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The use of paleoecological data in mire and moorland conservation

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For degraded mires and moorlands in Europe, paleoecological data from peats reveal how and when the present landscape developed. These data widen the vision of future landscapes and legitimate a greater range of targets for nature conservation agencies.

Context

The timescales and imperatives of scientists reconstructing past environments (paleoecologists), and those involved in modern ecology, have been very different (Birks and Birks 1980). Data produced by the former may be unread by, or unintelligible to, the latter, owing to the specialist journals in which they are published and their manner of presentation. Attempts to "bridge the gap" (Davies and Bunting 2010) between paleoecologists and ecologists are infrequent. Examples can be found in environments for which detailed paleoecological data are available to chronicle the past, showing how the present landscape developed (Gillson 2015). There is great potential to include these studies in restoration ecology.

Mires and moorlands

In Europe, while ecosystems responded to climate changes during the Holocene, many have also been affected by human activity over millennia. This is not always fully recognized by those responsible for their conservation. For example, in British mire and moorland environments, the most obvious human-induced effect of loss of *Sphagnum* (bog moss) species over the last century is well-known from naturalists' records, and attributed to pollution from sulfur dioxide. Yet, the long-term effects of centuries of grazing animals, at different stocking rates, with different species, is often ignored or unappreciated.

Mires and moorlands have the advantage that their underlying peats, which are incompletely decayed accumulations of plant remains, contain a record of their vegetation development over time. Analysis of these remains—pollen, spores, plant macrofossils—and of other properties of the peat, allows for reconstruction not only of their vegetation through time, but also of past climate change (Barber et al. 1994). Careful framing of multiple hypotheses permits inference of the relative effects of human activity on these landscapes.

Many nature conservationists may be unaware of the previous natural or semi-natural states of environments, beyond the past few decades. Indeed, 1949, when the national conservation agency was first established in the UK, has been used as a definitive baseline for comparative purposes of percentage habitat loss and degradation. Fortunately, enlightened staff in some of the national agencies have recognized the potential for paleoecologists to contribute much longer-term data to inform contemporary and future conservation. Nevertheless, assimilation and use of these data by conservation practitioners is not easy, requiring a more accessible form of presentation of paleovegetation data, particularly replacements for intricate pollen diagrams.

First overtures

An early attempt to combine the use of paleoecology with contemporary research into moorland restoration commenced on Exmoor, southwest England, in the late 1990s. The contemporary work, reported later by Marrs et al. (2004), but without reference to the paleo studies, had set out experimental plots investigating the use (or not) of herbicides, summer grazing (or not), and their use in combination to control and reduce the dominance of purple moor grass (*Molinia caerulea*). This dominance was regarded as undesirable in this designated Environmentally Sensitive Area (ESA), both on aesthetic grounds—the plant produced monotonous landscapes in a much-visited national park—and because it offered unpalatable grazing for stock, principally sheep. It was assumed, based on contemporary observations and oral accounts, that the purple moor grass had recently supplanted heather (*Calluna vulgaris*)—a plant regarded as aesthetically pleasing.

Palaeoecological data confirmed the relatively recent spread and expansion of purple moor grass, but unexpectedly revealed that the landscape had alternated between grass moor (with purple moor grass probably only a minor component) and heather moorland over the past millennium (Chambers et al. 1999). These results legitimized present attempts to control the hitherto unprecedented spread and dominance of purple moor grass but offered different visions of what the landscape *could* look like. Combining the two separate lines of research (experimental plots and paleoecology) suggests that generalist-feeding ponies or cattle, rather than sheep (who are finicky feeders), might help to reduce the dominance of purple moor grass.

The hitherto unprecedented stocking levels of sheep could, in part, explain the recent decline of heather and its replacement by *Molinia*. Speculatively, the combination of previous land management and grazing practices, combined with climate changes through the Medieval Climate Anomaly and the Little Ice Age, might explain the previous alternations between grass moor and heather moorland. Thus, the vision of the future landscape, upon restoration from its current monotonous state, does not necessarily have to be the replacement of one dominant (*Molinia*) by another (*Calluna*): a more diverse mosaic of grass–heather moor could be envisaged.

Degraded mires in South Wales

In South Wales, it was acknowledged that many upland mires and moorlands are depauperate, lacking some typical mire plants, particularly some of the bog moss species. This was variously attributed to overgrazing, too-frequent burning, airborne pollution, peat erosion, and climate change, among other causes. In many localities, *Molinia* was dominant.

Figure 1: Stainless-steel peat-cutter, showing safety-sheath (left) and field use (center); its sharp edge (right) ensures a clean cut, and minimal environmental damage.

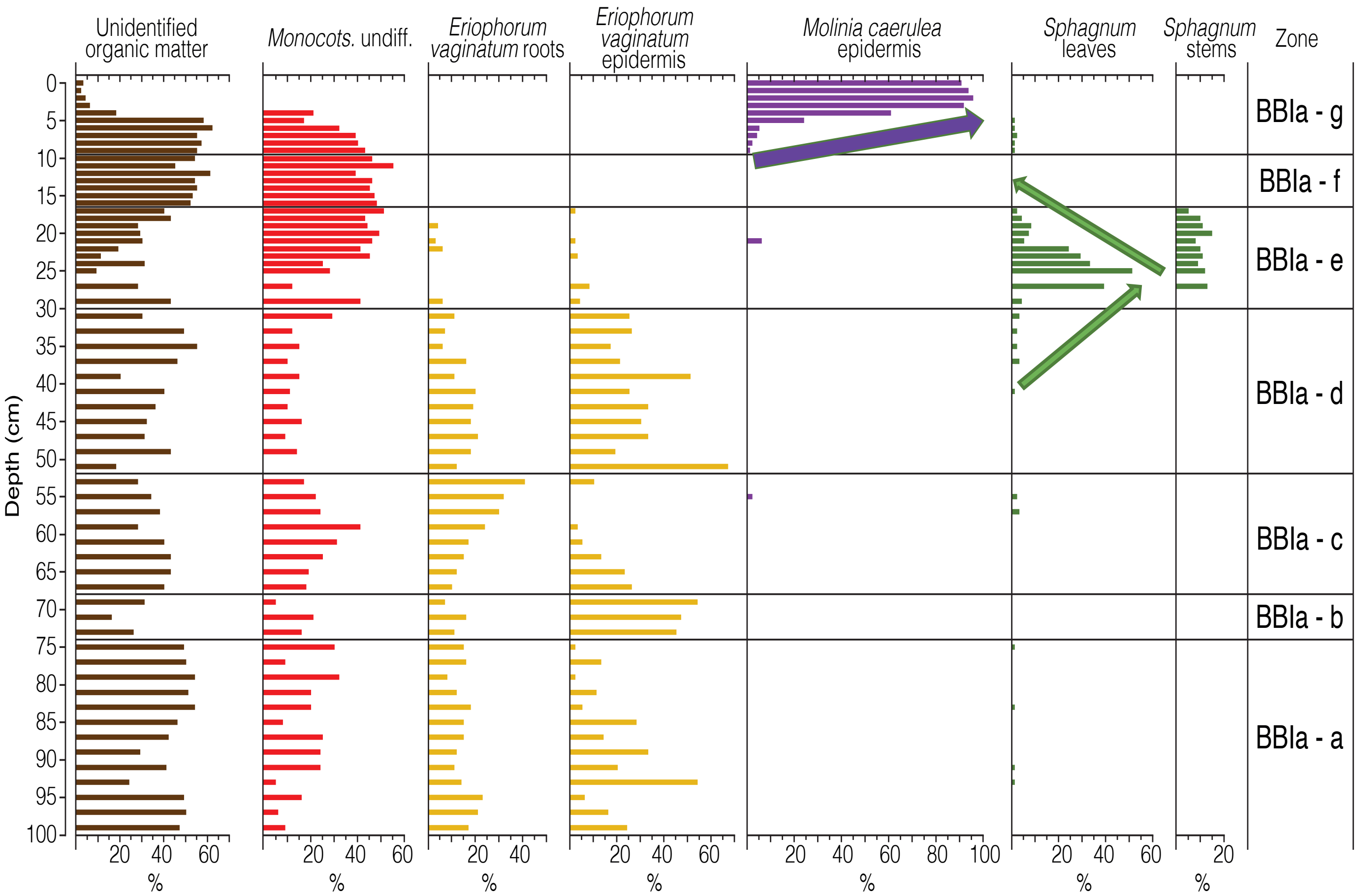

Figure 2: Paleoecological data (selected taxa) from Brecon Beacons, South Wales, showing rise and fall of *Sphagnum* (green arrows), and recent rise of purple moor grass (*Molinia*) *after* the start of the Industrial Revolution (14 cm depth).

The amount of carbonaceous pollution that fell on the uplands since the start of the Industrial Revolution had been roughly calculated (Chambers et al. 1979), and there had been the assumption that sulfurous atmospheric pollution was largely to blame for loss of *Sphagnum* species, as in the Pennines (Lee et al. 1987). However, any associated nutrient loading, which might give competitive advantage to *Molinia*, was hardly considered, and is not easy to assess. Other sources of eutrophication might be long-distance nitrogen deposition associated with agricultural practices, and the fertilizer effect of droppings from sheep at high stocking levels being fed winter feed supplement, which could result in nutrient enrichment of uplands.

On the Brecon Beacons, the current landscape is mainly treeless moorland and blanket bog. Some of the latter is eroding, with upstanding haggs (eroding blocks) of peat. The vegetation lacks diversity, with areas dominated variously by cotton sedge or purple moor grass. Palaeoecological research, commissioned by the Countryside Council for Wales (CCW; now Natural Resources, Wales), was undertaken to understand how the landscape had developed—not over the last few decades, but over the last 500 years. Radiocarbon dating showed that the peat had accumulated over several thousands of years, and so, with permission, the story was extended by taking peat monoliths economically using special field equipment (Fig. 1). The analysis of deep peat sections proved particularly useful, as it put the current vegetation state into a much longer time perspective (Chambers et al. 2013). The data showed that the current vegetation had no longevity, but rather had developed since the Industrial Revolution, with the rise of purple moor grass a recent feature after decline of centennial (but not millennial) dominance of *Sphagnum* (Fig. 2), suggesting a range of possible restoration targets.

Recent and future collaboration

In the decade since an earlier review in this magazine (Chambers and Daniel 2011), there has been limited application of palaeoecological data for mire and moorland conservation in the UK. A notable exception has been the Yorkshire Wildlife Trust, through the Yorkshire Peat Partnership, who sponsored research by McCarroll et al. (2016; 2017) on selected mires to understand better how to effect mire restoration. In Wales, too, earlier work co-published with CCW staff (Chambers et al. 2007) helped to inform conservation practice. These are exceptions rather than commonplace, and though a timely and potentially useful review of the utility of palaeoecological techniques for moorland management is available (Table 6 in Chambers et al. 2017), it has been scarcely sighted by conservation practitioners, and rarely cited. One possible reason why much mire and moorland restoration and management does not involve preceding paleoecological research is that, even with medium-term (5-yr) funding, conservation agency targets seem immediate or short-term compared with datasets covering hundreds or thousands of years. If longer-term goals were set, paleoecological research could be aligned and the long-term data generated could be better assimilated to inform the trajectory.

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