PEATLAND RESTORATION METHODS

NOTES FROM SNOWDONIA NATIONAL PARK

1. INTRODUCTION

Peatlands are naturally wet areas that provide a unique habitat, regulate our water catchments and water quality, and perhaps most importantly, act as a large carbon store that's been built up over millennia. In their natural state, peatlands have a near-neutral carbon *flux* (the movement of carbon in and out of a system). Their productive plants and mosses take up carbon dioxide (CO_2), but their waterlogged conditions result in methane (CH_4) emissions, balancing the flux out. The fact that methane doesn't sit in the atmosphere as long as CO_2 means that actually, over a longer time scale, natural peatlands are a small carbon sink. The important aspect of peatlands however is the carbon *stock* (the amount of carbon stored in a system). This stock is built up very slowly (on average only 1mm per year) by the plants and mosses dying and not fully decomposing due to the waterlogged, oxygen-free. Because peatlands are very stable systems, this carbon can be locked away for millennia. Therefore, although peatlands only cover 3% of the world's surface, they hold nearly 30% of the soil carbon - that's more than twice the carbon stored in the world's forests!

In the past, peatlands have been cut for fuel, drained for agriculture, over-grazed, and planted with conifer plantations, draining and eroding the peat, and changing the vegetation composition. At the time, focus was on increasing productivity on these apparently unproductive peatlands, as well as increasing stock safety. However, as our understanding has grown, we've come to realise what damage these activities have done. By draining the peat, oxygen is introduced into the system and the partly decomposed plant material that makes up the peat starts to get broken down, releasing tonnes of greenhouse gases, and damaging the long-term carbon stock in the peat. Direct erosion can occur too, in the ditches themselves, from peat 'haggs' (cliffs of bare peat) left as the water table drops, or from bare peat 'pans' (areas of flat, bare peat). While some of these drainage and erosion features can be natural, there's no doubt that past activities have exacerbated these issues.

Around 75% of Welsh peatlands in a modified or damaged state, releasing an estimated 510 kilotons of greenhouse gases (measured as carbon dioxide equivalents – CO_2e) per year. To counter this loss, nearly 8.5 million tree seedlings would have to be planted and grown for 10 years! There is therefore considerable effort across Wales to restore our peatlands and put a cap on these emissions, protecting the significant carbon store held within the peat itself.

RESTORATION CATEGORIES

Peatland restoration can be classified in to three broad categories:

- **Preventing or reducing erosion** by covering flat bare peat or re-profiling peat haggs
- **Re-wetting the peat** by blocking artificial ditches and furrows (e.g. from forestry planting), stopping or slowing the flow in gullies / at the base of peat haggs, and removing conifer trees
- **Managing the vegetation** by removing conifer trees and managing grazing

Exposed and eroded sections of peat, such as peat haggs and bare peat, act as 'hot-spots' for the release of greenhouse gases, and therefore the most effective way of reducing carbon losses from a peatland is to cover

bare peat by re-profiling haggs and re-planting patches of bare peat. Re-wetting peat brings the average annual water table level to just below the peat surface. It allows the anaerobic conditions to fully re-establish in the lower soil profile and allows natural fluctuation at the surface, promoting biodiversity and helping improve water quality. Managing vegetation has diverse effects on peatlands, for example removing conifer plantations can help re-wet the peat as the trees act like straws draining the peat and furrows left over from planting can be blocked. Removal of conifer 'regeneration' (trees that have spread from nearby plantations) and managing grazing intensity and livestock type can all help restore the vegetation community and prevent further erosion or drainage, while on other sites (particularly lowland bogs), sewing seeds to increase plant diversity can help rare species like the marsh fritillary butterfly thrive.

2. PREVENTING AND REDUCING EROSION

HAGG RE-PROFILING

Haggs are erosion features caused by a range of factors including drainage of the site, peat cutting and overgrazing. They often form along the edge of large gullies but can also form complex eroding networks that were once pool systems. Peat haggs are continuously eroding due to the combined effects of freeze-thaw, wind erosion and cantilever collapse (collapsing after being undercut). Actively eroding and exposed haggs create an extremely hostile environment for vegetation, so a hagg needs to be re-profiled before the bare peat can be covered.

Figure 2.1 | A hagg at Llwytmor on the Carneddau. Haggs are overhanging, bare 'cliffs' of peat that need to be re-profiled to prevent further erosion.

HAGG RE-PROFILING ANGLES

Hagg re-profiling or stabilisation is achieved by reducing the angle of a peat hagg from overhanging or vertical to around 35°. This is done by 'rolling back' the vegetation on the top of the hagg, digging out the peat under the vegetation to create a gentler and more stable slope, and then placing the vegetation back over the bare peat (Figure 2.2, Figure 2.3). Any remaining bare peat is then re-vegetated by teasing out the turf that has been laid back down on the re-profiled hagg and, if needed, turf is collected from nearby 'borrow pits'.

Figure 2.2 | Re-profiled haggs on Llwytmor, Carneddau. An eroding hagg on the left and the same hagg re-profiled on the right.

The ideal aim of hagg stabilisation is to achieve an edge that has no more than a 33°-35° stable slope and is well vegetated. However, for haggs bordering smaller gullies (less than three metres wide or deep) or those associated with dams or baffles, steeper slopes may be necessary to avoid losing material into the central water course or damaging the peatland adjacent to the gully. Similarly, for larger haggs (greater than three metres high) a moderate slope of 45° may be necessary due to insufficient material.

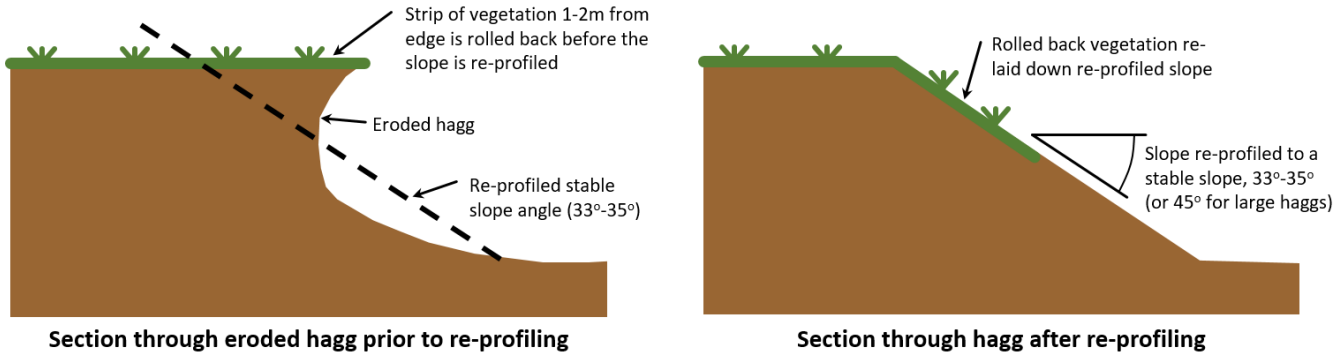

Figure 2.3 | Method for re-profiling large eroding haggs or hagged gullies. Adapted from Yorkshire Peat Partnership Technical Specification 2: Large gully and hagg stabilisation and re-vegetation.

HAGG RE-PROFILING METHOD

Some contractors prefer to use two excavators, one at the top and one at the bottom, but others prefer to work alone, working from the top first and then coming back to the bottom of a hagg. For smaller haggs it is easy to re-profile using just one excavator, and for really small or nearly 'self-healed' haggs, it may only be necessary to flatten the hagg with the bucket of an excavator.

1. A 1-2 metre length of vegetation is rolled back on the top of the hagg to a depth that retains the root structure of the vegetation. This will be rolled far enough back to enable the underlying peat to be removed and re-profiled.
2. The peat is dug out to create a stable 33° bank or a moderately stable 45° bank from the top of the hagg to the base (Figure 2.3, Figure 2.4). This will usually result in the hagg extending further out into a gully than it did before re-profiling, so baffles will be created at the base of the hagg to protect it from water flow (see "Slowing the flow in large gullies" below).
3. The vegetation will then be rolled back over the bare peat, compacted and carefully teased out to cover all of the remaining bare peat (Figure 2.3, Figure 2.4).
4. Any remaining bare peat at the base of the haggs will be covered with turf collected from borrow pits: a toothed digger bucket will be used to collect thin strips of turf and roots. The borrow pit will then be raked over at 90° to the original turf cuttings to spread the remaining turf across the borrow pit to aid recovery.

Figure 2.4 | Hagg re-profiling at a site in the Brecon Beacons. Two diggers work on the hagg – the one on the top of the hagg is laying down the turf, teasing it out and pressing it down firmly. The digger at the bottom of the hagg has just re-profiled the peat. There are also two workers with forks filling in any remaining gaps in the vegetation. Few borrow pits were used and any that were created were small and easily covered up by teasing out the vegetation (Photo: Rachel Harvey, SNPA).

COVERING FLAT BARE PEAT

Bare peat is unstable to the extent that wind, water, and livestock poaching easily result in the stripping away of peat soil to expose the mineral soil or bedrock. This eroded peat is usually washed into watercourses resulting in a significant carbon loss from the peatland. Once in the watercourse, the carbon in the peat gets broken down and may eventually get released as greenhouse gases. Peat in upland watercourses also causes problems in water quality, and can result in significant costs for water companies, and ultimately the customer, when large quantities of peat must be removed from the water. Bare peat can be caused by a range of different factors from livestock poaching and overgrazing, to drainage, peat cutting and fire.

Bare peat is usually associated with hagg systems, and thus most will be covered up by re-profiling and 'teasing out' the turf on re-profiled haggs. However, patches of bare peat may still remain that cannot be covered by turf. Instead, these areas should be covered and re-seeded using an appropriate seed mix for the site. There are a few ways to do this.

PLANT PLUGS

Cotton grass plugs or *Sphagnum* plugs can be planted directly on to bare peat. *Sphagnum* is, luckily, plentiful on Welsh peatlands, so sometimes it can be enough to leave wetter bare-peat patches to colonise naturally, perhaps with one or two helpful handfuls from nearby pools. In dryer areas cotton grass plugs are more appropriate, but care must be taken to protect these from grazers, either by fencing or by covering them with a geo-jute material. Plugs can be planted sparsely at one every 0.5m squared.

RE-SEEDING

Much like planting plugs, an appropriate seed assemblage (usually approved by NRW) can be spread across bare peat. However, they need a little more protection than the plugs so it's best to cover these with a geo-jute material or a mulch. Sometimes a 'nursery crop' can help: a collection of grasses that don't normally grow on peatlands that provide cover for the young seedlings and will die off in a couple of years once the seedlings have established.

MULCHING

By far the cheapest and most effective way of covering small areas of bare peat in an otherwise diverse peatland is to spread an appropriate mulch. A thick covering of mulch not only provides immediate and complete cover of the bare peat, but also contains seeds that will colonise the bare peat and provide a nursery for other seeds from nearby. Care must be taken to select the correct mulch, e.g. using a heather mulch on a heather-dominated peatland rather than a *Molinia* grass mulch. Ideally the mulch should come from nearby, but this isn't always possible. It is readily available after heather cutting, usually on sites managed for grouse and similar species.

3. RE-WETTING PEAT

BLOCKING DITCHES (GRIPS) AND SMALL GULLIES

Re-wetting the peatland will reduce the amount of oxygen available to microbial communities and prevent carbon loss from the long-term carbon stores. The most effective way to re-wet peatlands is to block artificial ditches using peat or other materials to completely block the ditch at several points along its length, reducing the strain on any one dam. This has the added bonus of making the ditches safer for livestock to cross, especially if the ditch sides have also been re-profiled. Many sites have a lot of artificial ditches criss-crossing the peat, and these may be in varying states of repair. Older dams can either silt up or become eroded and fast flowing, so it's always wise to check ditches on a site before considering the best way to block them.

Gullies on upland blanket bogs are often linked to larger watercourses that naturally drain the peatland. It can therefore be unwise to block gullies entirely, particularly if the gullies are large or steep. However, gully dams

can be used to great effect in small or slow-flowing gullies high up in the water catchment and baffles can be used to slow the flow in larger or faster flowing gullies.

All ditches and gullies should be treated starting from the top and working downslope to avoid damage to re-wetted peatland and to avoid damage to (or even loss of!) machinery.

It's important to note that fast flowing dams and gullies, especially those that are part of stream systems, should be treated with great care. It's unlikely that blocks or even baffles can be used effectively in fast flowing streams, especially if they are eroded down to the mineral layer. Furthermore, there is a risk of flooding an area rather than just re-wetting it – a serious risk to livestock and people alike.

CREATING A DAM

Dams can be made using several materials, but where it is available, peat is the preferred option as it can cause a tight seal and doesn't involve bringing in any external materials. Where there isn't enough peat, timber or stone can be used instead, or in the case of small gullies and ditches, heather (or other) bails can be dug into place. In the past, plastic dams were also used and were a cheaper and lighter alternative. However, it is very hard to create an effective seal with plastic dams, and with the rise of microplastics in the environment plastic is not used anymore.

With dams, it is essential to create a good seal. This is done by 'keying in' to the sides and base of the ditch or gully. The dam also needs to sit proud of the surface and (in the case of peat dams) must be covered in vegetation to avoid erosion and oxidation. Old specifications stipulated that the dam should sit well above the peat surface, but this often created pools that were too deep for *Sphagnum* growth and dangerous to livestock. Nowadays we suggest that dams create pools no more than 50cm (20 inches) deep, which may mean the dam does not come up to the top of the ditch / gully.

For both stock safety and re-wetting purposes, ditches should be re-profiled (have their sides flattened out) between the dams. This will result in wide runnels between the dams with wider pools, compared to deep, steep sided holes. This re-profiling is not usually necessary in gullies.

PEAT DAMS

(Specification from 'Moors for the Future': https://www.moorsforthefuture.org.uk/__data/assets/pdf_file/0026/87434/Peat-dams-Factsheet.pdf)

Peat dams are an impermeable block constructed from the peat itself. The key with peat dams is to use un-oxidised peat (which is impermeable if kept in this state) dug from the ditch to create a good seal. A peat dam should be watertight, so it's good practice to leave the top of the dam higher than the sides of the ditch and put in spillways to the side of the ditch to allow any overflow to escape out sideways into the peatland rather than flow over the dam. This isn't always possible however, especially in gullies (see "Considerations for blocking gullies" below), so some allowances can be made. Consideration should be made for livestock too – e.g. if cattle graze the site the dams should be sturdy enough to support their weight, and perhaps timber can be incorporated to make the dam stronger.

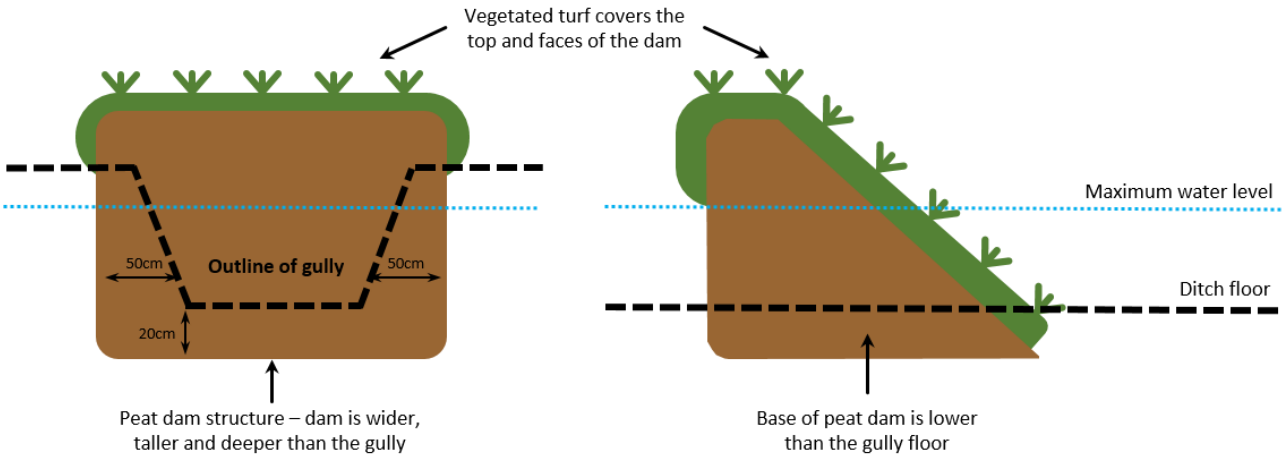

Figure 3.1 | The construction of a peat dam. Showing the front view (left) and the side view (right) of peat dam construction. The vertical edge of the dam is on the downstream side of the dam. Pictures adapted from Moors for the Future Partnership fact sheets.

1. A peat dam should be approximately twice as wide (front to back) as the original ditch / gully width, with a maximum depth of 3-4 metres. The dam will also be 'keyed in' to the edges and base of the ditch / gully by filling a space 0.5m on either side of the ditch / gully and 0.2m below the base.
2. The excavator will carefully remove the turf, underlying root layer and peat from around the ditch / gully to a width of approximately 0.5m on either side of the ditch / gully, 0.2m into the base of the ditch / gully and up to four metres upstream of the dam site (depending on the ditch / gully width).
3. Initially using the un-oxidized peat removed from the bottom of the ditch / gully upstream of the dam site, the peat will be inverted and placed within the gully slightly downstream from where it was excavated. This creates a wedge-shaped plug upon which more peat can be placed to build up the dam to the required height, leaving a pool no more than 50cm (20 inches) deep behind it (Figure 3.1).
4. If required, further peat will be placed on top of the plug from a nearby 'borrow pit' that has also had the turf carefully removed. This borrow pit will be nearby and 90° or 180° from the dam so that the excavator does not have to move.
5. The whole dam will be firmed down using the excavator bucket.
6. The turf will be replaced or spread out on the borrow pit (if one was created).
7. Shallow crescent-shaped runoff channels will be created around to the lower side of the dam to direct overflow and reduce erosion.
8. All bare peat will be re-vegetated by teasing out nearby turf edges and by firmly pressing down the turf previously set aside.

TIMBER DAMS

(Specification from 'Moors for the Future': https://www.moorsforthefuture.org.uk/__data/assets/pdf_file/0031/87529/Timber_Dams_Factsheet.pdf)

Timber dams aren't often used in Wales as Welsh peatlands tend to have enough peat to create peat dams. However, where there isn't enough peat to work with (but where there's still enough peat to key the timber into the sides and base), or where the water flow is too fast for peat dams, these can be used effectively. Due to the cost of materials, they are more expensive than peat dams, but they are easy to install. They do not however provide safe crossing places for livestock, so on a grazed site it would be worth considering installing either some peat dams or stock bridges.

Timber dams are slightly permeable gully blocks that are used both to slow the flow of water downstream, and to create pools. They are (deliberately) leaky, such that they can trap water from high rainfall events and then slowly release some or all of it (thereby making an empty space ready to trap the next rainfall event).

During this process they also trap sediment that would otherwise be lost. Slowly the sediment accumulates until it fills the pool, at which time the dam loses its water storage function but has raised the bed of the ditch / gully, which can then be recolonised by vegetation such as cotton grass or *Sphagnum*.

Dams should be no more than five or six planks high. The planks and posts must be driven into the peat sufficiently to prevent undercutting of the peat and should be keyed into the sides by at least 30cm to prevent side-cutting (see Figure 3.2 below). A splash plate of stone or timber should be positioned beneath the spillway as a baffle to prevent undercutting.

Hard or softwood may be used for the dam construction. Elm and oak are preferred for durability with western red cedar or Douglas fir used as softwood alternatives. It's best to use FSC-approved timber that is untreated (to prevent chemicals leaching into the peat or water).

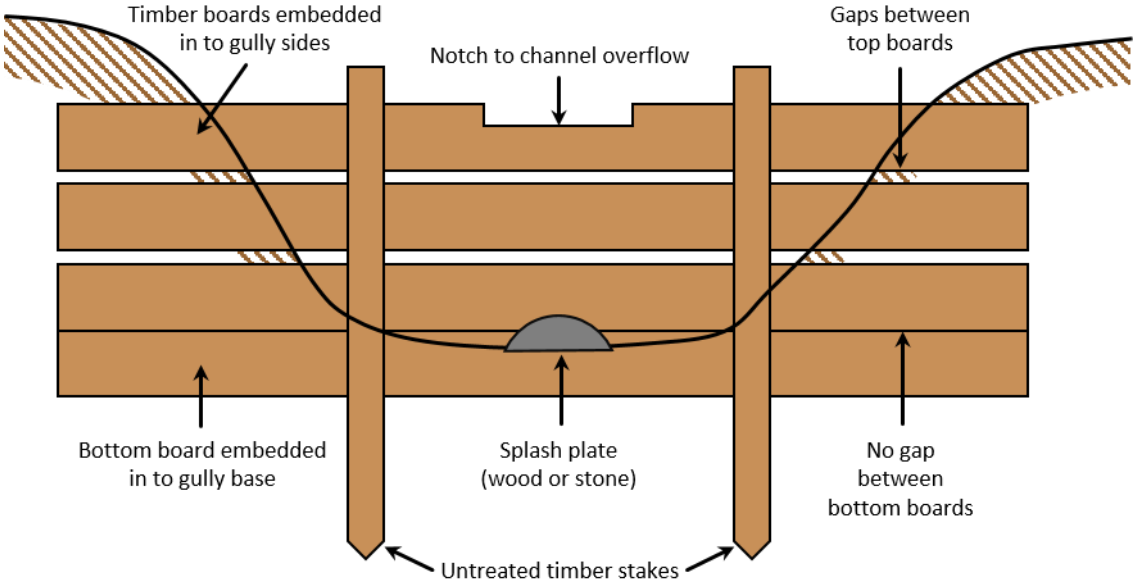

Figure 3.2 | A timber dam. Showing the front view a timber dam. Pictures adapted from Moors for the Future Partnership fact sheets.

STONE DAMS

(Specification from 'Moors for the Future': https://www.moorsforthefuture.org.uk/__data/assets/pdf_file/0031/87529/Timber_Dams_Factsheet.pdf)

Stone dams are fully permeable. They do not trap water immediately, instead slowing the flow of water and trapping sediment and eventually creating pools behind them. They are therefore primarily used for raising the level of the peatland rather than for re-wetting or creating pools. Being made of stone, they are incredibly robust, easy to cross over, and can last for a long time helping to raise the levels of deep ditches or gullies. Stone dams are similar to peat dams in shape, but do not need to be keyed into the sides or base of the ditch or gully, making them ideal for areas where the peat has eroded down to the mineral soil. However, as a helicopter is required to lift the stone into place, stone dams are usually prohibitively expensive and have not yet been used on Welsh peatlands.

OTHER MATERIALS

A variety of other materials can be used to block ditches and gullies, such as coir logs, sheep wool bails or logs, and heather (or other vegetation) bails (Figure 3.3). These are generally not as long-lasting as peat, timber or

stone, but can be used effectively in smaller runnels / early gullies, or to trap sediment in bare gullies. They are easy to install as long as there is a way to get them on to the site, and often easy for volunteers to install needing only a few spades and a lot of enthusiasm to dig them in to the edges of the gullies.

Figure 3.3 | Heather Bails. Heather bails installed at Blaen y Coed in September 2018 are still holding firm in some of the small gullies, creating small pools and re-wetting the peat (Photo: Rachel Harvey, SNPA).

DAM SPACING

To ensure the longevity of the dams, it is essential that no one dam is holding back too much water. This pressure is avoided by placing enough dams in the gully / ditch so that even a storm event will not cause the dams to fail. The exact distance between each dam will depend on the slope and the hydrological conditions, but a good rule of thumb is the average 'influence' (point to which water is held back) of each dam reaches the base of the previous dam. This reduces erosion caused by water flowing over the dam above (Figure 3.4), and also ensures that the water flow remains slow enough to avoid any dam failures. Typically, this distance is between 7-12m, and will be shorter on steeper slopes than on flat terrain.

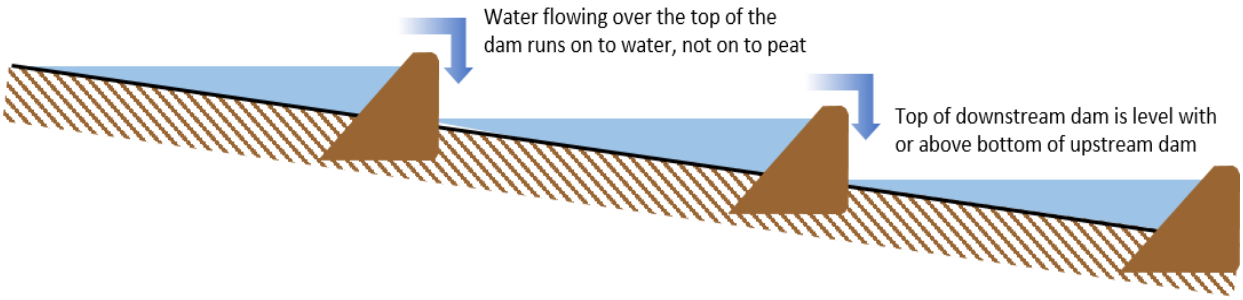

Figure 3.4 | Optimal spacing of dams. Dams should be installed using a 'top-to-toe 'principle to avoid undercutting and erosion. On average, dams should be placed every 7-12m, depending on slope, and water should fill the entire section between dams. Pictures adapted from Moors for the Future Partnership fact sheets.

CONSIDERATIONS FOR BLOCKING GULLIES

In recent years, several methods have been trialled for effectively blocking larger gullies. As gullies tend to be deeper and wider than ditches, it is often not possible to place runoff channels as the dams cannot sit above the gully edges. However, it can be difficult to block a gully completely without causing damage to the dams, as the water must go somewhere. Before considering blocking gullies, it is important to consider a few points:

1. What is the purpose of blocking this gully?

If the gully is small (less than three metres wide), it is likely that blocking it will not be any different to blocking a ditch and it is unlikely that the gully will hold very much water. Considerations need to be made for the dams if no runoffs can be built, such as creating more dams, building the dams up with timber, or allowing for leaky edges.

With larger gullies, blocks will cause larger pools. These can cause issues with access across a site and even the dams will be difficult to cross due to the amount of water held back, making the site potentially dangerous for livestock. Lots of pools or large pools can also cause spikes in methane, so may result in a net carbon loss. However, pools can be excellent for biodiversity and re-wetting a larger area of peat, so it may be a preferred method depending on the aims for the site.

2. How much water will be held back by a dam?

This is rather difficult to predict completely until the dam is made, but a tall, wide dam is going to hold back a lot more water than a short, narrow dam. Also, where there are a series of dams, each dam will hold back less water than if there was just one big dam. It's important to consider the pressure water will have on an individual dam and to carefully consider the placement of dams. Look for natural pinch points and be wary of fast flowing water.

3. If the dam is going to hold a lot of water, can the pressure on the dam be alleviated somehow?

In large gullies, low-lying but wide dams can be used effectively to slow the flow of water and create shallow but large pools (Figure 3.5). As with any ditch or gully, it is best if a series of dams can be created to take the pressure off any one dam. These long dams can be built to be deliberately leaky with water flowing gently over the top or down one side, although they must be checked regularly to make sure the dam isn't eroding too much. Alternatively, a right-angle plastic pipe can be installed into the dam to take the pressure off the dam: the top of the pipe is levelled to just below the top of the dam, so the water drains out through the pipe to the other side of the dam, rather than over the top of the dam.

Another alternative for creating a series of pools in a gully is to create a 'honeycomb' effect. This is an extension of baffles (below), so essentially each dam comes out of the gully edge at a 45-degree angle rather than straight across it. The dam meets another dam in the middle of the gully, and the dams support each other, creating a sort of 'honeycomb' effect (Figure 3.5)

Figure 3.5 | Wide gully dams **Top:** a wide 'leaky' peat dam at Blaen y Coed (Photo: Rachel Harvey, SNPA). **Middle:** a plastic pipe drainage hole installed into a dam – this right-angled pipe allows water to flow through the pipe to the bottom of the dam on the other side (Photo: Chris Holgate Contractors). **Bottom:** A gully blocked using a 'honeycomb' effect. This site is being restored with biodiversity and the bird assemblage in mind, so pools like this will be of great benefit.

SLOWING THE FLOW IN LARGE GULLIES

While it can be unwise to completely block large or fast flowing gullies, water can be slowed by creating baffles extending part way out into the centre of the gully. Placed on alternative sides, these baffles cause the water to meander down the gully, slowing the flow to re-wet the peat and trap any peat sediment. Furthermore, these baffles can be used to deflect water away from newly re-profiled haggs along gully edges, reducing the risk of erosion in years to come. This less extreme method of re-wetting the peat may be preferable to landowners concerned about livestock safety, and this method is recommended for those wanting to prioritise carbon benefits over biodiversity benefits.

Baffles are installed part way across the gully in a staggered pattern down the gully (Figure 3.6). The length of the baffle varies depending on the size of the gully, but each baffle is generally between 1 and 5 metres long. They are be angled from the side of the gully to push water to the centre of the watercourse in all but the stormiest conditions (Figure 3.6, Figure 3.7). This will create a meandering flow and a series of small pools / wetter areas which, in calmer conditions, enables sediment deposition and re-vegetation.

Where gullies join, baffles should be placed in the individual gullies before they join to reduce the flow and water pressure further downstream. Elsewhere, variation in the positioning of baffles should take advantage of the natural topography for example at pinch points, confluences, or changes in substrate. Locations of individual baffles should ideally be identified in consultation with an experienced contractor before placement. To avoid influencing natural stream flows, baffles should be concentrated at the top of the gullies and become more spread out towards the bottom.

As with dams, baffles can be made using peat, timber (Figure 3.8), stone or other materials. So far, only peat baffles have been used on Welsh peatlands.

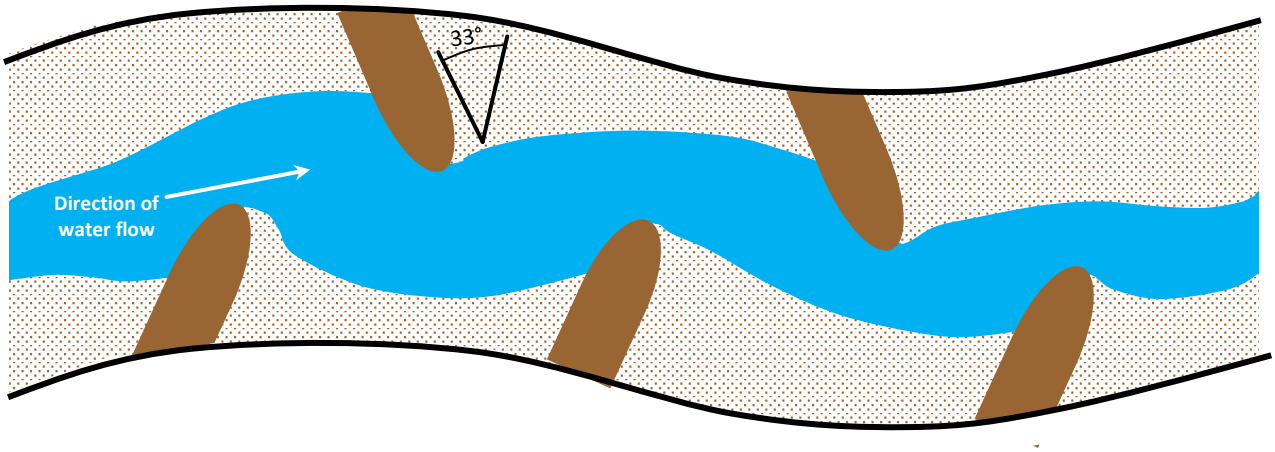

Figure 3.6 | Baffle placements down a large gully. Optimum placement will be to avoid bank erosion, thus keeping the main water flow in the centre of the gully and away from the re-profiled edges.

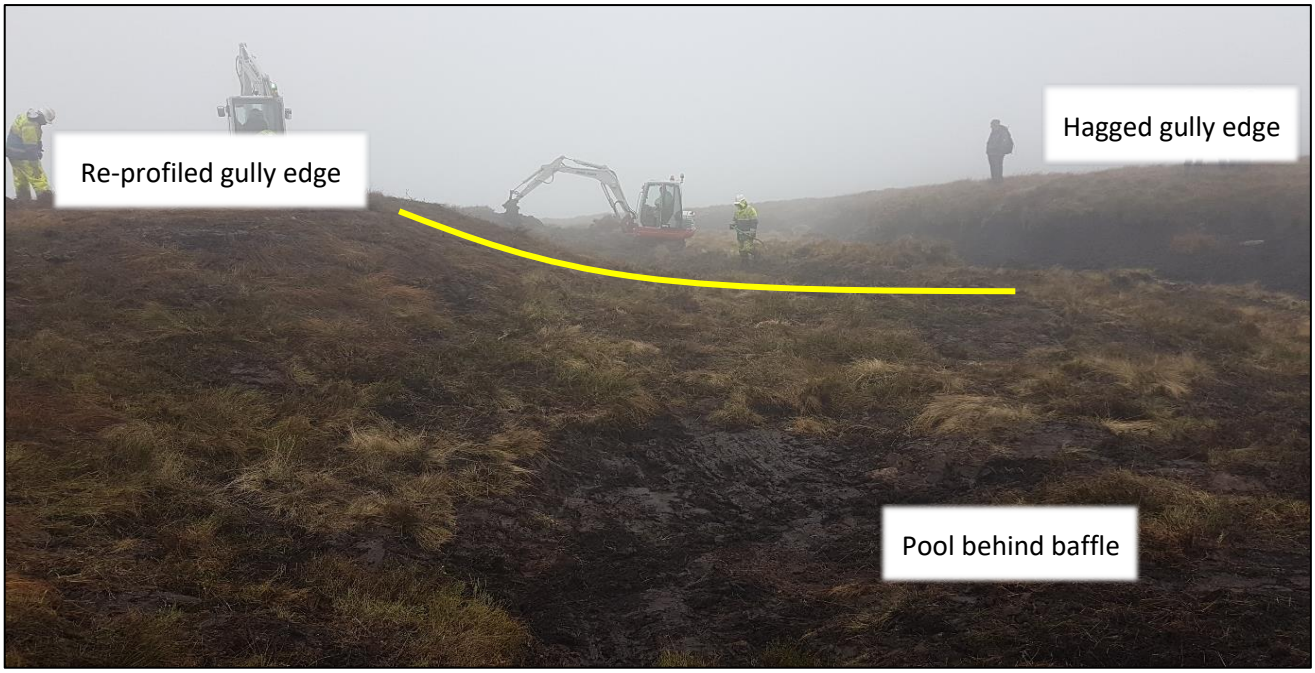

Figure 3.7 | A peat baffle in a gully. An example of a peat baffle in the Brecon Beacons (the baffle is highlighted by the yellow line). This baffle is approximately four metres long and stretches across more than half the width of the gully. A small pool (less than ten centimetres deep) has been created behind the baffle to facilitate colonisation of peat-forming vegetation such as *Sphagnum* moss.

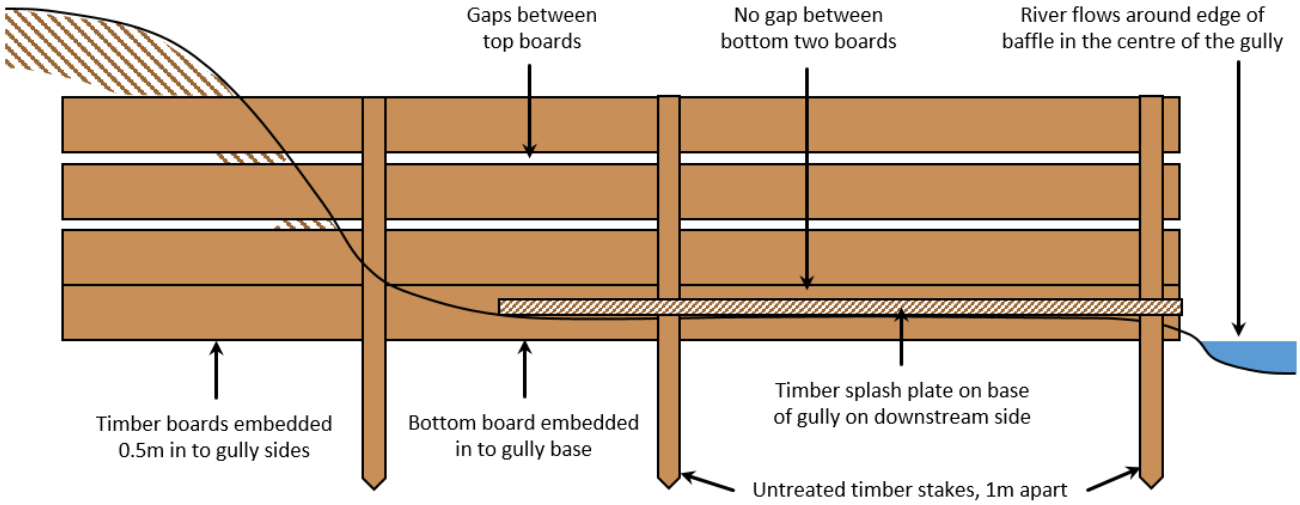

Figure 3.8 | A timber baffle. An example of a timber baffle. Diagram adapted from Moors for the Future.

4. MANAGEMENT OF VEGETATION

TREE AND SCRUB MANAGEMENT

A naturally wet peatland will not be a hospitable place for trees, except around it's edges and riverbanks (indeed, the 'wet woodland' around the edge of lowland bogs is a rare and special habitat). However, as so

many peatlands are drained, trees can all to easily encroach on to the peat and both drain the peat and impact the unique biodiversity. Furthermore, a few decades ago many peatlands were planted up in a well-meaning attempt to 'improve' the ecological and economical value of the peatlands.

Removing conifers from peat has two benefits: it helps re-wet the peat (the trees can act like straws, drying out the surface of the peat), and it helps to restore biodiversity. Many peatlands are still fully afforested, but these are old plantations and are gradually being removed by specialist contractors. Further treatment after felling may include stump grinding, stump removal or flipping, ground smoothing, and brash clearance, again requiring the expertise of specialist contractors.

A significant problem remains when plantations are located next to peatlands and wind-blown seedlings establish across the peatland. Removal of 'regenerated Sitka spruce' is a very common and ongoing management practice across many sites and can be accomplished by a contractor or landowner with the appropriate chainsaw licences and first aid certificates, or in the case of the very small trees, a good tug with a gloved hand.

Broadleaf trees are often left on a peatland if they are scattered. They are (a) harder to get rid of and (b) provide more biodiversity benefits. However, they may be removed for things like curlew protection if they provide obvious 'perching spots' for birds of prey. Where broadleaf trees begin to take over a dried-out peatland, they cause a more obvious issue in further drying out the peat. On deep-peat sites they are removed by injecting the stems with specific herbicides, using a highly targeted and selective approach that has little or no impact on the wider environment. This slightly harsher method has to be used for broadleaf trees as, unlike conifer trees, simply cutting them below the lowest branches will not kill them – they can grow back on a stump.

This same stem injection method is used for invasive shrubs like *Rhododendron ponticum*. Other scrub or dominating species like heather or *Molinia* grass is cut to improve biodiversity.

GRAZING

Peatlands are natural grazing grounds, along with salt marshes and other 'open' spaces in what would have been surrounding forests. Evidence of large grazers on these grazing grounds goes back to the ice age, and remains of the giant Irish elk have been found in peat. However, peatlands have evolved to be grazed lightly by large grazers – the best modern-day equivalent is light cattle grazing.

Historically, and particularly since the 1940s, our peatlands have been heavily grazed by sheep to try and increase productivity from the land. Headage payments (payments per head of sheep) only stopped in the early 2000's so the vegetation still hasn't recovered in many places. Coupled with around a 10-year delay in re-wetting initiatives, heathers and Molinia grasses have taken over on many sites, while others are still dominated by rough acid grasslands. Scrub control can take care of the worst cases in the short-term, but the best remedy in the long term is to adjust the grazing to a low level, and ideally switch from sheep to hardy cattle. The introduction of sustainable farming schemes such as Tir Gofal and Glas Tir have gone a long way to addressing this, but they were / are very prescriptive and don't consider the individual issues at each site. The new scheme due to come in will take more of a 'payment for outcomes' approach, which will allow landowners to find the best solutions for their own sites. Stock management is a useful tool for managing peatlands long-term after the initial re-wetting and re-vegetating, and this can be achieved through the installation of cattle grids, stock bridges and water supplies for cattle.