

Integrative assessment of terrestrial and aquatic fluxes of carbon dioxide, methane, and dissolved organic carbon in a managed boreal forest landscape in Sweden

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Abstract

The boreal biome exchanges large amounts of carbon (C) and greenhouse gases (GHGs) with the atmosphere and thus has significant effects on the global climate. A managed boreal forest landscape consists of various sinks and sources of carbon dioxide (CO₂), methane (CH₄), and dissolved organic carbon (DOC) across forests, mires, lakes, and streams. Due to the spatial heterogeneity, large uncertainties exist regarding the landscape-scale full C budget, i.e. the net landscape carbon balance (NLCB). In this study, we compiled terrestrial and aquatic fluxes of CO₂, CH₄, and DOC obtained from tall-tower eddy covariance measurements and extensive stream monitoring for an entire boreal catchment (~68 km²) in northern Sweden to estimate the NLCB across the land-water-atmosphere continuum. Our results showed that a boreal forest landscape with active management was a net C sink (NLCB = 63 g C m⁻² yr⁻¹) with the landscape CO₂ flux being the dominant component, while aquatic C losses contributed up to 18% during a wet year. Accounting for the global warming potential of CH₄, the landscape was a sink of -144 g CO₂-eq m⁻² yr⁻¹ and thus providing a climate-cooling effect. The contribution of landscape CH₄ flux to the GHG budget increased from 1% during summer to 5% during winter. Meanwhile, the aquatic C loss was most significant during spring contributing 5% to the NLCB. We further found that abiotic controls (e.g. air temperature and incoming radiation) regulated the temporal variability of the NLCB and its individual fluxes, whereas land cover types (e.g. mire vs. forest) and management practices (e.g. clear-cutting) determined their spatial variability. Overall, our study advocates the need for integrating terrestrial and aquatic fluxes based on tall-tower eddy covariance measurements and stream monitoring networks to improve our understanding of the full C budgets in managed boreal forest landscapes and their potential for mitigating climate change.