

A Survey of 15 Scottish Lowland Raised Bogs in Summer 2012

Findings from a survey of Scottish lowland raised bogs with landowners supportive of restoration



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Cover photograph: *Sphagnum capillifolium* and *Polytrichum commune* at White Moss, Scottish Borders.

Executive summary

1. A total of 15 Scottish lowland raised bog sites were surveyed during summer 2012 as part of the Scottish Wildlife Trust's lowland raised bog project. These sites were additional to the 62 sites that were surveyed during 2010/11 during the first stage of the project. These formed the basis of a study to assess the current state of Scotland's lowland raised bogs and to assess change since the mid-1990s.
2. The aim of the current study is to identify and determine the state of 15 sites that are suitable for restoration, and to calculate the costs associated with returning them to favourable condition. Furthermore, the information generated from this study adds to the understanding of the current state of the Scottish lowland raised bog resource. The sites were selected on the basis that they had landowners supportive of restoration and that they did not benefit from statutory nature conservation protection.
3. The 15 sites surveyed cover a total area of 282 hectares representing 1.2% of the total Scottish lowland raised bog resource. The average site size is 19 hectares and the sites range in size from 4.2 hectares to 51.6 hectares.
4. The survey sites were mapped to include only deep peat that has the potential for restoration and archaic peat (in practice less than 0.1% was archaic). Of this survey area 50% was primary (uncut) mire and 50% was secondary (cut-over) mire. Furthermore 60% of the survey area was classified as wet.
5. *Sphagnum*-dominated areas occupy 13% of the survey area and it is here that peat accumulation, and therefore carbon sequestration, is likely to be taking place. A further 45% of the survey area has *Sphagnum* species co-dominant in the ground layer. The remaining survey area supports drier open mire with only bryophytes in the ground layer and areas dominated by scrub and woodland.
6. Analysis of drainage on a site by site basis shows all sites have drainage ditches across the mire expanse and around the site perimeter. The majority of those across the mire expanse are infilling with vegetation and the majority at the perimeter are scouring. Only 16% of the mire expanse area is classed free from artificial drains.
7. Damage caused by animal impacts is not significant and there was little micro-erosion recorded across the survey area. In contrast evidence of historic and recent burning was recorded at 27% of sites. No active or recent domestic or commercial peat cutting affects any of the sites surveyed.
8. Compared to the original sites surveyed during 2010/11, the current survey area has a higher proportion of mire that is uncut, a higher proportion of ground classified as wet and a lower proportion of the survey area is covered by scrub and woodland.
9. The average primary mire peat depth at the centre of the site is 4.5m and the average secondary mire peat depth is 3.2m. This compares with an average primary mire depth of 4.7m and an average secondary mire depth of 2.2m from the original study. The increase in the average depth of secondary peat, compared to the 2011/11 surveyed sites, may indicate that the calculation of carbon stored in all Scottish lowland raised bogs may have been an under-estimate.

10. The restoration potential of each site is assessed. Of the 15 sites surveyed, 12 sites have a high potential for restoration and the remaining 3 sites have a low to medium potential for restoration.
11. The capital cost of restoring the 15 sites is estimated to be £326,000 and the annual management cost is estimated to be £20,200. On a unit area basis the capital costs are £1,160/ha and the annual costs £72/ha. Compared to the original study, the unit area capital costs are just under 10% lower and the annual costs are significantly higher - an increase of over 75%. The calculated costs are indicative only and the discrepancy in the capital costs is likely to be within the margin of error whilst the difference in annual costs is likely to be a result of differences in the average site size for each study.

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1 Introduction

1.1 Background and Aims

The Scottish Wildlife Trust's raised bog project has involved the survey of 77 Scottish lowland raised bogs between 2010 and 2012 using a methodology originally developed in the mid-1990s by the Scottish Wildlife Trust's Peat Bog Team (Parkyn and Stoneman 1996). There were 62 sites surveyed during 2010 and 2011 and 58 of these were used as the basis of a study to assess the current state of Scotland's lowland raised bogs and to assess change since the mid-1990s (Matthews *et al* 2012). The current report details the study of a further 15 lowland raised bog sites surveyed during summer 2012.

The aim of the current study was to identify and determine the state of 15 sites that are suitable for restoration and calculate the costs associated with returning them to favourable condition. Furthermore, the information generated by this study adds to the understanding of the current state of the Scottish lowland raised bog resource. These additional sites were selected on the basis that they had landowners supportive of restoration and that they had no statutory nature conservation protection.

1.2 Sites overview

The selected lowland raised bog sites were chosen to broadly reflect the distribution of lowland raised bogs in Scotland. The sites are shown in Table 1 below.

Table 1. Sites surveyed during summer 2012 by council area.

Site	Location
Beckhall Moss	Dumfries and Galloway
Commonhead Moss	City of Glasgow
Corthie Moss	Aberdeenshire
Grangeneuk Moss	Falkirk
Harestone Moss	Aberdeenshire
Kennox Moss	East Ayrshire
Langlands Moss	South Lanarkshire
Moss of Rothiemay	Moray
Muiryfield Moss	Aberdeenshire
Portmoak Moss	Perth and Kinross
Redhall Moss	Dumfries and Galloway
Riccarton Moss	East Ayrshire
Skiehill Moss	Aberdeenshire
Toxside Moss	Midlothian
Woodhead Croft Moss	Aberdeenshire

The sites cover a geographical area from Dumfries and Galloway in the south to Aberdeenshire in the north and they are located in nine different council areas.

Whilst none of the surveyed sites have a statutory nature conservation designation, Commonhead Moss and Langlands Moss are Local Nature Reserves and Portmoak Moss is owned by the Woodland Trust.

The total survey area covered by the 15 sites is 282 hectares (2.8 km²), based on boundaries determined from aerial photographs and ground-truthed in the field. The average site area is 19 hectares with the smallest site measuring 4.2 hectares and the largest 51.6 hectares.

The lowland raised bog inventory gives a total Scottish figure of 807 sites covering 27,892 hectares, with an average site area of 34.6 hectares. The area covered by all Scottish lowland raised bogs, excluding archaic sites, is 23,861 hectares. The current study sites have a smaller average site area size than the average for all Scottish sites. This is in contrast to the 62 sites surveyed during 2010/11 which have an average site area of 70 hectares, which is larger than the average for all Scottish sites.

The current survey of 15 sites represents 1.2% of the total Scottish lowland raised bog resource by area excluding archaic sites. The combined total of 77 sites surveyed as part of the SWT's Peatland Project represents about 18% of the total area of Scottish lowland raised bogs.

A full list of sites by area is found in Appendix I.

2 Methodology

2.1 Site selection

A number of criteria were used to select sites for the current survey. Initially potential sites were identified from SNH's inventory or lowland raised bogs from the three main areas with the highest density of raised bogs including Aberdeenshire (extending into Moray), Dumfries and Galloway and the central belt. There is no requirement for the current survey to assess change compared to the original SWT surveys undertaken in the mid-1990s and therefore site selection was not constrained by the quality or completeness of the original survey data (or whether the site had been surveyed at all). A subsequent screening stage involved visiting the sites to determine ownership and gauge the landowner's attitude to site restoration. Sites were discarded where ownership could not be easily determined, if the site had a complicated multi-owner structure or if the owner(s) were not fully or broadly supportive of site restoration. Furthermore, site selection was also restricted to privately owned sites that do not benefit from statutory nature conservation protection.

A short-fall of sites remained after the screening stage and 1:25,000 scale OS maps and online aerial photographs, covering the main three site areas, were searched for lowland raised bogs that were not present on the inventory. Identified sites were screened as above and entered onto SWTs database of sites.

2.2 Survey method

The survey method has two main components – the aerial photograph interpretation (API) methodology and the field survey methodology.

In broad terms the API methodology uses aerial photographs to determine site compartment boundaries based on changes in vegetation type. Aerial photographs are also used to classify each site compartment using various criteria such as vegetation type and presence or absence of various types of damage. For example each compartment is assessed for the presence or absence of woodland, and sub-classified to the level of woodland type and whether the canopy is open or closed. The final stage involves field validation of both the chosen boundaries and the classification criteria, and both are amended where necessary.

The distinct field survey methodology was undertaken at the same time as the field validation of the API-generated compartments and provided whole site and point location based data. Whole site data include, for example, an assessment of burning and grazing damage, and point location based data include, for example, vegetation quadrats and peat depth measurements. Field data was collected using a paper field form and was transferred at a later date to a database.

2.3 Changes to the original method

The original methodology was largely repeated in order to provide consistency with the surveys undertaken by SWT in the mid-1990s (Parkyn and Stoneman 1996). The main addition to the current survey was the measurement of peat depth at each site. The current surveys also used the latest digital mapping and hand-held GPS technology which was not widely available during the mid-1990s.

During the mid-1990s surveys, pairs of unprocessed black and white photographs were viewed using a stereoscope and site compartment boundaries were drawn by hand onto transparent acetate sheets before being transferred to field maps. In the field, the surveyor's geographical location, and the location of site compartment boundaries, had to be estimated by reference to physical features that were illustrated on base Ordnance Survey (OS) maps.

In contrast, for the 2010/11 surveys, geo-rectified colour aerial photographs were imported into ArcGIS mapping software, and site compartment boundaries were digitised and laid over digital base OS maps. Site compartment criteria were then assessed and the results recorded in a linked attribute table. The site compartments and base maps were viewed in the field on a hand-held GPS device that indicates position to an accuracy of within a few metres. The location of point data such as vegetation quadrats can also be recorded with the same level of accuracy. In order to allow a comparison to be made between the current survey and the original mid-1990s survey, the original paper maps were digitised and the assessment data entered into linked attribute tables.

Specific methodological issues and clarifications are addressed as necessary in 'Section 4 Survey results'. Copies of the aerial photograph interpretation and field survey methodologies are available from the Scottish Wildlife Trust.

3 Site details

3.1 Beckhall Moss

3.1.1 Site summary

Beckhall Moss is situated 5km west of Canonbie in Dumfries and Galloway and covers an area of about 15 hectares. The site has been completely cutover and true raised bog vegetation is either very degraded or absent. The ground conditions are fairly wet although the presence of fen species indicates raised nutrient levels. Evidence of cutting can be seen in the rectangular inter-connected drains that remain, although these are infilling and poorly defined. There is also a bisecting scouring drain that runs south-west to north-east and further scouring drains around most of the site perimeter. The bog is periodically grazed by cattle and burnt annually during the summer. The peat depth was measured to be 3.2m and 4.8m at two central locations.

3.1.2 Vegetation

Beckhall Moss is a very modified site which has no significant areas of M18 raised mire vegetation. The majority of the cutover area is MG9 *Deschampsia cespitosa* grassland which has scattered fen associates including *Angelica sylvestris*, *Cirsium palustre* and *Juncus acutiflorus*. This indicates mesotrophic nutrient levels that are higher than those expected on a raised bog. This area has locally abundant areas of *Sphagnum palustre*, which is also a species typical of fen conditions.

There are local areas of M25 *Molinia caerulea* grassland particularly in compartment 8 in the south-east of the site where ground conditions are drier. In the centre-south area there is a raised area compared to the surrounding bog that is a mosaic of M25 and M6d flush vegetation. There are areas dominated by *Juncus acutiflorus* over *Sphagnum fallax* and scattered *Dactylorhiza maculata*. It is within this area that the vegetation comes closest to raised bog where there is a little *Calluna vulgaris*, *Erica tetralix*, and *Sphagnum capillifolium* (a typical raised bog *Sphagnum* species).

At various locations at the edge of the site there is M23b *Juncus effusus* rush pasture which may be the remnants of a natural lagg fen system.

3.1.3 Damage

Historic peat extraction, that appears to have taken place across the whole site, is the primary cause of damage. The presence of fen species indicates that the site is influenced by mesotrophic groundwater which can be the result of peat cutting and drainage. There is also a scouring drain that cuts across the north-west section of the site causing local drying of the mire surface. The drying effect may be exacerbated by a series of inter-connected drains although these are becoming infilled with vegetation and their influence will be diminishing.

3.1.4 Assessment and restoration potential

The condition of Beckhall Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment' below. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and

burning and grazing impacts. Out of a maximum score of 15, Beckhall Moss scored 7 placing it 10th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the third quartile of 73 sites assessed for condition

This is a fairly small site that is no longer a functioning raised bog and the condition assessment exaggerates its condition as a raised bog (it achieves high scores for being open mire vegetation and for having a low density of drains despite little raised bog vegetation being present). The site does, nevertheless, have value as a wet fen habitat.

The site has a low potential for restoration as a raised bog because of its modified nature and small size. Re-wetting and maintaining high water levels across the site may eventually lead to the re-establishment of bog vegetation, but this would be over a long timescale.

3.1.5 Further comments

The owner of the site, Mr. Coates, periodically grazes cattle on the site during the drier summer months. This is likely to benefit the site by inhibiting scrub regeneration.

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.2 Commonhead Moss

3.2.1 Site summary

Commonhead Moss is situated 2km to the west of Coatbridge adjacent to the M73 motorway and covers an area of about 34 hectares.

It is a modified site that appears to be completely cutover (secondary mire) as a result of past commercial peat extraction. There is a large central area of open mire, compartment 8, which has a high density of parallel drains running east-west that are infilling with vegetation or have been dammed. The ground conditions across the open mire vegetation are wet overall. The centre of the open area has the highest water table and there is fair to good quality raised mire vegetation on the raised strips between the drains. Where the water table is lower, the raised strips are drier and they support degraded vegetation. There are also local areas of rush fen vegetation indicating mildly minerotrophic conditions, possibly as the result of ground water influence. Natural mature birch woodland almost entirely surrounds the area of open mire and ground conditions are typically dry underneath the canopy. The woodland is on deep peat which again appears to have been cutover. An interesting feature is a raised strip of peat colonised by mature birch woodland, compartment 11 that runs east-west across the centre-south of the open mire. This was probably an access route for transporting cut peat off the site, and narrow gauge rails can still be seen at the eastern end of this strip.

Peat depth was measured at two locations in the central area of the site with minimum depths of 6.5m and 5.0m recorded. These figures are based on the maximum depth that could be measured and the bottom of the profile was not reached (the maximum sample depth that can be achieved depends on peat bulk density).

3.2.2 Vegetation

The main central area of open mire has a complex patterning of wet and dry ground conditions caused by the high density of drains and the presence of dams. The majority of the vegetation falls under the M18 raised bog vegetation category although the quality of the vegetation varies depending on the ground conditions.

In areas where the water table is high, particularly in the central areas of compartment 8 and locally where dams are sited, there has been regeneration of fair to good quality M18 vegetation which is characteristic of the M18a *Sphagnum magellanicum* – *Andromeda polifolia* sub-community. The sub-shrub layer is fairly open and *Calluna vulgaris* shares dominance with *Eriophorum vaginatum* whilst *Drosera rotundifolia* and *Erica tetralix* are locally frequent, *Andromeda polifolia* rare, and the ground layer has a good cover of *Sphagnum* species. The most common species recorded are *Sphagnum palustre*, *Sphagnum fallax* and *Sphagnum papillosum* (the first two indicative of slightly raised nutrient levels) whilst *Sphagnum capillifolium* is locally frequent. *Sphagnum magellanicum*, characteristic of good quality M18 is occasional. In the wetter areas the drains occasionally open out and there are lawns of *Sphagnum cuspidatum*, *Sphagnum palustre* and *Sphagnum papillosum*.

The most degraded raised bog vegetation is found on the peripheral areas of compartment 8, on the ridges between drains, where the water table is relatively low. Here there is overwhelming dominance by *Calluna vulgaris* with only scattered *Eriophorum vaginatum* and *Eriophorum angustifolium* and locally frequent *Polytrichum commune* making up the ground layer. In the driest areas the vegetation grades towards dry heath and birch regeneration is densest.

Locally along the drain lines there are areas of the fen species *Carex rostrata*, *Juncus effusus* and *Potentilla palustris*. This indicates some influence from minerotrophic ground water and is a common feature of sites that have been cutover.

The birch woodland found mainly around the edge of the site is on deep peat with, overall, dry ground conditions. The ground flora is variously dominated by *Dryopteris dilatata*, and bryophyte species, or can be rather bare of vegetation. This woodland type is not adequately described by the national vegetation classification (NVC) but is probably closest to the W11 *Quercus petraea* – *Betula pubescens* woodland (or arguably degraded W4 *Betula pubescens* – *Molinia caerulea* woodland). There are also areas of birch woodland over a ground flora dominated by *Sphagnum* species, particularly compartment 6 and the east end of compartment 7. This is closest to W4c woodland, the *Sphagnum* sub-community.

Other vegetation types found on the site include areas of M23b *Juncus effusus* rush fen and M25a *Molinia caerulea* mire at the south-western and western edge of the site respectively.

3.2.3 Damage

The main damage to the site is the historic peat extraction that appears to have affected the whole site. This is evidenced by the dense network of wide drains that would have been used to prevent water-logging of the peat surface while peat removal was taking place. Also there is no obvious dome shape to the site and little evidence of a sloping rand at the edge of the bog.

Birch woodland has developed on the margins of the site covering about 50% of the total area and, although this can be a natural element of a raised bog margin, it extends onto areas of the central mire expanse. Woodland can damage raised bog vegetation by further drying the ground through evapotranspiration and by shading the typical raised bog plant species.

Finally there is some localised burning damage at the western side of compartment 8 evidenced by charred *Calluna vulgaris* stems. This was adjacent to a track giving public access and may be the result of vandalism.

Despite the past damage, raised bog vegetation has recolonised the cutover surfaces across the central areas of the site and rewetting of the bog, and birch scrub clearance, is encouraging the regeneration of good quality M18 raised bog vegetation across the site.

3.2.4 Assessment

The condition of Commonhead Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment' below. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, Commonhead Moss scored 9 placing it 9th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the second quartile of 73 sites assessed for condition.

The fairly high score achieved, despite the past damage to the site, is in part a result of the restoration work that has taken place at Commonhead Moss to rewet the site and to maintain the central area as open mire. In summary, the score achieved is based on the site's overall wet condition, the high proportion of open mire habitat, the presence of species such as *Drosera rotundifolia* and *Sphagnum magellanicum* that indicate good quality vegetation and the classification of the artificial drains as either dammed or infilling.

The site is currently undergoing a programme of site restoration coordinated by the owner of the site Glasgow City Council.

3.2.5 Further comments

The distribution of dams is rather patchy across the site. The installation of more dams, particularly at the drier margins of the open mire expanse, would help to further rewet the site and promote the development of good quality raised mire vegetation.

3.3 Corthie Moss

3.3.1 Site summary

Corthie Moss is a fairly large site of about 62 hectares situated 4km west of New Pitsligo in Aberdeenshire. It is an elongated raised bog that sits in a shallow valley and has a primary (uncut) central area with a fairly wide outer lower area of mire and lagg fen. The site shows evidence of historic domestic cutting at the northern and southern ends, and along the western side of the central area. The central area has rather dry degraded raised bog

vegetation, with a low cover of *Sphagnum* species, and the outer area of mire has a mosaic of degraded bog and fen vegetation.

The site has a low density of wide and deep internal drains which are infilling with vegetation and there are scouring drains around most of the perimeter. There are no signs of burning damage or significant impacts from grazing. There are scattered stunted rowan and birch across the mire expanse however there is little regeneration.

Peat depth was measured to be 2.3m in the centre of the site where uncut and 2.2m at a representative cut-over location at the southern end.

3.3.2 Vegetation

There is rather dry degraded M18 raised bog vegetation across the centre of the site which has an open sub-shrub canopy and is co-dominated by *Calluna vulgaris* and *Eriophorum vaginatum*. *Sphagnum* species are only scattered and mostly there are pleurocarpous mosses in the ground layer indicating rather dry ground conditions. The grass species *Deschampsia flexuosa* is constant across this area and is another indicator of dry degraded raised bog habitat. Occasional wetter areas have scattered *Sphagnum capillifolium* and locally frequent *Erica tetralix*. The cut-over areas have slightly better raised bog vegetation but remain dry overall. There are scattered stunted birch and rowan across the central area and little regeneration - with some evidence that tree seedlings are being grazed and suppressed by deer.

The outer area of mire forms a wide band around the margin of the site and is a step down from the main central area. The main vegetation type is M20 *Eriophorum vaginatum* mire with lesser areas of M23b *Juncus effusus* fen. M20 is a degraded raised bog habitat and is often a result of past burning or over-grazing, although no evidence of these impacts was present at the time of survey. There are occasional stands of *Salix aurita* in some locations within the secondary mire. Occasional areas of natural lagg fen are present at the edge of the site, although mostly there is a perimeter drainage ditch which has allowed agricultural reclamation beyond.

3.3.3 Damage

Whilst there is only a low density of drains across the mire expanse, those present are wide and deep and appear to be having a significant drying affect on the bog surface. The hydrology of the site may also have been affected by the historic peat cutting that has occurred at the site margin. There are also scouring drains around most of the site perimeter which will be having a drying affect on the margins of the site.

3.3.4 Assessment

The condition of Corthie Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, Corthie Moss scored 12 placing it 5th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

Corthie Moss has a high potential for restoration and would benefit from the installation of dams in order to rewet the bog surface.

3.3.5 Further comments

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.4 Grangeneuk Moss

3.4.1 Site summary

Grangeneuk Moss is situated 9km south-west of Falkirk and covers an area of about 18 hectares. The site has good quality raised bog vegetation, it is largely primary (uncut) and there are no drains across the main mire expanse. The site is elongated, sits in a shallow valley and has a natural sloping rand at its margin. There is also a narrow natural lagg fen at the edge of the mire which is contained by rising land beyond. Where a perimeter drain is present, this is on the outer side of the lagg fen. There is little significant damage to the site beyond limited areas of historic domestic peat cutting at the edge of the site and some moderate grazing and trampling impacts at the eastern end. There is some indication of past grazing pressure on the main body of the site, but at the time of survey there was no evidence of recent grazing impacts. Overall the site has been little modified and is in good condition.

Peat depth was measured to be 7m+ in the centre of the site and 1.9m at a cutover location at the margin.

3.4.2 Vegetation

The vegetation of the main mire expanse is good quality M18 raised mire vegetation with an open sub-shrub layer and a good cover of *Sphagnum* species. The ground layer typically has abundant *Sphagnum papillosum*, frequent *Sphagnum capillifolium*, *Sphagnum magellanicum* and locally abundant *Sphagnum tenellum*. The field layer has constant and frequent *Vaccinium oxycoccus*, *Drosera rotundifolia* and locally frequent *Narthecium ossifragum*. There is also, rather unusually, scattered *Dactylorhiza maculata* across the mire expanse and particularly in the lagg fen areas.

The marginal areas of the mire are a mosaic of M18, M20 *Eriophorum vaginatum* mire, M6c *Juncus effusus* flush ad M23b *Juncus effusus* rush pasture. These lagg fen areas are generally very wet and support a good cover of *Sphagnum palustre* and *Sphagnum fallax*. The cut-over compartment 12 is particularly wet and there are pools dominated by *Sphagnum cuspidatum* with *Drosera rotundifolia* and frequent *Erica tetralix*.

3.4.3 Damage

Grangeneuk Moss is one of the least modified sites surveyed as part of this project. Areas of historic domestic peat cutting are limited to local areas at the north-eastern and eastern edge of the site and a single short internal drain is found within this cutover area. There is a scouring perimeter drain running along the north site of the site, however this is situated on the outer edge of the lagg fen and is probably having only a limited effect on site hydrology. The east end of the site is fenced off (it is probably under different ownership) and is open to grazing from the adjacent pasture. The raised bog and lagg fen in this area is moderately

grazed and trampled and there is some bare peat. However the raised bog vegetation still remains in fair condition. A old march fence-line (in disrepair) runs east-west across the main mire expanse and the southern area shows some signs of historic grazing damage. There was no evidence of recent grazing at the time of survey.

3.4.4 Assessment

The condition of Grangeneuk Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, Grangeneuk Moss score 14 placing it equal 1st in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

This is a good quality site overall with only limited area of past cutting and little internal artificial drainage. The quality of the raised bog vegetation is good and there is a high cover of *Sphagnum* species characteristic of good quality M18 raised mire vegetation. The eastern end of the site shows moderate grazing and trampling damage and the condition of this area could be improved by reducing grazing intensity. The site overall may benefit from periodic grazing to inhibit any potential regeneration of scrub, although none was present at the time of the survey.

The site has a high potential for restoration, although there are only limited restoration works that could be carried out at the site.

3.4.5 Further comments

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.5 Harestone Moss

3.5.1 Site summary

Harestone Moss is a small site of about 7 hectares which is located 10km north of Aberdeen. The area of raised bog is within a more extensive valley mire and it is difficult to determine its exact boundary of the peatland area. The raised bog has been cut-over in the past and is now a mosaic of degraded raised mire vegetation and mesotrophic fen with some areas of willow carr and gorse scrub. The ground conditions are very wet and some areas have a very good cover of *Sphagnum* species although they are mainly species indicative of raised nutrient conditions. There is also a raised metalled road that bisects the northern section of the site. The peat depth was measured to be 1.9m in the central area of the raised bog.

3.5.2 Vegetation

There is a complex mosaic of degraded M18 and M20 raised bog and mesotrophic fen. The degraded raised bog is typically dominated by *Eriophorum vaginatum* over *Sphagnum palustre* and *Sphagnum fallax* with scattered *Deschampsia flexuosa* and herbs such as *Potentilla erecta*. These areas grade in M23b *Juncus effusus* mire and M9 *Carex rostrata* swamp with abundant *Potentilla palustris* where there is a more mesotrophic influence. At the southern area of the raised bog there is also willow carr that has a fen and swamp

ground flora. A metalled road cuts through the north side of the site east-west and is a raised strip of mineral ground which extends to the south side of the road and supports gorse scrub.

3.5.3 Damage

The raised bog is probably entirely cut-over although there is little concrete evidence of this on the ground. Nevertheless the vegetation is very modified and influenced by mesotrophic groundwater which is often an indication of deep peat cutting. The other main damage to the site is from the raised strip of mineral ground that carries the road across the raised bog and associated drains that run by its side. There are also a few single infilling drains within the area of raised mire.

3.5.4 Assessment

The condition of Harestone Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 10 placing it equal 8th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the second quartile of 73 sites assessed for condition.

The score probably exaggerates the condition of the site which is small and modified and therefore has a low to medium potential for restoration. If restoration were to take place it would involve removal of scrub and trees where these encroach on areas of deep peat and damming of drains that are present across the mire expanse.

3.5.5 Further comments

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.6 Kennox Moss

3.6.1 Site summary

Kennox Moss is a small site of about 19 hectares which is located 5km west of Stewarton in East Ayrshire. The site is mainly wooded with a combination of plantation Scots pine and birch, with a central open area of scattered mature and regenerating trees. The open area has fair quality raised bog vegetation although the density of scrub and trees is probably increasing and this may lead to further drying of the bog surface. The majority of the site is primary (uncut) with some limited area of secondary (cutover) mire at the northern and south-western edges. Within the wooded area there are occasional drains that are becoming infilled with vegetation whilst the central open area has none. Most of the perimeter of the site has scouring drains although in some areas these are becoming blocked with vegetation.

3.6.2 Vegetation

The central area has fair quality M18 raised mire vegetation that is dominated by *Calluna vulgaris* with subordinate *Eriophorum vaginatum* and scattered *Sphagnum capillifolium* and *Sphagnum fallax* in the field layer. Where the ground conditions are drier, particularly at the edge of this area, there is an increase in the cover of *Cladonia impexa* and there are

occasional degraded hummocks with *Polytrichum strictum* and poor quality *Sphagnum capillifolium*. This suggests a trend of drying conditions which may relate to the increase in woodland cover. The best quality vegetation is found in the central area where the sub-shrub layer is more open and there are local areas of the T1 where *Sphagnum* species dominate the ground layer and *Sphagnum magellanicum* is occasional. The central area has scattered mature and regenerating Scots pine and birch which is dense enough in some areas to be classified as open woodland.

The woodland is a mixture of natural birch woodland and Scots pine plantation. The main area of pine is found across the west of the site and has an understorey of birch. The ground conditions are a mosaic of dry and wet areas; the ground flora of the dry areas is typically dominated by *Dryopteris dilatata* and the wetter areas are characterised by scattered tussocks of *Eriophorum vaginatum* and lawns of *Sphagnum palustre*. The dry birch woodland is closest to the W11 NVC community and the wetter areas are a reasonable fit to W4c.

3.6.3 Damage

The site has a high cover of closed-canopy Scots pine and birch woodland, as well as scattered scrub and trees across the central area of open mire. The presence of trees on the site will lead to a drying of the bog surface through evapo-transpiration and the loss of typical bog vegetation through shading. Within the wooded area there is a low density of infilling drains, and these will exacerbate the drying of the bog surface locally. The scouring perimeter drains will also cause a significant lowering of the water table at the margins of the site. There was no grazing on the site at the time of the survey, although some minor poaching damage in the central area indicates that grazing has occurred in the past. Peat cutting has only taken place at limited areas at the margin of the bog.

3.6.4 Assessment

The condition of Kennox Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, Kennox Moss scored 10 placing it equal 8th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the second quartile of 73 sites assessed for condition.

Kennox Moss is a largely uncut site that has few surface drains and, where woodland is absent, fair quality raised mire vegetation. The main feature reducing its nature conservation value as a raised bog is the presence of Scots pine plantation and birch woodland. The site would therefore be very suitable for restoration which could be achieved by removing trees from the main mire expanse. The site may also benefit from periodic grazing in order to inhibit scrub and woodland regeneration in the central area.

Kennox Moss has a high potential for restoration.

3.6.5 Further comments

The owner of the site, Mr R Noble, would consider restoration works on the site if suitable environmental grants were available.

Pheasants are reared within woodland on the site.

3.7 Langlands Moss

3.7.1 Site summary

Langlands Moss is situated just beyond the southern outskirts of East Kilbride in South Lanarkshire and covers an area of about 36 hectares. The site is largely primary mire (uncut) with only local areas of old domestic cutting at the site's northern margin. Originally a conifer plantation occupied the western two-thirds of the site and this was removed as part of restoration works in the late 1990s.

It is a largely intact raised mire that has only limited historic domestic cutting at the north-east corner, displaying a natural rand elsewhere. Scouring drains are found at the edge of the dome and a few single irregular drains are found at the east end of the site. There is fairly good quality raised mire vegetation across the mire dome with an undulating topography that gives a mosaic of wet and dry ground conditions. The site is open to the surrounding sheep-grazed pasture, however the grazing pressure on the mire is not significant. Peat depth was measured to be 6m+ in the centre of the dome and 0.95m at the western margin beyond the mire rand.

3.7.2 Vegetation

There is degraded primary M18 raised mire at the western end of the open mire where a conifer plantation has been removed and regeneration of raised mire vegetation has taken place. There are ridges and furrows with the best quality vegetation in the furrows and rather dry raised mire vegetation on the ridges. In places there is also some degree of hummock and hollow formations that have probably developed post plantation felling.

Across the central and eastern area of the site, which has always been open mire, there is fair quality M18 raised mire with some hummock – hollow development. Typically there is an open canopy of *Calluna vulgaris* co-dominant with *Eriophorum vaginatum* and scattered *Sphagnum capillifolium* in the ground layer. There are some very local areas of T1 with *Sphagnum papillosum* and *Sphagnum magellanicum*.

A couple of lower areas compared to the surrounding primary mire, where domestic cutting has probably occurred in the past, are found at the northern edge of the site. The vegetation is mainly fair quality M18 raised mire with some areas of *Juncus effusus* showing a mesotrophic influence.

3.7.3 Damage

The main historic damage to the site was the establishment of a conifer plantation across the western area of the mire expanse. The trees were removed about 15 years ago and raised mire vegetation has since become re-established across this area. However the ridge and furrow topography, created during the planting process, remains and there are also drainage ditches that run across this area.

3.7.4 Assessment

The condition of Langlands Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning

and grazing impacts. Out of a maximum score of 15, the site scored 14 placing it equal 1st in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

Langlands Moss demonstrates that successful regeneration can be achieved after the removal of a mature conifer plantation. Overall the site has fair quality raised bog vegetation and further re-wetting of the bog surface should be encouraged to improve the quality of the vegetation. This could be achieved by installing more dams on internal drains as appropriate, and/or by damming or re-aligning perimeter drainage ditches.

3.7.5 Further information

The site is managed by South Lanarkshire Council and the Friends of Langlands Moss who intend to continue the restoration works at Langlands Moss should suitable funds become available.

3.8 Moss of Rothiemay

3.8.1 Site summary

Moss of Rothiemay is a small to medium-sized site of about 29 hectares situated 12km west of Keith in Aberdeenshire. The northern third of the site is largely primary (uncut) open mire with fair quality raised vegetation and a few drainage ditches. There is scattered Scots pine and birch across this area and closed canopy woodland at the margin. There is some evidence of historic domestic cutting at the western side. The southern section of the site is wooded and there is a step down of 1m-2m from the primary area to the north indicating that this area has been cutover on a commercial or semi-commercial basis. This area is mainly semi-natural birch woodland with areas of Scots pine plantation inter-mixed with birch on the western side. The ground conditions are mainly dry although there are some wetter areas dominated by *Sphagnum* species in the ground layer. Peat depth was measured to be 5.3m in the centre of the uncut area and 4.1m in a representative cutover area.

3.8.2 Vegetation

The open mire area has fair quality M18 raised mire vegetation that is co-dominated by *Calluna vulgaris* and *Eriophorum vaginatum* with frequent *Erica tetralix*. There is a fairly good cover of *Sphagnum capillifolium* and *Sphagnum fallax* in the ground layer, the latter indicating a degree of nutrient enrichment. *Vaccinium myrtillus* is scattered across the open mire, although other preferential raised bog species are largely absent. Local wetter areas, particularly in compartment 7 where historic domestic cutting has taken place, have a lawn of *Sphagnum papillosum* and an increase in *Eriophorum angustifolium*. There are scattered Scots pine and birch across the open mire and the presence of frequent seedlings suggests that the tree cover is likely to become denser. W4 closed canopy woodland is found at the margins of this area with the exception of the northern boundary where there is only a thin line of trees adjacent to the road.

The cutover southern area of the site has mainly semi-natural mature birch woodland with predominately dry ground conditions and a ground flora dominated by *Dryopteris dilatata* or grass species. However there are also wetter areas, particularly to the south, that have *Carex nigra* or *Juncus effusus* over lawns of *Sphagnum palustre*. In the centre of the site

there is an open area with willow and *Sphagnum palustre* that may have been open water in the past. At the south-east corner of the site the land falls away and is probably mineral ground that supports M23b *Juncus effusus* fen and MG9 wet grassland. There are areas of Scots pine with birch inter-mixed in the west.

3.8.3 Damage

The southern two-thirds of Moss of Rothiemay has been severely cutover, as evidenced by a 1m-2m high peat face that runs east-west across the site. Semi-natural birch woodland will have developed on this area post-cutting, in addition to the areas of plantation Scots pine, causing the mire surface to dry through evapotranspiration. The woodland canopy will also have shaded out any typical bog vegetation that regenerated on the cut surface. The open mire area to the north has scattered mature and regenerating Scots pine and birch and it is likely that the density of trees and scrub will increase. Finally there are scouring drains around the majority of the site perimeter that will be contribute to surface drying around the margins of the site.

3.8.4 Assessment

The condition of Moss of Rothiemay is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 6 placing it 13th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked between the third and fourth quartiles of 73 sites assessed for condition.

The site scores poorly because of the overall dry conditions, the high proportion of the site that is wooded and the presence of drainage ditches throughout the wooded areas. However the open mire to the north of the site is uncut and is fair to good quality raised bog habitat.

Moss of Rothiemay is suitable for restoration and the focus of restoration works should be on this area and could include removal and control of the scattered regenerating trees and scrub and the blocking of drains at the margin of this area. These measures would help to re-wet the mire surface encouraging the regeneration of better quality raised bog vegetation and the increased cover of *Sphagnum* moss species. The cutover and wooded area to the south could also be restored through the removal of trees and blocking of drains.

The site has a high potential for restoration.

3.8.5 Further comments

The current owners are developing self-catering accommodation to the north of the site and plan to use Moss of Rothiemay as an area for amenity. They are broadly supportive of carrying out restoration measures, subject to these being compatible with their plans for the site.

3.9 Muiryfield Farm Moss

3.9.1 Site summary

Muiryfield Farm Moss is a small site of 5.4 hectares which is situated 9km west of Turriff in Aberdeenshire. The site is completely secondary (cut-over) and largely covered with semi-natural birch woodland. The main area of mature birch has dry ground conditions in the centre-north and wetter ground conditions to the south-west. There is an area of open birch woodland in the north-west of the site which has the best quality wet degraded raised bog vegetation. There are also lesser areas of dry degraded raised bog and fen vegetation. There are few internal artificial drains across the site however there are scouring drains around the majority of the perimeter. The site is constrained by a metalled road to the north and west, and there may be archaic peat to the west of the road. Peat depth was measured to be 2.2m in the centre of the site and 2.4m at a representative cut-over location.

3.9.2 Vegetation

The majority of the site supports W11 closed-canopy mature birch woodland, with scattered Scots pine, which has mainly dry ground conditions dominated by grass species. To the south and west the canopy becomes more open with both newly regenerated birch and old stunted trees which support a rich lichen flora on the branches. The ground conditions are wet with abundant *Eriophorum vaginatum*, *Sphagnum palustre* and *Sphagnum fallax*. An area to the north-west has open woodland over a mosaic of degraded M18 raised mire and M20 *Eriophorum vaginatum* mire. The ground conditions are very wet with *Sphagnum fallax* and *Polytrichum commune* between tussocks of *Eriophorum vaginatum*. *Calluna vulgaris* and *Sphagnum capillifolium* are locally frequent. The trees are generally very mature stunted birch and regeneration is being suppressed by deer grazing. Within the site there are also smaller areas of dry degraded M18 raised bog vegetation, M6c *Juncus effusus* mire, M6d *Juncus acutiflorus* mire and improved grassland over archaic peat.

3.9.3 Damage

The site has been completely cut-over which is evidenced by different cut levels seen within the area of birch woodland. The owner also cites anecdotal evidence from locals that peat was domestically cut at the site 50+ years ago. The other main damage to the site is the birch woodland that has developed on the site post-cutting. Tree cover dries the bog surface through evapo-transpiration and leads to the loss of bog vegetation through shading. There are also scouring perimeter drains around most of the site perimeter, although there are few internal site ditches.

3.9.4 Assessment

The condition of Muiryfield Farm Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 5 placing it 14th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the fourth quartile of 73 sites assessed for condition.

Muiryfield Farm Moss is a very modified small site that is largely wooded with semi-natural birch woodland. Nevertheless the ground conditions remain wet over the southern and

western areas probably because there are few internal drainage ditches. There is therefore a good potential for site restoration which would involve removing trees from the site to allow the regeneration of the natural raised bog vegetation.

The site has a high potential for restoration.

3.9.5 Further information

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.10 Portmoak Moss

3.10.1 Site summary

Portmoak Moss is situated immediately to the west of Scotlandwell in Perth and Kinross covering an area of 34 hectares. The site is managed by the Woodland Trust and a local community group.

The central area of the site is largely primary (uncut) raised mire whilst the periphery has been cutover creating an unusually high 2m-3m cut face. The raised bog was originally entirely covered with mature conifer plantation however in 2004 and 2005 trees were removed from the central area of the site (from the primary area) and dams installed in drainage ditches as part of a project to restore the raised bog.

The central open area has recovering raised bog vegetation, and there are significant areas of colonisation by *Sphagnum* moss species and other raised bog vegetation in vegetating drains and other local areas. This demonstrates that the removal of trees and installation of dams has raised the water level and rewetted localised areas of the site. Nevertheless, the ground conditions remain rather dry overall and the most common vegetation type is grassland dominated by wavy hair-grass *Deschampsia flexuosa*. Regeneration of birch and conifers occurs across the open area and this is being controlled by a programme of scrub removal. Whilst the process of recovery is an on-going process, the level of vegetation recovery observed is impressive in view of the relatively short time since tree removal took place. Recommendations for future management are made below.

The peat depth was measured to be at least 5m at the centre of the site (this is a minimum depth because the bottom of the profile was not reached) and 1.7m at a representative cut-over area on the south side of the site.

3.10.2 Vegetation

In terms of the national vegetation classification the central open area of the site, compartments 5 and 8, is classed as a mosaic of recovering M18 *Erica tetralix* – *Sphagnum papillosum* raised mire vegetation and U2 *Deschampsia flexuosa* grassland. The wavy hair-grass *Deschampsia flexuosa* grassland is the most common vegetation type and is found on the areas with the driest ground conditions. Site restoration measures across the open area has caused local rewetting and the recovering raised mire vegetation is characterised by areas of *Sphagnum* moss species.

The central area of the open area (compartment 8) has the highest water table and the best area of recovering raised bog vegetation. Typically the recovering raised mire is dominated by scattered heather *Calluna vulgaris* over a ground layer of *Sphagnum palustre* and *Sphagnum fallax*, which are species indicating slightly raised nutrient levels. There are also a few areas of the *Sphagnum papillosum* and *Sphagnum magellanicum* which are species more typical of good quality raised mire vegetation and it is encouraging that these species are present at an early stage in restoration. Other vascular plant species typical of raised bogs such as cross-leaved heath *Erica tetralix* and horsetail cotton-grass *Eriophorum vaginatum* show a very scattered distribution and will take longer to colonise the site than the *Sphagnum* moss.

Away from the central area of the site the ground conditions become drier and the areas dominated by *Sphagnum* moss species become more local. Rather encouragingly though, whilst the recovering raised bog vegetation is found along vegetating drain lines and in depressions as expected, *Sphagnum* moss species are also colonising the higher areas of ground. The likely explanation is that the ability of these species to hold water is causing a localised surface rewetting and contributing to the on-going process of recovery. Localised areas of regeneration are found throughout the central open area (compartments 5 and 8).

The vegetation under the canopy of the remaining areas of conifer plantation and birch woodland is rather patchy, dominated in areas by grass species and broad buckler fern *Dryopteris dilatata*, reflecting the dry ground conditions found across these areas.

3.10.3 Historical site damage

The main historical damage to the site was caused by peat extraction and the establishment of a conifer plantation. The hydrology of the site has also been detrimentally affected by the presence of a deep scouring perimeter drain and internal drains, some of which are now infilling with vegetation.

The damage from peat extraction involved the removal of a large volume of peat from the edge of the site and these operations have left a vertical peat face up to 3m in height that encircles the central area of primary mire. The height of the peat face and the area involved suggests that this was not solely the result of cutting for local domestic use. It is more likely that peat was removed for commercial purposes or as an attempt to reclaim land for agriculture use (as occurred at Flanders Moss in Stirling). The result is a central island of peat (the primary uncut surface) that is higher than the outer cutover area, and this will have a detrimental effect on site hydrology. In particular the areas of primary mire closest to the peat face will suffer from a draw-down effect lowering the water table and causing dry ground conditions. Unfortunately the damage associated with peat removal is the most difficult to repair although re-contouring the vertical peat face, if practical, could ameliorate its effect on site hydrology.

Another factor effecting site hydrology is the presence of drainage ditches. There is a very deep scouring drain around the perimeter of the site which prevents water-logging of adjacent agricultural land whilst also lowering the water table of the adjacent areas of the raised bog. Internal drains will also have the same effect, although the drains across the central open area have been dammed and are beginning to infill with vegetation.

The other major damage arises from the mature conifer plantation present on the edges of the site, and the legacy of degraded raised bog across areas where the plantation was removed. Woodland affects raised bog vegetation by drying the bog surface as a result of evapotranspiration and by shading the raised bog ground flora. The areas of the site under woodland have very dry ground conditions and either a very sparse woodland ground flora or one dominated by broad buckler fern *Dryopteris dilatata*. Typical raised bog vegetation was also almost entirely lost from the central area prior to the implementation of restoration measures.

3.10.4 Assessment

The condition of Portmoak Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scores 4 placing it last in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the fourth quartile of 73 sites assessed for condition.

Scoring Portmoak Moss for site condition does not reflect the true value of the site because the scoring methodology does not take into account the potential of on-going recovery.

3.10.5 Management recommendations

The Woodland Trust will shortly undertake a site management review and under consideration is whether to maintain the scrub clearance effort across the entire open area or to retrench and maintain only a smaller core area as free of trees. Whilst the best quality recovering bog vegetation is found in the central area of compartment 8, there are areas of *Sphagnum*-rich recovering vegetation throughout the open area despite the short time since felling. Therefore there are few areas that could be sacrificed without compromising the quality of the recovering mire and it is recommended that the open mire is maintained in its entirety if at all possible. In practice there are a few small areas at the edge of the central open area that already have semi-mature regenerating birch that could be left and these include compartments 4 and 7, and areas to the south and west of compartment 5. The alternative option of allowing compartment 5 to regenerate as birch woodland, whilst retaining compartment 8 as open habitat, would be a less desirable solution.

A further recommendation is to install additional plastic piling dams across the central open area in order to raise the water table and promote further rewetting of the raised bog surface. Currently the distribution of dams is rather patchy and a higher concentration of dams on the inner side of the peat face would help to lessen the draw-down effect of this man-made feature. A survey of the current dam positions in relation to network of ditches is recommended to aid placement of new dams. Further rewetting of the mire would enhance the rate of recovery and may have the added benefit of inhibiting tree and scrub regeneration.

3.11 Redhall Moss

3.11.1 Site summary

Redhall Moss is a fairly small site of about 11.5 hectares situated 17km NE of Dumfries in Dumfries and Galloway. This is a very modified site that has been fairly extensively cut-over and about a quarter of the area is covered with mature conifer plantation. The east and south sides of the raised bog have only a thin layer of peat and are dominated by rush-dominated marshy grassland and *Molinia caerulea* mire rather than raised bog vegetation. In the centre of the site there is a relatively small core area of very good quality primary (uncut) raised bog habitat. Despite suffering from moderate trampling damage and evidence of historic burning a good range of raised bog vegetation indicator species are present. The peat depth was measured to be 4.4m at the highest point of the site and 0.9m at a representative cut-over area.

3.11.2 Vegetation

The most common vegetation type is M25 *Molinia caerulea* mire that is found across the eastern third of the site where deeply cut-over, extending onto the central area in mosaic with M18 raised bog. Overall ground conditions are wet and *Sphagnum palustre* and *Sphagnum fallax* are locally abundant, with occasional *Sphagnum capillifolium* hummocks where the vegetation grades towards M18 raised mire. To the south there is also an area of M23b *Juncus effusus* rush pasture.

There is a step up to the primary central area, the outer margins of which support a mosaic of degraded M18 raised mire, M25 *Molinia caerulea* mire and dense stands of *Myrica gale*. Notable species present include *Andromeda polifolia*, *Drosera rotundifolia*, *Vaccinium oxycoccus* and *Sphagnum magellanicum*. The central core area has the best area of primary degraded M18 raised mire although there is evidence of historic burning and moderate poaching damage (occasional bare ground). Notable species include *Rhynchospora alba*, *Andromeda polifolia*, *Drosera rotundifolia*, *Vaccinium oxycoccus* and *Sphagnum magellanicum*. Overall *Erica tetralix*, *Eriophorum vaginatum*, *Calluna vulgaris* and *Sphagnum capillifolium* provide the bulk of the cover. Ground conditions are wet and there are no drains across this area.

To the north and cutting across the central area is a mature spruce plantation on deep peat. This area appears to be primary and the conifers have been planted using a ridge and furrow technique.

3.11.3 Damage

The site has suffered from fairly extensive peat cutting in the past although the central area is primary, and the north-west area under the spruce plantation may also be uncut. The cut-over areas have a low to medium density of ditches which are infilling with vegetation and the primary central area has no drainage ditches. The north-west side of the site is covered with a mature spruce plantation and this has caused the surface of the mire to dry and has shaded out the typical raised bog vegetation. Finally the central area shows signs of moderate poaching damage, past burning events and may be under threat from invasion by scrub.

3.11.4 Assessment

The condition of Redhall Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive

indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, Redhall Moss scored 13 placing it 5th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

Redhall Moss is suitable for restoration. It has suffered from significant modification but has a central uncut area that supports a full suite of M18 raised bog indicator species. Suitable restoration measures would include control of the invading scrub from the central area, blocking of drainage ditches across the outer areas of the site and removal of the spruce plantation.

The site has a high potential for restoration.

3.11.5 Further information

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.12 Riccarton Moss

3.12.1 Site summary

Riccarton Moss is a small site of about 8 hectares situated immediately to the south-east of Kilmarnock in East Ayrshire. The site has been completely cut-over and the vegetation is mainly *Molinia caerulea* mire with only limited areas of raised bog vegetation remaining. Nevertheless the site has very wet ground conditions and a good and uniform cover of *Sphagnum* species, although mainly species that indicate some degree of nutrient enrichment. There is a low cover of *Calluna vulgaris* which may be a result of past grazing and burning regimes although there was no sign of these impacts at the time of survey. The margins of the site are drier, particularly along the east side where there is a scouring drain, and the cover of *Sphagnum* species is reduced. Within the site there is a medium density of drains although these are fairly narrow and infilling with vegetation. The peat depth was measured to be 3.6m and 3.8m at two central site locations.

3.12.2 Vegetation

The wet ground conditions encountered on the site were partly the result of prevailing wet weather conditions, although the high cover of *Sphagnum* species shows that the site is generally wet. The main vegetation across the site is intermediate between M20 and M25 and is dominated by *Molinia caerulea* and *Eriophorum vaginatum* in the field layer and by *Sphagnum fallax* and *Sphagnum papillosum* in the ground layer. True M18 raised mire is local to the raised strips of peat and to the eastern side. *Sphagnum* species typical of raised mire such as *Sphagnum capillifolium* and *Sphagnum magellanicum* are locally abundant and are forming into hummocks in some areas. There is also scattered *Drosera rotundifolia* across the site which is a M18 preferential species.

At the margins of the site the ground conditions become drier and the cover of *Sphagnum* species becomes lower. Along the eastern side there is vegetation more typical of drying raised mires including degraded M18 co-dominated by *Calluna vulgaris* and *Eriophorum vaginatum* with either *Sphagnum capillifolium* or pleurocarpous mosses in the ground layer.

Elsewhere at the margins M25 dominates again with a lower cover of *Sphagnum* species and more herb species including *Succisa pratensis* and *Potentilla erecta*. Other plant communities present include an area of M23b *Juncus effusus* lagg fen at the north and west edge of the site and W23 gorse *Ulex europaeus* scrub along the eastern scouring drain.

3.12.3 Damage

This is a wet site which has a good cover of *Sphagnum* moss species indicating that there is a permanently high water table. A perimeter drainage ditch is only present along the east of the site and there are narrow internal drains across the mire expanse, however these have become infilled with vegetation and are ill-defined. The low cover of *Calluna vulgaris* suggests the vegetation has been modified as the result of past treatments such as grazing and burning.

3.12.4 Assessment

The condition of Riccarton Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 14 placing it equal 1st in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

Riccarton Moss is a site with a high cover of *Sphagnum* species and modified raised bog vegetation which is suitable for restoration. The main measure would be to dam the main internal drainage ditches in order to further rewet the bog surface. The re-alignment of the eastern perimeter ditch away from the site would also improve site hydrology. The current regime of periodic grazing during the summer months when the site is at its driest, is appropriate and will suppress any regeneration of scrub or birch that could occur. More intensive grazing regimes, or burning management, should be avoided.

The site has a high potential for restoration.

3.12.5 Further information

The owner is broadly supportive of site restoration, subject to the details of financial support offered by any proposed environmental scheme.

3.13 Skeibhil Moss

3.13.1 Site summary

Skeibhill Moss is a very small site of about 5 hectares that is very modified and only fragments of raised bog vegetation remain. The raised mire was probably centred on the southern area of the site and the northern end is mesotrophic mire and may have been part of the original lagg fen. The raised bog was cutover in the past, and the triangular shape of the site indicates that significant areas have been reclaimed as agricultural land. The remaining peat layer is patchy and was measured to be 0.6m and 0.2m at two locations at the south end of the site.

3.13.2 Vegetation

The site is characterised by grassland and mire communities. At the southern end there is dry U2 *Deschampsia flexuosa* acid grassland and M6c *Juncus effusus* flush, over the deepest area of peat, with abundant *Sphagnum palustre* in the ground layer. To the north there is a mosaic of MG9 *Deschampsia cespitosa* grassland and M23 *Juncus effusus* marshy grassland. There are also smaller areas of dry heath, over a thin layer of peat, as well as scrub and scattered rowan and birch.

3.13.3 Damage

Historic peat cutting has caused the loss of the majority of the raised bog vegetation and remaining peat cover is patchy. There is also some evidence that the raised bog extended over a greater area originally and that land was reclaimed for agricultural use. There are also scouring drains at the site perimeter.

3.13.4 Assessment

The condition of Skiebhil Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 7 placing it equal 11th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the third quartile of 73 sites assessed for condition.

Skeibhill Moss has been cutover and reduced in size, and is no longer a functioning raised bog. The small size of the site and the patchy cover of peat that remains means that it is a low priority for restoration. The condition score exaggerates the site's quality as a lowland raised bog.

The site has a low potential for restoration.

3.14 Toxside Moss North

3.14.1 Site summary

Toxside Moss North is a fairly large site covering 41 hectares located 7km south-east of Penicuik in Midlothian. There is a shallow dome with a natural gently sloping rind at the edge of the main mire expanse and a lower area of raised mire and lagg fen at the site margin. Overall there is fair to good quality raised bog vegetation with a good cover of *Sphagnum* moss species and wet ground conditions. There is a moderate to high density of internal drains across the site although these are infilling with vegetation and are ill-defined on the ground. There is also a major canalised burn at the eastern side of the site although it is on the outer edge of the lagg fen area and so its influence on the mire expanse is probably limited. There are two small areas of old domestic peat cutting at the north end of the site and there may have been some peat cutting activity across the lower areas of raised mire at the margins of the site. The depth of peat was measured to be 5.9m in the centre of the site and 5.8m at one of the cutover areas in the north.

3.14.2 Vegetation

Across the undulating topography of the main mire expanse the fair to good quality M18 raised mire vegetation has an open sub-shrub layer and a good cover of *Sphagnum* species. The characteristic vegetation is dominated by *Calluna vulgaris* and *Eriophorum vaginatum* with frequent *Sphagnum capillifolium* and *Erica tetralix*. There are also local areas where the ground layer is dominated by *Sphagnum papillosum* with occasional *Sphagnum tenellum* and *Sphagnum magellanicum*. Drier raised areas support *Cladonia impexa* and pleurocarpus mosses in the ground layer.

There is a step-down from the main mire expanse to an area of degraded raised mire and lagg fen at the margin of the site. These areas are dominated by M25 *Molinia caerulea* mire, which grades into M18 raised bog vegetation in places, or M20 *Eriophorum vaginatum* mire. There are also areas of M23b *Juncus effusus* lagg fen at the edge of the site.

3.14.3 Damage

There is a medium to high density of artificial drains across the main mire expanse running parallel in an east – west direction. These are ill-defined and infilling with vegetation so their influence may be reducing, but they will nevertheless by having a drying effect on the mire surface. There is also a major canalised burn at the eastern side of the site although it is on the outer edge of the lagg fen area and so its influence on the mire expanse may also be limited.

There are two local areas of old domestic peat cutting at the north of the site, and some cutting may have taken place across some of the lower marginal areas of raised bog.

3.14.4 Assessment

The condition of Toxside Moss North is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 14 placing it equal 1st in

the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the first quartile of 73 sites assessed for condition.

This is a good lowland raised bog site that is uncut over the main central area but has a moderate to high density of internal artificial drains across the mire expanse. This would be suitable site for restoration and the main works would involve damming the drainage ditches in order to re-wet the mire surface and encourage the development of better quality raised mire vegetation.

The site has a high potential for restoration.

3.15 Woodhead Croft Moss

3.15.1 Site summary

Woodhead Croft Moss is a small site covering about 15 hectares located 2km south of New Aberdour in Aberdeenshire. It is a site that has been extensively cutover as evidenced by a pattern of different peat levels and raised baulks. The raised bog habitat is rather dry and degraded overall and has been affected by draining and burning. There is also mesotrophic fen vegetation in the south and at the northern and eastern areas where deep cutting has led to higher nutrient groundwater influencing the vegetation. The raised areas have the driest ground conditions with the vegetation grading towards dry heath, whilst the more deeply cut areas in the centre are wetter and have local areas of better quality raised bog vegetation.

There is a medium density of infilling drains across the mire expanse and a scouring ditch present around the perimeter of the site. There are also local areas of dense scrub on drier areas at the bog margin and along internal drain lines. The peat depth was measured to be 3.3m in the centre of the site and 3.8m at a representative cut-over location.

3.15.2 Vegetation

The centre-east of the site has dry degraded M18 raised mire vegetation which grades into dry heath in places. Overall there is only scattered *Eriophorum vaginatum* and *Erica tetralix* and the cover of *Calluna vulgaris* has been severely reduced as a result of a recent burn (however there is good regeneration). There are localised wetter areas have *Sphagnum capillifolium*, *Narthecium ossifragum* and *Empetrum nigrum* but little *Sphagnum* species overall. The other common vegetation type is M20 *Eriophorum vaginatum* mire and in the south-western and northern areas it is found in mosaic with M23b *Juncus effusus* fen. M20 is considered a degraded form of M18 raised bog vegetation and can occur as a result of burning or over-grazing. The other vegetation type present is W23 gorse *Ulex europaeus* scrub. This is found on drier ground for example at the southern edge of the site and along the line of internal drains.

3.15.3 Damage

The site is extensively cut-over and it appears that no primary (uncut) surface remains. The presence of a scouring perimeter ditch and internal drains, despite infilling with vegetation, have caused the bog surface to dry out and the water table to be lowered. Finally there is evidence of recent burn events which has led to some further degradation of the bog vegetation.

3.15.4 Assessment

The condition of Woodhead Croft Moss is assessed based on a scoring methodology described in Section 6 'Site condition assessment'. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts. Out of a maximum score of 15, the site scored 11 placing it equal 7th in the ranking of the 15 sites surveyed. Including the 58 sites surveyed earlier, the site is ranked in the second quartile of 73 sites assessed for condition.

The site is suitable for restoration which would involve rewetting the bog surface through the damming of internal drains. The site would also benefit from the removal of scrub from the central areas of the site and controlling its regeneration.

The site has a high potential for restoration.

4 Survey results

4.1 Peatland resource

4.1.1 Survey results

The total survey area is 282 hectares of which less than 0.1% is archaic peat and almost 100% is 'restorable peatland area'¹. The restorable peatland area includes near natural and degraded open mire, mire with woodland cover and commercially worked bare peat. This is the area of lowland raised bog that has the potential to be restored to a favourable condition.

The restorable peatland area covers 282 hectares, of which 50% is uncut primary mire and 50% is cutover secondary mire (Figure 2). All of secondary mire was historically cutover and has become re-vegetated.

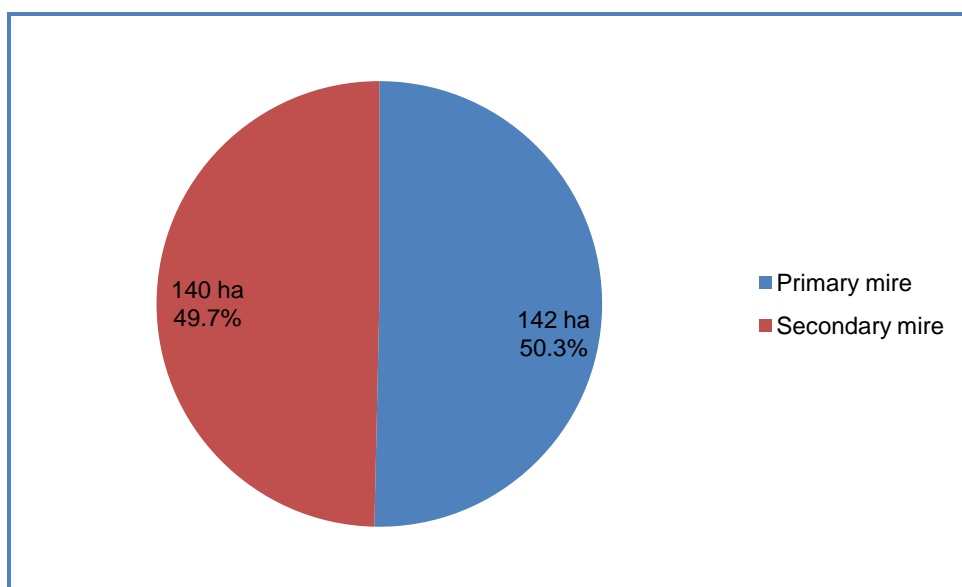


Figure 2. Restorable peatland area categorised by primary and secondary mire.

4.1.2 Analysis of results

The very small mapped area of archaic peat may be an under-estimate because of the difficulty in identifying archaic peat in the field. Determining the extent of archaic peat was problematical where vegetation, such as a grassland sward, provided unbroken cover over the soil or peat substrate. Furthermore, areas of developed land, housing and private gardens, which were not accessed, were assumed not to be archaic peat and were not included within the site boundary.

Compared to the sites surveyed during 2010 and 2011, the current survey area has a higher proportion of primary mire (50% compared to 38%). This may be because smaller sites are less likely to be cut-over on a commercial basis - larger sites would be more attractive because of the economies of scale involved.

4.2 Ground conditions

¹ Peatland is mapped where peat depth is greater than 30cm.

4.2.1 Methodological issues

The methodology does not provide a clear definition of 'wet' and 'dry' ground conditions; however during the 1994/5 survey a vegetation proxy was used (*pers. comm.* Jonathan Hughes, Scottish Wildlife Trust). A compartment was classified as 'wet' where *Sphagnum* species were constant (at a low cover or otherwise) and the microtope type T2 or wetter (i.e. T1, A1 etc) provided at least 20% of ground cover. For compartments where mesotrophic conditions prevailed, a compartment was defined as 'wet' where fen and swamp species were dominant, regardless of the ground cover of *Sphagnum* or other bryophytes.

4.2.2 Survey results

Ground conditions, classified as wet or dry, were mapped and recorded at a site compartment level for all 15 sites.

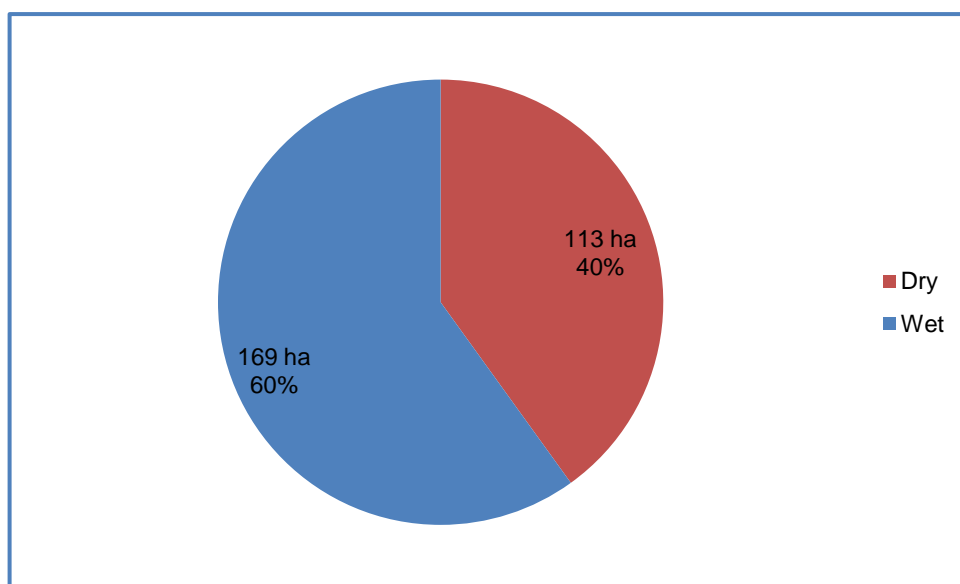


Figure 3. Peatland area (hectares) by ground condition category.

The results in Figure 3 show that 60% of the peatland area is classified as wet and 40% is dry.

4.2.4 Analysis of results

The assessment of ground condition uses the presence of *Sphagnum* cover to determine the distinction between the wet and dry categories. In practice this means that vegetation classed as dry includes very degraded M18 raised mire that has little if any *Sphagnum* species cover, dry heath, the drier *Molinia caerulea* grasslands and much of the closed woodland and scrub cover.

Vegetation classed as wet largely comprises the better quality areas of M18 raised mire in addition to smaller areas of fen, swamp and wet woodland. The areas classified as wet include areas dominated by *Sphagnum* species, where peat accretion is likely to be occurring, but also more degraded raised bog vegetation. At many sites which have both primary and secondary mire, it tends to be the lower cutover areas that are the wettest and most *Sphagnum*-rich, whilst the higher uncut areas are drier with more degraded vegetation.

Compared to the sites surveyed during 2010 and 2011, the current sites have a higher proportion of ground classified as wet (60% against 33% by area originally). This may be partly related to the higher proportion of primary mire where the original hydrological system is less damaged. There may also have been some degree of selection bias through choosing sites for the current study that had open mire vegetation (as opposed to sites covered with woodland) and which were not completely degraded.

4.3 Open mire vegetation

4.3.1 Methodological Issues

Open mire vegetation was recorded in a variety of ways including site species lists, vegetation quadrats, and dominant ground layer vegetation type at the site compartment level. The latter category gives the most systematic and complete data set and this can be aggregated by area at a whole site level. The ground layer vegetation type was classed as 'Sphagnum-dominated', 'bryophyte-dominated' (i.e. not including *Sphagnum* species), bare ground or as two categories co-dominant. A record was also made of compartments that were dominated by herbs (indicating fen conditions).

4.3.2 Survey results

The results for open mire vegetation type by area are in Figure 4 below.

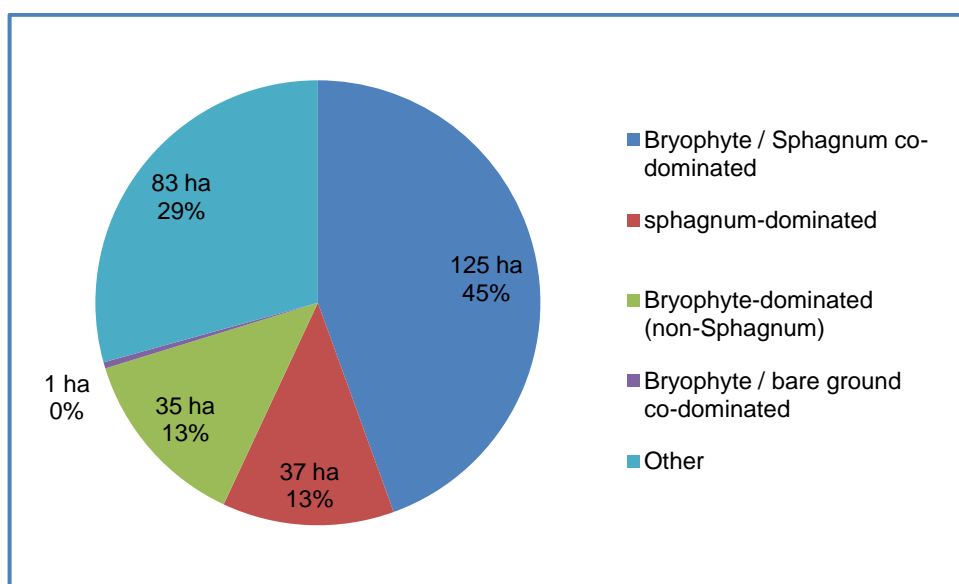


Figure 4. Open mire vegetation category by area for all sites.

Vegetation categories were only recorded for open mire areas (including under open scrub and woodland) but for the sake of completeness Figure 4 also includes areas of closed canopy woodland, scrub and herb dominated areas (combined in the category 'other').

The ground layer vegetation types with the highest cover are 'Bryophyte / Sphagnum co-dominated' which covers 45% of the surveyed area, 'Bryophyte-dominated (non-Sphagnum)' which covers 13% and 'Sphagnum-dominated' which also covers 13%.

4.3.4 Analysis of results

The analysis of open mire vegetation types shows that the majority of the survey area (58%) has some Sphagnum component in the ground layer (it is either 'Bryophyte / Sphagnum co-dominated' or 'Sphagnum-dominated') which is also the area that is categorised as wet under the ground conditions category (excluding areas of wet fen).

The results show that 13% of the survey area has a ground layer dominated by *Sphagnum* species and these are the areas that have the greatest potential for peat accumulation and carbon sequestration (Lindsay 2010).

Compared to the sites surveyed during 2010/11 there is a significant increase in the area that has some Sphagnum component in the ground layer in the current survey (27% increasing to 58%) which is also reflected in the increase in the area of primary mire and wet ground conditions. It is notable, though, that this increase is largely in the area of 'Bryophyte / Sphagnum co-dominated' ground whilst the area of 'Sphagnum-dominated' ground only increases from 11% to 13%. This demonstrates that, whilst the sites surveyed during 2012 appear to be in better condition overall compared to those surveyed during 2010/11, the relative area of potential peat accumulation is very similar.

4.4 Damage

4.4.1 Trees and scrub

4.4.1.1 Methodological issues

Woodland and scrub are categorised by tree type (broadleaved, conifer or mixed) and by canopy type (open or closed). The identification and mapping of woodland and scrub features by aerial photograph interpretation is normally straightforward, however ground-truthing is important to determine whether areas of woodland have been felled or whether recent scrub or tree regeneration has occurred.

Trees and scrub are defined as open canopy where space can be seen around most individual trees or shrubs on an aerial photograph or in the field. Trees can be up to 24m apart on average within this category, whilst trees or shrubs that are more widely spaced are classed as scattered trees on open mire.

4.4.1.2 Survey results

Figure 5 shows area of scrub and woodland across the restorable peatland area for all sites (282 hectares in total). Closed and open canopy woodland covers 29% and 1% of the survey area respectively, and closed and open canopy scrub both cover 1% of the survey area. Overall 32% of the survey area supports woodland and scrub, and the remaining 68% of the area is open mire.

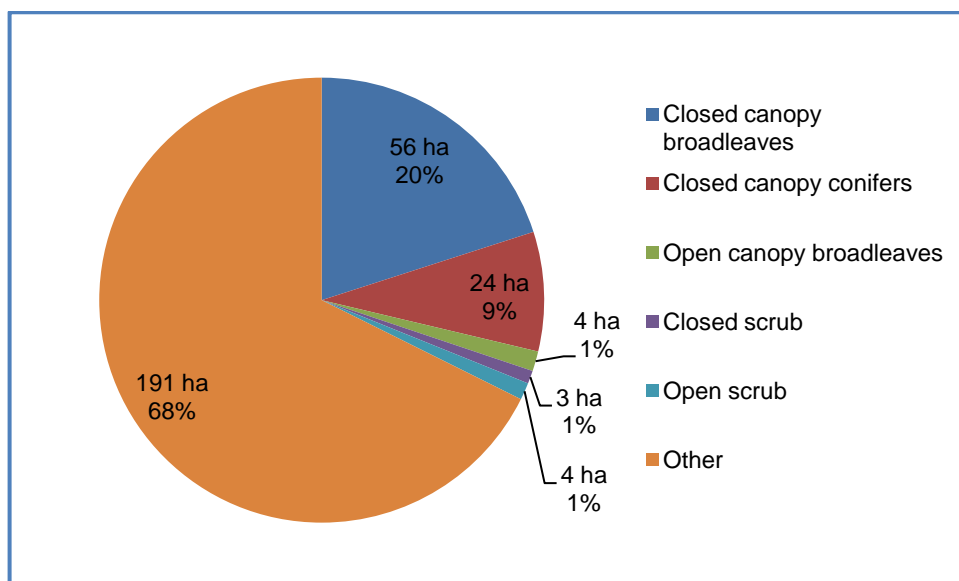


Figure 5. Restorable peatland area categorised by open and closed woodland and scrub types.

4.4.1.4 Analysis of results

The results show that about a third of the survey area supports open and closed canopy woodland and scrub. Trees and scrub impact the condition of a raised bog by causing the surface of the bog to dry and loss of bog vegetation through shading. Consequently, trees and scrub are one of the major negative impacts across the survey area.

Compared to the sites surveyed during 2010 and 2011 there is a lower cover of woodland and scrub (32% of the current survey area compared to 45% for the sites previously surveyed). The lower area of scrub and woodland may have been partly a result of selection bias. Sites for the current survey were chosen where they had a significant area of open vegetation rather than being completely wooded.

4.4.2 Artificial drainage

4.4.2.1 Methodological issues

At a compartment level, where present, drains are categorised as narrow, moderate, wide or irregular-spaced. Narrow-spaced drains have parallel spacing between 5m and 10m (or equivalent density if not parallel), moderate-spaced drains are 10m to 50m apart, and wide-spaced drains are 50m to 100m apart. Irregular-spaced drains have a similar density to wide-spaced drains but are more fragmented and irregular. A site perimeter drain that is concurrent with the border of a compartment polygon is not captured by that compartment to allow a distinction to be made between drains that are present across the peatland expanse and those at the perimeter.

4.4.2.2 Survey results

Data on artificial drains and ditches were mapped and recorded on a site compartment level in addition to their status being recorded on a whole site basis.

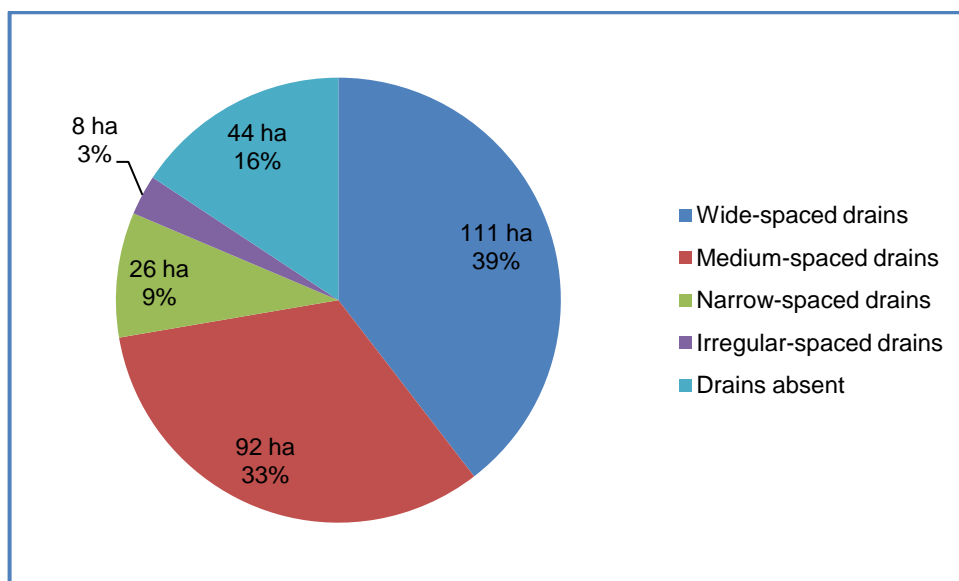


Figure 6. Survey area categorised by drainage density.

The results of artificial drainage type by area across all 15 sites are shown in Figure 6.

The results show that 84% of the survey area is affected by artificial drainage and that wide-spaced and medium-spaced drains are the main drain types recorded.

Analysis of drainage on a site by site basis shows that the majority of sites have 'infilling only' drains across the mire expanse (67% of sites) and 'scouring drains' around the site perimeter (73% of sites). The remaining sites have either 'infilling drains and dams' or 'infilling drains and scouring drains' across the mire expanse and 'infilling drains and scouring drains' or 'infilling only drains' at the perimeter.

4.4.2.4 Analysis of results

Analysis of drainage data shows that all surveyed sites are affected both by drains across the mire expanse and by perimeter drainage ditches. Furthermore, only 16% of the survey area is free from drains.

The high proportion of sites with internal infilling drains indicates that these drains are not being maintained in contrast to perimeter ditches which are generally scouring. These results are broadly in line with the findings from the sites surveyed during 2010/11.

4.4.3 Micro-erosion, bare peat, burning and animal impacts

4.4.3.1 Methodological issues

Micro-erosion is recorded at a site compartment level and it is defined in the field survey methodology as small scale interconnecting channels on a primary mire surface where the natural *Sphagnum* cover is becoming 'micro-broken' (Scottish Wildlife Trust 2010). This definition was extended to include fine-scale erosion caused by animal poaching or other factors across the peatland.

Damage from burning was recorded at a whole site basis and was categorised as either 'recent' or 'historic'. The historic category was used for sites where the burn event appeared to have taken place more than two years ago as evidenced by charring of tree trunks, fence posts and the largest heather stems. Recent burning is likely to be seen as charring of finer vegetation, the ground layer and / or the peat surface.

Damage from animals, both livestock and wild animals, was also recorded at a whole site level including grazing, trampling and dunging enrichment. Each type of damage was categorised as either 'insignificant', 'moderate' or 'heavy' and only one category was assigned to each site (i.e. the worst damage category present was assigned).

4.4.3.2 Survey results

Micro-erosion affects only 1.3% of the restorable peatland area. In two out of the three sites that have local areas of micro-erosion, it appears to be the result of livestock poaching.

No large-scale commercial, semi-commercial or domestic peat cutting was occurring, or had recently occurred, at the sites surveyed. Consequently there were no recorded significant areas of bare peat (as opposed to local micro-eroded areas of bare peat).

Damage caused by animal grazing, trampling and dunging enrichment, as well as evidence of recent and historical burning, was also recorded on a whole site basis. Recent and historic burning was recorded at 4 sites (27% of the total) and localised heavy livestock grazing was recorded at a single site.

4.4.3.4 Analysis of results

Micro-erosion was rare across the survey area and there were no significant areas of bare peat resulting from peat cutting or extraction operations. Furthermore, there were no significant impacts recorded from animal grazing, trampling and dunging enrichment. In contrast burning was recorded at 4 sites (27%) indicating that its use as a management technique and/or burning occurring as a result of vandalism is fairly widespread.

The results from the current study are broadly in line with the findings from the surveys carried out during 2010 and 2011.

5 Peat Depth

5.1 Methodological issues

Peat depth sampling was undertaken using a set of ten steel rods measuring 1m in length and 10mm in diameter that were joined by means of a threaded connector (providing a maximum sampling depth of 10m). The leading end of the first rod was designed with a pointed tip and a threaded handle could be attached to the trailing end of the final rod.

In practice there was a limit to the depth that could be measured by a single operator using this equipment in the field and this related to the bulk density of the peat being sampled. The maximum sampling depth for typical wet areas of primary and secondary mire was between 5m and 7m whilst the maximum depth for areas of dry and compacted peat could be significantly less (one dense area of archaic peat could only be measured to a depth of 1m). Secondary mire on which well established woodland had been self-sown or planted could also provide a higher level of resistance and could restrict depth measurements to 3m or 4m.

The minimum requirement for each site was one depth measurement on primary mire (at the highest point of the dome in the centre of the site), one depth measurement on secondary mire (at a representative cut-over area) and one depth measurement near to the edge of the peatland expanse. In practice, if a site comprised only primary or secondary mire, or if secondary mire were only present at the edge of the mire, two samples fulfilled this requirement, but additional measurements were usually taken.

5.2 Results

Peat depth samples were taken from all 15 sites and the recorded depth ranged from 0.2m to 7.0m. The average primary mire (uncut) depth is 4.5m and the average secondary mire (cut-over) depth is 3.2m. The figures for the average depth of primary and secondary mire are in fact under-estimates of the true value because at two sites in each case the measurements are a minimum figure only (i.e. the resistance of the peat was too great to allow the depth probe to reach the bottom of the profile).

The results show that seven sites (47%) have a depth of 5m or greater based on the maximum depth of peat recorded, irrespective of whether the maximum was measured on primary or secondary mire.

5.3 Analysis of results

A comparison with the sites surveyed during 2010/11 shows that the average peat depth for primary mire is similar (4.5m compared to 4.7m from the earlier study) and somewhat greater for secondary mire (3.2m compared to 2.2m from the earlier study). Taking into account that the average site size by area of the original sites is more than three times that of the current sites, this indicates that there is no positive correlation between site area and peat depth.

The greater average peat depth of secondary mire recorded in the current study may be the result of greater commercial exploitation and deeper cutting of larger secondary sites. In contrast the smaller secondary sites surveyed during the current study are more likely to be cut-over domestically at a shallower depth on average.

6 Site condition assessment

6.1 Methodological issues

Sites surveyed during 2012 are assessed in terms of their quality or condition as lowland raised bogs and are ranked accordingly. Whilst the assessment uses data recorded during the survey, the choice of criteria and the scoring system used is necessarily subjective. Nevertheless the assessment aims to give high scores to factors that indicate favourable condition and low scores to factors that indicate a degraded or damaged condition in order to give a relative site quality score for all sites surveyed based on the restorable peatland area. The five criteria used in the assessment are positive indicator species, ground conditions, artificial drainage, closed canopy woodland and burning and grazing impacts.

The positive indicator species scoring protocol is the same as that used to assess open mire vegetation (see Section 4.3 'Open mire vegetation'). An assessment of positive indicator species is arguably the most important indicator of site quality and is given double weighting compared to other criteria.

Ground conditions scores are based on the area of the site classified as wet. If less than 30% of the restorable peatland area is wet the site scores 0, if the wet area is 30% to 59% the score is 1 and if the wet area is greater than 60% the score is 2. For a definition of the ground condition 'wet' and 'dry' classifications see '3.3.1 Methodological issues'.

Artificial drainage scores are based on the presence or absence of drain type within the peatland expanse on a whole site basis. Sites that have scouring drains only score 0, those that have infilling and scouring drains score 1, those that have infilling drains only score 2 and those that have no drains or dammed drains score 3. For more information on the whole site drainage classification see '3.4.2.1 Methodological issues'.

Closed canopy woodland scores are based on the area of each site classified as broadleaved, conifer or mixed closed canopy woodland. If greater than 60% of the peatland area is occupied by closed canopy woodland the site scores 0, if the area is 30% to 59% the site scores 1 and if the area is less than 30% the site scores 2. For more information of the classification of closed canopy woodland see '3.4.1.1 Methodological issues'.

Burning and grazing impact scores were based on the presence or absence of burning and grazing damage on a whole site basis across the restorable peatland area. Grazing damage is defined as heavy animal grazing, trampling or enrichment impacts and burning damage is defined as either current or historical burning (as recorded during the survey). Sites that have both grazing and burning damage score 0, those with either burning or grazing damage score 1 and those sites with no burning or grazing damage score 2.

6.2 Assessment results

The condition assessment scores on a site by site basis are shown in Table 2. The sites are ordered by decreasing total assessment score (best quality sites first).

Table 2. Condition assessment scores by site broken down by assessment criteria.

Site name	Indicator species	Ground conditions	Drainage	Closed canopy woodland	Burning and grazing	Condition score
Grangeneuk Moss	6	2	2	2	2	14
Langlands Moss	6	2	2	2	2	14
Riccarton Moss	6	2	2	2	2	14
Toxside Moss	6	2	2	2	2	14
Redhall Moss	6	2	2	1	2	13
Corthie Moss	4	2	2	2	2	12
Woodhead Croft Moss	4	2	2	1	2	11
Harestone Moss	2	2	2	2	2	10
Kennox Moss	6	0	0	2	2	10
Commonhead Moss	4	2	1	1	2	9
Beckhall Moss	0	2	2	1	2	7
Skiebhill Moss	0	2	2	2	1	7
Moss of Rothiemay	2	0	0	2	2	6
Muiryfield Moss	0	1	1	2	1	5
Portmoak Moss	0	0	0	2	2	4

6.3 Analysis of results

The site assessment scoring protocol provides a snapshot of site quality at the time of survey and provides a relative ranking score as well as the basis for comparing site condition with an assessment undertaken at another time (where the same survey methodology has been used).

A subjective analysis of the condition assessment scoring scheme indicates that it gives a reasonable ranking of sites in terms of their ecological quality. In particular it appears to be successful in identifying the five or six best quality sites although the scores attributed to more degraded sites may be more arbitrary. For example Beckhall Moss and Skiebhill Moss are fairly small sites that have been highly cutover and have only fragments of raised bog vegetation remaining, but gain points for being wet, having low grazing impacts and for having a low woodland cover.

The condition assessment scores also fail to highlight sites that are in the process of recovery such as Portmoak Moss and Commonhead Moss. Both sites have recently had the

benefit of restoration works including the installation of dams and, in the case of Portmoak Moss, the removal of conifer plantation. In both cases there has been considerable success in the rewetting to the mire surface and it is likely that the quality of the raised mire vegetation will improve over time. However, future potential or an improving trend in condition is not captured by the scoring system.

7 Site restoration

7.1 Attitudes to restoration by landowners

As part of the selection process for the 15 sites surveyed during 2012, landowners were questioned about their attitude to potential grant-aided site restoration. Only those sites that had landowners that were broadly or fully supportive of restoration were included in the survey.

In general publicly owned sites (local councils and Forestry Enterprise etc), commercially operated sites, designated SSSIs, sites with unknown ownership and sites that had already been restored were not considered for inclusion. However three sites that have been partially restored were included in order to support future management and restoration work. These were Commonhead Moss owned by Glasgow City Council, Langlands Moss owned by North Lanarkshire Council and Portmoak Moss owned by the Woodland Trust.

7.2 Site restoration potential

An assessment of the potential for each site to be restored is made for each site. The criteria used to make the assessment are:

- attitude of owner to restoration
- ownership complexity (multiple or unknown owners reduce restoration potential)
- extent of deep peat
- site size (small sites have a reduced restoration potential)
- constraints on restoration (the presence of housing, transport infrastructure etc close to, or across, a site reduces the restoration potential)
- site condition (a site dominated by fen or other mesotrophic vegetation has a reduced restoration potential)
- damage from historic peat extraction (a cutover site has a reduced restoration potential)
- any other site specific factor that may have a bearing on undertaking restoration works (e.g. site access, prohibitive costs)

The assessment categorises sites as having a low, medium or high potential for restoration and the results are shown on a site by site basis in Table 3 below.

Table 3. Restoration potential on a site by site basis

Site	Restoration potential	Notes	Ownership	Capital cost (£)	Annual cost (£)
Beckhall Moss	Low	Small site, mainly fen habitat	Private - supportive of restoration	9090	963
Commonhead Moss	High	Restoration on-going	Local authority	71680	1877
Corthie Moss	High	Scope for ditch blocking	Private - supportive of restoration	13897	2616
Grangeneuk Moss	High	Good quality site but limited scope for restoration works	Private - supportive of restoration	110	1324
Harestone Moss	Low / Med	Small site that is part fen habitat	Private - supportive of restoration	8058	810
Kennox Moss	High	Scope for tree removal	Private - supportive of restoration	38585	1340
Langlands Moss	High	Restoration on-going	Local authority	20981	1284
Moss of Rothiemay	High	Scope for tree removal and ditch blocking	Private - supportive of restoration	50026	1618
Muiryfield Moss	High	Scope for tree removal and ditch blocking	Private - supportive of restoration	7997	780
Portmoak Moss	High	Restoration on-going	Woodland Trust	67832	2153
Redhall Moss	High	Scope for scrub and tree removal	Private - supportive of restoration	13629	1062
Riccarton Moss	High	Scope for ditch blocking	Private - supportive of restoration	4141	915
Skiebhil Moss	Low	Small, degraded site (not a functioning raised bog)	Private - supportive of restoration	975	767
Toxside Moss	High	Scope for ditch blocking	Private estate - supportive of restoration	12433	1594
Woodhead Croft Moss	High	Scope for scrub removal and ditch blocking	Private - supportive of restoration	6579	1113

Of the sites surveyed, 12 have a high potential for restoration and 3 have a low or medium potential for restoration. For more information see Section 3 'Site details'.

7.3 Site restoration costs

7.3.1 Approach to estimating restoration costs

The restoration of a lowland raised bog site involves reversing past damage and returning the habitat to a favourable condition. The main forms of damage affecting raised bogs are past and present peat cutting, the presence of scrub and woodland, and artificial drainage. Whilst removed peat cannot be put back in the short-term, restoration efforts can focus on the removal of scrub and woodland, and raising the water table by damming drainage ditches. There may also be ongoing management practices that cause damage, such as poaching damage from livestock and management of the bog vegetation by burning, and it may be possible to address these issues by entering into landowner management agreements.

The actual costs involved in restoring a site are likely to be fairly complex and based on a management prescription specific to each site. Nevertheless a reasonable estimate of costs can, arguably, be made based on past restoration project costs and on grants available for the restoration of raised bogs or similar habitats. This is the approach used to calculate the costs of restoration for the sites surveyed during 2012 and the survey results are used as the basis for these calculations.

Restoration cost information from grants is taken from the South Scotland Bog Scheme (SSBS) which is specific to raised bogs (SNH 2006) and the Scotland Rural Development Programme (SRDP) which includes items that apply to both raised and blanket bogs (SNH 2011). Cost information is also available for recent and current blanket bog restoration work being undertaken by the RSPB at Forsinard in Sutherland, Scotland (Norrie Russell *pers. comm.*). Other blanket bog restoration projects being overseen by SNH and other conservation bodies have been collated by the IUCN (Clifton Bain *pers. comm.*). The restoration costs from a project at Lake Vyrnwy in Powys, Wales, undertaken between 2009 and 2011, are also used in the current calculations.

A number of broad assumptions are made when calculating site restoration costs. For example, it is assumed that the example costs relating to blanket bog projects can be applied to raised bog sites, and that the size of the site has no bearing on cost (many of the raised bog sites are relatively small in size and may not benefit from economies of scale). Furthermore, although past project costs are necessarily historic, it is assumed that inflation has no bearing on current or future costs.

The estimate of capital and annual management costs covers the restorable peatland area and excludes areas of archaic peat and non-peat. It is assumed that agriculturally improved or urbanised archaic peat cannot be restored.

All other specific assumptions are outlined in Section 6.2.2 'Restoration cost calculations'.

7.3.2 Restoration cost calculations

The capital costs considered in the calculations are scrub removal and control, woodland removal and control, and the installation of dams to block drainage ditches. The 2010/11 survey generated data on scrub, woodland and drainage density category types by area for the entire peatland area and these data are used as the basis for estimating restoration costs.

Estimates of the capital restoration costs for the sites surveyed during 2010/11 are summarised in Table 4. A breakdown of costs on a site by site basis is provided in Appendices II and III.

Table 4. Estimate of capital costs of restoration for all 2012 survey sites.

Capital expenditure category (15 survey sites)	Cost (£)
Scrub clearance	7,027
Tree clearance	175,061
Dam installation	143,925
Total	326,012
Cost per hectare	1,158

The estimates of restoration capital costs are based on the following assumptions:

1. Open scrub is equivalent to 'light scrub' under the SSBS and SRDP. The clearance and treatment cost per hectare is an average of the SSBS and SRDP figures (£525/ha).
2. Closed scrub is equivalent to 'intermediate scrub' under the SSBS and SRDP. The clearance and treatment cost per hectare is an average of the SSBS and SRDP figures (£900/ha).
3. Removal of cut material is only required for closed scrub, cut open scrub is left on site (£1,050/ha).
4. The cost per hectare of clearing closed canopy conifers is an average of Forsinard and Lake Vyrnwy figures (£2,050/ha). The cost of control of regeneration up to five years post-felling is based on Forsinard figures (£380/ha in total).
5. The clearance of open conifer woodland is equivalent to 'felling to waste of young/low yielding conifers' from the Lake Vyrnwy project and 'shear to waste of small to medium lodgepole pine/sitka spruce trees' from the Forsinard project. The clearance cost per hectare value used is an average of the figures from these two projects (£744/ha).
6. The income generated from the timber produced by closed conifer plantation clearance assumes a timber yield of 120-140 tonnes per hectare and income of £1,000-£2,400 per hectare (based on the Forsinard project). The lower value from the income range is used (£1,000/ha).
7. The cost of clearance and control of regeneration of closed canopy and open canopy broadleaved and mixed woodland is equivalent to the costs associated with the clearance of closed and open canopy conifer plantations (no past project or grant-aided costs specific to clearing broadleaved or mixed woodland from peatland sites are available).
8. The income generated from the timber produced by closed canopy broadleaved and mixed woodland clearance is zero.
9. Narrow-spaced drains are 7.5m apart on average (or equivalent density if not parallel), moderate-spaced drains are 30m apart on average, and wide-space drains are 75m apart on average.
10. The recorded drain density category is equivalent to the actual drain density (N.B. the actual drain length was not measured either in the field or from aerial photographs).

11. Installed dams are 'medium' plastic piling and (1m wide x 1m deep) as defined by the SSBP and SDRP. The cost of installing each dam is the average of the SSBP and SDRP figures (£90).
12. The gradient is equivalent to a 1m drop every 200m and a dam is installed at every 0.25m drop (therefore every 50m).
13. Conifer plantation has wide-spaced drains by default for the purposes of costing dam installation post-felling. The 2010/11 survey generally classed the furrows created by the ridge and furrow planting technique to be drains and therefore categorised the drains as narrow-spaced. However, it is assumed that only the major drainage channels are dammed in practice (for example this was the case at Longbridge Muir).
14. Sites that have dams installed are excluded from the dam installation cost calculations.

The principle capital costs that are excluded from these calculations are those associated with site livestock grazing (to inhibit scrub and tree regeneration), the realignment of perimeter drains, the provision of buffer land and the commissioning of a management plan. These costs are site-specific and the information recorded during the survey is not suitable for estimating the requirement for these capital costs.

Annual management costs are also estimated and presented in Table 5.

Table 5. Annual management costs for all 2012 survey sites.

Annual expenditure (15 sites)	Cost (£/yr)
Grazing	11,215
Monitoring and maintenance of dams	6,750
Scrub control monitoring	2,250
Total	20,215
Total (per hectare)	72

The estimate of annual management costs is based on the following assumptions:

1. Grazing is required to inhibit regeneration of scrub and trees across all areas of primary and secondary mire (including recently felled areas).
2. Annual grazing management costs are equivalent to those detailed in the SSBP (£40/yr/ha for the first 50 hectares, £10/yr/ha thereafter with a maximum cost of £3,000 per site).
3. The costs associated with the monitoring and maintenance of dams are equivalent to those detailed in the SSBP (a flat £450 per site).
4. Scrub control and monitoring costs are equivalent to those detailed in the SSBP (a flat £150 per site)

N.B. The annual management costs taken from the SSBP for 'monitoring and maintenance of dams' and for 'scrub control and monitoring' are not related to site size and are likely to significantly under-estimate the costs for larger sites.

The main annual management costs excluded from these calculations are general management costs and treatment of invasive species such as *Rhododendron*

7.2.3 Analysis of estimated costs

The calculation of the survey area and whole Scotland restoration costs are based on a large number of assumptions and there will therefore be a large potential margin of error implicit in the stated values.

In comparison to the sites surveyed during 2010 and 2011, there is some difference in the estimated restoration costs on a 'per area' basis. The current study estimates average capital costs to be £1,158/ha/yr (Table 3) against £1,281/ha/yr from the earlier study (Matthews *et al* 2012) which is a 9.6% decrease. This difference is likely to be explained by the lower proportion of woodland and scrub recorded on the current survey sites that would require, proportionately, a higher cost of removal. However, bearing in mind the lower sample size of the current survey compared to the original study (15 sites against 58 sites) and the uncertainty in some of the underlying cost assumptions, the difference in the figures is likely to be within the margin of error.

There is a larger difference in the 'per area' annual costs which are estimated to be £72 per hectare for the current survey (Table 4) against £40 per hectare for the sites surveyed during 2010/11. The difference in this case can be largely accounted for by the lower average site size in the current study compared to the earlier study (19 hectares against 70 hectares). The costs for 'monitoring and maintenance of dams' and 'scrub control monitoring' are on a 'per site' basis and so will lead to a lower 'per unit area' cost for the original sample of sites (that have a higher average site size by area) and a higher 'per unit area' cost for the current study sites (that have a lower average site size by area).

8 Conclusion

The current study aims to identify 15 additional lowland raised bog sites that have potential for restoration through the selection of sites with landowners who are sympathetic to restoration. In practice three of the sites were partially restored and these were included in the study in order to provide with advice on further restoration measures and information on current condition of the sites. Furthermore, after completion of the surveys it became clear that a further two of the surveyed sites have only a limited potential for restoration owing to their degraded nature and small size (Skiebhill Moss and Beckhall Moss).

The study also aims to add to the understanding of the current state of Scotland's lowland raised bog resource by increasing the sample size of those sites surveyed. The average size by area of the 15 surveyed sites is significantly lower than the average of all Scottish lowland raised bog sites and this helps to counter-balance the higher than average size of the sites selected for the original survey. In broad terms the main overall finding from the original survey, that Scottish lowland raised bogs are overall highly modified and degraded, is reinforced by the results of the current study.

Notwithstanding this general conclusion, and taking into account the small sample size of sites surveyed for the current study, there is some evidence that smaller sites are in slightly better condition than larger sites. For example, based on the current survey, there was a higher proportion of the survey area with primary mire and better quality vegetation, and a lower proportion of the survey area colonised by scrub and woodland. Furthermore, the peat depth data suggests that secondary areas are less deeply cut-over, on average, compared to the larger sites of the original survey.

The results from the current study also raise the question as to whether the peat depth and restoration cost calculations, extrapolated for the whole Scottish lowland raised bog resource, are still valid. With regards to restoration costs, the 'per unit area' capital costs are within 10% of the figure calculated for the sites surveyed during 2010 and 2011 and this is likely to be within the margin of error of the original calculations. In contrast, the calculated 'per unit area' annual costs are significantly higher than for the original study, but this is largely explained by the costs being inversely correlated to site size. The use of the figures from the original study to provide an extrapolation for the costs of restoration of all Scottish sites probably gave rise to an under-estimate of actual annual costs because the sites were on average larger than the average size for all Scottish sites (however this fact was noted in the original study).

The measurement of peat depth at the sites in the current study indicates that there is little change in average primary mire peat depth for smaller sites, and that there may be an increase in the average depth of secondary peat. The finding for primary mire is rather counter-intuitive because it could be assumed that the basin underlying a large raised bog would be deeper, and the dome of peat above higher, than for a smaller raised bog. The other finding indicates that average secondary mire peat depth is higher for smaller sites, which may be a result of smaller sites being less likely to be deeply cut-over on a commercial basis. In conclusion, the earlier study may have under-estimated the peat depth of secondary mire and therefore, through extrapolation, under-estimated the carbon stored in all Scottish lowland raised bogs by a fairly small extent.

9 References

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10 Appendices

Appendix I – Site area and other selected area data by site

Site name	LA location	Site area (ha)	Closed canopy woodland (ha)	Wet ground conditions (ha)	Primary mire peat depth (m)
Beckhall Moss	Dumfries and Galloway	9.1	0.0	7.8	n/a
Commonhead Moss	City of Glasgow	31.9	13.8	17.7	n/a
Corthie Moss	Aberdeenshire	51.6	0.0	38.0	230
Grangeneuk Moss	Falkirk	18.1	0.0	17.4	700
Harestone Moss	Aberdeenshire	5.2	0.0	4.0	n/a
Kennox Moss	East Ayrshire	18.5	14.9	12.4	230
Langlands Moss	South Lanarkshire	17.1	1.1	16.0	505
Moss of Rothiemay	Moray	25.5	20.2	5.2	530
Muiryfield Moss	Aberdeenshire	4.5	2.7	1.7	n/a
Portmoak Moss	Perth & Kinross	38.8	25.6	0.0	500
Redhall Moss	Dumfries and Galloway	11.5	2.5	7.0	440
Riccarton Moss	East Ayrshire	7.9	0.0	6.5	n/a
Skiehill Moss	Aberdeenshire	4.2	0.0	0.5	n/a
Toxside Moss	Midlothian	24.9	0.0	24.9	590
Woodhead Croft	Aberdeenshire	12.8	0.0	9.7	330
Total		181.6	80.8	168.8	n/a

Appendix II – Capital restoration costs by site

Site	Scrub costs (£)	Woodland costs (£)	Dam costs (£)	Total (£)
Beckhall Moss	0	0	9090	9090
Commonhead Moss	0	34888	36792	71680
Corthie Moss	0	0	13897	13897
Grangeneuk Moss	0	0	110	110
Harestone Moss	1667	0	6391	8058
Kennox Moss	0	35320	3265	38585
Langlands Moss	0	2680	18301	20981
Moss of Rothiemay	0	45298	4729	50026
Muiryfield Moss	0	7088	909	7997
Portmoak Moss	599	45189	22044	67832
Redhall Moss	403	4598	8629	13629
Riccarton Moss	0	0	4141	4141
Skiehill Moss	178	0	796	975
Toxside Moss	0	0	12433	12433
Woodhead Croft Moss	4179	0	2399	6579
Total	7027	175061	143925	326012

Appendix III – Annual management restoration costs by site

Site	Grazing cost (£/yr)	Monitoring and maintenance of dams (£/yr)	Scrub control monitoring (£/yr)	Total (£/yr)
Beckhall Moss	363	450	150	963
Commonhead Moss	1277	450	150	1877
Corthie Moss	2016	450	150	2616
Grangeneuk Moss	724	450	150	1324
Harestone Moss	210	450	150	810
Kennox Moss	740	450	150	1340
Langlands Moss	684	450	150	1284
Moss of Rothiemay	1018	450	150	1618
Muiryfield Moss	180	450	150	780
Portmoak Moss	1553	450	150	2153
Redhall Moss	462	450	150	1062
Riccarton Moss	315	450	150	915
Skiehill Moss	167	450	150	767
Toxside Moss	994	450	150	1594
Woodhead Croft Moss	513	450	150	1113
Total	11215	6750	2250	20215