Identifying effective treatments to reinstate heath vegetation on commercially extracted peatlands at Hobbister RSPB Reserve, Orkney, Scotland

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SUMMARY

Trials were undertaken to assess the effectiveness of various treatments aimed at reinstating heathland vegetation at Hobbister RSPB Reserve (Orkney Islands) on a denuded area where no vascular plant growth had occurred since peat had been extracted commercially over 30 years previously. A management history of Hobbister was collated and information (derived from a literature search of restoration techniques) combined with observations of physical conditions at the site, was used to develop a list of possible impediments to heathland vegetation regeneration. Based upon these findings, eight sets of treatments were designed and applied to trial plots devoid of vegetation in June 2006. Plots were surveyed in August 2009. A combination of peat dust, heath mulch and geojute gave best results with 80% cover of vascular plants (including 70% by heather *Calluna vulgaris*). Although two grass-seed addition plots had higher cover values (91 and 86%) these were dominated by one of the sown species (red fescue *Festuca rubra*). Peat dust plus heath mulch addition also produced good cover (40%) of *Calluna*. Adding fertiliser did not assist in target heathland plant species re-colonisation. On the untreated control plot, vascular plant cover remained at zero.

BACKGROUND

West European heathlands are semi-natural habitat found on acidic nutrient-poor soils dominated by ericaceous dwarf shrubs, such as heather *Calluna vulgaris* (Webb 1986). Although semi-natural, evolving as mid-successional habitats through hundreds of years of anthropogenic exploitation (e.g. livestock grazing and turf-stripping), they are very important wildlife habitats (Riley & Young 1972, Gimingham 1975) which are now threatened (Crushell 2009, Diaz *et al*. 2008). Heathlands formerly covered approximately one third of the land area of Great Britain (Averis *et al*. 2004). Today only around 70,000 ha of lowland heathland remains in the UK, about 16% of its extent in the 19th century (JNCC 2010); losses have occurred due to urbanisation, agricultural conversion, cessation of management and extraction for peat. Heaths support a characteristic fauna and flora including many species of conservation concern.

In light of heathland loss due to peat extraction, understanding factors that drive successful heath restoration and management will assist in conserving this important habitat (Crawford 2008, Shaw & Goffinet 2000). In this present study undertaken at the Royal Society for the Protection of Birds (RSPB) Hobbister reserve on Mainland Orkney island (northern Scotland), rather than applying agricultural practices to heathland restoration such as aqua-seeding, the approach of Campbell *et al*. (2003) and Walker *et al.* (2004) was followed where the focus of heathland vegetation reestablishment is to start successional pathways to recreate native plant communities over a longer time period, similar to those existing around a denuded site. Re-establishment of heathland flora on sites that have been subject to commercial peat extraction will help to reinstate overall biological diversity (Rowlands & Feehan 2000).

Highland Park Distillery has commercially extracted peat from a site in the Hobbister area for over 30 years to use in the whisky malting process. The majority of this extraction was on peat at least 2 m deep, and as peat was not extracted to the underlying mineral soil, vegetation was able to recover on the peat that was left causing little environmental problem regards heathland re-establishing. However, during the 1970s in an area of approximately two hectares, peat was extracted down to the sandy mineral soil. The mineral soil contains very low levels of humus and nutrients. After extraction it is normal to replace the top layer of vegetation turf to encourage vegetation establishment, however, in this particular area this did not happen.

High levels of rain water run-off, coupled with the low water holding capacity of the mineral soil, subsequently created an unstable medium with highly fluctuating moisture levels. This is exasperated by high levels of soil erosion brought about by frequent high winds. After over 30 years, the result was a bare mineral soil surface with almost no plant growth.

Potential techniques to reinstate heathland vegetation at Hobbister were identified by conducting a literature review (including projects documented by Perrow& Davy 2002, SNH 1996, Holland 2002, and the Environmental Advisory Unit 1988). Re-creation methods and results vary greatly (Chambers *et al*. 1996, Owen & Marrs 2000, Williams *et al*. 1996) and, at a first glance, there appears to be much conflicting evidence. However, differing outcomes can be attributed to specific causes. Different types of heath (Rotundo & Aguiar 2005), as well as heath in different condition (Graf & Rochefort 2008, Walker *et al*. 2004), respond differently to similar treatments. In this present study, methods were adopted, adjusted or discarded, according to whether they were considered applicable to the heath type and environmental conditions at Hobbister.

Techniques that appeared potentially useful at Hobbister were identified as: 1) spreading a peat layer to create appropriate humus-rich topsoil (Environmental Advisory Unit 1988, Graf & Rochefort 2008); 2) spreading heath mulch to provide a seed source as well as to potentially create suitable micro-habitat conditions to enhance seedling establishment (Environmental Advisory Unit 1988); 3) using geojute (hessian mat) as a soil stabiliser to mitigate water loss/erosion and wind erosion (Gilbert & Anderson 2000); supplying nutrients to encourage plant growth (Gilbert & Anderson 2000, Campbell *et al*. 2003); and 5) sowing native companion grass species to accelerate peat topsoil binding through the root structure created by companion grasses (Environmental Advisory Unit 1988). These techniques were incorporated into several treatments that were applied to trial plots in which vascular plant establishment was monitored to measure their effectiveness.

ACTION

Study site: The heathland restoration trials were undertaken on Hobbister RSPB Reserve (Ordnance Survey grid reference HY3906) on the Mainland island of Orkney. The 50 ha area was established as an RSPB reserve over 20 years ago. Management has consisted of continued peat extraction with turf replacement coupled with light grazing by sheep. An area consisting of a gently sloping homogeneous strip of bare mineral soil 5 m wide by 80 m long (60 m a.s.l. on a 260° north westerly aspect) was identified for establishment of trial plots. Water from rainfall that previously flowed onto the area was diverted using a soil barrier and a shallow trench at the top of the site.

Target vegetation community: The surrounding 5 ha of heath was surveyed in August 2009 according to UK National Vegetation Classification (NVC) survey methods (Rodwell 1998) to identify plant communities that it is hoped that will be reinstated in the denuded area. Vegetation within seven randomly located 5 x 5 m quadrats was surveyed; the NVC community was a H10a *Calluna vulgaris-Erica cinerea* heath, typical sub-community. The floristic table for this survey is given in Appendix 1.

Treatments: Nine 5 x 5 m trial plots were marked out. The individual treatments and treatment combinations (summarised in Table 1) were applied during June 2006.

Table 1. Treatments applied (+) to each trial plot at Hobbister in June 2006.

Treatment	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9
No treatment	+								
Peat		+	+	+	+	+	+	+	+
Geojute			+					+	+
Fertilizer				+	+				
Mulch					+	+	+	+	
Grass seed			+		+	+			

The control plot (Plot 1) was left untreated. Peat was applied using a tractor and front loader as peat dust (peat that has been crumbled to a powdery mix) to a post-compaction depth of between 5 and 10 cm to the surface of all other plots. Peat for this purpose was taken from the Highland Park peat store (i.e. originating on site). The peat was compacted by a tractor driving over it. A mixture of red fescue *Festuca rubra* and common bent *Agrostis capillaris* (10:1 ratio respectively) of Scottish provenance seed was spread at a rate of 1 g per metre square on plots 3, 5 and 6. A layer of geojute (hessian mat, mesh size 30 mm with 5 mm-thick threads which degrade within 5 years in wet peat) was then pinned over plots 3, 8 and 9. Fertilizer addition plots (plots 4 and 5) comprised manure of organically-raised chickens spread by hand at a rate of 10 g per metre square. Heath mulch (10 to 20 cm thickness) was rolled on top of the peat in plots 5, 6, 7 and 8. The mulch comprised material taken from a nearby area of rank, ungrazed and mature heath (categorised as NVC H10 community; Rodwell 1998) cut at an average height of 5 cm above ground level using a brash cutting machine attached to a tractor. The cuttings (gathered by hand, transported by trailer and spread on the day of collection) were applied in layers between 10 and 15 cm as application depths above this have been shown to seeds being denatured.

Monitoring: In order to minimise any edge effects, trial plots were buffered by a 1 m border, hence areas of 5 x 5 m were treated but monitoring was undertaken in nested areas of 4 x 4 m within each. All plots were surveyed on 12 August 2009. The occurrence and abundance (% cover) of all vascular plants were recorded in each plot. Vegetation response within each plot was recorded as estimates of percentage cover of individual plant species. Percentage covers of vegetation were also adjusted to allow for the added *Festuca* and *Agrostis spp.* seed component to reveal the extent of colonisation by other (unsown) species in each plot.

CONSEQUENCES

Vegetation response: Results of vegetation response in terms of percentage cover in each of the trial plots are presented in Table 2. The plots responded markedly differently to the treatments, producing from 6 to 91% total vascular plant cover after just over three years. The main difference in resultant plant cover was brought about by the presence or absence of mulch. Without mulch (plots 2, 3, 4 and 9) 26% vegetation cover was the highest achieved (using peat, geojute and grass seed in plot 3), whereas with mulch addition (plots 5, 6, 7 and 8) the lowest vegetation cover (included added grass seed) was nearly twice that, at 43% (plot 7) and the highest 91% (plot 5).

Some *Festuca* and *Agrostis spp.* (identification to species not always possible) colonised via other sources (as shown by their presence in unsown plots; up to 7% in plot 4) rather than just by seeding. Hence the values presented to adjust for sown *F. rubra* and *A. capillaris* only give an indication of their potential cover contribution. Plots without mulch addition had a mean of 10% vegetation cover, those with mulch 46% cover but plot 8 (peat, mulch and geojute) was the most effective treatment with a cover of 75% of vascular heath species.

Table 2. Percentage cover of vegetation in trial plots, Hobbister RSPB Reserve, August 2009.

Vegetation category	**Plot 1**	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Plot 6**	**Plot 7**	**Plot 8**	**Plot 9**
Heather *Calluna vulgaris*		4	5	5	18	30	40	70	10
Bell heather *Erica cinerea*		2	1	3	2			2	5
Total ericaceous cover	0	6	6	8	20	30	40	72	15
Bent grass *Agrostis spp.*			5	3	5	10			2
Red fescue *Festuca rubra*			15	4	60	35	2	5	
Wavy-hair grass *Deschampsia flexuosa*					5	7			
Sharp-flowered rush *Juncus acutiflorus*									3
Heath wood-rush *Luzula multiflora*					1	4	1	3	
Total graminoid cover	0	0	20	7	71	56	3	8	5
Total graminoid and ericaceous cover	0	6	26	15	91	86	43	80	20
Cover adjusted to remove potential sown grass seed component	n/a	n/a	**6**	n/a	**26**	**41**	n/a	n/a	n/a

The control plot demonstrated that vegetation establishment was initiated by the treatments applied as no vegetation grew in the control plot during the experimental period.

Discussion: Some trial plots are being rapidly re-colonised by a variety of vascular heathland plants. However, at present it is not possible to say if these will develop into a similarly diverse plant community to the NVC H10a heath community that surrounds the trial area. Peat and mulch addition appeared as the main treatments to initiate successful re-colonisation. Fertiliser (chicken manure) or grass seeding appeared not particularly beneficial. Geojute proved to encourage re-colonisation.

Mulch affects the microclimate by regulating water loss in the topsoil (Carson & Peterson 1990, Xiong & Nilsson 1999) as well as light levels (Facelli & Pickett 1991). This treatment appeared beneficial, allowing drought-prone heather seedlings to better survive (McDonald 2003). The area where the plots were established had undergone peat extraction down to the mineral soil and thus would have had a very low seed bank (Ash *et al.* 1994). Seed appears to have been suitably supplied via mulch addition (an also to a lesser extent via peat addition); heather is a prolific seed producer (McDonald 2003) and is perhaps the most important species to try and re-establish at Hobbister. It is the provision of conditions that allow this seed to germinate and grow that is critical to re-creating heath, best achieved by adding peat, mulch and geojute.

Despite nutrient levels being low in the mineral soil, fertiliser was not required to encourage growth of ericaceous and other heathland target species, as peat added to the trial plots proved sufficient. Where fertilizer plus peat was added (plots 4 and 5) the highest cover (after adjusting for added grass species) was 26% whilst plots 6, 7 and 8 (peat added, no fertilizer) achieved vegetation cover (again adjusted for added grass) of 41%, 41% and 75% respectively. Where fertiliser was applied, it encouraged vigorous growth of grasses e.g. *F. rubra* that may inhibit desired heath species, such as heather, from establishing.

Conclusions: Peat plus mulch addition and geojute was the most effective treatment (80% vascular plant cover) excluding the grass-seeded plots. Although geojute will help stabilise moisture levels and minimises wind erosion, peat plus mulch addition may be the preferred method over large areas as placing geojute is labour intensive, hence expensive.

Although trialled, sowing of *F.rubra* and *A capillaris* seed was not deemed in retrospect a pertinent treatment for two main reasons: seed of local Orkney provenance was unavailable, hence foreign genetic material was introduced; and they may have competed with, and therefore reduced establishment of, desired plant species (rather than acting as a nurse to enhance their colonisation). It is also considered that it is probably preferable not to add fertiliser (heathlands are characterised by low levels of plant available soil nutrients) as the extra nutrients may create conditions suitable for a few competitive nitrophilous grasses to permanently dominate the sward (D'Antonio & Chambers 2006).

There are several future studies that would supplement the findings of this study. It would be interesting to see how plant communities develop longer-term within each plot. Investigation of the effects of mulch in contributing to the introduction of bryophytes and their subsequent colonisation would also be worthwhile, especially given that several moss and lichen species are pioneer colonisers of bare peat.

ACKNOWLEDGEMENTS

Many thanks to Geoff Ayres (2006) an ecological contractor with experience of agricultural practice adaption to re-create heath, Andrew Dixon (2008) a farmer at Hobbister RSPB Reserve (Hobbister Farm) and Angus Mcdonald (2003) SNH Upland Habitat Specialist, for personal communications regarding the project.

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Appendix 1. Floristic table for 5 ha of heath surveyed adjacent to the trial plot area in August 2009, Hobbister RSPB Reserve. Vegetation was surveyed within seven randomly located (5 x 5 m quadrats), plant frequencies (i.e. number of quadrats in which a species occurred), and mean abundance (as assessed using the Domin scale) are presented.

Species	**Mean frequency**	**Mean abundance (Domin scale)**
Heather *Calluna vulgaris*	V	9
Cross-leaved heath *Erica tetralix*	IV	3
Bell heather *Erica cinerea*	IV	2
Crowberry *Empetrum nigrum*	III	2
Heath rush *Juncus squarrosus*	IV	2
Purple moor-grass *Molinia caerulea*	II	1
Red fescue *Festuca rubra*	II	0
Deer-grass *Trichophorum cespitosum*	IV	2
Heath wood-rush *Luzula multiflora*	II	1
Hard shield-fern *Polystichum aculeatum*	II	1
Tormentil *Potentilla erecta*	II	1
Hare's-tail cottongrass *Eriophorum vaginatum*	II	1
Common cottongrass *Eriophorum angustifolium*	V	4
Glittering wood-moss *Hylocomium splendens*	III	4
Heath plait-moss *Hypnum jutlandicum*	V	8
Rusty swan-neck moss *Campylopus flexuosus*	IV	3
Acute-leaved bog-moss *Sphagnum capillifolium*	I	2
Broom fork-moss *Dicranum scoparium*	III	3
Catherine's moss *Atrichum undulatum*	I	1
Rough-stalked feather moss *Brachythecium rutabulum*	II	3