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Assessment of CO_2 and CH_4 fluxes from a forest-to-bog restoration in Scotland

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Northern Peatlands play an important role in the regulation of the atmospheric greenhouse gas (GHG) balance. In Scotland, deep peats (>0.5m) cover an area of approximately 18,000 km^2 and under undisturbed conditions they function as a net C sink due to organic matter accumulation with low rates of organic decomposition. Modifications like drainage increase aerobic decomposition which may lead to an enhancement of gaseous greenhouse gas (GHG) release. For this reason, many blanket bogs are protected by environmental legislation and the number of restoration projects has increased over recent years. Restoration is undertaken without key underpinning knowledge of the impact of restoration upon GHG dynamics, particularly for sites restored from commercial forestry. The Flow Country of Northern Scotland represents an extended area of blanket bogs and pools of about 4,000 km^2 and it hosts the largest stretch of deep peats in the country, some of them afforested, others nearly undisturbed or under active restoration, involving tree removal and site modification to aid rewetting of the peat surface. We summarise an investigation of the effect of forest-bog restoration practices focusing on the inter-annual climatic variability driving carbon dioxide (CO_2) and methane (CH_4) exchange dynamics on a deep peat soil area located in the Royal Society for Protection of Birds (RSPB) nature reserve of Forsinard that has undergone restoration with tree felling in 2003 and management promoting rewetting in April 2018. Flux measurements were collected using different chambers techniques, with collars positioned along a transect in which different vegetation types and micro topography were represented (i.e. ridges, furrows, original surfaces and pools). Gas analysis was performed both in-situ using a Los-Gatos Ultraportable Gas Analyser and by gas chromatography from static chambers. Our results show that CO_2 exchange is primarily controlled by soil moisture and microtopography (e.g. higher CO_2 fluxes on ridges), while undisturbed bog areas and pools could be regarded as hotspots for methane emissions. Average annual emission for undisturbed bog surface was 4.6g CO_2eq m^{-2} y^{-1} and pools emitted 16g CO_2eq m^{-2} y^{-1} in comparison to ridges (1.4g CO_2eq m^{-2} y^{-1}) and furrows (2.1g CO_2eq m^{-2} y^{-1}). Methane exchange is also likely to be influenced by vegetation composition. Plots with abundance of vascular plants like Tricophorum spp. and Eriophorum spp. showed higher CH_4 fluxes (12g CO_2eq m^{-2} y^{-1}) compared to Sphagnum dominated locations (4.1g CO_2eq m^{-2} y^{-1}). Preliminary interpretation from this study suggests restoration practices, that aim to bring the peatland back to pristine or more natural (pre-forestry) conditions, cause an increase in methane emissions, since original surfaces and pools (which appear to be hotspots for this GHG) will extend post restoration. This study will provide a better process-based understanding of the C and GHG dynamics associated with peatland restoration, and will make a significant contribution to better informing the development of rural land management policy, especially in relation to climate change mitigation and reporting at the national and international level.