How does restoring erosional features over deep peats affect emissions of carbon dioxide and methane in the short-term?

- Degraded peatlands such as Flat Tor Pan are losing carbon as gaseous carbon dioxide from the visibly degraded bare peat areas and the surrounding vegetated areas.
- Water levels were significantly higher, the coverage of purple moor grass (*Molinia caerulea*) lower and cotton-grass (*Eriophorum angustifolium*) higher in restored vegetated sites.
- Restoration significantly reduced below-ground (heterotrophic) respiration of the peat store.
- In the short-term restoration had no significant effect on net ecosystem exchange but significantly increased methane (CH_4) emissions.

Dartmoor is estimated to store 13.1 mega tonnes of carbon[1] roughly equivalent to 10 % of the UK's greenhouse gas emissions in 2018[2]. High water tables in a healthy peatland prevent the complete decomposition of dead vegetation, allowing carbon to slowly accumulate. However, much of Dartmoor's peatlands are currently degraded[3] putting this carbon store at risk. Restoration offers the potential to not only protect the existing carbon store but also promote carbon sequestration to mitigate the current climate emergency.

Pre-restoration the water table was lower but more stable in the haggs (9.1 ± 5.4 cm) than the pans (7.1 ± 10.1 cm)[4] causing substantial differences in vegetation coverage and composition (Figure 43). Consequently, carbon dioxide fluxes (photosynthesis in and ecosystem respiration out) were greater in the vegetated haggs than the pans. An empirically derived net ecosystem exchange model estimated that the haggs (29 and 20 gC m^{-2}) and the pans (7 and 8 gC m^{-2}) were growing season carbon sources for 2013 and 2014[4]. This suggests both the visibly degraded peat pans and the surrounding vegetated haggs are losing carbon to the atmosphere, highlighting the need for restoration.

Water table depths were higher in the restored locations than the unrestored control locations for both the haggs (2.0 cm restored; 9.3 cm control) and the pans (-11.8 cm restored; 8.9 cm control). In the unrestored control hagg sites, coverage of purple moor grass (*Molinia caerulea*) and bog cotton-grass (*Eriophorum angustifolium*) was significantly greater ($p=0.036$). No other significant differences were observed in the vegetated haggs or the peat pans. Wider vegetation monitoring across Flat Tor Pan (79 quadrats) also found significant decreases in purple moor grass (*Molinia caerulea*) and increases in bog cotton-grass (*Eriophorum angustifolium*) but also found *Sphagnum capilifolium* to decrease and *Sphagnum denticulatum* and *Sphagnum subnitens* to increase post-restoration[5]. Despite this (limited) vegetation change, net ecosystem exchange (the balance between photosynthesis and ecosystem respiration) was not significantly different between the unrestored control and restored areas (Figure 44)[6].

High water tables promote an oxygen free environment. This reduces the volume of oxygenated peat, limiting more rapid aerobic respiration, significantly reducing ($p<0.001$) (heterotrophic) respiration of the peat soil (Figure 45)[6]. Consequently, restoration reduced the carbon being lost from the peat store via this pathway.

However, high water tables also enable the production of methane by soil microbes (methanogens). Vegetation with hollow stems (aerenchyma) e.g. cotton grasses (*Eriophorum* spp.) allow methane to by-pass the oxygenated zone and diffuse directly to the atmosphere. Higher water tables and the presence of cotton grasses (*Eriophorum* spp.) in the restored locations have resulted in significantly ($p<0.001$) higher methane emissions (Figure 46)[6]. Over time it is expected that cotton grass (*Eriophorum* spp.) will be replaced by *Sphagnum* spp. which do not facilitate methane release. This change in vegetation composition would also shift the balance in organic matter production and decomposition towards a blanket bog that slowly accumulates carbon. Future monitoring is planned to test this hypothesis over the next 5 years.

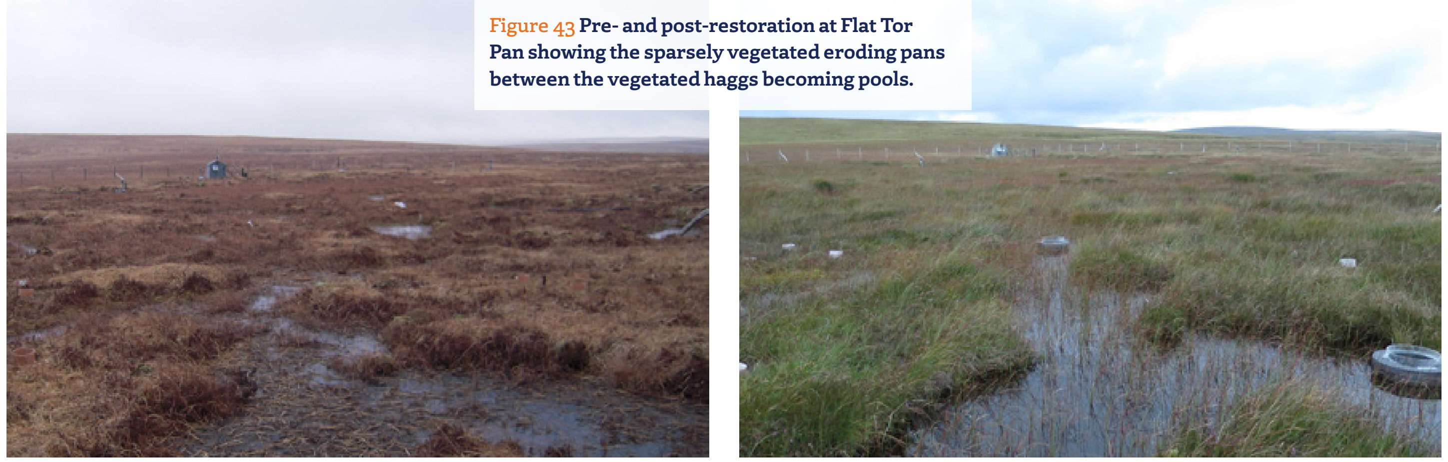


Figure 43 Pre- and post-restoration at Flat Tor Pan showing the sparsely vegetated eroding pans between the vegetated haggs becoming pools.

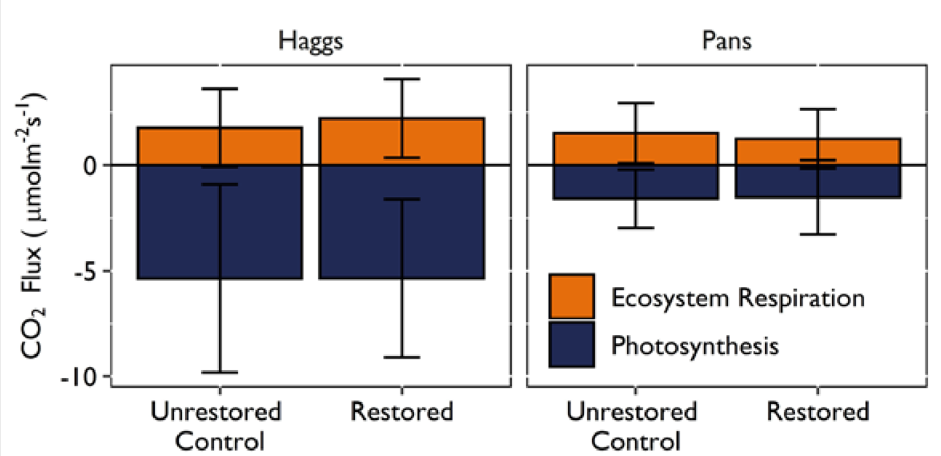


Figure 44 Photosynthesis (CO_2 drawdown) and ecosystem respiration (CO_2 release) from the haggs and pans at the unrestored control and restored locations.

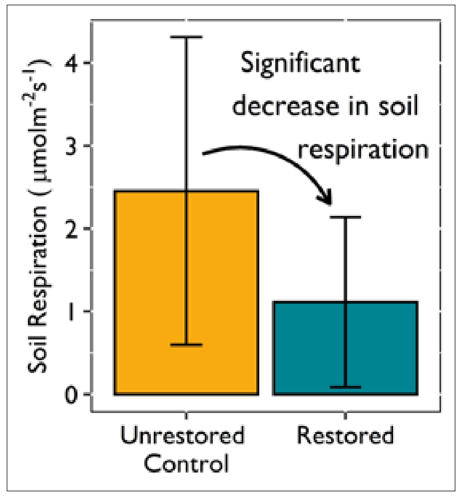
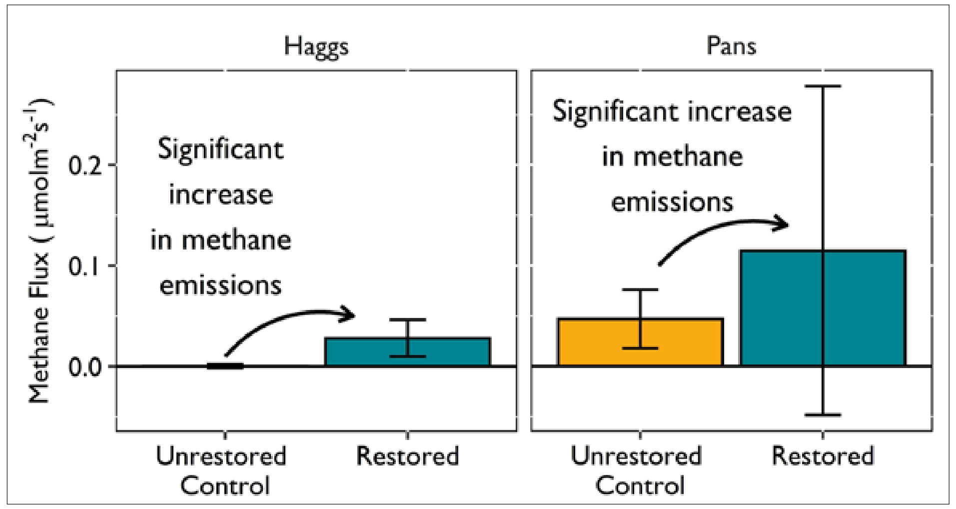


Figure 45 Significant reduction ($p=0.001$) in below-ground (heterotrophic) respiration of the peat soil at the restored location compared to the unrestored control.

Figure 46 Methane emissions at the restored and unrestored control showing significantly greater emissions ($p\leq0.001$).



Monitoring carbon dioxide and methane emissions.

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The appendices are available to view at www.exeter.ac.uk/creww/research/casestudies/miresproject

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