EGU26-8133, updated on 07 Nov 2026
https://doi.org/10.5194/egusphere-egu26-8133
EGU General Assembly 2026
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Impacts of bund construction and Sphagnum reintroduction on peatland CO□ and CH□ fluxes: insights from field monitoring and mesocosm experiments

Wenlue Miao[1], Jonathan Ritson[1], Emma Shuttleworth[1], and Martin Evans[2]
[1]Department of Geography, University of Manchester, Manchester, UK
[2]Faculty of Social Sciences and Health, University of Durham, Durham, UK

Peatlands are a major component of the global carbon cycle, storing large quantities of soil carbon. However, widespread drainage and land-use change have degraded many peatland systems, converting them from net carbon sinks into important sources of greenhouse gases. Water-table lowering is a key mechanism underlying this shift, as enhanced oxygen availability accelerates peat decomposition and alters CO□ and CH□ fluxes. Although restoration is widely promoted, the effectiveness of specific interventions—particularly bund construction and Sphagnum reintroduction—in regulating greenhouse gas emissions remains insufficiently understood.

To address this knowledge gap, we combined long-term field monitoring with controlled mesocosm experiments to assess the effects of bund construction and Sphagnum reintroduction on peatland CO□ and CH□ fluxes. Field measurements were conducted at Holcombe Moor, a blanket bog in Greater Manchester, northern England, UK. Continuous water-table depth was recorded to capture hydrological responses to restoration, alongside biweekly chamber-based measurements of CO□ and CH□ fluxes across restored and control plots. Flux measurements were conducted under contrasting light conditions to partition net ecosystem exchange into photosynthetic and respiratory components, with accompanying measurements of temperature and pH to characterise key environmental controls.

To enable controlled manipulation of key variables, a mesocosm experiment using intact peat cores was established to disentangle hydrological and vegetation controls under controlled conditions. Mesocosms were planted with either native graminoids or reintroduced Sphagnum and subjected to contrasting water-table treatments. Greenhouse gas fluxes were measured biweekly. Additional biogeochemical indicators, including dissolved organic and inorganic carbon, iron speciation (Fe^{2}□/Fe^{3}□), and phenolic compounds, were quantified through laboratory analyses, with DOC and DIC measured using a total organic carbon (TOC) analyser, phenol content determined by FT-IR spectroscopy, and iron speciation assessed using the ferrozine assay.

The field monitoring design incorporated both spatial and temporal contrasts, with greenhouse gas fluxes measured concurrently at restored (treatment) and unrestored (control) plots, as well as repeatedly at the same plots before and after bund construction. This design provides the basis for quantifying treatment effects relative to background temporal variability. Owing to the availability of pre- and post-treatment observations, treatment effects will be quantified using a combination of Before–After Control–Impact (BACI) and progressive-change BACIPS approaches.