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Using palaeoecology to support blanket peatland management

A. Blundell *, J. Holden

School of Geography, University of Leeds, Leeds LS2 9JT, UK

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ABSTRACT

Many peatlands have a recent history of being degraded by extraction, drainage, burning, overgrazing and atmospheric pollution often leading to erosion and loss of peat mass. Restoration schemes have been implemented aimed at rewetting peatlands, encouraging revegetation of bare peat or shifting the present vegetation assemblage to an alternative. Here we demonstrate the use of palaeoecological techniques that allow reconstruction of the historical development of a blanket peatland and provide a historical context from which legitimate restoration targets can be determined and supported. We demonstrate the applicability of simple stratigraphic techniques to provide a catchment-wide peatland development history and reinforce this with a detailed macrofossil reconstruction from a central core. Analysis at Keighley Moor Reservoir Catchment in northern England showed that the present vegetation state was 'atypical' and has been characteristic for only the last c. 100 years. *Sphagnum* moss was an important historic contributor to the vegetation cover between 1500 years ago and the early 1900s. Until the early 1900s *Sphagnum* occurrence fluctuated with evidence of fire, routinely returning after fire demonstrating good resilience of the ecosystem. However, from the turn of the 20th century, *Sphagnum* levels declined severely, coincident initially with a wildfire event but remaining extremely diminished as the site regularly underwent managed burning to support grouse moor gun sports where practitioners prefer a dominant cover of heather. It is suggested that any intention to alter land management at the site to raise water tables and encourage greater *Sphagnum* abundance is in line with peatland development at the site over the past 1500 years. Similar palaeoecological studies providing historical context could provide support for restoration targets and changes to peatland management practice for sites globally.

1. Introduction

The world's peatlands cover 3% of the earth's land surface but contribute 30% of its soil carbon (Parish et al., 2008) and store more organic carbon per hectare than any other terrestrial store. Degraded peatland (one tenth of the peatland resource) contributes 6% of global anthropogenic CO_2 emissions (Joosten et al., 2012). Globally, peatland degradation is mainly via agriculture, forestry, peat extraction for fuel or horticulture and urbanisation. Such degradation jeopardises the ecosystem services peatlands provide (Parry et al., 2014a,b,b; Maltby and Acreman, 2011; Bonn et al., 2009). Blanket peatlands form over sloping landscapes under conditions of a large moisture excess and poor underlying drainage. They are typically found in temperate hyper-oceanic regions (Lindsay et al., 1988) such as eastern Russia, the South Island of New Zealand, southern Alaska and parts of the Atlantic northwest Europe (Gallego-Sala and Prentice, 2012). It is estimated that 10–15% of all blanket bog worldwide is located in the British Isles (Tallis et al., 1997). In the UK, blanket peatland covers 1.5 million hectares with around 14% (215,000 ha) in England (Jackson and McLeod, 2000). These areas are also the largest terrestrial carbon reserves in the UK acting as a net carbon sink of between 0.7 Mt C/year (Cannell et al., 1999) and 0.3 Mt C/year (Worrall et al., 2003).

A recent history of often interlinked factors such as drainage, burning, atmospheric pollution and overgrazing is often blamed for degradation of UK peatland environments (Holden, 2007). Some peatlands have suffered from severe erosion since the middle of the last century (Bower, 1961, 1962; Tallis, 1973; Maltby et al., 1990; Evans, 2005). Drainage of agriculturally marginal uplands expanded rapidly after the Second World War in Britain (Holden et al., 2007). Since the start of the 19th century systematic controlled patch burning to attain the optimum habitat for gun sport related birds has been widespread in the UK uplands and this has included burning of vegetation on blanket peatlands (Yallop et al., 2006). Atmospheric pollution since the industrial revolution, particularly the deposition of sulphur and nitrogen, has been linked with the declining abundance of

* Corresponding author. Tel.: +44 1133431593.
E-mail address: a.blundell@leeds.ac.uk (A. Blundell).

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Sphagnum (Ferguson et al., 1978; Lee, 1998). Elevated stocking densities for sheep associated with the EU Common Agricultural Policy have been linked with enhanced erosion and degradation of upland peatlands in the UK (Rawes and Hobbs, 1979; Holden et al., 2007) since peatlands often have a very low carrying capacity (Simpson et al., 1998).

However, realization of the economic and environmental value of peatlands and the damage that has been caused to them has led both public and private organizations to implement 'restoration' schemes (Holden et al., 2007). On the whole, restoration schemes in blanket peatlands have focused on the objectives of raising the water table via blocking drainage channels and gullies, re-vegetating bare areas of peat that are prone to erosion (Parry et al., 2014a,b) and attempting to replace some vegetation assemblages with assemblages that are thought to be suitable for rapid peat formation (Holden et al., 2008). The word 'restore' implies that practitioners attempt to reverse the adverse effects that have occurred and return the ecosystem to a pre-disturbance state (Charman, 2002). However, rarely is the full historical development of a site investigated, and so target restoration points related to a former condition are not known with any certainty (Chambers and Daniell, 2011). Information from surveys and aerial imagery regarding vegetation will only span at most the last two centuries providing a limited context. In many instances 'full restoration' is not feasible as the damage is too severe. However, restoration to conditions similar to those pre-disturbance may be attainable and lead to a peatland more resilient to climate change.

A further impetus for peatland restoration schemes has been the increased dissolved organic carbon (DOC) in watercourses that has been widely reported across European and North American peatland systems. Changes in atmospheric deposition chemistry (Evans et al., 2005; Skjelkvåle et al., 2005; Stoddard et al., 2003), land management and vegetation type have been shown to be important drivers of DOC release in peatlands (Holden et al., 2012; Wilson et al., 2011; Wallage et al., 2006; Armstrong et al., 2012). High levels of DOC entering raw water treatment works are very costly to deal with because complex methods of treatment are required to avoid the production of carcinogens which can be released during water disinfection when dissolved organic loads are high (Pereira et al., 1982; Chow et al., 2003). Thus a number of water companies are seeking to invest in catchment management on peatlands to reduce DOC loads to treatment works. Implementing changes in land management practice can be difficult as landowners may be doubtful of the benefits and question whether their peatland site is really 'atypical' in terms of its vegetation history, preferring to view the current landscape as a norm, a view based largely on living memory.

Palaeoecological techniques offer an excellent way to gain information regarding the past ecological status of a site, providing a long term perspective (Willis and Birks, 2006) from which plans for remediation devised by land managers can be well informed and supported. Despite this, palaeoecological studies have rarely been employed in peatlands with the aim of informing future land management (Davis and Wilkinson, 2004; Chambers et al., 2007, 2013). As Willis and Birks (2006) suggest 'conservation-related research largely ignores palaeoecological records'. Palaeoecological techniques have been employed on peat-based archives in the UK for over a century, but since the 1970s there has been a sharp increase in studies examining peatland development and also determining mid-late Holocene climate change (Blundell and Barber, 2005; Charman et al., 2009). Many techniques have been employed including examination of macrofossils (Barber et al., 1994, 2003), testate amoebae (Charman et al., 2007), levels of humification (Chambers and Blackford, 2001), isotopes (Daley et al., 2010) and biomarkers (Bingham et al., 2010).

This study takes a reservoir catchment in northern England (Keighley Moor) and undertakes palaeoecological analyses in order to illustrate how they can provide important tools for informing and shaping blanket peat restoration targets. We seek to test whether the vegetation condition of the site today is unusual in the context of the site's development over the past few thousand years. If the current vegetation condition is unusual then this would support those who seek to adopt interventions on the site to alter the vegetation cover and the data would provide some ecological indicators of restoration success. If the vegetation cover is not unusual in the context of the site's peatland development history then this would support those who wish to continue to manage it to maintain its current state.

The objectives of the study were:

a To establish the ecological history of the site.
b To test whether *Sphagnum* (as a common contemporary indicator of peatland condition) has been of historical importance at the site.
c To test whether the present ecological status is 'atypical' based upon the derived ecological history.
d To assess the extent to which the current vegetation is a function of contemporary management practice.

2. Site description

Keighley Moor Reservoir catchment (KMRC) has an area of 1.48 km^2 (Fig. 1) and is 3.5 km west of Oakworth in northern England (53°85′31″ N, −02°02′13″ E). The underlying geology is predominately formed from the Millstone Grit Group of the Carboniferous period. Superficial geology recorded by the British Geological Survey is that of 'Peat' although a detailed peat depth survey has never been carried out on the site. The reservoir is fed by two main streams from the 'northern' and 'southern' catchments. These streams have a series of tributaries constituting first and second order streams with their own sub-catchments. Present day vegetation is dominated by *Calluna vulgaris* (common heather) but also regularly includes *Eriophorum* vaginatum (hares tail cotton grass), *Eriophorum angustifolium* (common cotton grass) and *Vaccinium myrtillus* (bilberry) especially on shallow substrate. *Sphagnum* is rare but species include *S. fallax* in flushed gulleys and *S. capillifolium, S. fimbriatum* and *S. cuspidatum*. Present day vegetation at the key sampling point (master core location, see below) is dominated by *C. vulgaris* with lesser components of *E. vaginatum,E. angustifolium* and *Campylopus pyriformis.* The present day vegetation at most of the site would suggest a relatively inactive bog with regard to peat accumulation. The site is managed to promote grouse shooting, is grazed by sheep and there is no evidence of artificial drainage, especially near the area where the key detailed palaeoecological analyses have originated (master core, see below). KMRC has been managed for grouse since the 1870s (pers comm. Gamekeeper) and burning has been employed systematically with the classic 'patch' pattern characteristic of many of England's uplands. Reports from the previous gamekeeper suggest that at least two wildfires occurred in the last century, one in 1918 and one in the 1940s. Evidence of wildfire, including isolated peat pedestals and isolated 'whale back' formations has been documented. Records of depth to water table from an automated logger (2010–2013) in the area where we have carried out detailed palaeoecological analyses (master core, see below), which is in a part of the catchment free of erosion features, indicates that the water table is within 0–5 cm and 5.1–10 cm of the surface for 66% and 87% of the time, respectively, with the deepest recorded water-table depth being 24.6 cm.