Methane emissions from the forest floor and woody plants in a boreal upland forest

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Boreal upland forests are considered as an important sink for the greenhouse gas methane (CH_4) due to methane oxidizing bacteria (methanotrophs) in the soil. Recent studies, however, suggest that boreal forests could occasionally emit CH_4, thus raising the question about the possible origins of CH_4. Over the last ten years, there has been increasing research into CH_4 emissions from vegetation. Riparian trees have been demonstrated to transport CH_4 produced by CH_4 producing microbes (methanogens), from belowground to the atmosphere, and methanogens have also been discovered from the roots, mycorrhizae, and stems of trees, also boreal tree species. Moreover, CH_4 emissions have also been detected from living plant material. However, the sources and the mechanisms of the observed CH_4 emissions from vegetation and from boreal forests at large are still mostly unknown.

We studied CH_4 flux in a boreal upland forest at SMEAR II station in Hyytiälä, Southern Finland (61° 51' N, 24°17' E; 181 m asl) at the forest floor, from the tree stems and shoots, and above the canopy in 2013–2014. The aim was to reveal the sources of CH_4 emissions in a boreal upland forest, and to estimate the contribution of the tree and forest floor fluxes to the ecosystem scale CH_4 flux. The forest floor flux was measured with manual soil chambers covering the main source area of the continuous above canopy flux measurement using a concentration gradient method. A chamber method was also applied to the stems and shoots of Scots pine (*Pinus sylvestris*), and to the stems of silver birch (*Betula pendula*) and Norway spruce (*Picea abies*). Furthermore, we conducted a laboratory experiment to study separately the above- and belowground CH_4 fluxes of boreal plants. The studied plants were bilberry (*Vaccinium myrtillus*), lingonberry (*Vaccinium vitis-idaea*), heather (*Calluna vulgaris*), and Scots pine (*Pinus sylvestris*), which were grown in microcosms. In addition to the flux measurements, we analysed methanogens by qPCR method, both from samples from the field and from the laboratory experiment.

The results of the forest floor indicate occasional considerable CH_4 emissions, mainly during May–July, the largest emissions resulting from two moist areas of the forest, where the water table was often at the surface. Due to the domination of dry areas in the studied forest, however, the forest floor in general is a sink of CH_4. Nevertheless, the measurements above the canopy demonstrate occasional CH_4 emissions, especially during the spring and late summer. However, the emissions from the forest floor cannot entirely explain the emissions at the ecosystem level. The tree measurements show CH_4 emissions from both the stems and the shoots of Scots pine, the shoot emissions being substantially higher than the stem emissions. Also birch and spruce emitted CH_4 from their stems. The results of the laboratory experiment suggest that the shoots of heather and Scots pine emit CH_4, while the *Vaccinium* species show on average small uptake. The roots of all the studied species induce consumption of CH_4 compared to bare humus soil, which on average emitted CH_4. Ongoing methanogen analyses may reveal whether the CH_4 emissions from plants, detected both in field and laboratory experiment, could be of microbial origin.

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