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Behind the stability of boreal bog carbon sink: Compositional and functional variation of vegetation across temporal and spatial scales

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Boreal bogs are nutrient poor peatland ecosystems, characterized by strong spatial variation in water table and vegetation composition. Although the number of species is small in bogs, the spatial variability supports a large diversity of functionally different plant groups. The aim here is to quantify how the spatially varying vegetation modifies the carbon sink of a boreal bog. Photosynthesis, respiration, biomass composition, biomass production and net ecosystem exchange were studied on three levels: plant species, community and ecosystem.

There was a clear plant species turnover and a strong decrease in standing biomass from dry to wet plant communities. Biomass production was even along the water table gradient due to higher biomass turnover rate of wet habitat species than hummock species. Both respiration and gross photosynthesis were the highest in dry plant communities, but their symmetrical water table responses resulted in no differences in net ecosystem exchange among plant communities. However, this evenness did not hold in the absence of Sphagna; sparsely vegetated bare peat surfaces were mostly carbon sources. The small difference in water table between Sphagnum-covered hollows and bare peat surfaces suggests that even a small change in water table could induce shifts between them.

The observed spatially even carbon sink contradicts earlier studies. However, the components behind that spatial evenness showed high variability and responded to environmental conditions as previously observed. The site-specific relative abundances of functionally varied species appeared to have a larger effect on the overall carbon sink than anticipated.

Different plant species and communities had the highest photosynthesis and carbon sink at distinct times of the growing season, decreasing the ecosystem-level seasonal variation. Over the three studied years, the roles of plant communities in the ecosystem-level carbon sink changed. This indicates that the presence of species with different seasonal growth patterns and responses to environmental conditions could increase ecosystem resiliency in changing conditions. To verify this, the responses of functionally different components to environment, either based on natural variation or experimentally defined, should be included in process-models predicting the fate of bog carbon sink in changing climate.