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What affects successful restoration of cutover bogs? Lessons from a two-year reciprocal monolith transplantation experiment

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Peatlands are important carbon sinks, but drainage transforms them to large carbon dioxide (CO_2) sources. Rewetting of peat bogs is therefore important to halt aerobic carbon oxidation and to regenerate carbon accumulation. However, often found graminoid dominated vegetation on rewetted peatlands has been shown to increase methanogenesis and methane emissions, and thus, the warming potential of such restoration sites. Moreover, high nutrient concentrations in organic matter or in pore waters, as well as labile organic matter have been described to accelerate the decomposition of peat ('priming'). Graminoid derived, labile organic matter could thus increase the decomposition of deep peat deposits, and additionally fuel methanogenesis. We conducted a reciprocal transplantation of peat monoliths (40 cm depth, 20 cm diameter, in slitted conduits allowing pore water exchange) between two contrasting restorations sites (both rewetted in 1990) in North-West Germany: MW with a recently formed, but nutrient poor peat layer vegetated with *Sphagnum fallax,* and NM, with highly refractory, nutrient rich peat at the surface colonized with *Juncus effusus*. We herewith tested if the site-specific pore water chemistry or the transplanted peat materials determine decomposition processes, to find out if methanogenesis could be fueled or priming induced. For this, we measured concentrations and gas fluxes of CO_2 and methane (CH_4), and pore water - and peat chemistry. We furthermore conducted anaerobic incubations where peat and pore water were recombined to parallel the field transplantation under constant temperature and moisture conditions. Incubations confirmed that MW peat was readily decomposable compared to the NM peat. However, amendments of MW pore water did not increase decomposition of NM peat. Also in the field, the transplantation of NM monoliths into MW did not increase decomposition or CH_4 formation. Amendment of NM pore water increased decomposition rates of MW in the incubations, however, this effect was not verified in the field experiment. We thus can exclude priming effects due to nutrient enrichment (pore water and peat of NM) or supply of labile carbon (pore water and peat of MW). Analysis of controls on decomposition revealed that CO_2 was mainly determined by the water table level. For CH_4, 56% of the variability in the data could be explained by a positive relation to labile peat organic matter quality indices, CO_2 concentrations, and by a negative relation to root density. Moreover, high electron acceptor capacity, low isotopic fractionation factors of CO_2 and CH_4, and low hydrogen concentrations suggested CH_4 oxidation in the rhizosphere. NM was on average a net carbon sink during summer days of -11±40.5 g C m^{-2} d^{-1} and exhibited a cooling potential of -0.5±48.4 g CO_2(eqv) m^{-2} d^{-1}. MW lost net 4.7±10.6 g C m^{-2} d^{-1}, and the warming potential was high with 23.1±33.0 g CO_2(eqv) m^{-2} d^{-1}. However, radio carbon dating confirmed long-term carbon accumulation at MW of 11–18 g C m^{-2} yr^{-1}. Our results suggest that restored peatlands covered with graminoids may represent a suitable intermediate stage until peat-forming *Sphagna* can reestablish and lead to effective carbon accumulation.