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Charcoal production in a UK moorland wildfire – How important is it?

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ABSTRACT

Wildfires are a common feature of peatland environments, but the carbon balance of these wildfires is often not considered and the production of refractory black carbon in these wildfires could be an important addition to carbon accumulation and mitigate losses of biomass during the fire. This study investigates the biomass and carbon losses during a moorland wildfire. Changes in above-ground carbon stocks were calculated using a combination of field data, laboratory measurements and literature values. The results show that approximately 14% of the carbon in the original above-ground biomass remained on the site after the burn. Black carbon production was approximately 6 gC m^{-2} which constituted 4.3% of the biomass lost. The survival of biomass and black carbon may help to mitigate the loss of carbon during the fire.

1. Introduction

Wildfires are common phenomena within many ecosystems with vegetation fires present in tropical, temperate and boreal regions. Worldwide vegetation fires are estimated to burn between 530 and 555 × 10^6 ha per year (Gonzalez-Perez et al., 2004) and van der Werf et al. (2006) estimate annual global carbon emissions from wildfires to be approximately 2.5 Pg yr^{-1}. Wildfires not only represent a loss of biomass and ecosystem carbon stocks but also have damaging effects upon human health and well being, the economy and biodiversity (Lohman et al., 2007).

The UK routinely experiences wildfires and vegetation fires. In the period between 1974 and 2005, the Fire Service attended on average, 71,700 vegetation fires a year with more frequent fires in periods of drought e.g. in 1995 and 2003, 174,600 and 152,700 fires respectively were recorded (McMorrow et al., 2009). Many wildfires in the UK occur on moorlands and peatlands. These locations, which are internationally important ecosystems (Tallis et al., 1998), are intensively managed and support a variety of land uses e.g. grouse shooting, sheep farming, water resources and recreation/tourism (Holden et al., 2007).

Wildfires in upland landscapes can have important effects on different ecosystem services. The ecological impact of fire is particularly important as it has the potential to be very harmful to habitats (Legg et al., 1992; Maltby et al., 1990) and their associated flora and fauna e.g. ground nesting birds. Wildfire can also lead to a long-term change in the ecology of an area. In a wildfire in the Derbyshire Dales, England, the destruction of the vegetation and humus layer led to change from acid grassland to limestone grassland (Grime, 1963). The direct physical effects of wildfire have also been investigated. Vegetation cover plays an important role in binding the peat surface together. If the vegetation layer is weakened by fire, physical erosion of the peat may occur (Evans, 2009).

Wildfire also has an important impact on carbon stores and fluxes. Furthermore, the fire can burn through the above-ground biomass and burn the litter layer, the soil organic matter and the belowground biomass. In addition to the carbon that is lost through combustion, fire could lead to enhanced export of carbon via a range of pathways, e.g. post-fire erosion could be enhanced due to the loss of vegetation leading enhanced losses particulate and dissolved organic carbon from peat to streams (Evans, 2009). With the peatlands of the UK storing around 3 Pg of carbon (Cannell et al., 1993), the consequence of wildfire and post-fire erosion could have important impacts on this important carbon store.

During the process of combustion carbon is released to the atmosphere in the form of various gases and particulates with most of the carbon in the form of CO_2 (Lobert et al., 1991). Fumes and smoke represent the airborne fraction of the combustible biomass, however, depending on fire conditions, a percentage of the original biomass is converted to solid char and remains on the site following burning.

These charred materials, often referred to as black carbon (BC), are the product of incomplete combustion of vegetation and fossil fuels. Novakov (1984) defines BC as "combustion-produced black

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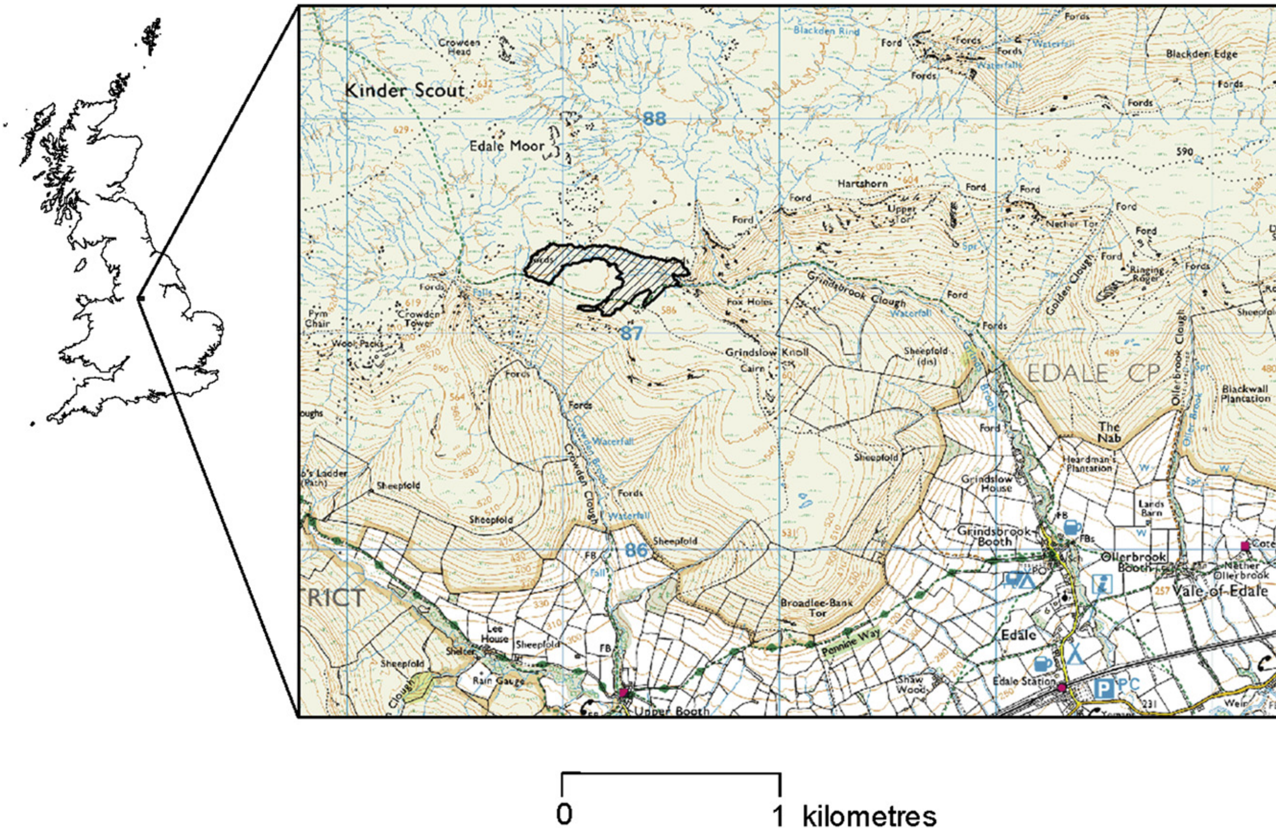

Fig. 1. Location of fire scar (hashed area). © Crown Copyright Ordnance Survey. An EDINA Digimap/JISC supplied service.

particulate carbon having a graphitic microstructure". In the field, however, BC can be thought of as a continuum of products ranging from slightly charred degradable biomass through to highly graphitized soot spheroids (Hedges et al., 2000; Masiello, 2004). The interest in BC primarily comes from its importance to the global carbon cycle and its potential role as a carbon sink (Kuhlbusch, 1998). Due to its long mean residence time, often on the millennial time scale (Lehmann et al., 2008), and its high degree of resistance to chemical agents (Bird and Gröcke, 1997), BC may have the potential to remove significant amounts of carbon from the short term bio-atmospheric system and transfer it to the longer geological carbon cycle. Thus BC production has the potential to mitigate part of the carbon losses during the fire itself.

Forbes et al. (2006) discuss the many problems associated with the definition and quantification of BC and how it is expressed relative to other components of the carbon cycle. Forbes et al. (2006) propose a standard way to express BC by expressing it as a percentage of the amount of carbon consumed by the fire (BC/CC). By using this method, BC formation in forest fires ranged from 5% to <3% BC/CC and in savannah and grassland fires a value of <3% BC/CC is reported. The studies included in Forbes et al. (2006) are from a narrow range of ecosystems, and of the grassland and savannah studies included, two were from Africa and four were from Australia. This paper is the first to estimate BC production of wildfire in a European moorland setting.

2. Materials and methods

2.1. Field survey

On the 26th May 2008 a wildfire was reported on moorland near Edale, Peak District, UK (Fig. 1; UK Grid Ref: SK 104 873). The fire burnt for three days and covered an area of approximately 10 ha, crossing several major gullies and numerous small gullies. The surrounding vegetation is dominated by heather (*Calluna vulgaris*), bilberry (*Vaccinium myrtillus*), and cotton grasses (*Eriophorum vaginatum* and *Eriophorum angustifolium*) with areas of *Sphagnum* spp. (a moss genus). The area is one of peat soils and are underlain by gritstones and shales of the Millstone Grit series which, in this area, are exposed as the Kinder Scout Grits and underlying Grindslow shales (Gluyas and Bowman, 1997; Stevenson and Gaunt, 1971).

In order to assess the loss of biomass and the production of char a survey of the burnt area was carried out three weeks after the fire (16th–19th June 2008). The primary field data was gathered through a series of 0.25 m^2 (0.5 m by 0.5 m) quadrat surveys in the fire scar and surrounding unburnt vegetation. An obvious limitation of studies of wildfires is that it impossible to know where the wildfire will occur prior to happening and thus it has to be assumed that the unburnt area surrounding the fire represented the area of the burn before the fire. Following a site walkover, the survey was conducted in a semi-stratified manner in order that the following key regions were surveyed: length of fire scar; width of fire scar; a back burn area i.e. burnt against the principal wind direction; and spur from the main fire (Fig. 1).

A total of 65 quadrats (42 burnt, 23 unburnt) were surveyed. At each quadrat location a general description of the plot was made and various data was collected including: GPS location, altitude, vegetation types and cover, and vegetation heights. Samples of vegetation, litter and char were removed from each quadrat whenever possible for later laboratory analysis. Vegetation was clipped to peat surface to remove representative samples for later analysis. Litter and char were removed by scraping areas clean within the quadrat. Samples were placed in sealed bags in the field and stored in airtight desiccating chambers prior to lab analysis.