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# RESTORATION OF *SPHAGNUM* ON DEGRADED BLANKET BOG

A.E.Rosenburgh[1], S.J.M.Caporn[2], R.Sen[2], N.Dise[2], N.Wright[3]& M.Buckler[4]

[1] Manchester Metropolitan University, Chester Street, Manchester, UK M1 5GD; tel. +44 07753 991974; e-mail A.Rosenburgh@mmu.ac.uk; [2]Manchester Metropolitan University; [3]Micropropagation Services Ltd.; [4]Moors for the Future Partnership

## SUMMARY

Following centuries of industrial pollution, the southern Pennines have begun to support *Sphagnum* growth once again. However, legacy of this pollution may still be influencing the performance of *Sphagnum* in the area. By comparing growth of *Sphagnum* on different substrates, it is clear there are at least several chemical properties that may be limiting its growth potential.

KEY WORDS: *Sphagnum*, blanket bog, restoration, pollution

## INTRODUCTION

### History of the southern Pennines

The southern Pennines is an upland region, nestled between several major industrial conurbations of the north of England, and is home to some of the most polluted and degraded peatlands in the UK (Tallis, 1997; Caporn & Emmett, 2009). A history of industrial pollution and poor land management over the last 200 years has led to the development of large areas of bare, eroding peat, and vast expanses of species-poor vegetation (Holden *et al.*, 2007). Deposition of nitrogen, sulphur and heavy metals have produced changes in vegetation structure and composition, and resulted in the loss of pollution-susceptible species, such as bryophytes (Lee, 1998). *Sphagnum* mosses once dominated the vegetation (Conway, 1954; Montgomery & Shimwell, 1985) but it was virtually eradicated from this region (Tallis, 1997).

### Current conditions

Thanks to environmental legislation, various clean air acts and a reduction in industrial activity, deposition of many pollutants has fallen sharply; sulphate has seen the greatest reduction, with nitrate and ammonium following this trend (Caporn *et al.*, 2006). Bryophytes appear to have responded to this improvement in conditions, showing increases in species richness and distribution (Caporn *et al.*, 2006) compared with surveys carried out 20 years earlier (Studholme, 1989). It is unclear however if conditions are still limiting *Sphagnum* performance in the southern Pennines.

## Current restoration techniques

Remedial measures have been successful in restoring grass and dwarf shrub cover to bare peat surfaces (Anderson *et al.*, 2009). The focus of this restoration work has been to stabilise eroding surfaces and prevent further peat loss; the largest export flux of carbon in these systems (Worrall *et al.*, 2011). Heather brash is applied to helping to mesh the surface together. NPK Fertiliser, lime and a nurse crop of amenity grasses are the next stage of the process. The lime raises the pH of the highly acidic peat and the fertiliser replenishes nutrients leached due to acidification. This allows rapid growth and binds the surface together, sustained by further applications of lime and fertiliser over several years. Natural recolonisation by more typical species occurs, including cotton grass, bilberry and cloudberry. Where this process is slow, plug plants are used to help diversify areas of the bog.

## Limitations of current restoration

*Sphagnum* is an essential component of a functioning blanket bog, and as such, its absence significantly reduces the value of the ecosystem (Tallis, 1998). The simple answer would appear to be to add more propagules of *Sphagnum* to the ecosystem. In Canada, following peat extraction, *Sphagnum* cover is regenerated through the application of adjacently-sourced fragments, using agricultural machinery (Rochefort *et al.*, 2003; Quinty & Rochefort, 2003). In the southern Pennines, there is no substantial, local source of *Sphagnum* to use as donor material. In addition to this, the upland area would prove inaccessible to the machinery required for application.

## Sphagnum delivery

With the established methods of lowland *Sphagnum* regeneration shown to be unsuitable, a novel approach was developed to solve the problems encountered. BeadaMoss™ is a gel capsule containing fragments of growing *Sphagnum*. The material is locally sourced and bulked to sufficient quantities using micropropagation techniques, before being encapsulated. Glasshouse trials of this propagule return extremely high levels of viability, and earlier field trials show it can successfully establish and persist *in-situ* (Hinde, 2009).

## Objective

The legacy of industrial pollution may still be exerting an influence upon the establishment and growth of *Sphagnum*. By using an indoor growth experiment, variables such as hydrology and climate can be controlled, allowing a simplified understanding of the peat properties affecting *Sphagnum* performance. In addition to this, several species of *Sphagnum* propagule will be tested to identify which are of most use in restorative treatments.

# MATERIALS AND METHODS

## Establishment

A small quantity of peat was collected from a bare, eroding area at Holme Moss; a degraded blanket bog in the southern Pennines, typical of the region. Restorative works as detailed earlier have been carried out at this site and it will be used to trial large scale application of *Sphagnum* propagules. Five half-trays (21 cm x 16 cm) were filled with 2 cm of peat and the BeadaMoss™ applied. Five species were used; *S.cuspidatum*, *S.fallax*, *S.fimbriatum*, *S.palustre* and *S.papillosum*, all of which are sourced within the Holme Moss site. To act as a control, trays of horticultural peat (Growmoor Irish Moss Peat) were also set up, with the same *Sphagnum* applied.

### Growth conditions and harvesting

The trays were moved to an artificially lit room and randomly arranged. A clear plastic sheet was used to cover the trays to improve the humidity and reduce water loss. Lighting (150 µmol $m^{-2}$ $s^{-1}$) was provided for 16 hour per day and mean day temperature of 20°C. Trays were watered using distilled water to avoid any additional inputs through contamination of rainwater. After 6 months, the trays were removed from the growth room and the *Sphagnum* propagules harvested, dried and their mass recorded. Chemical analysis of the peat was carried out using ion chromatography for cations and anions on extracts of 1% KCl, and atomic absorption spectroscopy for metals on extracts of 0.1M EDTA.

## RESULTS

All species of *Sphagnum* grew better on the commercial peat than on Holme Moss peat. *S.cuspidatum* was the best performing species, on both of the substrates (Fig. 1.). Analysis of variance revealed significant differences in the performance of each *Sphagnum* species on the two substrates.

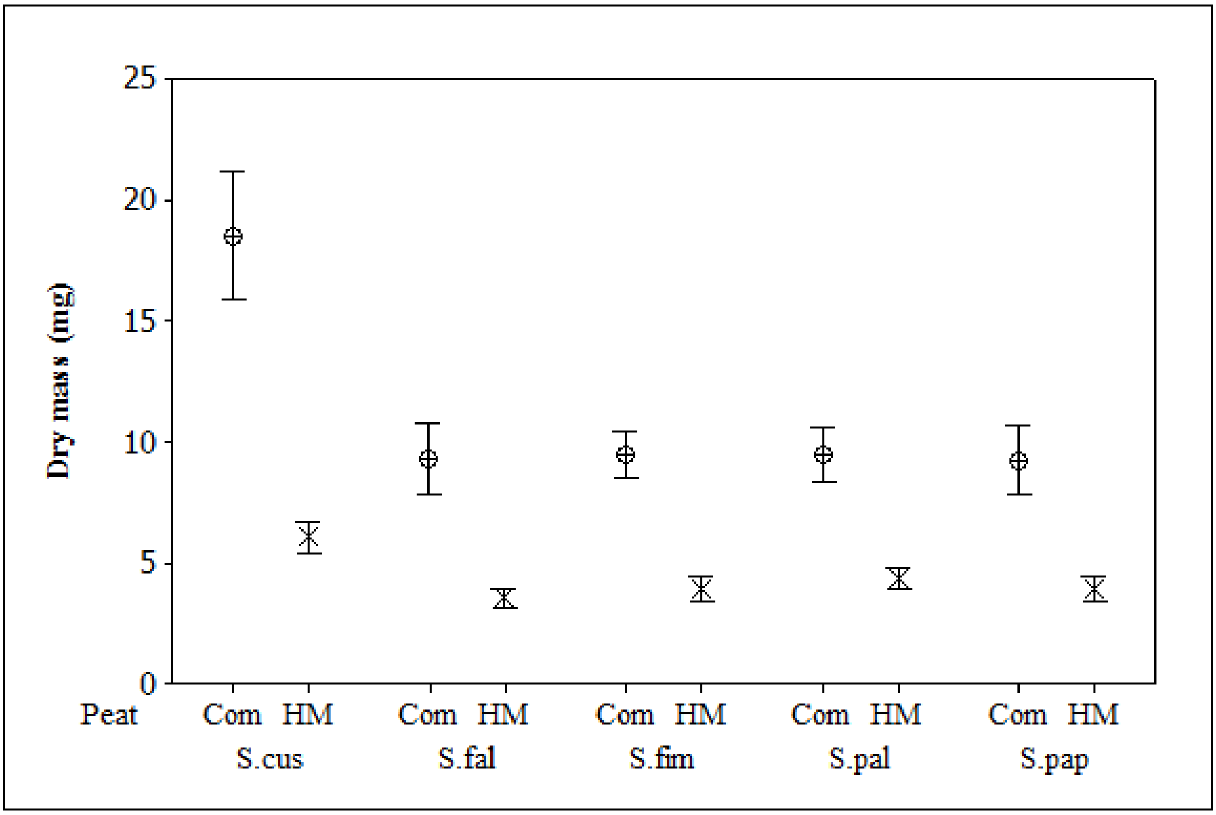


Fig. 1. Dry mass of BeadaMoss™ grown on commercial (Com) and Holme Moss (HM) peat (± 1 SE).

From the chemical analysis, Holme Moss peat was found to contain more ammonium, magnesium, manganese and zinc. The commercial peat had greater levels of sulphate, sodium, calcium, iron and lead than Holme Moss peat (Fig. 2.). Significant differences were once again found between the different peats, this time for all the nutrients and metals tested.

## DISCUSSION

Best fit regression models were used to determine which of the measured nutrients and metals were still exerting influence upon the growth of the *Sphagnum* species. These were:

*S.cuspidatum* = -0.117 Fe + 0.835 Mn + 2.48 Pb; $F = 73.37$, $p < 0.001$
*S.fallax* = 5.86 - 0.0465 Fe + 0.955 Pb; $F = 14.68$, $p < 0.001$
*S.fimbriatum* = 14.5 - 0.0281 Mg + 0.0204 Ca; $F = 14.14$, $p < 0.001$
*S.palustre* = 0.688 Pb + 0.228 Zn; $F = 84.85$, $p < 0.001$
*S.papillosum* = -0.0815 $NH_4$ + 0.0447 Mg - 0.024 Ca - 1.26 Mn + 0.678 Pb; $F = 29.80$, $p < 0.001$

*S.papillosum* appeared to be affected by the greatest number of factors, a fact reflected by its somewhat sparse distribution in the Holme Moss area. Surprisingly most of the species showed a positive relationship with lead levels. This can be explained by the collection of the Holme Moss peat from bare and actively eroding site. Lead is relatively stable and will not move down the peat profile like zinc does. These eroding areas lose a considerable depth of peat each year to erosion, taking with it the upper most and heavily lead-contaminated layers.

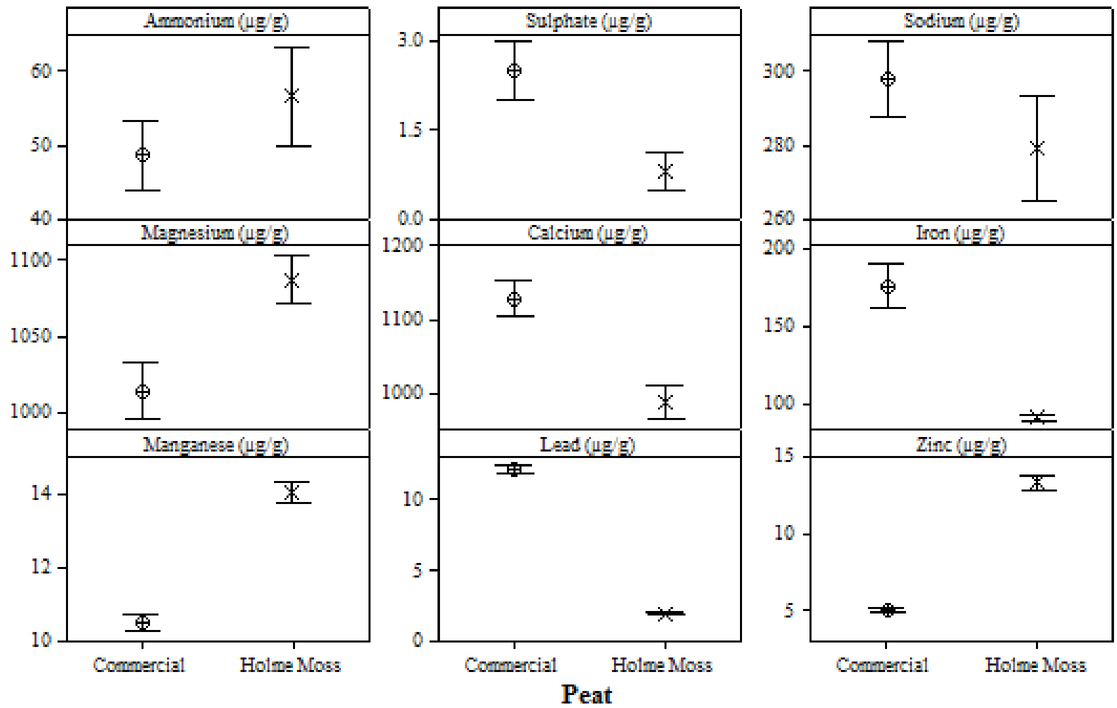


Fig. 2. Peat chemistry for major nutrients and metals in the commercial and Holme Moss peat (concentrations in µg/g dry weight ± 1 SE).

Initial expectations may be for the Holme Moss peat to be higher in sulphate, ammonium and heavy metals. Certainly, levels of zinc and manganese were higher compared to the commercial peat. Where peat has been sampled from areas which have retained their vegetation, levels of these pollutants are markedly higher than even the results presented here. Levels of nutrients and more reactive chemical components of the peat are somewhat different from analysis of freshly collected peat. This is more than likely due to the length of time the substrate was left in order for the BeadaMoss™ to grow. Under warm, moist conditions, a host of chemical and biological reactions will have occurred leading to oxidation of nutrients and transformation of ions and complexes. Analysis of fresh peat showed Holme Moss to be higher in levels of ammonium and sulphate, with commercial peat having higher levels of nitrate (personal data). The peat was also analysed for copper, nickel, nitrite and phosphate but levels were insufficient for detection.

*S.cuspidatum* performed best in this experiment, due to its ability to cope with pollution and rapid growth under optimum conditions. As an aquatic/ lawn species it grows best in high levels of humidity and moisture, however it is susceptible to desiccation during periods of drought. Along with *S.fallax*, these species can be considered as an initial phase of restoration and once cover with these species has been established diversification with other BeadaMoss™ species should be possible. *Sphagnum* cover will improve microclimate, hydrological and chemical conditions for further colonisation. The initial establishment of *Sphagnum* on these areas will prove critical in the restoration of damaged blanket bogs.

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