Bwlch Corog: 2020 Vegetation Assessment

Report to Wales Wild Land Foundation

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Wild Plants and Vegetation

Abstract

Bwlch Corog is a massif in North Ceredigion acquired in 2016 by Wales Wild Land Foundation in order to demonstrate innovative approaches to the ecological restoration of upland habitat. A 2005 vegetation survey of the area was revisited in 2017 in order to provide vegetation surveillance data. An upshot was the blocking of moorland grips on the site.

Changes to management – both the blocking of grips and the introduction of wild ponies and highland cattle to the site - dictated a further requirement for vegetation surveillance in 2020. A series of permanent quadrats was revisited and extended, but proved inconclusive in terms of detecting vegetation change. A selection of blocked grips was also examined. Most were retaining water and operations had resulted in some of the characteristic plants of blanket peat benefitting from the management in very restricted locations.

The observations are used to make further management and monitoring recommendations.

Acknowledgements

Thanks to Simon Ayres for initiating the work and to Joe Hope for accommodation and skilled assistance in the field.

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1 Introduction

Cambrian Wildwood is an initiative of Wales Wild Land Foundation. In 2017 it secured its first land acquisition, that of Bwlch Corog, a small massif in north Ceredigion.

The initiative centres on the restoration of upland habitats and species whilst offering people the opportunity to commune with the natural world in a relatively wild place. For more information see the Foundation's web-pages. The land is grassy, but lies below the theoretical natural tree-line, an altitude at which tree species would, were they present, naturally give way to low scrub and true montane habitat, thought to be around 600m in Britain (Horsfield & Thompson, undated). Because of this, the re-establishment of trees and woodland is a cornerstone of Cambrian Wildwood policy.

The Foundation initially approached Stuart Hedley in 2017 to undertake a baseline vegetation survey of the land according to the National Vegetation Classification (NVC), but existing surveys were discovered prior to work commencing, and this finding shaped subsequent vegetation study by pushing it toward surveillance. For details see Hedley (2017). This showed (i) that between 2005 and 2017 there had been further losses within already impoverished moorland vegetation as a consequence of a failure to proactively engage in site restoration; (ii) that peatland was widespread on the site and that restoration of blanket bog and wet heath should be incorporated into woodland objectives in view of the value of these habitats to wildlife and carbon sequestration.

In the summer of 2018 a herd of Konik horses was established on Bwlch Corog, and in the summer of 2019 grip-blocking took place in order to re-wet the peat and create conditions favourable to the re-establishment of blanket bog species. These twin activities are perceived as core planks in the restoration of moorland vegetation, and after a year it was deemed desirable to see if they had had any effect.

The site's vegetation is being monitored in a number of ways, comprising at the time of writing the informal use of aerial photography, referenced fixed-point photography, and through use of a series of 'permanent' quadrats (PQs). The PQs have essentially been bequeathed to the project by the earlier NVC survey in 2005, when they had been recorded not with the intention of monitoring, but as reference samples with which to diagnose the NVC type at that time. As such they were not actually permanently marked, but because they had been accurately GPS-referenced, they offered an opportunity for use as a baseline from which to monitor change. Although accurate relocation of the quadrats is in fact very unlikely in the absence of a permanent marker because of the vagaries of typical GPS devices, the magnitude of change across the twelve-year period 2005-2017 essentially over-rode this and allowed deductions about vegetation change to be made. The PQs were therefore the obvious choice to use again in an investigation of change across the three-year period 2017-2020.

Fieldwork took place on 9 and 10 September 2020. English plant names in the text follow Dony et Al (1986), Latin names of vascular plants follow Stace (2019), and those of mosses and liverworts follow Atherton et Al (2010). In the main text, both English and Latin are given at first usage, thereafter Latin only.

2 Method

2.1 Permanent quadrats

The GPS references of the PQs are given at the head of Appendix 1. For their location on an aerial see Hedley (2017).

Points were located with a Garmin Etrex 10 hand-held GPS by use of the 'find waypoint' function. Given the difficulties imposed by variable satellite reception and the physical problems of moving over much of the very hummocky ground at Bwlch Corog, the following procedure was used. As distance to the waypoint fell to c 15 m, pace was slackened and particular attention paid to the bearing arrow and conditions underfoot so that a steady, uninterrupted and straight path could be walked toward it. Attention was then placed on the 'distance to point' reading, following as it fell. As soon as a zero reading was given a temporary marker was dropped to register the point. Where a zero reading was hard to obtain, the vicinity was vacated to a distance of c 10 m in order to work back to the waypoint for a second or third time. Following a zero reading there was a short wait to allow the reading to stabilize.

Quadrat samples taken at the GPS reference are 2 x 2m, following 2005 (and 2017) practice. No reference was made in the 2005 reports about whether the grid-reference equated to the centre of this square or to one corner of it, but to reflect typical practice and reduce potential error this was taken to mean the centre. Once the GPS reference was located therefore, an actual quadrat of this size of string and corner pegs was pegged out around this point, and with its western side aligned to due north using a compass.

Once established, all species of lichen, moss and higher plant were recorded within the quadrat using the DOMIN scale (Appendix 2). This is a cover scale with blocked cover values structured around readily-appraised fractions of the quadrat, such as one third to one half, or one half to three-quarters, which is more practical and reliable than estimating % cover.

Up to 15 minutes were taken to comb through dense vegetation searching for small and etiolated specimens at ground level. Some other variables were recorded, including dung. This was measured by estimating volume in cm^3, as per the 2005 survey.

In order to gain further information in species poor vegetation, species additional to those in the quadrat were also recorded where they fell up to 10 m outside.

2.2 Surveillance of Blocked Grips (Pool Surveillance)

Blocked grips were a new feature on the hill in 2020. The technique deployed involves the removal of peat turves from either side of the grip with an excavator bucket attachment on a tracked vehicle, and their subsequent use to dam the grip downstream by placing them into the grip channel then tamping them down. This results in a series of roughly circular depressions which fill with water, and which will display a tangibly stepped profile where the profile of the original grip is steep. As there had been no opportunity to take a pre-blocking baseline, it was decided to make a simple survey of a sample of the resultant pools ('pool survey'). All or most of the pools on a non-randomly chosen sample of eight grips were thus censused for substrate (peat or mineral), whether they still retained water or not, and the presence of certain key indicator plant species, sometimes coupled

with an assessment of abundance. For the latter, the pool was defined as the entire circular depression created, including both standing water and the fringing belt of bare damp peat which was present in almost all instances. Some photographs were taken. The grips in question are shown below in Fig 1.

Note there is at present no definitive map of blocked grips at Bwlch Corog. Maps in Hedley (2017) were produced from the interpretation of aerial imagery not systematically checked on the ground, and contractual maps used for the grip-blocking contractors derived from them are different. 2019 imagery on GoogleEarth differs again, bearing more resemblance to the 2017 maps and showing that far more dams were needed to accomplish the aims than were envisaged in the contractor's documentation. The grips evident from this imagery are shown below in Fig 1, but note that the map is incomplete as the aerials were taken prior to completion of the work. A definitive map will probably be useful in the future, but it is perhaps best to wait for new satellite imagery to inform this.

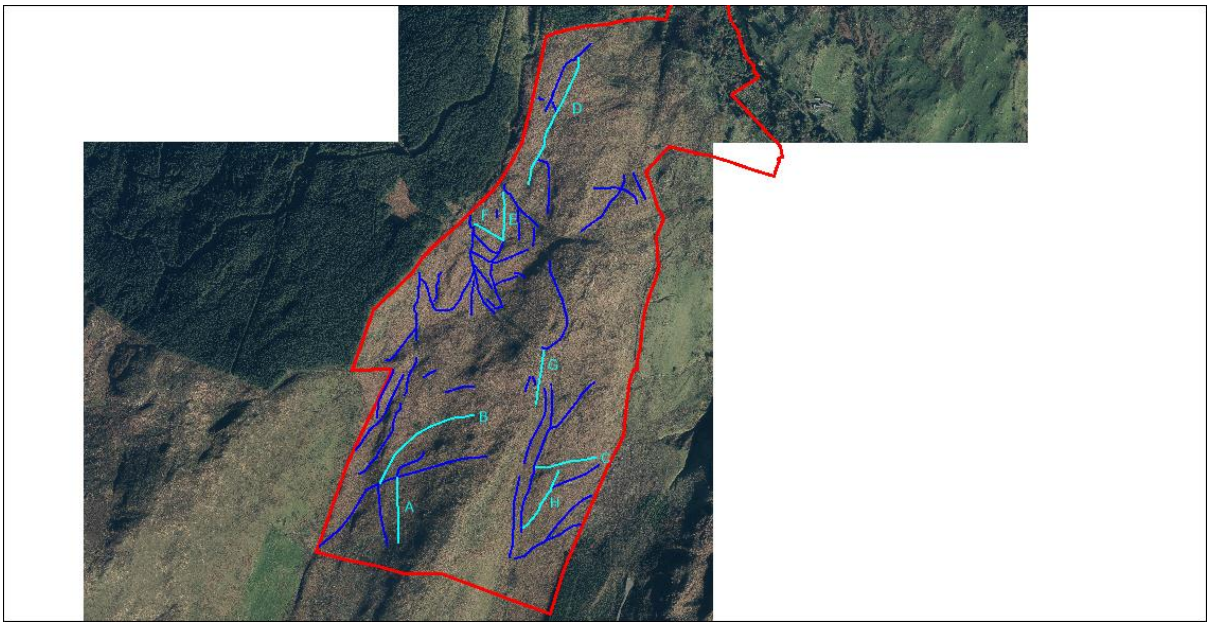

Fig 1. Blocked grips at Bwlch Corog. The full extent is not quite shown for reasons given in the text. Grips subject to a pool survey shown in light blue.

2.3 Other observations

In moving about the site other observations were made in a non-systematic manner. A request had been made in particular to establish whether grazing animals were having any beneficial or adverse effect on the vegetation.

A further two PQs were established in places deemed likely to show change in the years ahead.

3 Results

Results of the 2020 PQ recording are given in Appendix 1 and of the pool sampling in Appendix 3.

4 Discussion

4.1 Permanent Quadrats

Re-recording of the permanent quadrats in 2020 three years after their last recording in 2017 has revealed no evidence of significant change, either positive or negative. This is likely to be because insufficient time has elapsed since changes to grazing and water management were put in place. However, it has also highlighted that accurate quadrat placement is not possible under current circumstances. Marking with a system of posts and ground-level feno markers is being put in place to rectify this.

Quadrat 1 returned conspicuously lower species diversity than three years ago. This perhaps reflects further losses of species to the overwhelming dominance of *Molinia,* with those hanging on in 2017 finally giving up the ghost owing to light starvation and perhaps root competition, but could equally be due to a slight alteration of positioning this year, as with the exception of *Molinia* all the species are present as single or scattered individuals. It is perhaps most likely that both are occurring. Weathered dung (thought horse) was found in the quadrat, showing that grazing animals had had access to the area, even though at the time of survey it lay outside of an electrically-fenced enclosure.

Quadrat 2

Quadrat 3 is from one of the better relicts of blanket bog, unaffected by gripping, and as such is richer vegetation with *Molinia* less prominent than in other quadrats. The majority of species display presence and cover-values consistent with the vegetation being largely stable. However, the lower value for *Eriophorum vaginatum* and the absence of *Trichophorum* again suggest some misalignment of the quadrat, as a reduction in DOMIN value of 6 to 4 is unlikely for the former, as is 'disappearance' of the latter, especially as it was not found in the surrounding zone either; both species are perennial tussocky plants if anything likely to have benefitted from re-wetting. Larger values for *Molinia* and *Pleurozium schreberi* may reflect real increase. Horse dung was found within 2 m of the quadrat but there was no evidence of grazing or browsing damaging the vegetation.

Quadrat 4 is another blanket bog relic in which the majority of species also display presence and cover-values consistent with the vegetation being largely stable and the quadrat consistently placed. However, unlike Q3, this quadrat potentially registers changes in vegetation following grip-blocking, as it lies on the main, almost level saddle mire at the top of the site, with former grips draining both to the north and south now having been blocked. Higher values for *Sphagnum capillifolium* might be construed as a positive sign related to this, and the retention of the more exacting *S. papillosum* from the area is also welcome, though corresponding increases that might reasonably be expected in eg *Narthecium, Erica tetralix* and *Eriophorum angustifolium* are not seen in the data.

Quadrat 5. As with the previous, this quadrat potentially registers changes in vegetation following grip-blocking, lying as it does in the well-marked summit valley mire. The occurrence of *Cladonia portentosa,* a localised and conspicuous lichen, in both 2017 and 2020 suggests that the quadrat is approximately in the right area, but other values such as the inexplicable sudden rise in the *Molinia* and the heather values equally suggest minor but significant realignment. If this is the case the apparent ongoing decline of *Spahgnum papillosum* cannot be taken with any certainty.

Quadrat 6 has a fairly good correspondence between species between years with no inexplicable differences, and is probably accurately placed. The vegetation

In spite of this inconclusive picture, it can be seen that wherever *Eriophorum angustifolium* and *E. vaginatum* had been found, their cover values appear to have fallen or the species were not found at all in 2020. In contrast, wherever *Molinia caerulea* had been found (all quadrats), it increased.

4.2 Pool Surveillance

Results from the pool survey are given in Appendix 3. In total 205 pools were assessed.

4.2.1 Retention of water after one year

26 pools (13%) were dry a year after creation (Figs 2-4, Photo 1). The number is not very useful for extrapolation across the whole site as the sample was not a random one, but the deliberate selection of grips did reveal the strong correlation between exposure of the bedrock and pool failure. Excavation of turves which exposed the underlying bedrock usually failed to hold water, whereas those in which a layer of peat was retained usually held water. The soil profile was not properly studied but the retention of water in the peat pools is probably because a thin layer of impermeable clay beneath the intact peat continues to seal them and make them 'waterproof'. Typically, pools thus failed on the distal stretches of blocked drains where the gradient steepened and the underlying peats became thinner (see grips A, B, D, G). Where pools failed on deeper peat, this was because peat dams had been insufficiently tamped down into the grip, and water escaped into the next lowest pool.

In some full pools, dead or moribund *Molinia* was evident.

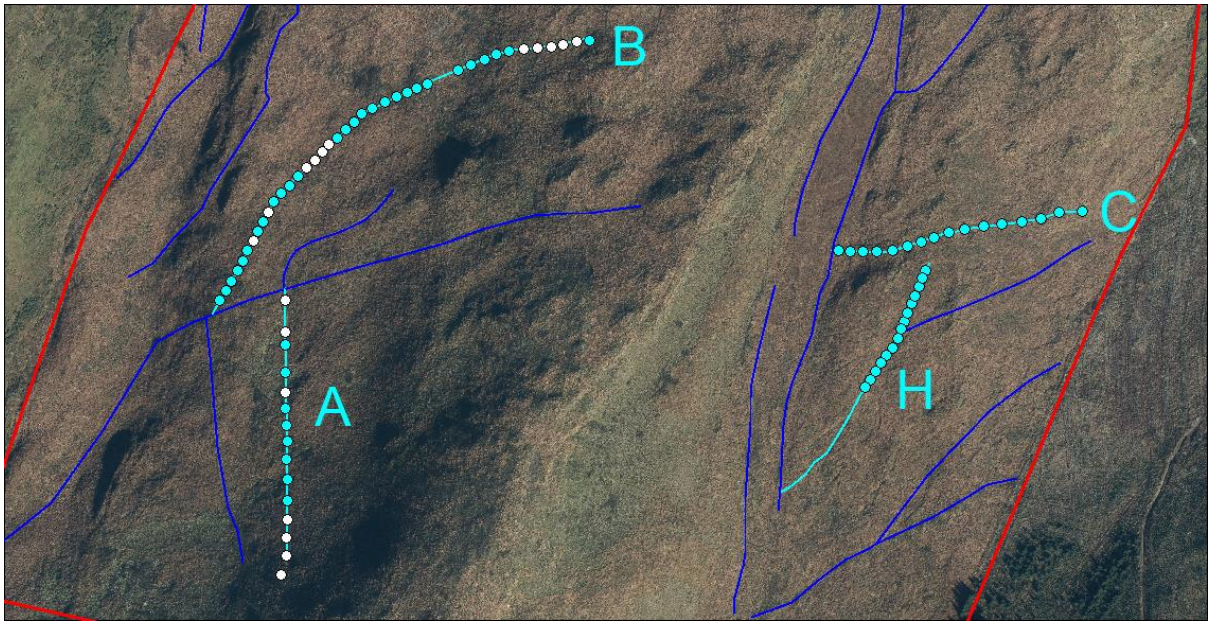

Fig 2. Pools on grips in the south of the site. The number is accurately represented, though H was incompletely surveyed. Pools coloured blue are holding water at September 2020, those coloured white have failed.

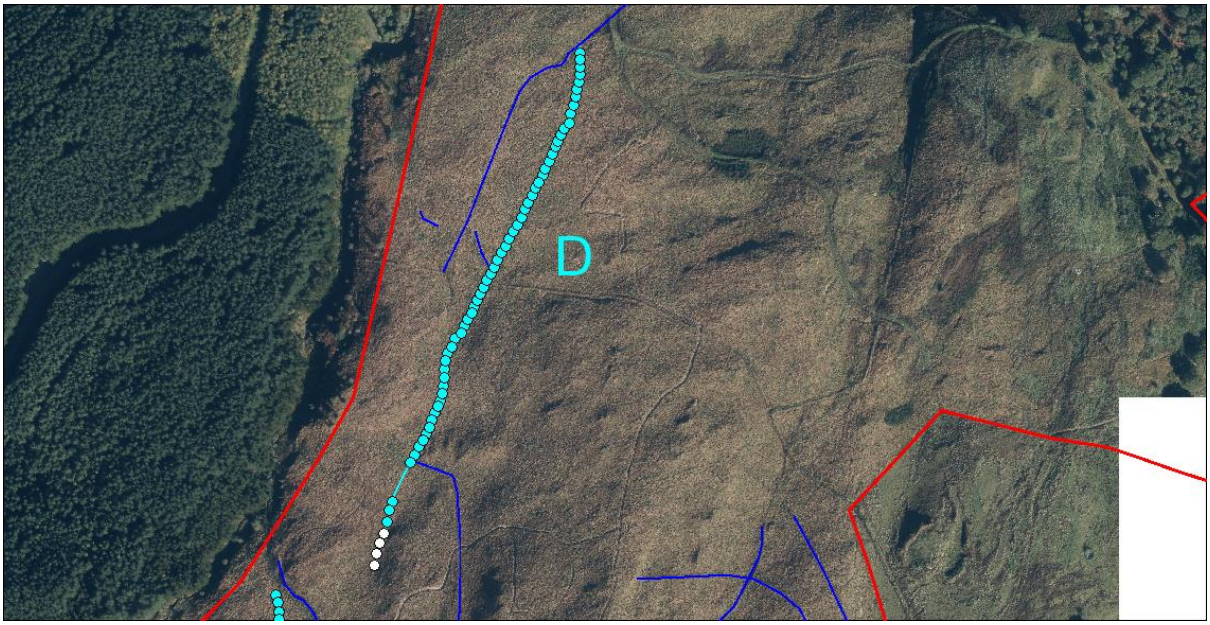

Fig 3. Pools on grip D in the north part of the site. Coding as Fig 2.

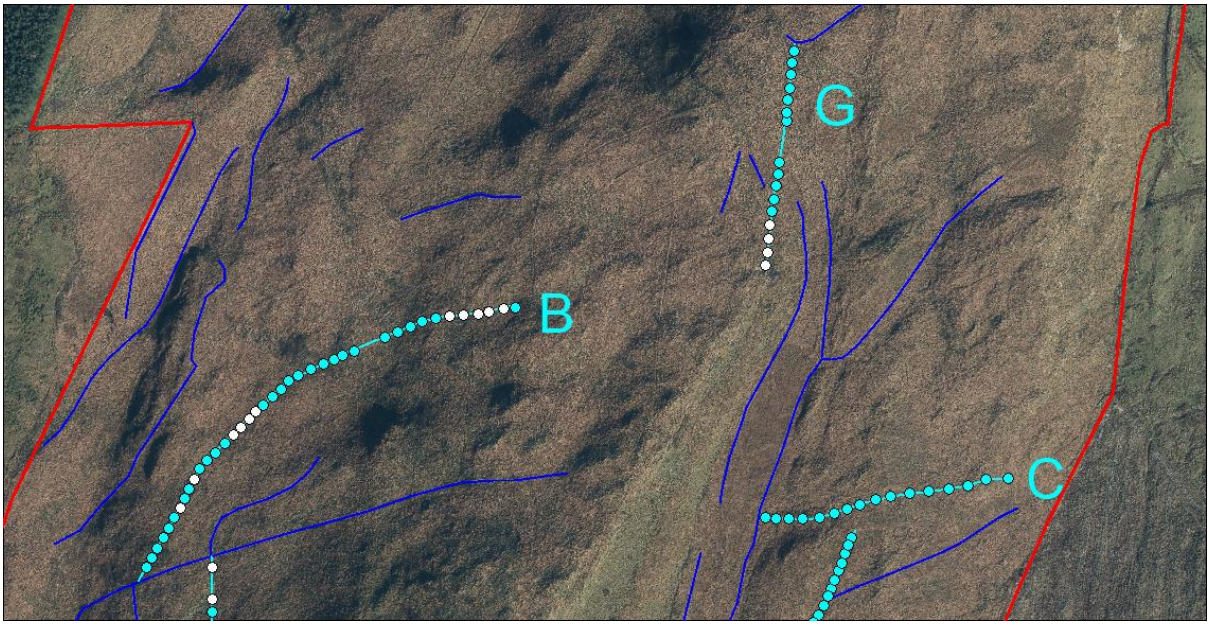

Fig 4. Pools on grips in the central part of the site. Coding as Fig 2.

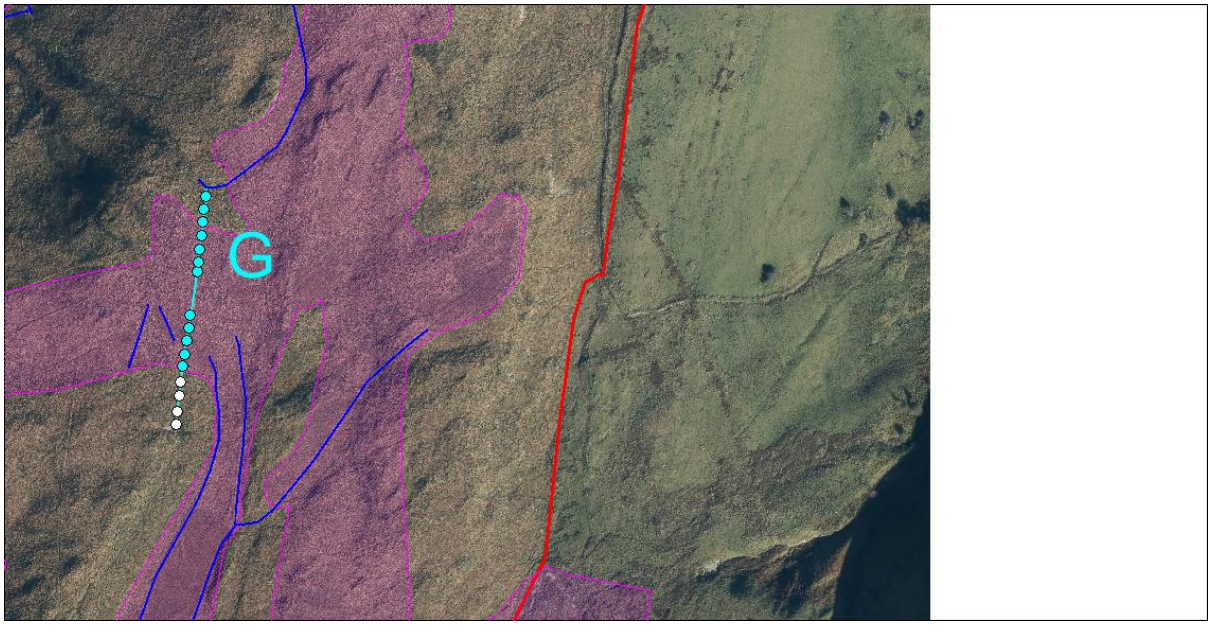

Fig 5. Grip G, showing the correlation between failed pools and peat depth. The pink hatch is areas of deep peat as mapped in 2017, probably missed in the vicinity of the northern two pools which have in fact retained their water.

4.2.2 Revegetation of pools – non-specialist species

After one year all pools had had at least some re-vegetation, but in just over a quarter (28%) this was composed only of widespread non-mire opportunists such as creeping soft-grass *Holcus mollis.* A further 9% had soft rush *Juncus effusus* in them. Though a natural component of several mire-types, *Juncus effusus* is also a widespread, relatively unspecialised and highly competitive plant which is probably increasing in the countryside in general and has invaded moorlands in the north of England following drainage in the mid 20th C (Hedley, ref) and Fig... Future management on Bwlch Corog should take potential dominance of this species into consideration.

Although it was not systematically censused, several pools contained a further mire species, star sedge *Carex echinata,* come from seed and/or rhizome fragments. This is of note as the species is a plant of poor fens, not a plant of blanket bogs in the strict sense. Poor fens are where water trickles or flows over wet peat, as opposed to places where the bog derives its moisture from rainfall alone. Its presence indicates either that there were poor fens in the area historically or, more likely, that the plant responded favourably to past drainage operations by 'climbing up' the grips from natural flushes and streamsides which they intersected. The presence of this plant, especially with species of sphagnum such as *S. fallax* and *S. palustre* alerts us to the fact that reversion to vegetation characteristic of the undamaged site may be difficult, or only attainable in parts of the remaining peat mass.

4.2.3 Revegetation of pools –specialist species of blanket bog

Discounting pools with only non-mire species or *Juncus effusus,* the remaining two-thirds of pools (63%) had begun to be recolonised by at least one desirable mire species. In many instances, this was bulbous rush *Juncus bulbosus* alone. *Juncus bulbosus* (Photo 3) is an excellent colonist of bare

peat on account of having both a strong seed bank and very good powers of vegetative spread. It is also able to cope on both peaty and mineral soils (check). However, 89 pools (43%) also contained at least one more exacting species of true bog, either sphagnum, dwarf-shrub, or another species, as shown in the table below.

	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	common cotton-grass *Eriophorum angustifolium*	bog asphodel *Narthecium ossifragum*	sphagna (any type)	Peat-builders *Sphagnum capillifolium* or possible *S. papillosum* present	sphagna present at >5% cover in pool
number of pools where present	16	18	2	1	3	83	21	11
ditto, as a % of total surveyed wet pools on peat (n = 149)	10.7	12.1	1.3	0.7	2.0	55.7	14.1	7.4

Figures 6 – 11 depict the spatial situation for sphagnum and dwarf-shrubs. Sphagnum presence unsurprisingly shows a strong correlation with mapped peat, and the high number of records (56%) shows how these plants spread very easily by plant fragmentation. Species were tentatively identified macroscopically but not removed for the microscope on account of the quantities in question. *S. fallax, S. palustre, S. denticulatum* and *S. russowii* were seen, with the peat-building specialist *S. capillifolium* also. A further peat-builder, *S. papillosum* was perhaps present in 1-2 pools. Peat builders show an especially strong correlation with mapped peat. In most cases plants occurred on the wet peat margins, but in some instances they were beginning to form small floating masses in the pools (Photos 3, 4). It is very likely these will increase in the years ahead as happens elsewhere (Hedley, 2012). This is crucial as their expansion will further slow water loss as they physically bulk up. Some 7% of the wet pools visited already have sphagnum cover in excess of 5% of the pool area, and 14% contain at least some of the peat-building specialists.

Dwarf-shrubs are more local, but very encouragingly almost all those censused appear to have arisen from buried seed (Photos 5, 6), with freedom from competition and a substrate now kept damp across a whole summer both no doubt instrumental in bringing this about. The patchy occurrence both across pools and within the individual pool may reflect a patchy seed-bed given the long period of time which has probably elapsed since dwarf-shrubs were abundant on this site. The germination from seed of Cross-leaved heath *Erica tetralix* in 12% of pools is especially encouraging; although this plant does not feature on the Wales Red List (Dines, 2008) it is threatened elsewhere in the UK and is probably especially vulnerable to nutrient nitrogen deposition (Strandberg et al., 2012).

Hare's-tail cotton-grass *Eriophorum vaginatum* was present in only two pools, where existing plants appear to have been rejuvenated by inadvertent movement by the ditch-blocking machinery into more permanently wet situations. The related common cotton-grass *E. angustifolium,* now very scarce at Bwlch Corog because of the dryness of the mire there, was found in only one pool where it may have

come from seed or rhizome fragments, but can be expected to increase in future years as it is something of a pool specialist. Bog asphodel *Nathecium ossifragum* plants had also come from seed.

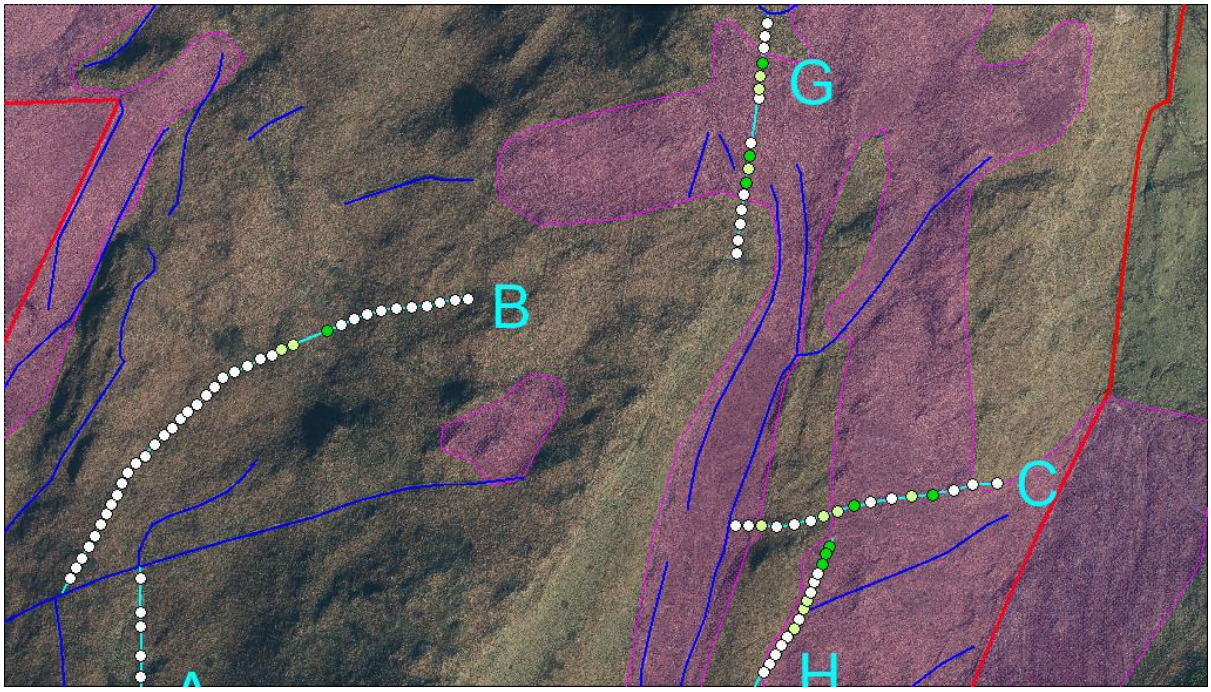

Fig 6. Surveyed grips from the south part of the site showing pools with sphagnum. Dark green symbols show pools thought to hold at least some of the major peat-building species, and light green symbols other species. Deep peat, as mapped in 2017, is shown in pink.

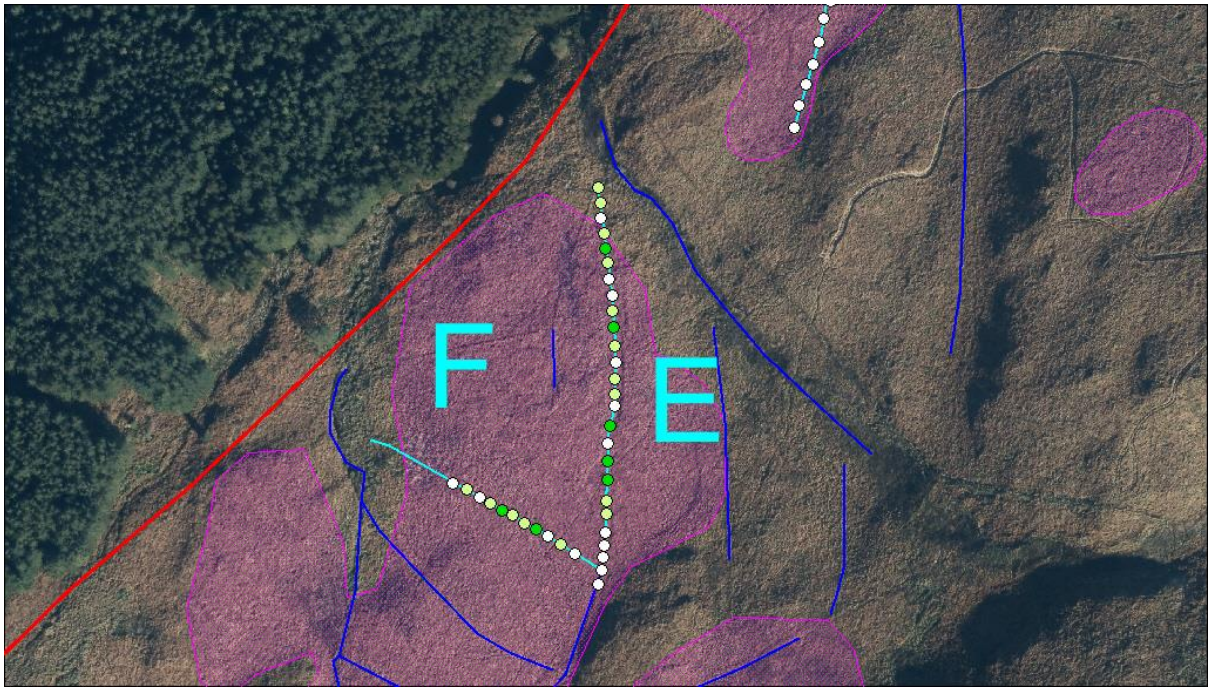

Fig 7. As Fig 6 for grips in the central part of the site.

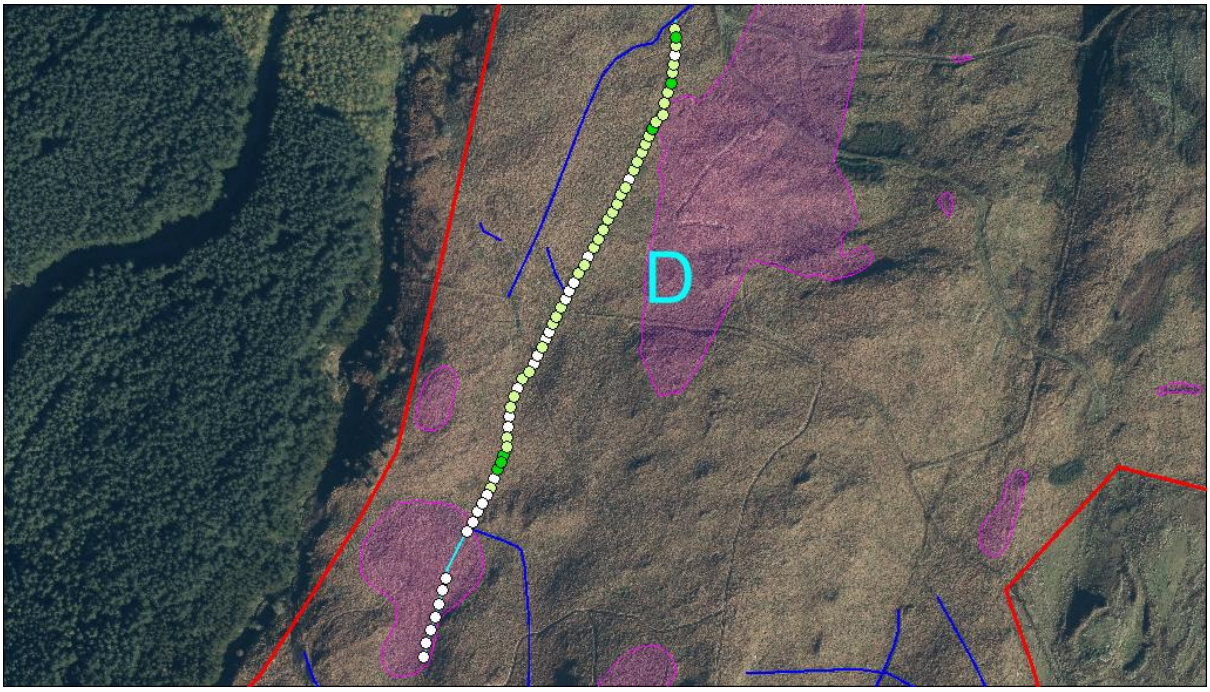

Fig 8. As Fig 6 for grip D in the north part of the site.

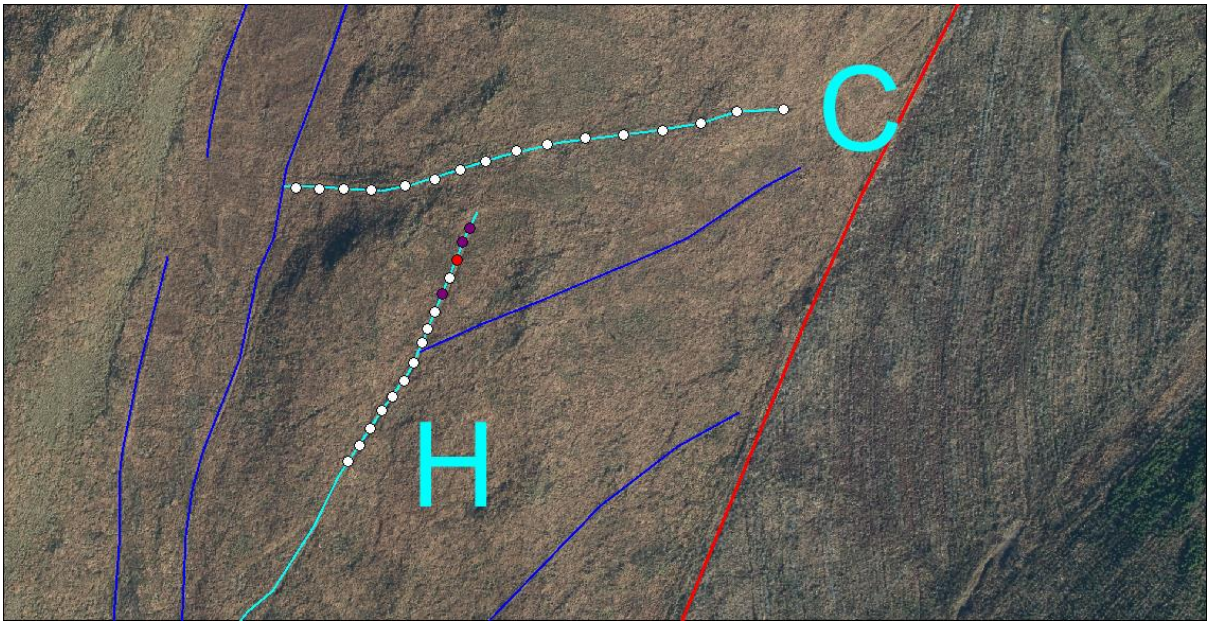

Fig 9. Surveyed grips from the south part of the site showing pools with dwarf-shrubs. Purple symbols show pools with heather, pink symbols pools with cross-leaved heath, and red symbols both species.

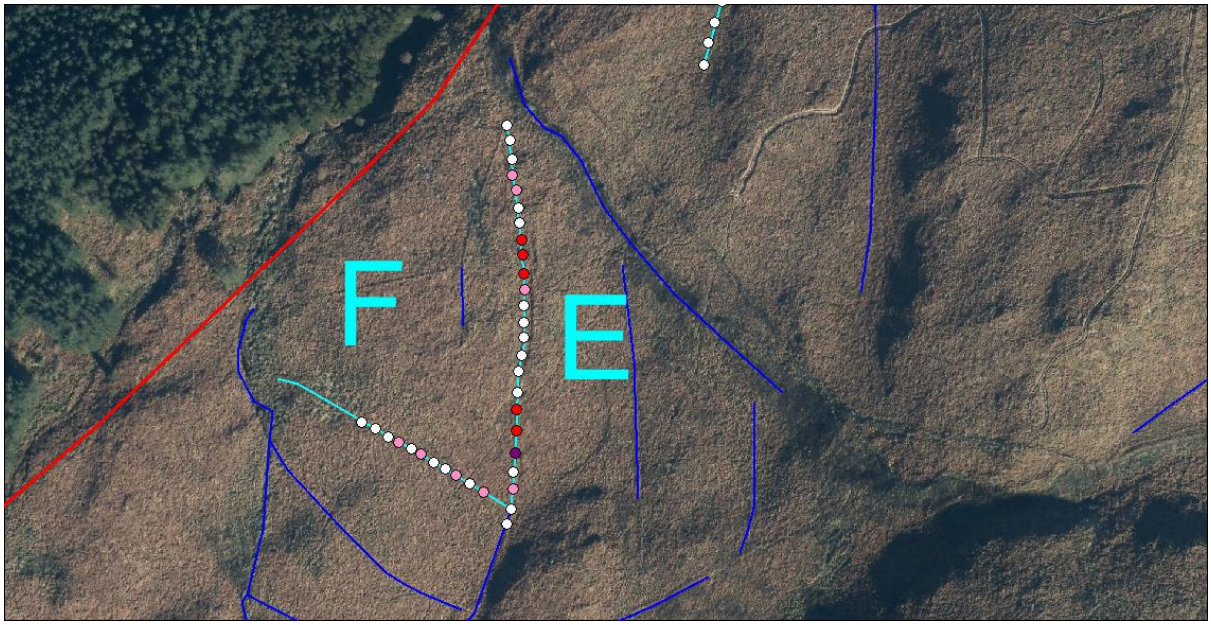

Fig 10. As Fig 9 for grips in the central part of the site.

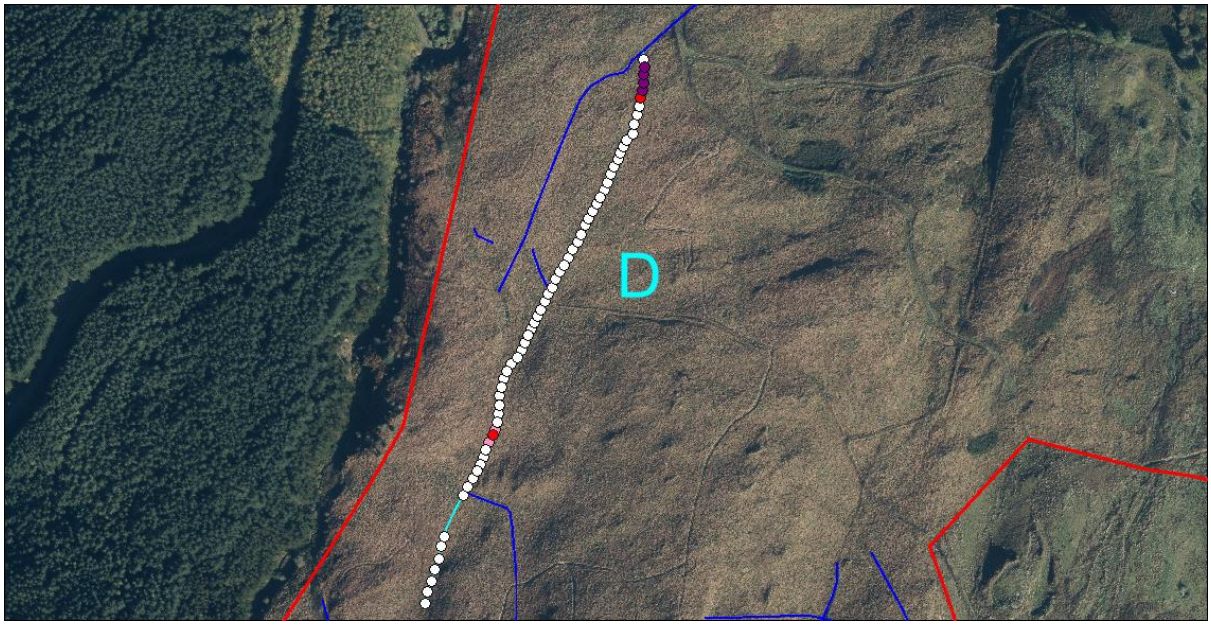

Fig 11. As Fig 9 for grip D in the north part of the site.

4.3 General Observations

In moving about the site whilst recording PQs and pools the following additional observations were made.

Although there is no way to prove this at present, many areas of the site felt wetter underfoot than they did in 2017. Standing (eg. whilst quadratting) in the flatter valley mires often resulted in water rising over the lower parts of wellingtons, in both the better quality mire relicts and in *Molinia*-dominated areas. The discovery of a few patches of cranberry *Vaccinium oxycoccus* at SN 7366 9527 (Photo 7), was a welcome find, not known to the author here to date and apparently a new tetrad record for Ceredigion. The site is perhaps the best remaining mire on Bwlch Corog. This perennial plant is unlikely to be a new colonist but it is just conceivable that it has spread a little and become more visible in response to a raised water table with the blocking of a drain of very shallow gradient which falls away to the south-west.

I concur with the opinion of key staff that there has been a vegetation shift on the drier slopes of the main Bwlch Corog ridge with shorter swards expanding their cover in response to pony and cattle grazing. I suspect this is benefitting common moorland axiophyes such as tormentil and heath bedstraw, and possibly bilberry (Photo 13). Stock linger in this area and it is not difficult to find signs of their beneficial effects on the coarse vegetation, including grazed *Molinia* and other forage and gap-creation in the turf. The vegetation shifts accomplished so far cannot be said to be of very great significance in conservation terms as the beneficiary vegetation (NVC type U4, U5 and U6) is common and widespread in the uplands. However, the shifts do represent an increase in structural diversity (Photo 8).

With one exception, there are not many signs that grazing animals are impacting on the vegetation away from the relatively clement circumstances on the main ridge. The exception is where rides through the *Molinia* have been mown for access reasons. It is not possible to disentangle the relative contributions of mowing and grazing to sward diversification in these areas, but the diversification itself, though patchy, is clear to see. There may be a higher concentration of dung in these places. Examples of sward diversification include birch regeneration from windblown seed (Photo 12), and thriving bryophyte cushions, frequently Sphagnum, benefitting from increased light (Photo 14). A common beneficiary is heath bedstraw, which adopts a procumbent form when low-sward conditions prevail, flattening its leaf-whorls to exploit the increased light and in the process becoming very conspicuous. A particularly diverse area occurs in the NE parts of the site around SN 7376 9592 where a south-trending ride branches from the long-existing track in the vicinity of a low rocky knoll and electric fencing has been erected. The combination of mowing over the shallow soils which naturally limit *Molinia*-growth and the focussed cattle grazing brought about by proximity to the electric fence has produced a diverse M25 grassland with good cover of sphagnum, dwarf-shrubs and other moorland axiophytes. However, in the main such areas still remain rare.

Relict patches of flowering heather appeared rather prominent in 2020. These are almost certainly spreading slowly on account of layering (Photo 9), though such vegetative expansion is not a meaningful way of increasing heather cover on site. Informal photo comparisons between 2017 and 2020 suggest there has been a programme of the removal of isolated conifers from the bog in recent years. There has been conspicuous tree growth (though many of the saplings are being browsed by the new livestock) and low-profile plantings of further trees were noticed in one or two places.

4.4 Management and Monitoring into the Future

The problem of *Molinia* dominance on blanket peat is widely-recognised in literature related to conservation management, catalysing a three-day conference on the matter in 2015, the proceedings of which are given in Meade (2015). Of most relevance to the situation at Bwlch Corog are the papers therein by Marrs et al. (a summary of Milligan et al. (2004)), Daggett & Perry.

4.4.1 Grazing

There is no sign that grazing is having any deleterious effects on the few areas of bog at or close to favourable condition. Equally, grazing at current levels is unlikely to make rapid inroads into *Molinia,* but the pace of change is not in fact prescribed by WWLF and it could in any case be said that at Bwlch Corog the horse really is being put before the cart. However, the presence of ponies and cattle is an advantage not available to the majority of moorland managers. Perry (2015) cites how summer grazing by cattle was significant on similar ground at Elenydd until the mid 19th C. In particular teaming strategic ride-mowing (below) with these animals may make for surprising results. Pilkington, writing in Meade (2015), acknowledges that less resource intensive methods are necessary for *Molinia* (p 186):

> *A means of controlling Molinia that involved low management and fewer resources, while being less polluting to the habitat itself and those around it, would be highly desirable*.

This is the strength of Bwlch Corog.

4.4.2 Re-wetting

Anderson (2015) summarises research on the water-relations of *Molinia* and concludes:

> *The research shows that Molinia growth is much poorer on waterlogged soils provided the water table is close to the surface (10cm maximum in depth) and the water is stagnant. The plant cannot oxygenate its root environment sufficiently in such conditions to grow vigorously. The plant in these conditions tends to have a thin canopy, poor growth and be less tussocky. However, if there is added nitrogen and or phosphorus, the Molinia can respond positively and be more vigorous, even if waterlogged. However, this effect is much greater if the water is flowing and the soils aerated, or if the water table is lower.*

The findings are echoed by Jepson (2015) in the same volume.

Grip-blocking at Bwlch Corog, even if it is too early to detect much effect of raised water-tables on the wider vegetation, is clearly a good thing which can only improve the chances of success in other management interventions. Death of *Molinia* one year on in several of the pools has already been mentioned. Here there will have been permanent and deep flooding of the plant's crown.

It is recommended that there should be periodic checks that failed sections on peat do not deteriorate, imposing strain on downstream dams, and that all functioning grips are in fact blocked.

The bare, damp peat which has arisen as a by-product of pool creation has shown that there is, at least locally, an active seed-bank of the key axiophytes heather and cross-leaved heath. This is probably sufficient – especially when taken in conjunction with the Foundation's aspirations for a wooded ecosystem – to obviate the need for the introduction of heather and other seeds considered necessary in many other cases of moorland restoration. The creation of bare ground is one of the benefits of cattle and ponies, but at present stocking levels very little of this will be taking

place and, because the seed-bank appears not to be ubiquitous, the chances of reactivating it significantly by grazing animals alone is probably small.

4.4.3 Creation of areas of bare ground on deeper peat.

It is suggested that the inadvertent creation of bare ground around the pools is followed up by the deliberate creation of larger areas with the aim of increasing diversity. These should be focussed on, but not necessarily restricted to, the deeper, more level areas of peat as blanket bog recovery is a key aim, such areas are not suitable for planting, and because the bog relicts are likely to have retained their axiophytes better than the dry, surrounding slopes. Choosing sites adjacent to those areas which showed a good indicator response within the pools might give best chance of success. It is advisable not to create bare ground immediately adjacent to areas with soft rush however, as this species is likely to exploit them successfully. Seed of this species is spread by animals but also by wind (Richards & Clapham, 1941), so siting treatment areas upwind or 3m+ away from rush beds downwind will be advantageous (see also Photo 10). Treatment patches should be small to minimise sheet erosion, perhaps of the order of 3 x 4m and ideally set within a zone of cut *Molinia* to limit recolonisation of the patch by vigorous plants. Organic shapes will be less intrusive than rectangular blocks, as practised now by some moorland managers during heather cutting (Photo 11). However, much will depend on the type of machinery available, access issues, and contractor experience.

Although turf-stripping has been used as a tool in the restoration of *Molinia*-dominated mires in the Netherlands, these are small fen sites and no precedents have been found in use on blanket mire in Britain. However, flailing, cutting the *Molinia* tussocks as close to the ground as possible with a heavy-duty blade towed by a more powerful machine, has been trialled eg. at Elenydd (Perry, 2015). Some retention of cut *Molinia* as a mulch may be advantageous in retaining moisture for developing seedlings, which is critical, though too much would seem likely to be counterproductive. Further information on flailing of *Molinia* is in Smith & Bird (2005).

Four possible areas are suggested within which new bare ground creation could be trialled. They are shown in Fig 12 below and in more detail in Appendix 4.

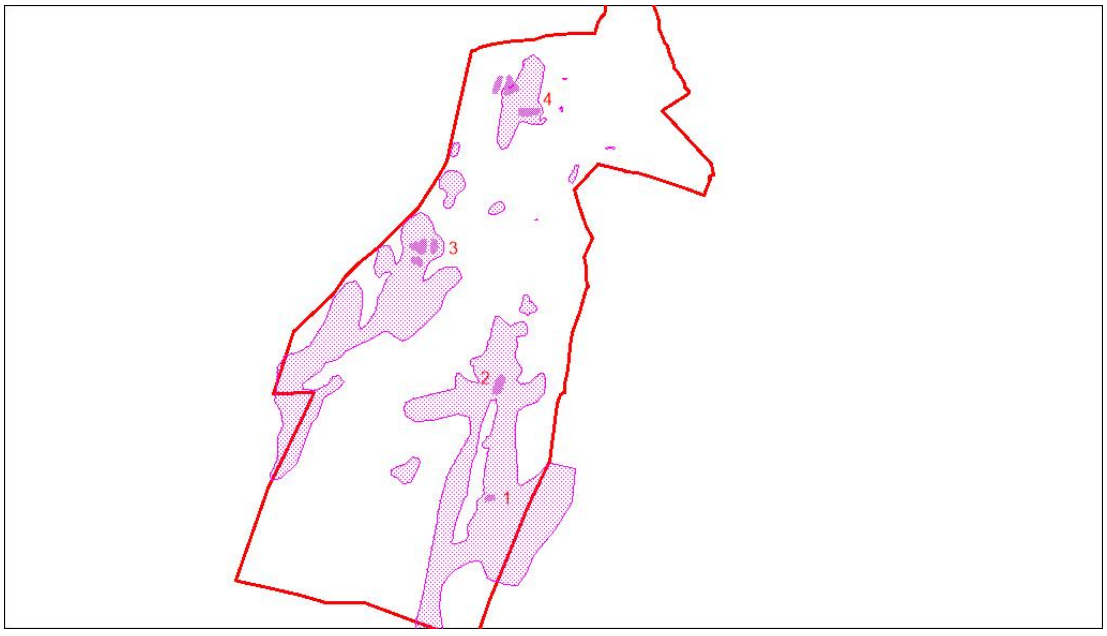

Fig 12. Possible areas in which to trial flailing

Note there is a risk grazing animals will damage dwarf-shrub seedlings (Wood, 2015). However, this paper will be talking of sheep. The effects of ponies and cattle are not known but it seems improbable they will actively select young seedlings.

4.4.4 Make permanent and extend the ride network

The cutting of rides through *Molinia* in order to facilitate access is not exactly the same as flailing but brings similar benefits – some exposure of bare ground and increased light at ground level (Photo 15). As described above, the practise (unknown) at Bwlch Corog is already having minor beneficial effects and it seems likely that this is the single best tool for increasing vegetation diversity directly and by promoting stock movement. Milligan et Al (2004) showed that a one-off 'assault' of three cuts a year (1st in winter at 25cm height, 2nd in June at 10cm, and lastly July at 5cm) coupled with grazing potentially maintain low *Molinia* cover for as long as four years and, where a heather seed-bed remains, activating it. Two cuts are less successful, and there was some evidence that a single cut could act to temporarily increase vigour. It seems likely that enhanced cutting of this sort in tandem with herbivore grazing could create avenues of higher plant diversity through the *Molinia,* the nature of the avenues themselves offering exponential benefits for moving plant propagules around the site. It is thus important to try and mow the same rides each year, adding to them if necessary and possible, rather than re-routing them. Costs of this treatment, though no doubt dated, are given in Marrs et al. (2015). Further information can be found in Perry (2015), where a single flailing was used with a heavier-duty machine.

4.4.5 Monitoring

Completion of a pool survey for all grips would be of further value in forming a baseline from which healing of the peatland could be monitored, as well as identifying those areas with a seed-bank. It should prove suitable for a student or volunteer project.

Permanently mark the PQs.

Bare ground trials should be monitored, with a baseline taken immediately after creation and sampling within them at the end of the first summer thereafter.

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6 Appendices: 6.1 PQ samples

	quadrat number	1			4			6		
	NVC type in 2005	M15d			M17a			M17a		
species		2005	2017	2020	2005	2017	2020	2005	2017	2020
Calluna vulgaris	heather	4	1	++++					+	++
Erica tetralix	cross-leaved heath	5	+++	++++	6	5	5	5	4	5
Vaccinium myrtillus	bilberry	3	2	++		+				1
Juncus squarrosus	heath rush	4								
Trichophorum germanicum	deer-grass	7	++++		6	5	6	6		
Agrostis canina	velvet bent	2								
Anthoxanthum odoratum	sweet vernal-grass	2								
Molinia caerulea	purple moor-grass	6	10	10	5	4	6	7	6	7
Nardus stricta	matgrass	2								
Narthecium ossifragum	bog asphodel	3	4	+	4	6	5	5	6	8
Potentilla erecta	tormentil	3	3	1	3	2	2			++
Dicranum scoparium	broom fork-moss	3	1	+++		1				2
Hypnum jutlandicum	heath plait-moss	6		1	5	3	2	5	2	1
Polytrichum commune	common haircap	4	2							
Racomitrium lanuginosum	woolly fringe-moss	3								
Rhytidiadelphus loreus	little shaggy-moss	2	2	++					1	
Rhytidiadelphus squarrosus	springy turf-moss	3						3	1	2
Sphagnum capillifolium	red bog-moss	2	3		4	+	2	3		2
Sphagnum papillosum	papillose bog-moss	5			6	++	++	8		
Sphagnum subnitens	lustrous bog-moss	5			3					
Sphagnum tenellum	soft bog-moss	4				3		3		
Diplophyllum albicans	white earwort	3			3					
Gymnocolea inflata	inflated notchwort	2								
Odontoschisma sphagni	bog-moss flapwort	4			5	4	4	4		
Cladonia portentosa	a reindeer lichen	1								
Eriophorum angustifolium	common cotton-grass				5	4		5		
Eriophorum vaginatum	hare's-tail cotton-grass				4	6	4	4	6	4
Drosera rotundifolia	common sundew				3	1		3		
Polygala serpyllifolia	heath milkwort					1	2	3	2	1
Sphagnum denticulatum	cow's-horn bog-moss				6					
Sphagnum fallax	flat-topped bog-moss							5	4	1
Calypogeia fissa	common pouchwort					2	1	3	1	1
Pleurozium schreberi	red-stemmed feather-moss		2	+++			2		2	
Salix cinerea	grey willow			+++						
Aulacomnium palustre										1
dung (cm^3)				220						
number of species		25	9	3	15	14	12	16	11	13

	quadrat number	2			3			5		
	NVC type in 2005	M17c			M17c			M21b		
species		2005	2017	2020	2005	2017	2020	2005	2017	2020
Calluna vulgaris	heather	3	1		4	4	4		1	4
Erica tetralix	cross-leaved heath	5	2	+++	5	4	4	5	5	5
Vaccinium myrtillus	bilberry	3	4	4	4	5	5		3	4
Juncus squarrosus	heath rush	4								
Trichophorum germanicum	deer-grass	6			7	4		3	5	4
Agrostis canina	velvet bent		4							
Anthoxanthum odoratum	sweet vernal-grass	2								
Molinia caerulea	purple moor-grass	4	9	10	6	6	8	5	4	8
Nardus stricta	matgrass	2	1							
Narthecium ossifragum	bog asphodel	2	4		3			6	4	5
Potentilla erecta	tormentil	3		1				1	2	1
Dicranum scoparium	broom fork-moss	2		2					1	2
Hypnum jutlandicum	heath plait-moss	5	2	2	5		1	4		2
Polytrichum commune	common haircap	3	2	3	4	4	4		2	
Rhytidiadelphus loreus	little shaggy-moss		1	4	3	3	2			
Sphagnum capillifolium	red bog-moss	6	1	3	5	5	4		4	4
Sphagnum papillosum	papillose bog-moss	5	2		5		++	6	5	2
Sphagnum subnitens	lustrous bog-moss	4			5			3	2	
Sphagnum tenellum	soft bog-moss	3						3	2	
Odontoschisma sphagni	bog-moss flapwort	3			3			4	3	3
Cladonia portentosa	a reindeer lichen								3	2
Eriophorum angustifolium	common cotton-grass		2		3	3		6	3	2
Eriophorum vaginatum	hare's-tail cotton-grass	5	4	+++	5	6	4		4	3
Drosera rotundifolia	common sundew							3	1	
Polygala serpyllifolia	heath milkwort							3		1
Sphagnum denticulatum	cow-horn bog-moss							3		
Sphagnum fallax	flat-topped bog-moss	4	2	2				5		
Calypogeia fissa	common pouchwort								2	
Carex echinata	star sedge	2								
Deschampsia flexuosa	wavy hair-grass	4	2	3	3	4	3			
Aulacomnium palustre	bog bead-moss	2	2				2			
Pleurozium schreberi	red-stemmed feather-moss	2	4	4	4	6	8		1	2
Lophozia ventricosa	tumid notchwort	3								
Scapania sp	an earwort	3								
Plagiothecium undulatum	waved silk-moss			1	3					
Empetrum nigrum	cowberry								2	2
Sphagnum cuspidatum	feathery bog-moss							5		
Galium saxatile	heath bedstraw			4						
Sphagnum russowii?	russow's bog-moss			+++						
Hylocomium splendens	glittering wood-moss						1			

Cladonia arbuscula	a reindeer lichen									1
Racomitrium lanuginosum										2
Mylia anomala	anomalous flapwort									1
dung (cm^3)							++			
number of species		26	18	13	18	12	13	16	21	21

6.2 DOMIN scale

1 much less than 4% cover with shoot(s) rare

2 less than 4% cover with shoots scarce

3 less than 4% cover with shoots frequent OR cover of a single or few larger individuals approaching 4%

4 4 - 10% cover

5 10 - 25% cover

6 25 - 33% cover

7 33 - 50% cover

8 50 - 75% cover

9 75 - 90% cover

10 90 - 100% cover

\+ present within 1m of quadrat edge

++ present within 2m of quadrat edge (selected axiophytes only)

+++ present within 5m of quadrat edge (selected axiophytes only)

++++ present within 10m of quadrat edge (selected axiophytes only)

6.3 Pool Samples

Grip A (pools numbered from the south)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	d	m									
2	d	m									
3	d	m									
4	d	m									
5	w	m		\							
6	w	m	\								
7	w	m	\								
8	w	m									
9	w	m									
10	w	m	\								
11	d	m									
12	w	m	\								
13	w	m									
14	d	m									
15	d	p									

Grip B (pools numbered from the south)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p									
2	w	m									
3	w	m									
4	w	m									
5	w	m									
6	w	m									
7	d	m									
8	w	m									
9	w	m									
10	d	m	\								
11	w	m	\								
12	w	m									
13	w	m									
14	w	m									
15	d	m									
16	d	m									
17	d	m									
18	d	p									
19	w	p									
20	w	p									
21	w	p									
22	w	m									
23	w	p		\							
24	w	m									
25	w	m		\							
26	w	p		\							
27	w	p	\								
28	w	p	\		Sp	<1					
29	w	p		\	Sf	<1					
30	w	p		\	Sp, Sf, Sc	<1					
31	w	p	\								
32	w	p									
33	w	p									

34	w	p									
35	d	m									
36	d	m									
37	d	m									
38	d	m									
39	d	m	\								
40	w	p									

Grip C (pools numbered from the west)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p	\								
2	w	p									
3	w	p			Sf	<1					
4	w	p									
5	w	p									
6	w	p									
7	w	p	\	\	Sf	<1					
8	w	p			Sf	<1					
9	w	p			Sp	<1					
10	w	p									
11	w	p									
12	w	p			Sr	<1					
13	w	p			Sc	<1					
14	w	m	\								
15	w	m	\								
16	w	p?									

Grip D (pools numbered from the north)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p	\		Sf, Sd	<1					
2	w	p	\		Sc	<1	\				
3	w	p	\		Sf	2	\				
4	w	p	\				\				
5	w	p	\		Sf, Sd,Sp	3	\				
6	w	p	\		Sp	<1	\	\			
7	w	p	\	\	Spap,Sf,Sc	<1					
8	w	p	\	\	Sp	1					
9	w	p	\	\	Sf	<1					
10	w	p	\	\	Sd	<1					
11	w	p	\		Sf	<1					
12	w	p	\		Sf, Sp, Spap	20					
13	w	p	\	\	Sf	5					
14	w	p	\		Sf, Sp	10					
15	w	p	\		Sf, Sp	20					
16	w	p	\		Sf	20					
17	w	p	\	\	Sf, Sp	8					
18	w	p		\							
19	w	p	\		Sf	1					
20	w	p	\		Sf, Sp	8					
21	w	p	\		Sf	<1					
22	w	p	\		Sf, Sp	<1					
23	w	p	\		Sp	<1					
24	w	p	\		Sf, Sd,Sp	1					
25	w	p	\	\	Sf, Sd,Sp	2					
26	w	p	\	\	Sp	<1					
27	w	p		\							
28	w	p	\		Sf, Sd	3			\		
29	w	p	\	\	Sf	<1					
30	w	p	\	\							
31	w	p	\								
32	w	p		\							

33	w	p	\	\	Sf	<1					
34	w	p	\		Sf	<1					
35	w	p	\	\	Sp	5					
36	w	p	\	\							
37	w	p		\							
38	w	p	\	\	Sp	2					
39	w	p	\	\							
40	w	p		\							
41	w	p	\	\	Sf	1					
42	w	p	\	\	Sf, Sp	1					
43	w	p	\	\							
44	w	p	\	\	Sf	<1					
45	w	p	\	\	Sf	5					
46	w	p	\	\							
47	w	p	\	\							
48	w	p	\	\	Sf,Sp	<1					
49	w	p	\	\	Sp	<1					
50	w	p	\	\	Ss, Sp, Sc, Sf	<1		\			
51	w	p	\	\	Sp, Sc	<1	\	\			
52	w	p	\	\	Sp, Sc	<1		\			
53	w	p	\	\							
54	w	p	\	\	Sp	<1					
55	w	p	\	\							
56	w	p	\	\							
57	w	p	\	\							
58	w	p	\	\							
59	w	p									
60	w	p		\							
61	w	p		\							
62	w	p		\							
63	d	p		\							
64	d	m		\							
65	d	m		\							
66	d	m		\							

Grip E (pools numbered from the north)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p		\	Sf	<1					
2	w	p	\	\	Sf	<1					
3	w	p	\	\							
4	w	p	\	\	Sp	<1		\			
5	w	p	\	\	Sf, Spap	<1		\			
6	w	p	\	\	Sd, Sf	<1					
7	w	p	\	\							
8	w	p	\				\	\			
9	w	p	\	\	Sf	<1	\	\			
10	w	p	\	\	Sf, Sp, Sc	8	\	\			
11	w	p	\	\	Sf	1		\			
12	w	p	\	\							
13	w	p	\	\	Sp	<1					
14	w	p	\	\	Sp	5					
15	w	p	\	\							
16	w	p	\	\	Sc	<1					
17	w	p	\								
18	w	p	\		Sf, Sp, Sc, Sd	<1	\	\			
19	w	p	\		Spap	<1	\	\		\	
20	w	p	\	\	Sp, Sd, Sf	<1	\		\		
21	w	p	\		Sd, Sf	<1					
22	w	p	\					\			
23	w	p	\								
24	w	p	\	\							
25	w	p	\	\							
26	w	p	\	\							

Grip F (pools numbered from the east)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p	\					\			
2	w	p	\	\	Sp	<1					
3	w	p	\					\			
4	w	p	\	\	Sp, Spap	<1					
5	w	p	\	\	Sf, Sp	<1				\	
6	w	p	\	\	Sp	1		\			
7	w	p	\	\	Sp, Spap	2					
8	w	p	\	\	Sp	<1		\			
9	w	p	\	\							
10	w	p	\	\	Sp	<1					
11	w	p	\	\							

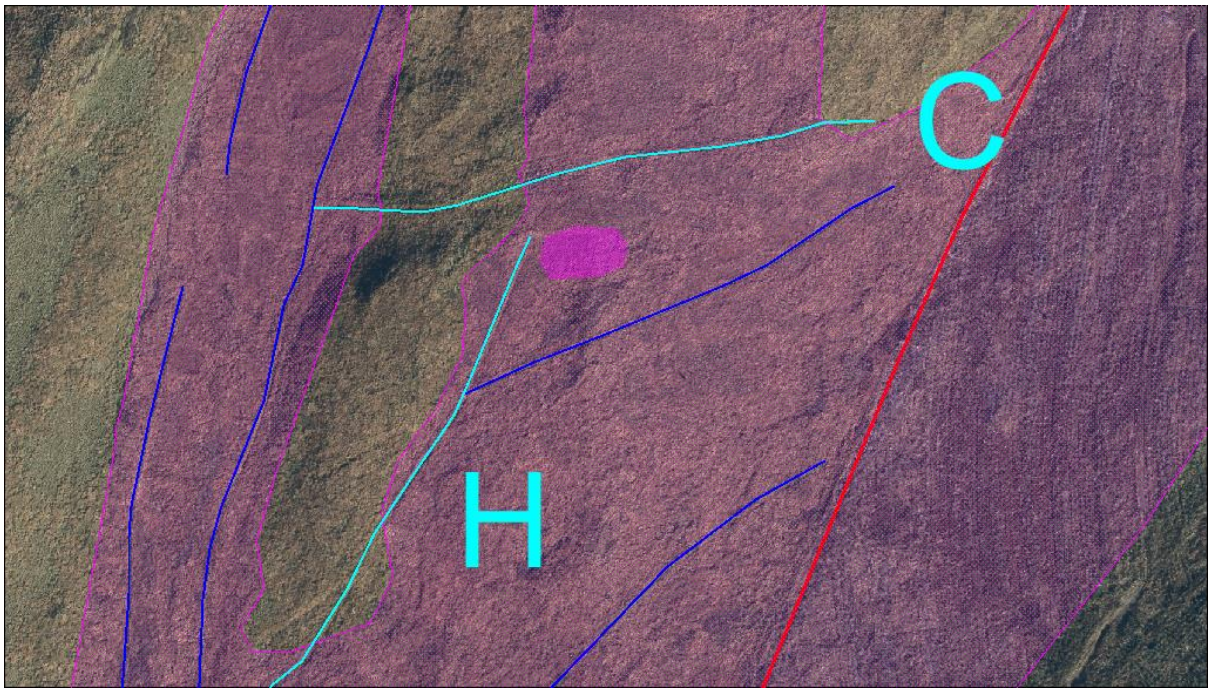
Grip G (pools numbered from the north)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p	\	\							
2	w	p	\	\							
3	w	p	\	\							
4	w	p			Sp, Sc	<1					
5	w	p	\		Sp	<1					
6	w	p	\		Sp	<1				\	
7	w	p									
8	w	p	\								
9	w	p	\		Sp, Spap	<1					
10	w	p		\	Sp	1					
11	w	p	\		Sc	1					
12	w	p	\								
13	d	m									
14	d	m		\							
15	d	p									
16	d	p									

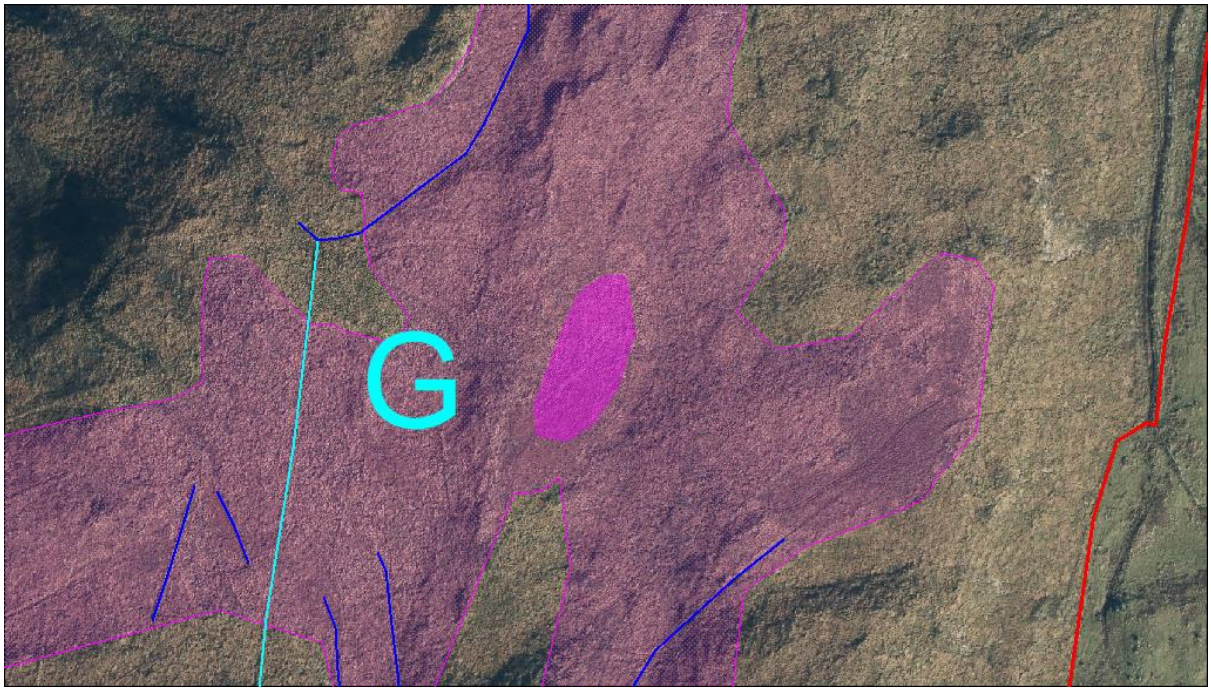
Grip H (pools numbered from the north)

pool number	wet or dry	substrate peat or mineral	bulbous rush *Juncus bulbosus*	soft rush *Juncus effusus*	sphagna	estimated sphagnum cover (%)	heather *Calluna vulgaris*	cross-leaved heath *Erica tetralix*	hare's-tail cotton grass *Eriophorum vaginatum*	bog asphodel *Narthecium ossifragum*	common cotton grass *Eriophorum angustifolium*
1	w	p			Sf, Sc, Ss	<1	\				
2	w	p			Sc	<1	\				
3	w	p			Sp, Sc	<1	\	\			
4	w	p	\								
5	w	p					\				
6	w	p									
7	w	p			Sf	<1					\
8	w	m			Sf	<1					
9	w	p									
10	w	p			Sf	<1					
11	w	m									
12	w	m									
13	w	m									
14	w	m									
15	w	m									

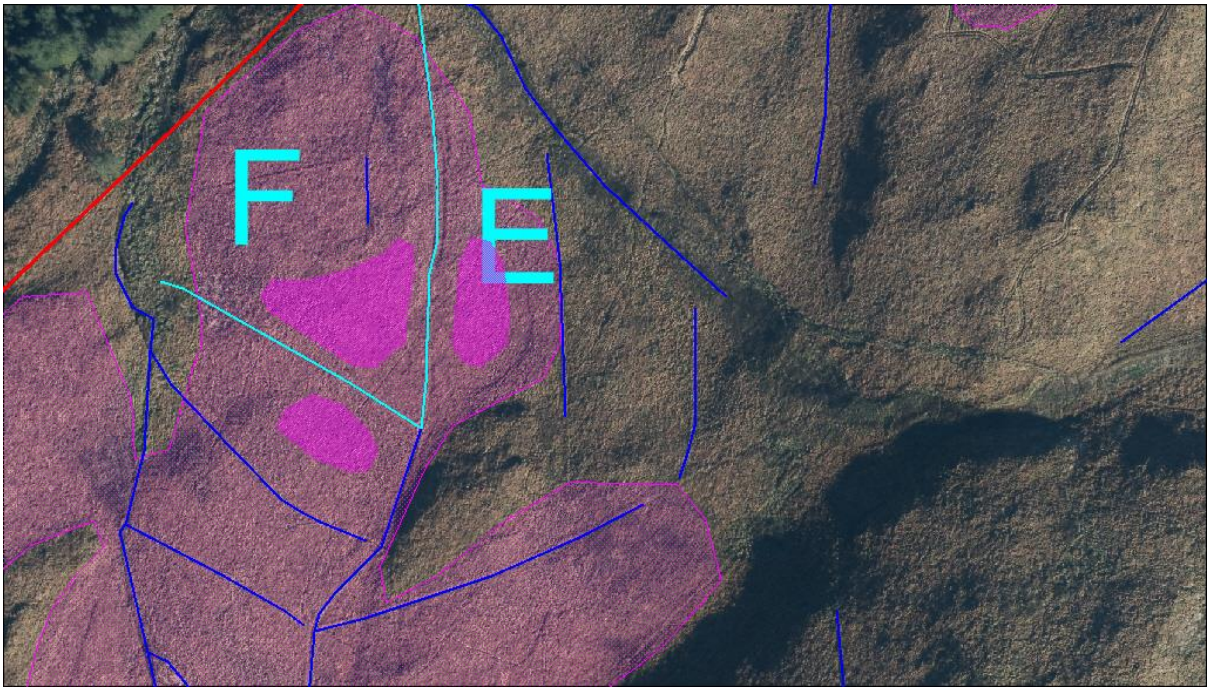
6.4 Possible Trial Flailing Areas



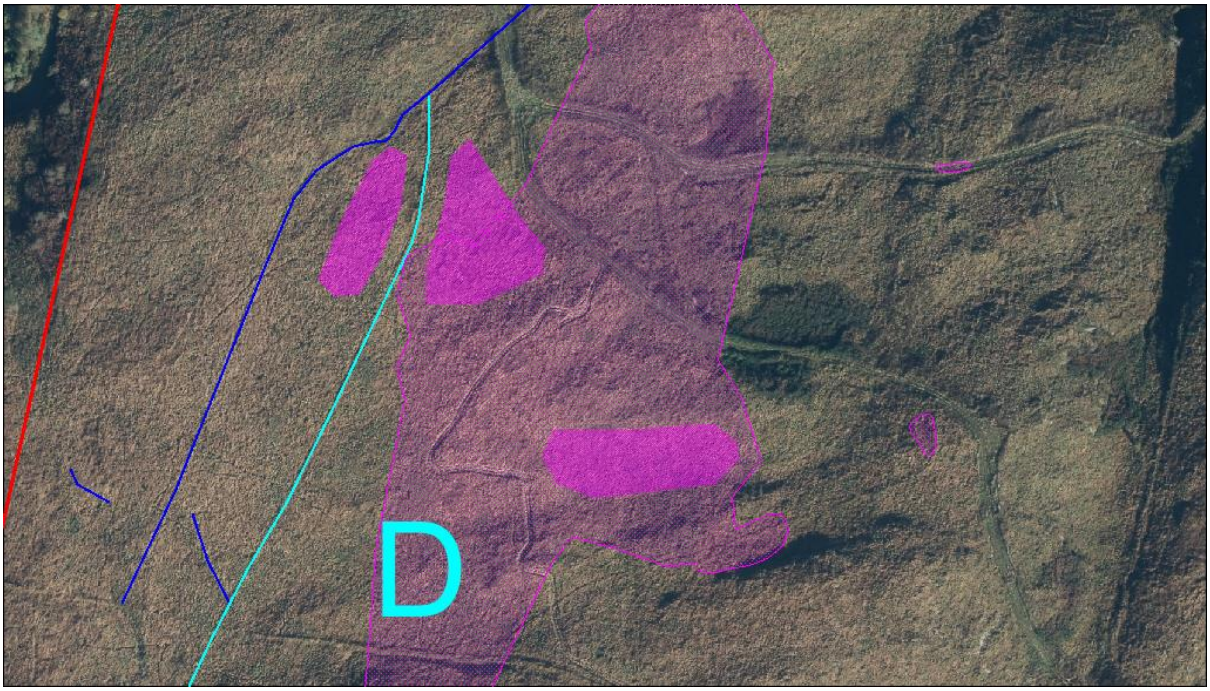
Area 1 lies on level ground east of the top of grip H where dwarf shrubs and sphagnum are probably present in the seed bank.



Area 2 lies on level ground between two ridges of bedrock. There is no proof of a seed-bank here but relict indicators have been found in the past and the area appears not to have been subject to drainage.



Area 3 lies on level ground with good seed-bank in one of the main former areas of mire. Access may be difficult in this area if heavy machinery is used.



Area 4 appears to have good access. The northern two patches have a seed-bank even though they do not overlie deep peat; the ground may accordingly be more stable. The southern area is known to hold relict indicators. There may be an unblocked drain in the area.

6.5 Selected photographs

Photo 1. A failed pool. A fringe of shallow peat is visible with bedrock in the centre and possibly a zone of reddish clay inbetween. Such depressions are prime locations for the expansion of soft rush unless cattle and ponies keep them open.

Photo 2. Two new permanent quadrats were installed in places deemed likely to show a vegetation response in future. Q8 is close to a line of functional pools on a bog surface and may show expansion of bog species in future as a consequence.

Photo 3. Grip E pool 14. Foreground with abundant *Juncus bulbosus,* background with a floating lawn of *Sphagnum* cf *fallax.* Larger patches of sphagnum such as this have probably survived the grip-blocking operations from cushions within the former drain void rather than representing fresh colonization and expansion.

Photo 4. A further sphagnum lawn in grip E pool 10. *Molinia* tussock left and soft rush clump top right.

Photo 5. Extensive germination of heather seeds in winter 19-20 can be seen on bare, damp peat around the base of a *Molinia* clump at the edge of pool 3 on grip D.

Photo 6. Germination of cross-leaved heath on bare, damp peat at the edge of pool 6, grip D. *Sphagnum palustre* is also flourishing in these conditions.

Photo 7. Cranberry *Vaccinium oxycoccus,* a good bog indicator*,* seen for the first time in 2020.

Photo 9. Heather seen to be layering successfully within the dense litter layer at Bwlch Corog. Small whitish roots can be seen on several of the stems.

Photo 10. Invasion of soft rush on blanket bog, Lunedale, NW Yorkshire. The plant colonized the mineral soil exposed by the grips and thus gained a foothold on the moor in the second half of the 20th C. It subsequently exploited bare peat created by heather burning. A strong spread northwards from the grips is evident in a series of ragged patches, perhaps driven by prevailing winds. Heather is dark, grass moor pale green, and soft-rush fawn with a blotchy texture.

Photo 11. Aerial image showing non-rectangular habitat management patches in the Pennines, here for heather management.

Photo 12. Self-sown birch seedling in trampled ground near summit.

Photo 13. Bilberry plants near the summit cairn. Established bushes on the left apparently spreading by rhizomes into turf rendered open and short in the middle of the picture by a combination of cutting and grazing.

Photo 14. The moss *Campylopus pyriformis* growing in the centre of a mown ride. Although not of any significance in its own right, this small cushion-former is a poor competitor and is reliant on areas of open ground to persist. It represents a large suite of species which will be favoured by allowing more light and open ground into the mix at Bwlch Corog

Photo 15. The more open structure of the rides. The frequency of cuts made to create the mown rides at Bwlch Corog is not known, but a review of the frequency and timing may offer greater opportunities for rapid vegetation diversification. For details see the text.

Photo 16. Young birch tree, planted or possibly self sown, at the foot of a crag at the head of grip D.

Photo 17. The distinctive colours of M15: magenta, yellow, turquoise blue (*Calluna vulgaris, Potentilla erecta, Carex panicea*). The rocks at Bwlch Corog should look like this.

Photo 18. The distinctive colours of M17: ox-blood, mustard, pink (*Sphagnum capillifolium, S. papillosum, Erica tetralix)*. The flats of Bwlch Corog should look like this.