BIODIVERSITY

Guidelines for Peatland Restoration

Peatlands and Uplands Biodiversity Delivery Group

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Peatland Restoration – some guidelines

1 Peatlands in Northern Ireland

The cool climate and high rainfall of Northern Ireland provide ideal conditions for the formation of peatlands, which cover around 12% of the land area. However, the extent of peatland has declined considerably in recent history whilst the quality of peatland vegetation has also been adversely affected by a range of factors. The global importance of peatlands for biodiversity and as a sink for carbon is well documented and it is widely accepted that there is a need to maintain and enhance peatland habitats as far as possible. This is being reflected in emerging planning policies such as PPS18 on renewable energy which sets a presumption against wind energy development on active peat.

Peatlands in Northern Ireland generally fall into three types – blanket bog, raised bog and fens. These habitats have different characteristics, mainly dictated by factors such as the rainfall, groundwater and bedrock in an area. They tend to have mosaics of smaller habitats within them, including open water and heather dominated areas and often also blend in to one another, forming 'transition' habitats.

These habitats, their characteristics and potential for restoration or re-creation are further explained in section 4 below.

2 Deciding whether restoration is appropriate

The first issue to be considered for any project is whether restoration is actually appropriate. The answer will depend on a number of issues that are related to the physical nature of the site, the state of the peatland prior to restoration and other factors such as cost and policy / planning requirements.

Restoration or re-creation of peatland habitat is likely to be appropriate if:

1. There is a reasonably deep peat layer at the site (eg >0.5 metre)

AND

2. Maintaining / creating a high water level is feasible.

Where these conditions are satisfied, restoration or recreation of peatland habitat should be the preferred option, especially if the site borders another peatland area. Where the development is adjacent to a peatland of conservation significance, the restored peatland could help to form an important buffer between the high value peatland and other habitats.

The one situation where it could be said that restoration of a peatland habitat is not likely to be appropriate is if there is no potential at the site for achieving and sustaining high water levels. It is important to remember that, while a site is being restored, there may be a need to provide an artificial water supply to restoration areas until a self-regulating water level can be guaranteed.

In the case of aggregate quarrying operations, it may be feasible to re-direct water taken from dewatering operations elsewhere on the site.

On sites where there is little peat remaining and limited scope for peatland restoration or re-creation, there is still potential for biodiversity gains. In such cases the creation of wetland habitats that, while not active peatland areas, may still perform an important ecological function (including some of the function of the previous peatland wetland). Such projects have been undertaken in the Lough Boora Parklands in County Offaly, for example, where a mixture of lakes and other wetlands have been created on a worked raised bog area. As the peatlands have been worked, the ground levels have lowered and the water table changed, meaning that these wetlands are now more influenced by the groundwater which, running over limestone, has resulted in more alkaline wetland areas. They are, however, still extremely rich in biodiversity.

In summary there is a sliding scale of what is feasible and appropriate at each site, depending on the condition of the site prior to restoration, ie the 'starting point' (see table 1 below). Some notes on the issues associated with different starting points are given below (English Nature 2003).

‘Start Point’ Scenario	Issues
Drained and Cut at the Edge	Edge effects can date back hundreds of years but the influence is ongoing
	Dryer woodland species colonise the dryer edges and can lead to subsequent seeding and drying further inwards,
	Management is often restricted by neighbouring land uses and does not address these impacts
Drained Across the Peat Body	Nearly always in combination with edge effects
	Often associated with agricultural improvements and tend to be *ad hoc*
	The impact of the drains will be determined by their location, size and age
	Single ditches and networks lower local water table and provide a way in for undesirable species such as birch and heather
	Ditches can be easily and effectively blocked with dams
Prepared and Part Extracted	Nearly always in combination with edge effects
	Associated drainage network is often *designed* and is more efficient than the *ad hoc* system. Deep ditches cutting through to the mineral soils are more difficult to deal with effectively and can lead to water chemistry problems
	The relative percentage of extracted area is significant
	Older style baulk and hollow cutting is much easier to restore than milled fields as compartmentalised hydrological management and availability of colonising species provides a better basis for restoration
Mechanically Extracted	Nearly always in combination with edge effects
	Extraction usually occurs over a significant timescale – with some permissions running for decades
	For peat extraction to be viable, extensive drainage networks are required
	Modern techniques involve the removal of vegetation which results in the loss of the functioning acrotelm and potential recolonising species
	The physical removal of peat leads to major functional changes in hydrological storage capacity and permeability rates
	The restoration of a functioning acrotelm on top of a previously extracted surface is arguably the most challenging objective. Manipulation of watertables to kick start bog ‘growth’ is also more challenging than the alternative of encouraging bog species via terrestrialisation (long term development of peatland from open water)

Table 1 – Restoration options and issues

Scenario		Issues
Site drained but vegetation cover and peat layers generally intact (eg ex forestry, windfarm damage)	Easier to restore peatland More likely to be similar to original habitat	Main issue is reinstatement of water table by drain blocking. Water chemistry likely to remain the same
Site to be worked for aggregate below peat – potential for peat layers to be translocated intact		Translocation of turves and peat layers is still experimental. Water control is key 'Growing' surface layer of peat (acrotelm) can be retained
Site worked for peat – significant peat left (over 50cm)	Likely to achieve different habitats to original Restoration to peatland likely to be more complex and unproven	'Growing' surface of peat (acrotelm) destroyed Lack of seed of or vegetation Need for reprofiling, reinstatement of water table and creation of new surface vegetation zone
Site worked for peat – less than 50 cm depth of peat left		All above issues plus increased likelihood of influence of groundwater / drainage. Restoration to heath or fen may be an option

3 Aims and objectives of peatland restoration

The main aim of peatland restoration considered in these guidelines is to reinstate an ecologically functioning peatland habitat for the benefit of biodiversity, although other aims can include creation of a working carbon sink, for example. This aim carries with it a number of objectives that will vary for different sites.

A worked peat excavation site for example will have no living plants on the surface, whereas a gravel quarry, having no interest in the peat layer, has the opportunity to lay turves aside or reinstate individual areas as the site is worked. The peat excavation site may have an objective of creating new surface vegetation whereas the gravel working may have an objective of re-establishing the existing turves. Either way, the overall objectives of any peatland restoration project will be:

- **To achieve a plant cover dominated by appropriate peatland species***
- **To ensure a water table near the surface that can be guaranteed in the longer term.**

* - what constitutes 'appropriate peatland species' will depend on the habitat that the project is aimed at restoring, and is discussed in section 4a.

How these objectives are met will depend on a number of different approaches and actions depending on the project and the starting point. **Therefore it is critical that a full *Restoration Plan* is put together for all projects.**

4 Making a Restoration Plan

A comprehensive Restoration Plan is needed before any peatland restoration project begins. Such a plan will include overall aims, objectives, the actions necessary to achieve them and agreed sequencing, timescales and working practices. The intention of these guidelines is not to instruct how to put such a plan together since management planning will be central to all aggregate and peatland working operations, but rather to identify issues that are particularly pertinent to peatland restoration.

Firstly, it is worth emphasising that the term 'restoration' is used in these guidelines to include everything from simple restoration of water levels through to major reinstatement or even re-creation of new habitat.

Issues that need to be considered in a Restoration Plan are set out in the different sections below.

4.1 Assessing potential for restoration and identifying intended end results

In order to understand what may be achieved in peatland restoration, it is necessary to look briefly at the physical conditions that determine different types of peatland habitat in Northern Ireland. These conditions and influencing factors are complex but some general rules have been highlighted below:

Sphagnum mosses are the key to active peat-forming systems. They require wet and (largely) acidic conditions. Some species, such as *Sphagnum subnitens* will tolerate higher pH levels and may be a transitional species suitable for early stages of peatland restoration on worked peatlands. Sphagnum mosses flourish in areas where rainfall is between 700 mm and 1000 mm and the number of rain days is between 150 and 175 per annum (Bord na Mona, 2001).

Raised bog is an 'ombrotrophic' system meaning that that its nutrients are derived from rainwater (and the habitat is therefore low in nutrients). Forming a dome, the vegetation surface is raised above the surrounding levels and so is not influenced by nutrients and minerals within the groundwater. Raised bog is typified by *Sphagnum* species, heathers and bog cotton.

Raised bogs in Northern Ireland are largely found in the lowland corridor extending from the Lough Neagh Basin north along the Bann Valley and also occur in the valleys between drumlins in Counties Down, Armagh and Fermanagh (EHS, 2004).

The nature of raised bog means that restoration is often not a feasible objective. However, reinstatement of an active lowland peatland system may give rise to a raised bog community in the very long term. Where raised bog has been damaged but not worked out (eg after forestry) restoration may be feasible.

Blanket bog occurs in Northern Ireland largely above 200m where rainfall is high (although in can also occur in more lowland areas where rainfall is high). Where iron deposits ('iron pan') in the soil impeded drainage, peat has formed in these areas to thicknesses of between 1 and 6 metres. Largely fed by rainwater, like raised bogs, blanket bogs tend to be acidic. Large areas of Northern Ireland's blanket bog are found in the north and west. The largest area of blanket bog in the east is on the Antrim plateau.

Fen is a 'minerotrophic' system meaning that its nutrients are largely derived from groundwater sources. These areas are higher in nutrients than raised bog and have a more diverse flora accordingly, often with a high proportion of sedge species. The nature of worked areas for peat or aggregates means that they usually end up lower than the surrounding land and are therefore strongly influenced by groundwater. Fen habitat is very much a viable target habitat for peatland restoration in lowland areas. Raised bog areas that have been cut for peat tend to develop into fen communities after

cutting has ceased. Many of Northern Ireland's remaining fens are located in the hollows between drumlins.

Wet heath occurs where peat depths are thinner (less than 50cm). Wet heath is often associated with other peatland habitats and may occur on the steeper slopes around blanket bog, for example where the peat may be thinner and water-logging is less permanent due to the ability for the water to run off. Where areas are free-draining, **dry heath** occurs. These habitats are dominated by heather species. As with blanket bog and raised bog, they are characteristically acid with a pH of between 3 and 5.

Other wetland habitats, including open water and wet grassland, are also important and should not be ruled out as restoration options. These may be viable options in areas where much of the peat is lost but water level control is still possible.

4.2 What was there before and what is its position in an ecological unit?

Knowledge of the nature of the site prior to being worked is one of the most important issues in determining the potential for restoration and shaping objectives. The presence of adjacent peatland habitat is also an important consideration at this stage. Answers to these questions will influence the restoration opportunities for an area:

- A worked area adjacent to existing habitat is more likely to re-vegetate from natural colonisation from the adjacent area. This has advantages from a number of perspectives including:
    - Guarantee of provenance of vegetation
    - Reduced costs associated with re-vegetating

  However, it should be noted that the changes to the area is likely to mean that the habitat may well not be the same as the unaltered adjacent area.
- Existing habitat adjacent to a worked site can provide a yardstick for target nutrient levels.
- Restoration targets for a small worked area that is part of a larger unit may only be to a single habitat type that can compliment adjacent areas. However, restoration targets for a larger, standalone worked area are likely to include a matrix of habitats / succession phases for ecological integrity.
- Existence of key species in an area may shape the restoration objectives (such as the need to link two adjoining areas where marsh fritillary butterflies occur).

- Where an excavation site is adjacent to an existing peatland, the water level within the adjacent peatland is likely to need to be stabilised to avoid impact on the area. This may be feasible using a compacted peat berm (as detailed in section 5.2.1 below)

4.3 Is there potential to set aside a peat (seed) layer? How much peat will be left at the site? What other material is available?

These are important questions. The majority of viable seeds will be found in the upper / surface layer of a peatland. Retaining this upper layer could increase potential for successful colonisation of a restored peatland. Retaining viable turves may also bring success over a shorter time period. However - the approach to retaining viable turves is still experimental and outcomes can be very uncertain. To increase the prospect of success, turves will require to be kept fully wetted, ideally within a prepared receptor area with a high and stable water level. The ability to move the turves directly from the donor site to the (appropriately prepared) restoration site should further increase likelihood of success.

The amount of peat left at a site will influence what the target habitat is likely to be. While areas with deep peat may hope to restore back to an active bog habitat, restoration of thinner peat may result in heathland. Also the lower layers of peat can be more alkaline, meaning that restoration of a site where considerable upper layers of peat have been removed could result in a fen habitat.

Within an aggregate extraction site, there are likely to be a number of different materials available for use in habitat restoration. The peatland at any site will have developed specific characteristics as a result of a number of factors, including chemical composition due to contact with subsoil material. The use of different materials may therefore have an unknown effect on the characteristics of the peat. Where material is removed as overburden the general rule is to replace it in the same sequence that it occurred. Particular attention should be given to the replacement of impermeable layers that are central to the control of water levels.

Mineral soils and silts may only be used on the outside of retaining berms so that they are not in contact with the restored peat.

4.4 What is the potential for water level control?

The formation of peatland is reliant on a high water table, whether permanent or temporary. Water level control is therefore central to restoration of peatland areas. In many, if not most, cases control of water levels will need to be achieved through artificial bunds, dams and/or sluices.

In order to achieve sustainable water level control, a restoration plan will need to identify all the possible water losses from a site both by surface and sub-surface routes. This, together with an

understanding of flow and profile should be used to plan for water control structures and working units within the restoration site.

The water level control plan should include the need to protect adjacent sites from water loss or flooding during operations. Further information on water level control is given in sections 5.1.1 and 5.2.1.

4.5 What is the potential for short, medium and long term management of the site?

All sites will need management input at a certain level in order to develop and maintain biodiversity interest. Usually the simpler projects (eg water level control systems) will require less management input. However, there is a need for commitment to long term management of any restoration site. This may be through passing the site on to a nature conservation agency or NGO or to committing and setting aside sufficient funds. Management needs of peatlands are discussed in section 6.

4.6 What is the target restoration habitat(s)?

This is not an easy question to answer and it is probably not something to get too concerned about since many of the general restoration principles are going to be the same. However, the following notes should help with this task.

For sites where there is only a small amount of restoration required, eg where a site has been damaged by drainage but a vegetation surface largely remains intact, the target should be to return the area to the same habitat that it was before.

Where the peat is all retained, including the turves (eg where the peat is removed as overburden) the target habitat should be what was there before if the right hydrological conditions can be maintained.

Where the workings will leave a layer of peat and will result in a lowering of the final vegetation surface level and bring it under the influence of groundwater, the target may be fen (depending on the chemical composition of the groundwater). Where the site is in combination with existing blanket bog / base poor bedrock, this may result in a **poor fen** or **acid flush** habitat.

Where only a thin peat layer will remain and permanent waterlogging cannot be guaranteed, the target habitat is more likely to be a heathland habitat.

For worked peat extraction sites, the situation is more complex. The size of sites and difficulties associated with starting from a complete lack of vegetation means that target habitats will depend very much on the properties of the individual site (eg with respect to potential for water

level control). However, the restoration / re-creation should always aim to provide the conditions that will allow an active accumulating peatland in the long term.

5 Restoration Guidelines

5.1 Restoration of drained peatland sites

This may apply to parts of aggregate sites, wind farm sites, ex-forestry sites, and others.

5.1.1 Reinstating water levels

For sites that have been affected simply by drainage, raising and stabilising of water levels is the main restoration work needed. Drains have an influence on water levels in peatlands up to around 15m away. The target is to block the drains in order that the water level within them can be controllably maintained at surface level.

The first action in moving towards blocking drains is to undertake a drain slope survey of the site. Taking levels of the drain water surface at 1 metre intervals will allow for the creation of drain slope profiles across the site. In general terms, the aim should be to insert a dam for each 10cm drop in level of the drain – this is intended to ensure that the water level across the site is maintained within 10cm of the bog surface in order to allow for the growth of peat forming plants (IPCC undated – available at http://www.ipcc.ie/diymandrained.html).

Dams tend to be constructed from either highly decomposed peat or plastic drain piling. The following notes on the two dam options have been taken from IPCC guidance:

Peat dams –

- Must be made from highly humidified (decomposed) fully waterlogged peat;
- The peat needs to be compacted as it is inserted into the drain;
- Peat dams tend to be between 50 and 75cm in width;
- Drains over 1 metre across will require excavator machinery;
- Care must be taken to ensure that the bog surface is not further damaged by work carried out by excavators;
- Completed peat dams should be raised 30cm above the bog surface and covered with a layer of peatland vegetation;

Plastic drain piling –

- These have been used extensively by different agencies, including on formerly afforested sites where there was no peat available for dams;
- It comes in sheets up to 3 metres long and is impermeable, light, durable and easy to transport;
- Sheets 30cm across interlock with each other by ‘tongue and groove’ and can be individually hammered vertically into a drain using a rubber mallet;

In addition to blocking drains, some sites (for example where an aggregate quarry has cut into the edge of a peatland) may need to be 'dammed' using berms (either within the site or on the periphery). The use of berms is also likely to be needed in other peatland restoration projects and covered in more detail in section 5.2.1.

Having established the infrastructure for raising and controlling water levels, it is important that a water level monitoring system is put in place to check its effectiveness. This would normally involve a system of dipwells or piezometers.

5.1.2 Clearance of invasive vegetation

As a result of lower water tables and drier surface conditions, some sites will have become invaded by tree species such as birch and possibly conifers from adjacent plantations. It is important that these species are cleared (by feeling of larger trees and pulling of smaller seedlings) until such time as the higher water levels can allow the peatland species to compete. This is likely to take a number of years.

5.2 Restoration of aggregate extraction / quarrying sites where peat is an overburden

This guidance is provided in response to the need to restore peatlands from peat overburden that has to be removed as part of a quarrying operation. Because of the need to completely remove peat from an area to access the material below, restoration of the peatland would require a complete translocation of the peat from one area to another. Such an operation brings with it many potential difficulties and uncertainties, and it has been tried in some areas with limited success. The guidance provided here, therefore, comes with a warning that much of this type of habitat restoration is untested.

Despite this, aggregate extraction does provide potential for restoration. For instance, the growing part of the habitat can be simply moved from one place to another in order to get at the aggregate lying below. This ensures that an appropriate seed source can be guaranteed. Importantly for peatlands, it also means that it may be possible to keep the *acrotelm*, the active layer of the peatland, fairly intact. This is extremely important to the success of restoration projects, since kick-starting a new *acrotelm* where it no longer exists is considered to be one of the most difficult issues to overcome. Working practices that protect the *acrotelm* should therefore always be favoured.

The notes below relate to a scenario where a peatland surface is removed in order to access an aggregate layer. The ideal situation is where restoration is undertaken in phases, with the first section of removed peat laid aside for later in order to allow successive peat areas to be translocated immediately after their removal.

5.2.1 Water level control

The ability to maintain high water levels is crucial to restoring or re-creating peatland habitats. In order to re-create a sustainable peatland system it is important to understand how the water level at the site was kept high enough to form peat in the first place. While high rainfall is likely to be the primary influence, it may also relate to impeded drainage. For example, if a layer of silt lies below the peat and above a seam of gravel that is being quarried, then this needs to be replaced after the gravel has been removed to ensure that drainage is impeded and water levels can be maintained. ***Simply replacing the peat does not necessarily re-create a viable peatland habitat***.

Use of berms

For larger projects it may be necessary to use berms to create units for water level control. This means that areas of viable habitat can be created and water level controlled, as quarrying etc progresses. Berms can be created using compacted decomposed peat. The following guidelines have been taken from the Canadian

'Peatland Restoration Guide' (Quinty and Rochefort, 2003) but are considered applicable in the Northern Ireland context.

- Use well decomposed peat whenever possible because it is more impermeable than fibrous peat.
- It is necessary to compact the peat thoroughly once it has been pushed into a mound, to ensure it is impermeable and to make it more resistant to water and wind erosion
- The presence of wood, branches or other debris in the peat can weaken the berm and lead to leaking.
- Clean peat surfaces provide a better contact between the berm and the peat surface and limit the risk of water infiltration and leaking. Scrape the surface peat and any vegetation at the location of a berm prior to building on it. One way to work is to push or move the peat into a mound and then push it back on the clean peat surface.
- It is better to build wide berms instead of high berms. They are more resistant to pressure from water bodies.
- Peat is a material that erodes easily even when it is compacted, and breakages can be common. One way to prevent the erosion of berms is to install devices to allow discharge of surplus water.
- It is important to push the peat up the slope rather than down the slope. Pushing the peat toward the bottom of the field will accentuate the existing slope while pushing peat toward the top of the slope will help create flat terraces (see Section 5.2.2).
- Mineral soils can be used on the outside of berms where it is not going to be in contact with peat (eg where a retaining berm is used on the outside of a restored bog area). Their use can help vegetate and stabilise berms in these situations.

Berms can be used in many ways, including across the slope so as to allow water level control in sections of sloping ground. They can also be used in a 'chessboard' fashion whereby they are used to form a number of discrete water control units. This can be particularly useful where a project is being undertaken over a period of time. It can also allow for access routes into a site during operations without impacting on the fragile peatland habitats.

5.2.2 Land-forming

Compaction of peat during operations will reduce its capacity to hold water. It is important, therefore that operations are scheduled to minimise movement over peat areas during both winning and placement. This is particularly important with respect to the *acrotelm* which needs water-logging in order to facilitate growth of peat forming vegetation (this is further explained in section 5.2.3).

Where restoration is being undertaken on a slope it is likely that the area may need to be split into individual discrete water control areas 'paddyfield' style. Where this is the case, it is important that mechanical land-forming works from downslope towards upslope. This will enable a level finish between the water control berms. Working down the slope is likely to accentuate the slope and make water control more difficult.

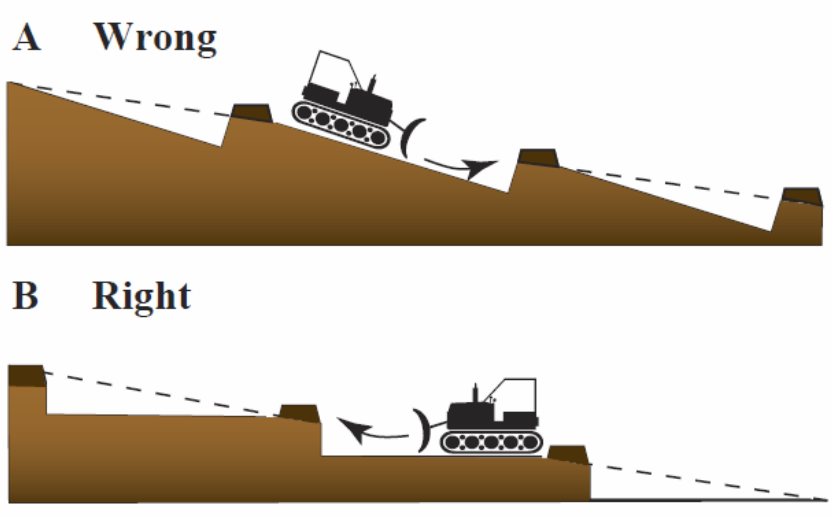

Figure 8. Diagram showing the resulting topography when berms are built by pushing peat downslope (A) or upslope (B). Pushing peat upslope results in the creation of flat terraces while pushing peat downslope accentuate the slope.

(Source – Quinty and Rochefort 2003)

When forming the new surface of the habitat it is important to note that peatlands are not completely flat. The hummocks, wet hollows and slopes are an integral part of the sites and support an important mosaic of peatland habitats. The wet hollows often support open water areas and / or high concentrations of *Sphagnum* moss while the drier hummocks may have a higher percentage of heather species for example. The south facing slopes can be important for invertebrates since they create a warm microhabitat, with direct sun at times. Bare peat can be particularly important in these areas for invertebrates (and lichens).

Variations in a finished surface will:

- Give different surface heights with respect to the water level. This, in turn, gives rise to a healthy mosaic of peatland habitats and, ultimately, a more sustainable peatland area;
- Provides protection for areas during restoration and vegetation development (large flat areas can cause problems after flood events for example where flooding and wave action affects the potential for new vegetation to take hold);
- Provide long term protection and microclimates needed by some species (such as south facing slopes for invertebrates).

5.2.3 Removing, storing and placement of peat and turves

Where there is the potential to lay aside a complete peat overburden, it makes sense to try and use that to the best advantage in habitat restoration. Ideally this would mean transporting the peat overburden, in a structured way, directly to the habitat re-creation site.

In this context it is first important to consider the functions and characteristics of the different peat layers. This will enable project managers to understand the issues that may affect the successful implementation, or otherwise, of peatland translocation projects.

Although peatlands are complex systems, it can be said that they contain two distinct layers – the *acrotelm* and the *catotelm*. The *acrotelm* is the upper, and mainly living, layer - usually the top 30-50cm of peat. This is the part where plant growth takes place since it has a varying water level and supports both aerobic and anaerobic conditions. It is essentially the peat forming part of the bog. The ability for water movement is essential to the functioning of this layer and such movement is critically affected by compaction. *Sphagnum* mosses rely on water for their growth and they are largely responsible for the creation of the *acrotelm*, which in turn regulates the water table within the bog, providing the *Sphagnum* mosses with the correct living conditions. The *catotelm* is the layer below the *acrotelm*. It is permanently waterlogged, largely anaerobic and is much more compacted than the *acrotelm*.

It is essential to understand the critical importance of a working *acrotelm* to a peatland system so that it can be accorded the appropriate attention in any habitat restoration or recreation.

The following guidelines seek to ensure that the vital *acrotelm* layer remains undamaged when being removed, stored or transported.

Note that these approaches are still experimental and there is little information available on the success of peatland 'translocation'. Monitoring of results is therefore extremely important both to inform other projects and to learn lessons so that project costs can be reduced in the future. General rules for removing, storing and placement of peat are as follows:

- Turves should be taken up ideally in autumn or winter when most plants are dormant and outside the bird breeding season (March to August). Realistically, turves are likely to be sourced during the autumn since sites are likely to become harder to work on as the winter progresses.
- Peat taken from the *acrotelm* must be protected from compaction or dessication and should be kept as intact as possible. Ideally operations should be designed so that it is moved from source point to end placement point in a single movement;
- Turves should be kept as large as feasible to increase the likelihood of a continued viable *acrotelm* (without unnecessarily increasing the compaction on other areas during transport);
- Careful consideration should be given to the placement of turves within the new, contoured area. For example seek to place turves from hollows within new hollows etc;
- If turves are being spread over a larger area than the source area, spreading them out is likely to enhance vegetation spread over bare peat areas (which may be formed using stored peat), but is also likely to increase the need for keeping water levels high through artificial means.
- *Catotelm* turves will need to be kept watered if stored for any length of time;
- Translocated *catotelm* peat needs to be protected from dessication if being stored. Avoid storage in mounds which results both in drainage of upper areas and compaction (and consequent dewatering) of lower areas.

5.2.4 Encouraging vegetation growth

A key challenge is to ensure the survival of peatland vegetation while the water table in the new area stabilises.

One project in County Durham, had limited success in encouraging vegetation growth, with a significant decline in *Sphagnum*. Intact turves had been placed into prepared receptor cells running in strips, with the intention that the vegetation would colonise areas of bare peat that had been left around the turves. It was found that this approach accelerated the colonisation of the bare peat by ling heather *Calluna vulgaris* but by few other species. The reasons for the lack of success are not known, but it seems likely that hydrological conditions were not suitable for development of *Sphagnum.*

This illustrates the need for careful design of the restoration proposal to facilitate vegetation growth. For example it may be advisable to ensure that turves are placed at the base of formed basins to ensure that they are in the wettest part of the site and have the greatest chance of maintaining species such as *Sphagnum* while the site achieves a stable water level.

Section 5.3.3 provides general advice of re-vegetating blanket bog, which is likely to be relevant to restoration projects.

5.3 Restoration of peat extraction sites

These sites are also known as cutaway bogs or milled peatlands. The restoration of peat extraction sites to viable peatland systems holds many difficulties, not least since the living vegetation component, seed bank and original peat structure are all lacking. In addition, sites have been re-profiled by the extraction process and to facilitate drainage, a process which will need to be reversed.

With no *acrotelm* and with changes to the physical properties of the peatland due to compression and decomposition, the water retention capacity of the peatland has been reduced. However, there is no major chemical difference between natural and harvested bogs unless the deep peat layer or mineral substrate is reached (Quinty and Rochefort, 2003).

There have been a significant number of projects aimed at restoring peat extraction sites, particularly in Canada and various parts of Europe. Many of the lessons learnt are likely to be relevant to the situation in Northern Ireland.

As with all such projects, the key objectives are to achieve and sustain a high water table and to reinstate a vegetation community characteristic of the peatland habitat. With peat excavation sites, the latter objective is likely to be particularly difficult since the peat surface will be devoid of vegetation and unlikely to hold any viable seed source. In such situations, the intention is to restore a working *acrotelm*. If that can be achieved, then it could be argued that a sustainable, peat-forming habitat has been restored.

5.3.1 The Canadian Approach – a successful case study

In Canada, the following approach has been taken to reinstating *Sphagnum* on cutaway peatlands. The starting point is of fairly deep acidic peat from which horticultural grade peat has been removed. This technique has achieved a rapid colonization of areas including a complete moss carpet in 4-7 years on different sites with most species colonizing the zones being typical peatland species (Boudrea and Rochefort, 2008, Quinty and Rochefort 2003). The work has been summarized by the Irish Peatland Conservation Council (IPCC) as follows (available at http://www.ipcc.ie/diymancutaway.html):

1. The surface crust of hard peat is broken up so that all plants introduced are in contact with the water level in the peat substrate. Harrowing machinery is used. Between 5 and 10cm of the surface may need to be milled depending on local conditions. In addition, excessive loose peat is removed.

2. Dome shaped harvesting fields need to be re-profiled in order to reduce drainage. Ditches need to be filled in or blocked.

3. *Sphagnum* is harvested from a donor site. The top 10cm are removed using a rotovator to first break up plant fragments and facilitate collection. This material is then

spread using a back mounted manure spreader. The recommended harvest area to spread area ratio is 1:10.

4. Straw mulch needs to be spread over the new *Sphagnum* moss area on the field surface using a blower. A minimum quantity to use is 3000kg per hectare. This represents 25 to 30 four foot bales per hectare (10 to 12 per acre). A sideward straw spreader may be used to apply the straw. The advantage of using this machine is that the machinery does not have to pass over plant fragments during straw application.

5. Fertilization is carried out once all of the previous steps are complete. A weak dose of granulated rock phosphate fertiliser is used. Use of other types of phosphorus containing fertilisers is not recommended as high doses of phosphorus promote invasive species such as birch. Nitrogen fertilisers are not required as disturbed peatlands already contain enough nitrogen to support their native flora. Rock phosphate releases just enough phosphorus over a long enough period of time to help promote the growth of species such as *Polytrichum* moss. *Polytrichum* mosses act as nurse plants that in turn promote the growth of *Sphagnum* mosses. A dose of 150kg of rock phosphate per hectare is recommended. Care should be taken however when any phosphorus containing fertilizer is used near to a watercourse so as to avoid contamination.

6. Blocking of drains is the final step in the restoration work.

Full details can be found in the Canadian Peatland Restoration Guidelines at:
http://www.peatmoss.com/pdf/Englishbook.pdf

5.3.2 Water level control – The use of berms

The use of berms in this context can help to control water levels and provide access. If there is a need to spread straw or another material such as heather brash, it provides an access into the site (the distance between berms can be designed into the project to facilitate such operations). It can also facilitate the creation of shallow hollows or basins – these can help retain water after rain events to better encourage vegetation growth.

The slightly higher berms can also protect the hollows in between by reducing the wind impact on spread mulches and also by reducing wave action in any open water areas (which can displace vegetation at early colonisation stages).

It is important to note that restoration of water levels in intensively drained and milled peatlands is never likely to be quick. The work in Canada found that it took around 10 years to achieve a stable high water table in such sites.

5.3.3 Encouraging vegetation growth

A number of papers on peatland restoration suggest that establishing vegetation on a cutaway bog is the most difficult part of habitat restoration. An ADAS guidance note (Restoration and Management of Blanket Mires, 2004) provides helpful information on re-vegetating the substrate and restoring the plant community. The ADAS guidance note itself is far more comprehensive and can be found at http://randd.defra.gov.uk/Document.aspx?Document=BD1234_2432_TRP.doc :

a) Stabilising the substrate. Bare peat needs to be stabilised to encourage seedlings to establish and persist. Peat stabilisers include:

- **Nurse crops**. These help stabilise the peat and provide a microclimate for pestland species seedlings to grow. They can include lowland species which are alien to the habitat and unlikely to hybridise with native species or persist beyond the restoration phase. They are likely to require some fertiliser input.
- **Common cottongrass** *Eriophorum angustifolium* plugs taken from donor sites. Once the peat has been stabilised, heather seed can be introduced and has a better chance of establishing successfully
- **Geojute** (a hessian jute-fibre that forms a biodegradable mesh with a high water absorption capacity) – or other geotextiles
- **Heather brash**. Careful design of the project to include berms can protect these from windblow.

b) Re-vegetating the substrate and restoring the plant community. Once the peat has been stabilised, *e.g.* with a nurse crop or common cottongrass, it may be desirable to restore some of the typical peatland species.

- Introduction of heather (*Calluna vulgaris*)

  i. Heather can be introduced in a variety of ways, as pure seed, litter or cut brash

  ii. Ideally the **seed** should be of local provenance. It should be collected when it is ripe, i.e. between October and November. To determine whether seeds are ripe, they can be examined with a hand lens - they should have turned from a pale straw to a chocolate brown colour and the capsule should easily detach from the stem.

  iii. **Heather litter** can be collected from the base of heather plants in the autumn when the pods have fallen off and seeds are ripe. It can be spread at a rate of 200gm^{-2}. It may contain seeds of other species that may or may not be desirable – consider doing a seed bank test first (details on how to do this are given in the original ADAS guidance). This option is often considered to be laborious and time-consuming.

iv. **Heather brash** collected and baled from donor sites can be spread directly onto the land or cut using a double chop harvester (this is more stable and less likely to blow away).

- **Introduction of other species**

i. Crowberry (*Empetrum nigrum*) can be successfully propagated from cuttings and transplanted to the field (mainly found in Fermanagh in NI)

ii. Bilberry (*Vaccinium myrtillus*) does not transplant effectively from turves but recent work in Wales suggests that it can be propagated from cuttings with some success

iii. Bell heather (*Erica cinerea*) and cross-leaved heath may be grown successfully from seed though cross-leaved heath may also take well from cuttings

iv. It is said, but also disputed, that crowberry, cowberry (*Vaccinium vitis-idaea*) and bilberry are difficult to establish from seed as they have to pass through the gut of a bird prior to germination.

v. Common cottongrass can be transplanted as individual shoots or using spade sized turves

vi. For all species, it is important, to collect the seeds when they are ripe, and to store them in dry, cool conditions until needed

vii. Some sources recommend that instead of trying to seed a large area, it may be preferential to seed a lot of discrete smaller areas which might then produce seed to colonise other areas

viii. The work in Canada, cited previously has had some success in re-introducing *Sphagnum*. See http://www.peatmoss.com/pdf/Englishbook.pdf for details.

6 Future management and other issues

Future management of peatland restoration sites is an important issue and one that should be considered as part of restoration plans. Some important issues are outlined below:

- Sustainable water level control is the most important part of future management of a site.
- While a site with permanently high water levels (such as active blanket bog) will not be very susceptible to invasion from scrub, a restoration site where water levels are unlikely to be stabilised for a number of years will be. In such a situation, a light grazing regime may help to keep the scrub level down. It is important not to overgraze since this can cause impacts from trampling and nutrient enrichment from dung.

  Some invertebrates actually need small areas of bare wet peat, so some localised trampling can be beneficial.
- A plan for managing invasive species, such as birch and bracken will be needed. The approach will depend on the level of the problem. Information on management options can be found in the Natural England scrub management handbook at http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductID=21718cb5-df0b-4861-acc3-b790ca97c84e . While much of this advice is transferrable to the situation in Northern Ireland, care should be taken particularly with respect to regulations governing herbicides etc.

  In general terms, scrub is likely to need to be controlled regularly (possibly annually) in the first few years of restoration. Allowing scrub 'islands' to take hold will increase the cost of scrub removal in the future and will affect the ability to keep the site wet.
- Water quality needs to be maintained. Higher nutrient levels in water entering the site, or pollution incidents, will result in changes and damage to the habitat.

7 References and useful links

7.1 References

Boudreau, S. and Rochefort,L. (2008) Plant establishment in restored peatlands: 10-years monitoring of sites restored from 1995 to 2003. In Proceedings of the 13th International Peat Congress. Available at (large file)
http://www.peatsociety.org/index.php?module=shop_view_product&id=82&product_id=81

Bord na Mona (2001) Raised Bog information leaflet. Available at
http://www.bnm.ie/files/20061124040538_raised_bogs.pdf

English Nature (2003) Proceedings from The Risley Moss Bog Restoration Workshop

EHS (2004) Northern Ireland Peatlands. Peatlands website. Available at
http://www.peatlandsni.gov.uk/formation/nipeatlnds.htm

Quinty and Rochefort, (2003) Peatland Restoration Guide. Available at
http://www.peatmoss.com/pdf/Englishbook.pdf

7.2 Links to useful information

There are many useful sources of information on this subject. Some particularly useful ones are given below:

7.2.1 Papers and documents

Natural England Upland Management Handbook
http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductID=8cc609ba-1d87-4b0b-8ca9-b1158c8a3ceb

Canadian Peatland Restoration Guide
http://www.peatmoss.com/pdf/Englishbook.pdf

Global Peatland Restoration Manual
http://www.imcg.net/docum/prm/prm.htm

Raised bog restoration to peat producing sphagnum species: an overview of European approaches
http://horticulture.cfans.umn.edu/vd/h5015/96papers/roos.htm

International Peat Congress Proceedings from Tullamore 2008 (very large but useful file)
http://www.peatsociety.org/index.php?module=shop_view_product&id=82&product_id=81

After-uses of industrial cutaway peatlands in Ireland
http://www.suoseura.fi/suo/pdf/Suo57_Renou.pdf

Upland Heathland Restoration
http://www.afterminerals.com/habitatadvise.aspx?p=Heathlands2

BOGLAND – Protocol for Sustainable Peatland Management in Ireland
http://www.ucd.ie/bogland/

Guidelines for cutover peat restoration: Insights from the EU RECIPE Project
http://www.macaulay.ac.uk/RECIPE/Microsoft%20Word%20-%20RECIPE_Guidelines_English.pdf

Proceedings from the Risley Moss bog restoration workshop
http://naturalengland.etraderstores.com/NaturalEnglandShop/product.aspx?ProductID=16824aff-9d07-4172-abb1-eb1a711d360d

7.2.2 Organisations and web sites

Northern Ireland Peatlands	http://www.peatlandsni.gov.uk/index.htm
Blanket Bog Restoration LIFE Project	http://www.irishbogrestorationproject.ie/
Raised Bog Restoration LIFE Project	http://www.raisedbogrestoration.ie/
Restoration Network Ireland	http://restorationnetworkireland.com/
Irish Bog Restoration Project	http://www.irishbogrestorationproject.ie
Irish Peatland Conservation Council	http://www.ipcc.ie/index.html
International Mire Conservation Group	http://www.imcg.net/imcgmain.htm
International Peat Society	http://www.peatsociety.org/index.php