soil and stems count together most of ecosystem exchange.

In conclusion, stem fluxes of CH4 and N2O, which previously have been overlooked, significantly contribute to forest C and N cycles.