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Plant phenology controls on methane emissions in a boreal peatland

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Methane (CH_4) emissions constitute an important component of the carbon cycle and greenhouse gas budgets of northern peatlands. A key substrate source for CH_4 production is the continuous supply to the soil methanogenic community from vascular plant roots. In addition, aerenchymatous plant species provide a direct diffusion pathway allowing CH_4 to be emitted from the saturated anoxic peat layers directly into the atmosphere, bypassing the aerobic zone. Thus, vegetation acts as a major regulator of peatland CH_4 dynamics. However, while many studies have explored the spatial variation in CH_4 emissions in relation to plant species composition, to date, the impact of seasonal vegetation development (i.e. phenology) on the temporal dynamics of CH_4 emissions is less well understood. In this study, we used an automated chamber system (incl. transparent and dark chambers) to estimate CH_4 emissions from natural and trenched/vegetation removal plots in a boreal fen over two growing seasons. In addition, we derived a vegetation greenness index from phenology cameras as a quasi-continuous proxy for plant phenology. The specific aims of this study were to: i) quantify the importance of vegetation presence in determining peatland CH_4 emissions by comparing fluxes from natural and vegetation-free plots, ii) determine the amount of CH_4 emitted via direct diffusion through stomata during photosynthesis and iii) disentangle the importance of plant phenology versus abiotic variables (i.e. temperature, solar radiation and water table level) as drivers of the temporal patterns in CH_4 emissions. We find that vegetation removal reduced daily CH_4 emissions by up to 80%, while CH_4 emissions from the vegetated plots during dark conditions (i.e. without photosynthetic activity) were on average 30% lower compared to those from vegetated plots under natural light conditions. Furthermore, a GLM analysis suggested that plant phenology rather than abiotic variables was the main driver of the seasonal patterns in CH_4 emissions. Overall, this study highlights the important role of plant phenology in regulating CH_4 emissions in northern peatlands.