The impact of wildfires on moorland carbon dynamics

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Background

Though we know that well-managed moorland burning can provide a range of benefits, wildfires can cause significant damage, particularly in areas of high severity where ground-level layers of moss and peat are extensively heated or ignited. Smouldering combustion in peat releases significant amounts of fossil carbon whilst killing the plants and destroying the below-ground soil seedbanks on which regeneration depends. Smaller scale changes in soil temperature and moisture content related to differences in fire severity may also cause changes in the rate of peat decomposition potentially precipitating the slow break-down of peat deposits and release of stored carbon, even where fires appear comparatively mild. Despite the seriousness of such impacts, almost all of our scientific knowledge of the impacts of wildfire on moorlands comes from a small number of studies on a single event, some 35 years ago. We also know little about what controls the transition from safe burning conditions to severe wildfire or how moorlands respond to fire along the spectrum of fire severity.

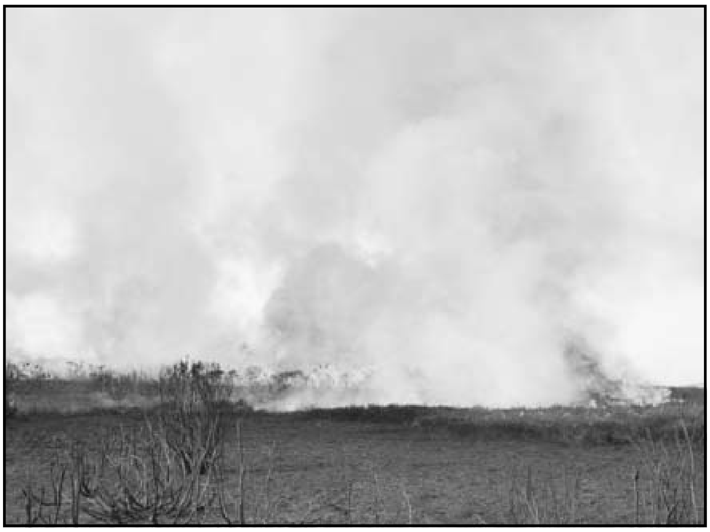
A severely burnt "hot spot" following a moorland wildfire. Dry, cracked peat has been exposed in the foreground whilst the area at the back has been burnt but smouldering has not propagated here. Working out what allows sometimes complex patterns of fire severity to develop, and what the longer-term effects of these differences will be, are key aims of the project.

The large number of wildfires in the springs of 2011 and 2012 added to increasing concern that climate change may drive a vicious circle of increasing wildfire severity, greater release of fossil carbon from peat deposits and further warming. The University of Glasgow, in collaboration with the Centre for Ecology and Hydrology, has secured funding from the Natural Environment Research Council for a pilot project to study the effects of a range of wildfires on vegetation regeneration and peat carbon dynamics. With fantastic support from a number of public and private landowners who have experienced wildfires over the last two years, we are aiming to develop a robust method to assess fire severity and to relate variation in severity to both weather conditions leading up to the fire, fuel conditions on the ground and the subsequent response of the affected moorlands. We are currently part way through our first full field season but already have some interesting results.

Methodology

Currently, we are working on six different wildfire sites located from the North York Moors up as far north as the Cairngorms. We have mapped each fire and established paired burnt/unburnt plots across the fire perimeter in areas where we were confident pre-fire vegetation conditions were similar on either side. Initial recording within the plots has focused on re-developing the "Composite Burn Index" (CBI) for UK moorland environments and on collecting data on the amount of vegetation burnt-off during the fires.

The CBI is a method developed by forest fire ecologists in the USA that attempts to summarise fire effects within a fire area and to gauge the extent of environmental change from pre-fire conditions. The method uses field data that are relatively quick to collect such as ratings of the colour of the soil or ash, visual estimates of the proportion of vegetation consumed by the fire, evidence of regeneration and colonisation by new species. Our modifications to the CBI aim to recognise the distinctive character of the moorland environment. Thus, for example, we account for the fact that moorlands are treeless, rendering several layers of the original CBI irrelevant. We compensate for this by recording additional impacts on ground layers where fire effects on peat-building species like Sphagnum mosses and the peat itself are vitally important. We have also been harvesting samples of burnt and unburnt vegetation in order to assess how fuel consumption varies across areas burnt under different severities.



A wildfire burning across an area of heather and gorse moorland. This fire was relatively severe with nearly all the above-ground vegetation burnt-off in addition to ground-level layers of moss and litter. Despite this the peat was only charred in places and was not ignited. Changes in soil temperature and moisture content due to charring and blackening of the surface and the removal of the protective vegetation may increase carbon emissions from the exposed peat.

Early results

Initial results point to substantial differences in fire severity both within and between different wildfires. CBI values recorded in individual plots varied more than four-fold, which suggests that fire severity can differ substantially even within a small number of wildfires. Absolute fuel consumption across all the fires ranged between 3.2 and 17.8 Tonnes/ha (1.3 to 7.1 tons/acre) and the proportion consumed between 54 and 95 %. The consumption of above-ground vegetation by the fires thus released, on average, 5 Tonnes of Carbon per hectare burnt. Interestingly, these results appear to be slightly higher than those recorded for prescribed fires in similar habitats. Few of the fires we were able to visit showed significant evidence of ignition or consumption of peat and the majority of the material consumed was from shrubs, grasses and litter. We did, however, encounter areas of scorched peat and in some fires the moss and litter had been almost completely removed. We also saw evidence of peat smouldering in areas where the habitat was already degraded and bare peat was exposed prior to the fires.

Ongoing work

Though the information on the consumption of vegetation by the fires is interesting, it is only a small part of the story. Where regeneration following the fire is good, and heather rapidly resprouts or establishes from seed, then the carbon lost through combustion should be sequestered by the growing vegetation within a relatively short amount of time. We thus need to understand how vegetation responds along the spectrum of severity we have recorded as, if what grows back is different to the pre-fire vegetation type, then the moorland's carbon balance will be affected. Thus in more severely burnt areas heather regeneration may be slow providing an opportunity for grasses to take over or for exposed peat to be eroded. We are also deploying "flux chambers" (which sounds fancy but these are really just big plant pots with a lid and their bottoms cut-off!) which will allow us to trap the gasses emitted by the peat as it decomposes. This data will let us examine whether the rates at which peat releases carbon dioxide and methane differ between burnt and unburnt areas and between areas burnt at different severities. This is crucial in order to get an overall picture of how wildfires affect the carbon balance of moorlands and to detect whether different levels of wildfire severity have pernicious effects on carbon emissions. Though a larger number of wildfire case studies will be needed in order to build up a truly accurate picture of the effects of these fires, we hope our research will contribute to forecasting when and where damaging fires are likely to occur so managers can burn safely, avoiding damaging periods and can ready fire control resources in conditions when wildfires are likely to be most damaging.

The project's research assistant Rut Domenech-Jardi installing a soil gas flux chamber in an area burnt by wildfire in 2011. Placing a lid on top of the chambers allows carbon dioxide and methane emitted by the peat to build up in the chamber. Gas samples are removed through a valve in the lid using a syringe and then injected into an air-tight glass vial. The samples can then be analysed using a gas chromatograph.

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