Geophysical Research Abstracts
Vol. 18, EGU2016-331, 2016
EGU General Assembly 2016

Long-term impacts of peatland restoration on the net ecosystem exchange (NEE) of blanket bogs in Northern Scotland.

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Unmanaged peatlands represent an important long-term C sink and thus play an important part of the global C cycle. Despite covering only 12 % of the UK land area, peatlands are estimated to store approximately 20 times more carbon than the UK's forests, which cover 13% of the land area. The Flow Country of Northern Scotland is the largest area of contiguous blanket bog in the UK, and one of the biggest in Europe, covering an area in excess of 4000 km2 and plays a key role in mediating regional atmospheric exchanges of greenhouse gases (GHGs) such as carbon dioxide (CO_2), and water vapour (H_2O). However, these peatlands underwent significant afforestation in the 1980s, when over 670 km2 of blanket bog were drained and planted with Sitka spruce (Picea sitchensis) and Lodgepole pine (Pinus contorta). This resulted in modifications to hydrology, micro-topography, vegetation and soil properties all of which are known to influence the production, emission and sequestration of key GHGs. Since the late 1990s restoration work has been carried out to remove forest plantations and raise water tables, by drain blocking, to encourage the recolonisation of Sphagnum species and restore ecosystem functioning.

Here, we report findings of NEE and its constituent fluxes, GPP and Reco, from a study investigating the impacts of restoration on C dynamics over a chronosequence of restored peatlands. The research explored the role of environmental variables and microtopography in modulating land-atmosphere exchanges, using a multi-scale sampling approach that incorporated eddy covariance measurements with dynamic flux chambers. Key age classes sampled included an undrained peatland; an older restored peatland (17 years old); and a more recently restored site (12 years old). The oldest restored site showed the strongest uptake of C, with an annual assimilation rate of 858 g C m-2 yr-1 compared to assimilation rates of 501g C m-2 yr-1 and 575g C m-2 yr-1 from the younger restored site and undrained sites, respectively. Although the oldest restored site had the highest assimilation rate, it was also associated with the highest Reco rate (846 g C m-2 yr-1), while the younger restoration site had a smaller Reco rate of 581 g C m-2 yr-1. The lowest Reco rates were observed at the undrained site (461 g C m-2 yr-1). Observed differences in these rates are driven by differences in temperature and soil moisture content associated with man-made microtopography.

Thus, although peatland restoration in this region actively increases CO_2 assimilation it also enhances Reco due to the presence of man-made microtopographic features. Although restoration results in peatland ecosystem functioning beginning to return to these sites after 17 years, these data suggest that more aggressive restoration practices (e.g. re-levelling of the soil surface to restore the original peatland microtopography) are required to reinstate C flux rates that are comparable to unmanaged peatlands. Further longer-term observational data are also required to better model and predict the recovery trajectory of these restored ecosystems at multi-decadal timescales, and in order to produce more robust ecosystem carbon budgets.