Bwlch Corog: 2017 Vegetation Assessment

Report to Wales Wild Land Foundation

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Stuart Hedley

Wild Plants and Vegetation

Abstract

Bwlch Corog is a massif in North Ceredigion recently acquired by Wales Wild Land Foundation for re-wilding purposes. A 2005 vegetation survey of the area was revisited and fresh field survey undertaken in order to understand where best to prioritise woodland establishment and where, if at all, other activities might be appropriate.

The surveys reveal a site with large areas of peatland but one which has suffered to severe degree from the late 20th century practises of drainage, burning and overstocking such that many of the mires on the site are no longer recognisable. The expansion of *Molinia caerulea* gives particular cause for concern, if anything escalating in the last eight years and continuing to displace bog vegetation to the point of extirpation, especially in the north. A reasonable proportion of the peatland probably still has capacity for recovery and it is suggested that this be given priority where possible.

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Contact Details

© Stuart Hedley

info@stuarthedley.co.uk

Stuart Hedley Wild Plants and Vegetation

Slate House, Vowchurch Common, Herefordshire, HR2 0RL

01981 550601

07747 090182

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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 around re-wilding, a notion springing from a sense that there should be some space, in a land intensively managed by humankind, for natural processes and systems to take their course unchecked by the seemingly omnipresent demands of agriculture, forestry and leisure; for more information on this topical issue see the Foundation's web-pages. The land is grassy, but lies beneath 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 to undertake a baseline vegetation survey of the land according to the National Vegetation Classification (NVC). An NVC survey requires homogeneous stands of vegetation to be sampled with quadrats and, preferably, mapped. The sample results, which combine cover and frequency values, are then compared to a national dataset which allows them to be set within a national scheme. For the method, which is widely practised, see Rodwell (1991). The national perspective gained allows the character of the vegetation to be understood in terms of regionality, derivation, typicalness and rarity, amongst other things, as well as enabling comparison of like-with-like, so its quality potentially becomes apparent.

However, prior to beginning, an existing NVC survey came to light (Turner et Al, 2008). The fieldwork for this survey had been conducted in 2005, and although it was a fairly broad-brush survey also covering neighbouring parcels of land, the standard of the work appeared more than adequate. It was felt that a straightforward repeat was unnecessary, as the majority of the vegetation encountered had been of limited significance in NVC terms, and gross change in the meantime seemed on the face of it unlikely. Instead, the 2017 survey was seen as an opportunity to build a more detailed understanding of certain aspects of the site, focussing on the issues of greatest relevance to the Foundation and, if possible, to use quantitative data as a baseline against which to get a handle on the actual amount of change in the intervening period.

In July 2017 a further survey relevant to the initiative was undertaken. The northern part of the Bwlch Corog holding holds a well-delineated parcel of ancient woodland, Coed Llechwedd Einion, which was fully assessed. For details see Thorogood (2017). This area was thus excluded from the current work which set out to be complementary to it.

English plant names in the text follow Dony et Al (1986), latin names of vascular plants follow Stace (2010), 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 Preliminary desk work

The 2005 survey report identified five types of heath, seven of mire, twelve of grassland and eleven other NVC types, although much of this tally lay on land outside Bwlch Corog. Of those which did occur, the following NVC types were selected as meriting a more detailed follow-up for the reasons given.

- M15. This is a type of wet heath characterized by cross-leaved heath *Erica tetralix* and deer-grass *Trichophorum germanicum*. It is valued in conservation terms because it harbours a specialist biota and because of historic loss driven by drainage, overgrazing and burning. It is also valued for the provision of ecosystem services, particularly the regulation of water flows from upland catchments but also the sequestering of carbon in the shallow peats where it occurs. Wet heaths are better represented in the British Isles than elsewhere in Europe.

- M17. This is a type of blanket bog characterized by hare's-tail cotton grass *Eriophorum vaginatum* growing with *Trichophorum germanicum*, and which is similar to the aforementioned wet heath. It is also valued for its specialist biota. It has perhaps suffered fewer losses to agricultural and other mismanagement, but provides better ecosystem services than wet heath, both in regulating water flows and in acting as a carbon sink, because it occurs over deeper peat. Blanket bogs are also better represented in the British Isles than elsewhere in Europe.

- H12. This is a type of dry heathland characterized by heather *Calluna vulgaris* growing with bilberry *Vaccinium myrtillus*. It is also valued for its specialist biota and because of historic loss driven by overgrazing and burning. Dry heaths are present elsewhere in north-west Europe, though not in this particular guise. H12 is likely to have a lesser effect in the provision of ecosystem services than the preceding types, but a substantially better one than many of the vegetation communities which have replaced it in the modern landscape. The constituent species of H12 are also often similar to those of certain types of upland woodland, and under some woodland re-establishment scenarios at least, might be favoured for planting in that they could be construed as providing 'a head start'.

Field maps were prepared showing the extent of these communities as mapped in 2005 to enable a focused search on the ground.

Almost no further study was made of the remainder of the vegetation. This is because these vegetation types are either favoured by agricultural and other land management, so that they are now common and increasing in the uplands (U4, U5, U6, some sorts of M25), or because they are highly localised features of limited extent which can often be identified remotely without field survey (M6). Where woodland is the objective, these relatively low-value vegetation types would constitute first choice in the re-establishment of woodland cover.

2.2 Field procedure

Broadly speaking, the site was traversed on foot and checked for the presence of the target communities using the 2005 map as a guide. There was not time to check the entire site, but the 2005 data allowed the most promising areas to be investigated. The south-western corner of the site received the least coverage, having been mapped in 2005 as largely devoid of the communities under investigation.

The 2005 NVC survey had shown that purple moor-grass *Molinia caerulea* was widely present across the site, cropping up in generally large amounts in all of the NVC types. On the fist visit to site, on 11 September 2017, the full extent of the overwhelming dominance of *Molinia* at Bwlch Corog became evident. In many degraded upland landscapes, for example in the south Pennines, *Molinia* dominance does not obliterate all other evidence of the vegetation of which it may be a part: associated species such as *Calluna* or *Eriophorum vaginatum* may impart characteristic colours and textures to the landscape which enable different types of vegetation to be discerned and mapped even from afar. However, this was not the case at Bwlch Corog where *Molinia* frequently obliterated almost all of any associated diversity. In the face of this problem it was decided to walk GPS-logged routes across sample transects of the hill, recording where stands of key peatland or heathland plants cropped up, and where they subsequently disappeared from the landscape.

The locations of the NVC samples taken during the earlier survey of 2005 were found and re-recorded with the aid of a GPS. There were six of them. They had not been permanently marked, but 10-figure GPS references enabled, in theory at least, relocation to within 1m. This is not ideal, as the original samples themselves had only been from quadrats (square sample frames) of side 2m, but given the fact that upland heath, bog and grassland vegetation is generally rather uniform and composed of a fairly small number of species, the exercise was considered worthwhile undertaking. Vegetation was recorded using the DOMIN scale, as is the case with all NVC work. 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.

2.3 GIS work

Field maps were transcribed into a GIS using Pitney Bowes MapInfo software, v11.5, overlain on recent aerial imagery (flown 14. 10. 15, Simon Ayres, pers. comm). Use of aerial imagery was important, as this is essentially an unenclosed upland landscape with many 'soft' vegetation boundaries that are not represented on Ordnance Survey maps. Field sketches thus approximately locate the key vegetation features on the ground, and these can be rendered more accurate at the desk by tracing the corresponding view from above. Three lots of GoogleEarth open-source imagery were also used, dated 16.04.15, 12.09.09 and 31.12.06; more than one image is useful as aerials are taken at different times of year and sometimes a particular season will emphasize the colour or texture of the vegetation under study more than others.

No vector data for Bwlch Corog was available. Such data very accurately locates linear features such as roads, rivers and boundaries, so that two maps compiled by quite separate workers of neighbouring landholdings would 'snap' perfectly to one another if opened together. Instead, the boundaries at Bwlch Corog were drawn from open source OS raster files, good for most purposes.

They can be refined in future if vector data becomes available, of assistance if the initiative ever expands onto nearby land.

In view of the relevance of peat to this work, open source BGS drift maps of the area were also consulted (http://www.bgs.ac.uk/data/maps/home.html). It was not possible to open the imagery in the GIS, but peat deposits were re-mapped into our data by eye.

3 Results

The results of the work comprise:

(i) GIS files submitted separately;

(ii) a small photographic record submitted separately;

(iii) the report in hand.

4 Discussion

4.1 General

It is felt that three-quarters of the site is now well-understood in vegetation terms and that there is a low probability that significant findings, in these terms at least, remain to be made in the remaining quarter. This is basically the south-west quadrant, where there is a possibility of further small mire relicts, and on the east-facing slopes above the main valley mire just east of the Bwlch Corog cairn. This is the area of greatest dry grassland diversity, though the interest is insufficient to really hinder a woodland restoration objective.

It should be noted that, because a full, new NVC was not compiled, anyone wishing to understand the vegetation on Bwlch Corog may now have to go to one of two sources: either this account (largely for peatland) or the 2005 survey for other areas and communities. It is recognised that this is less than ideal, though by focussing effort an improved understanding of the vegetation of greatest conservation significance has been gained instead. Merging the two sets of data would theoretically be possible, but is difficult in practise because of the differing scales of mapping used in the field, whereby the2005 survey tended to record mosaics of several types rather than delineating them individually.

4.2 Extent of dry heathland

Very little dry heathland now survives on Bwlch Corog. It would be easy to stroll around the site and see none. Two areas have been coded on the map (appendix 6.1). In the far north, next to Coed Llechwedd Einion, an old quarry retains thin, skeletal soils, not favoured by *Molinia,* and here some *Calluna* and *Vaccinium* persist in a grassy matrix; this could optimistically be called H12c. Further south a strip of east-facing rocky slope has occasional bilberry. In addition to these, rocky knolls throughout the site may support a few square feet of grassy heath with heather, bilberry and heightened lower plant diversity, again where thin soils over the rock have hindered the spread of *Molinia* and permitted more light to reach ground level. A crag at SN 7353 9542 for example has *Cladonia impexa, Racomitrium heterostichum* and *Diplophyllum albicans.* However, even here there is a strong case for regarding these as relicts of damper vegetation, probably M15. Sapling rowan shows a predilection for these places, presumably because birds favour them as perches, and dung there.

Had larger areas of dry heath been found, there might have been a case for trying to retain these as open space within a re-wooded landscape, or perhaps focussing on them in an attempt to create woodland with a heath understorey, such as W17. However, this was not the case and unless further work reveals relict heathland in the cairn area it is suggested that the presence of dry heathland need not shape or interfere with plans for re-establishing woody cover.

4.3 Extent of peatland habitats

Fig. 1 shows two different sources. The pink areas are those derived from field survey in 2017 subsequently refined by aerial tracing. They represent M17, M15, or areas derived from both which

retain at least some potential for recovery, ie areas of *Molinia* in which *Eriophorum vaginatum*, *Trichophorum germanicum* or bog-mosses *Sphagnum* (ie peat-building species) can still be found.

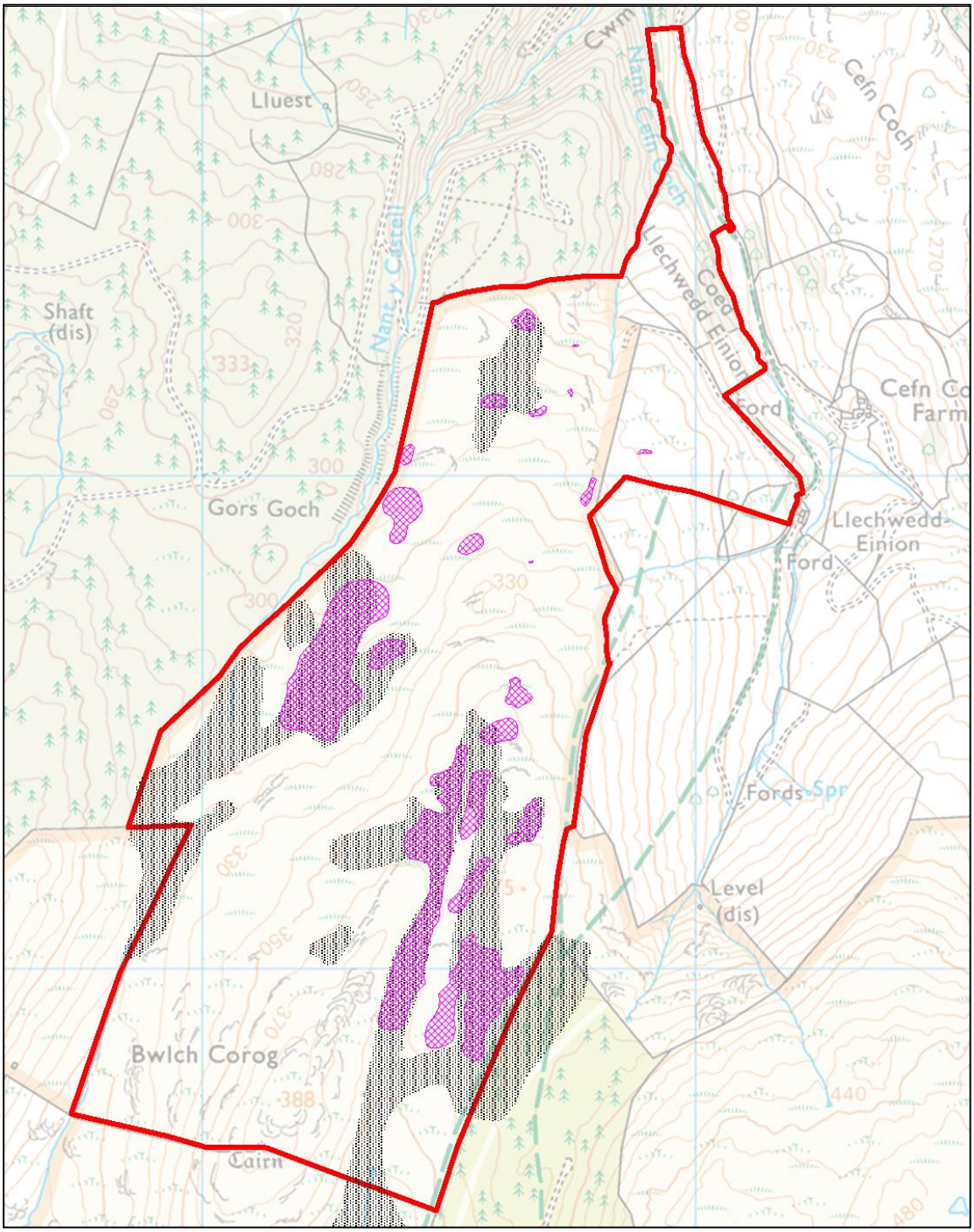

Fig 1. Extant peatland plant communities as mapped in this work by a combination of field survey and aerial photography interpretation (pink). In black hatch are those areas mapped as peat in the British Geological Survey. For discrepancies see the text.

The hatched areas are those shown on BGS sheet 163 (Aberystwyth, drift version) as holding peat, a quaternary deposit. It is thought that in the preparation of BGS maps a minimum 50cm of peat depth is required to classify the deposit as such.

Areas hatched pink but not black will thus probably equate to relicts of M17 or M15 occurring over shallow peat less than 50cm deep, and areas hatched black but not pink will be areas of deep peat from which the characteristic peat building species now appear to have been lost. This loss is likely to have taken place relatively late in the day, in the 20th century, and so these areas are still worth considering as places where peatland gain / restoration may be possible.

50cm of peat depth is often also used by the conservation agencies as a cut-off in the recognition of blanket peat vegetation or its derivatives, with M17 and other bog-types typically found on depths greater than this, and M15 and other wet heath types typically found on depths shallower. However, vegetation expression is never this black-and-white and it is certainly not possible to conclude that the black BGS areas equate to potential blanket bog and that any pink areas outside of these must therefore be wet heath.

So far in this section M15 wet heath and M17 blanket bog have been blocked together as 'peatland habitat'. Can M15 now be distinguished effectively from M17 at Bwlch Corog? Conservationists are inveterate classifiers. Is such an exercise worth it here?

Probably not. As mentioned, M15 is a community of shallow peats and M17 one of deeper ones. The two main sub-divisions allocated in 2005 were M15d and M17c respectively, and in terms of plant composition, the constants of these ostensibly different vegetation types in fact very largely overlap: *Molinia, Erica, Calluna,* and *Trichophorum,* with tormentil *Potentilla erecta.* M15d effectively contains no strongly preferential species, but M17c ought to be detectable by the additional presence of *Eriophorum* spp (both *E. vaginatum* and common cotton-grass *E. angustifolium)*, bog asphodel *Narthecium ossifragum* and the bog-moss *Sphagnum papillosum.* When healthy and well-expressed the two types can be separated by this means. On the Shap Fells in Cumbria, for example, thinning marginal peat at lowest altitude on the hill is marked off by the disappearance of *Eriophorum vaginatum,* a rise in the prevalence of *Molinia,* and a subtle shift in the bog-moss species present with some replacement of *Sphagnum papillosum* by *S. denticulatum* (Hedley 2015).

However, the poor condition of the vegetation at Bwlch Corog makes this impossible to see. On transects walked from lowest altitude, the first stand of peatland vegetation encountered did indeed seem closer to M15d. However, even from here *Eriophorum vaginatum* began to creep in in low amounts. On more than one occasion vegetation provisionally dubbed 'M15' in the notebook had to be reappraised as tussocks of *Eriophorum* were found nearby.

The 2005 report is quite detailed and paints a picture of rather more neatly circumscribed vegetation parcels than is currently the case, although as previously mentioned, many of these parcels are coded as vegetation mosaics. The 2005 account is highly descriptive but offers little insight into the derivation of the vegetation and its failure to mention the grips on the site is surprising. Not only are these ecologically significant, but they are also easy to fall into when criss-crossing the holding. They are shown in Fig 2. The fact that grips permeate all the peatlands raises the strong possibility that the wet heaths are less plagioclimax communities than they are degraded

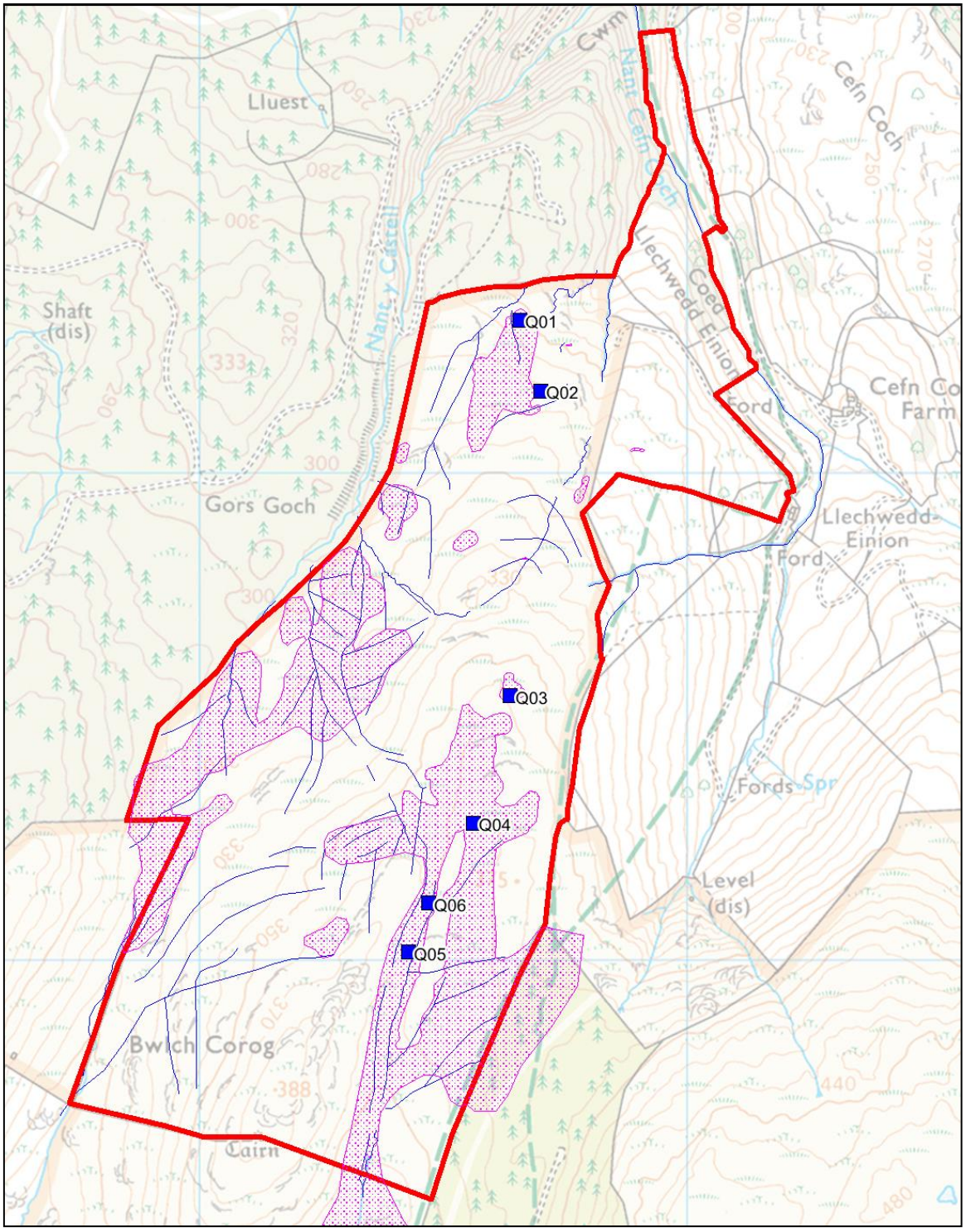

Fig 2. Minimum potential active peatland (field survey+ BGS peat) shown with grips. The depiction shows all watercourses the same for simplicity, but the majority are grips. Further details in the GIS browser. The location of quadrat samples is also shown.

blanket bogs, at least in part. Gripping drains the peat, exposes it to drying, oxidisation and wasteage and causes local falls in the water table. The accompanying vegetation shifts then mirror those which occur naturally where peat thins. When grips are superimposed on the 2005 vegetation map they potentially explain the curious pattern of wet heath occupying apparently *higher* ground on a *shallower* gradient (appendix 6.2), circumstances which would naturally favour M17 bog. If this area had been gripped, however, as we can see was the case, there could easily have been a shift from bog- to heath-like vegetation in the area. The grips in the south-west of the site offer an even more extreme insight into the effects of drainage, lying in an area where peat is not mapped by the BGS, nor was evidence of peatland vegetation found in 2017, nor was it even recognised as such in 2005, being then coded as holding mixtures of largely grass-dominated communities. Such areas must have been wet and peaty enough to have been drained in the 1970s, however, revealing a very great change in vegetation type since.

A further piece of evidence that unalloyed blanket bog may have been the original vegetation type of most of Bwlch Corog rather than mixtures of bog and wet heath is the persistence of occasional isolated stools of *Eriophorum vaginatum* in surprising places (eg in acid grassland on the Bwlch Corog ridge at SN 7333 9501 and buried in recent soft rush vegetation at SN 7337 9475).

In fact, if there was a desire to better understand the relationship of M15 and M17 in this part of the world (for example in order to refine conservation objectives), one could look to the adjoining massifs which are in better ecological condition. There, one might find blanket bog alone, or bog with wet heath on its margins, or bog and wet heath distributed according to other phenomena, for example in relation to the projection of the solid rocks which produce such a knobbly landscape (photo 14).

Needless to say, the condition of the M17 / M15, as gauged by NRW and other country agencies, for example in the process of SSSI condition assessment, is almost everywhere unfavourable (Appendix 6.5). The two best areas of remaning peatland vegetation are a small basin mire on the east side, which can probably be deemed favourable having completely escaped drainage, its unoxidised peats rather inimical to *Molinia;* and the main saddle mire which, although drained, lies on particularly deep peat in which there is still evidence of pool systems. Pool systems are a characteristic feature of pristine peatland (Lindsay et Al, 2014a), becoming more complex with increased oceanicity. A few small sinuous depressions here hold the M2 bogpool vegetation in rather dry form.

4.4 Surmised change since 2005

The six repeated vegetation samples, also shown on Fig 2, are tabulated in appendix 6.3. Twelve years has elapsed since they were first recorded. The results show:

- Five of the six quadrats show reduction in total number of species;
- The dwarf-shrubs *Calluna* and *Erica* appear to either maintain their DOMIN cover or decrease. Conversely the dwarf-shrub *Vaccinium* appears to maintain or increase its cover;
- the pattern for sphagnum is one of consistent decline in cover and reduction in species-richness;
- the pattern for pleurocarpous (scrambling) mosses is varied but includes at least some records of increase;
- *Narthecium* shows increase in five of the six quadrats

- *Molinia* shows a varied pattern including some very dramatic increases and some modest decreases
- *Eriophorum vaginatum* shows a varied pattern with some modest decreases but other, larger increases;
- *Trichophorum germanicum* declines in five of the six quadrats, some dramatically, but increases in one.

A considerable degree of caution is needed in interpreting the data as the samples were effectively not permanently marked, and the areas chosen for recording will all be at least slightly misaligned, some by perhaps as much as 2m. However, bog and heath vegetation tends to be rather uniform and so similar plants in similar proportions are likely to occur all around a sample taken from within them, and, as can be seen from the above list, some types of change are repeated across more than one quadrat, giving increased confidence that the records reflect genuine shifts.

The observations are consistent with what is known about site management. *Molinia* increase (not just cover but biomass, ie increased spread, height and litter) has suppressed the characteristic dwarf-shrubs and especially bog-mosses of the peatland, thus further eroding the capacity of an already highly compromised system to function effectively as a peatland. Pleurocarpous mosses are better able to complete in such an environment by scrambling through taller grass and into the light. *Vaccinium* may be benefitting from ongoing drying of peats in Qs 2,3 and 5 and is, as a rhizomatous perennial, better cut out for vegetative expansion from existing plants than the only weakly-layering *Calluna* and the much more low-growing *Erica.* The tussock-forming *Eriophorum vaginatum* and *Trichophorum* show mixed fortunes with losses in the latter much more evident.

Particularly dramatic are the changes in Q1 which is now almost unrecognizable as wet heath. Photo 1 shows something of the overwhelming dominance of *Molinia* in this quadrat, as do photos 10-12 (appendix 6.4).

Apparent sphagnum reductions are of great concern. Bog-mosses are now rather hard to find at Bwlch Corog, though scattered stems are likely to remain partly hidden amongst the *Molinia* thatch. Of especial concern is a possible high loss of *Sphagnum papillosum,* one of the principal builders of peat in the UK, and perhaps reliant on more open habitat (ie not shaded by tall *Molinia*) than some of the other species. Good material of *S. papillosum* was not seen on site until day 3, in the wetter saddle mire around Q5. In a literature review, Ptyxis Ecology (2008) cite *Sphagnum papillosum* as the principal positive indicator species for bog in the North Pennines, and *S. capillifolium*, perhaps now the commonest taxon on Bwlch Corog, potentially as a negative indicator.

This sad story is endorsed by the GoogleEarth imagery archive, which covers the years 2015, 2009 and 2006, the latter taken just one year after Turner et Al were out on site. Some aspects of the vegetation pattern, for example that of the *Nardus* grassland on the drier ground around Bwlch Corog summit, are astonishingly stable throughout. Others are not. The pale tones of *Molinia* seem relatively stable across the three year period 2006 - 2009, but the six year period 2009 - 2015 displays tangible increases in its density, especially in the north and east, the areas that contain Qs 1 and 2 in which massive increase in *Molinia* was documented.

Q5 is of interest, having been taken in 2005 from a stand of the rare bog-type M21b. This record is a little questionable, as context, altitude and some of the associates do not fit well with this ascription, especially when the 2017 data is taken into account, with *Eriophorum vaginatum* (a contra-indicator

for this sort of mire) having almost certainly been there all the time. However, the record for M21b is of interest in illustrating at least that the conditions necessary for this type were largely, if not completely met. Even at that time, the community was noted as very rare, and occupying small hollows within the M17 expanse. A shift from M21 to M17 would be entirely expected where the mire had been gripped, as it has. This is the only quadrat showing increase in species richness and this too is unsurprising, as a highly-specialised and rare but rather species-poor vegetation has become more diverse as it has dried and shifted to a typical oceanic blanket mire community. The documented increases in *Calluna, Vaccinium* and *Pleurozium* would all be expected.

4.5 Peatland history - a summary for context

After the last ice age forest cover slowly increased as temperatures rose, passing through a series of woodland types over five thousand years as climatic shifts favoured different canopy species. An account of the specifics in North Wales is given by Rhind & Jones (2003). Very locally, topography and climate yielded types of climax vegetation other than woodland, for example enclosed basins may have developed *raised bogs*, some extant examples of which can consequently claim to have peatland histories of as much as 10,000 years (Lindsay et Al (2014b)).

The major British bog type by area, *blanket bog*, is typically thought to be less old, forming 5-6,000 years ago as a consequence of both further climate shifts and human agency. At Waun Fignen Felen, a bog in Powys, there is good evidence that the onset of bog vegetation in cleared woodland was through human inception in Mesolithic times (Leighton, 1997). Rhind & Jones (2003) cite the early Neolithic.

Bwlch Corog may hold peatland of both types. Over most of the area the thin peats point clearly to blanket bog, but it is possible that the core saddle mire and some of the higher-level basins hold deeper peat which might predate clearance of wildwood by early man. A coring project would answer this question.

In the modern age, the Hill Farming Act of 1946 resulted in thousands of hectares of upland drainage in the 1960s and 70s. On peatlands, such gripping alters the vegetation, most significantly by reducing or eliminating sphagnum, whose presence is key to the very existence of the bog in the first place. It increases rates of run-off without significantly lowering the water table from an agricultural perspective and compromises the bog's ability to function as a carbon sink.

Probably from before this time and no doubt continuing for several decades afterwards, swaling also took place; this is the burning of grassland to improve its food value, as opposed to acts of bored vandalism. From an agricultural perspective this can be said to improve forage quality at a time when hill livestock were out on the hill with young. Details of the persistence of swaling in Wales are not known, but the practice still continues in south-west England. *Molinia,* being herbaceous and with overwintering buds hidden beneath the soil surface, springs back quicker after fires than the other moorland species with which it grows, such as woody dwarf-shrubs, and, in particular, moisture-dependent and fire-sensitive bog-mosses. Where burning cycles are shorter than the full recovery period of the precursor vegetation, *Molinia* will slowly gain ground, and in this way the bog becomes gradually impoverished almost to a monoculture. The same phenomenon, where burning cycles are shorter than the full vegetation complement can sustain, has converted bogs to heather monocultures in many parts of northern England.

Overgrazing is likely to have been a third factor shaping the current vegetation at Bwlch Corog, notably the paucity of dwarf-shrubs in almost all areas. Overgrazing can also impact on bog health through trampling of sphagnum. Whatever the particular cocktail of adverse management on the hill, the result today is a bog in extremely poor health, probably falling into the category of haplotelmic bog over most of its area. Such bogs are most at risk from further degradation.

Further recent changes include the expansion in areas of soft rush *Juncus effusus* along boundary banks where mineral soil has been exposed and the banks themselves acted as bunds ponding water (appendix 6.1). There has also been a peat slide, probably during a storm event this year, on the west side. The scar left certainly does not feature on aerial imagery of October 2015. The slide took place on a steep slope on peat which had been gripped in the past.

4.6 Closing remarks

Cambrian Wildwood is a multifaceted project involving a diverse range of interests and skills and making recommendations for the amount and location of woodland establishment was not part of the remit of this vegetation assessment.

However, it is recommended that peatland restoration be accommodated within future plans for the site by refraining from scrub and woodland objectives in the viable areas. Healthy peatland will combat climate change through functioning as a carbon sink, limit flood peaks, demonstrate sustainable land management and be in tune with NRW policy. Peatland restoration at Bwlch Corog will require considerable thought and planning and is likely to involve more than just the blocking of grips for which a specialist contractor may need to be engaged.

Trying to retain peatland as open space within a wooded massif might also yield a more varied and pleasing landscape than continuous canopy alone.

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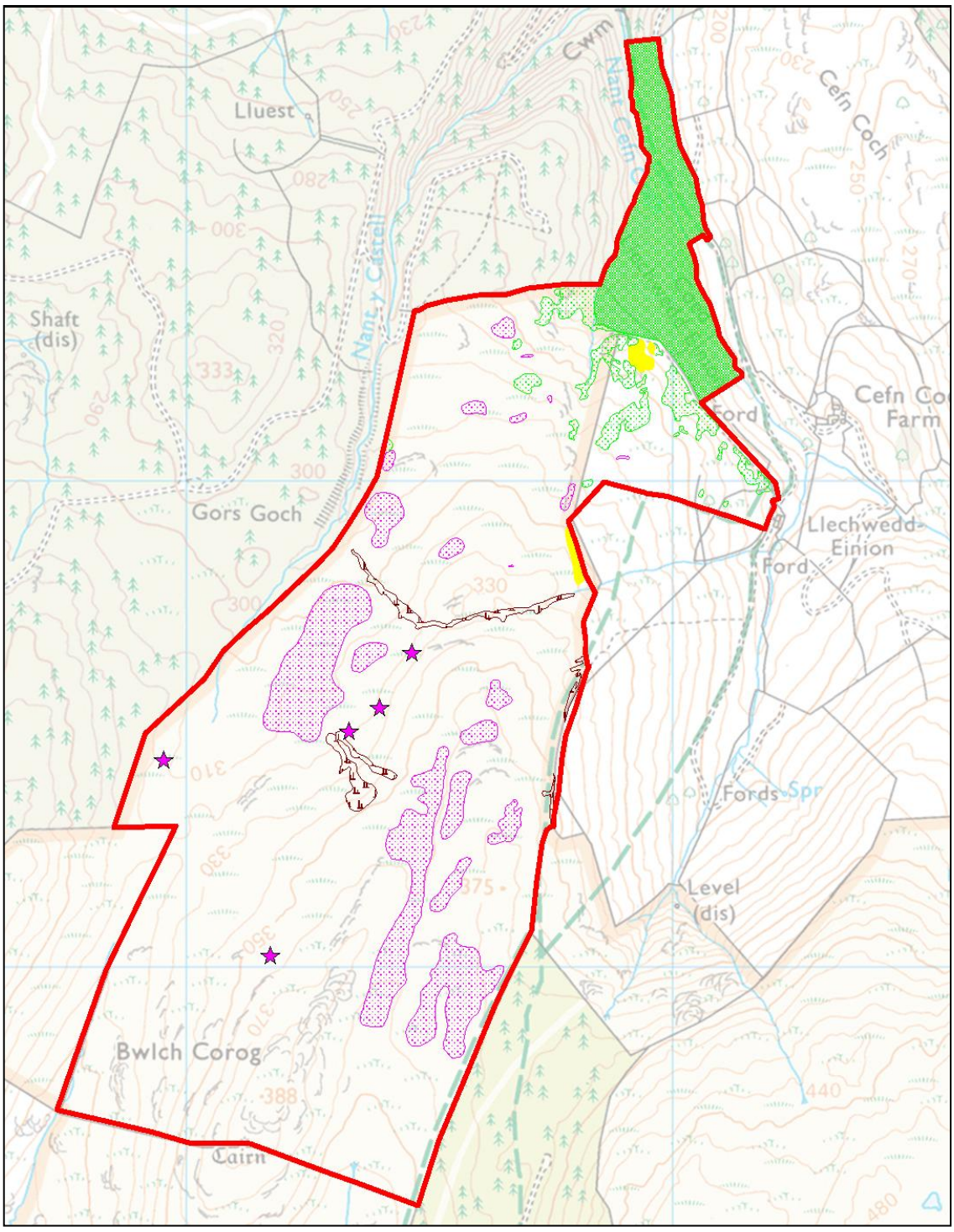
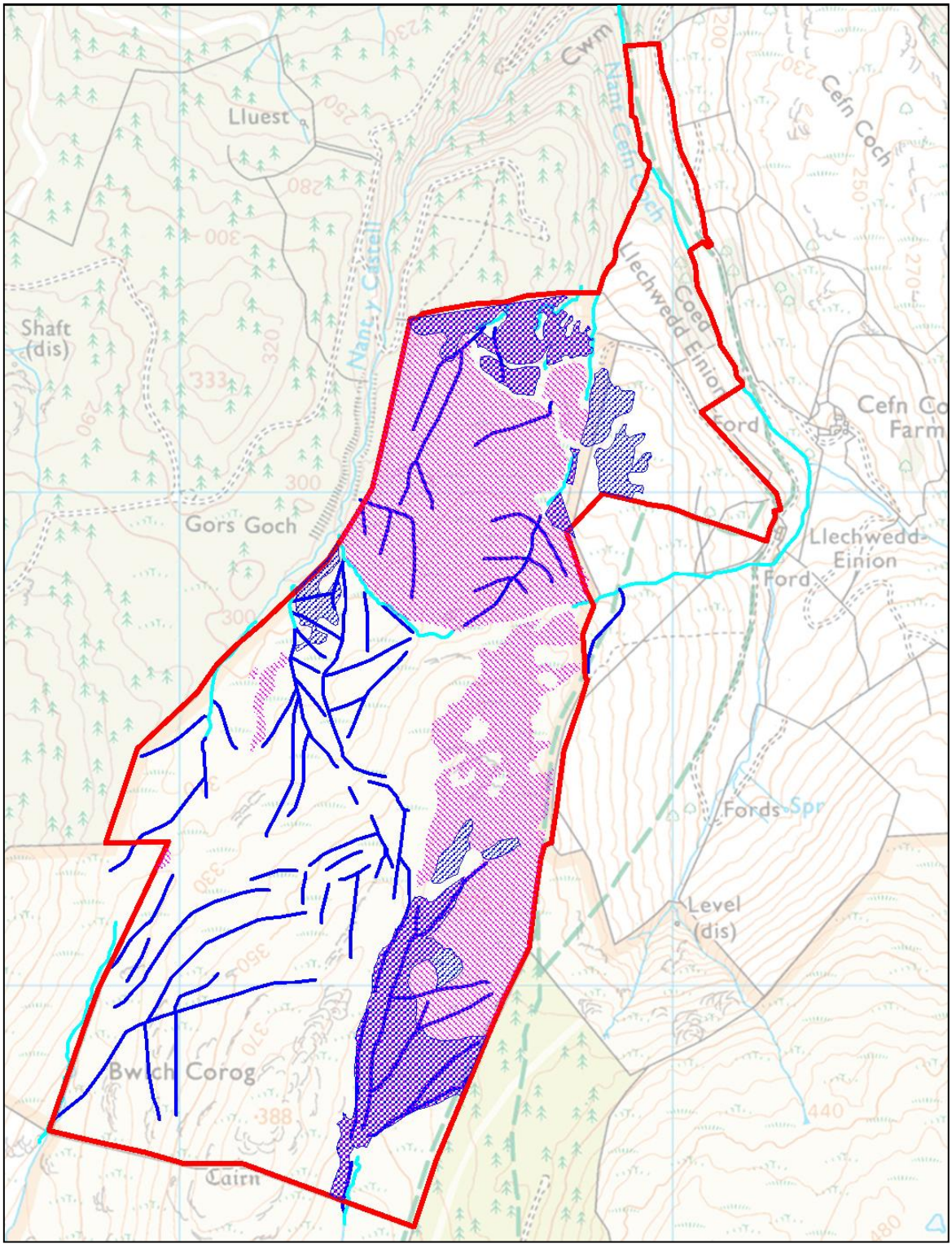
6 Appendices

6.1 Other vegetation features, 2017



Peatland plant communities in pink, as in Fig 1. Area covered by recent WGS survey (principally of upland acid oakwood) in solid green. South of this bracken stands in green hatch. Relict heathland in yellow. Flushes (point features) potentially of botanical interest shown as stars. Areas of dense soft rush shown in brown marsh symbol are 20th century features derived from man-made modifications of land and watercourse.

6.2 Peatland vegetation as mapped in 2005



Peatland vegetation as mapped in the 2005 survey. Pink shows areas deemed to hold a proportion of M15 wet heath (generally much less than 30%). Blue shows areas deemed to hold a proportion of M17 blanket bog. Grips are also shown. Note how some areas of (presumably) formerly-gripped peatland have no coding as such at all, and how other areas of peatland may have escaped gripping.

6.3 Repeat vegetation samples

quadrat number		1		4		6	
NVC type in 2005		M15d		M17a		M17a	
species		2005	2017	2005	2017	2005	2017
Calluna vulgaris	heather	4	1				+
Erica tetralix	cross-leaved heath	5	+++	6	5	5	4
Vaccinium myrtillus	bilberry	3	2		+		
Juncus squarrosus	heath rush	4					
Trichophorum germanicum	deer-grass	7	++++	6	5	6	
Agrostis canina	velvet bent	2					
Anthoxanthum odoratum	sweet vernal-grass	2					
Molinia caerulea	purple moor-grass	6	10	5	4	7	6
Nardus stricta	matgrass	2					
Narthecium ossifragum	bog asphodel	3	4	4	6	5	6
Potentilla erecta	tormentil	3	3	3	2		
Dicranum scoparium	broom fork-moss	3	1		1		
Hypnum jutlandicum	heath plait-moss	6		5	3	5	2
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
Sphagnum capillifolium	red bog-moss	2	3	4	+	3	
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	
Cladonia portentosa	a reindeer lichen	1					
Eriophorum angustifolium	common cotton-grass			5	4	5	
Eriophorum vaginatum	hare's-tail cotton-grass			4	6	4	6
Drosera rotundifolia	common sundew			3	1	3	
Polygala serpyllifolia	heath milkwort				1	3	2
Sphagnum denticulatum	cow's-horn bog-moss			6			
Sphagnum fallax	flat-topped bog-moss					5	4
Calypogeia fissa	common pouchwort				2	3	1
Pleurozium schreberi	red-stemmed feather-moss		2				2
number of species		25	9	15	14	16	11

+ present within 1m of quadrat

++ present within 2m of quadrat

+++ present within 5m of quadrat

++++ present within 10m of quadrat

		quadrat number	2		3		5	
		NVC type in 2005	M17c		M17c		M21b	
species			2005	2017	2005	2017	2005	2017
Calluna vulgaris	heather		3	1	4	4		1
Erica tetralix	cross-leaved heath		5	2	5	4	5	5
Vaccinium myrtillus	bilberry		3	4	4	5		3
Juncus squarrosus	heath rush		4					
Trichophorum germanicum	deer-grass		6		7	4	3	5
Agrostis canina	velvet bent			4				
Anthoxanthum odoratum	sweet vernal-grass		2					
Molinia caerulea	purple moor-grass		4	9	6	6	5	4
Nardus stricta	matgrass		2	1				
Narthecium ossifragum	bog asphodel		2	4	3		6	4
Potentilla erecta	tormentil		3				1	2
Dicranum scoparium	broom fork-moss		2					1
Hypnum jutlandicum	heath plait-moss		5	2	5		4	
Polytrichum commune	common haircap		3	2	4	4		2
Rhytidiadelphus loreus	little shaggy-moss			1	3	3		
Sphagnum capillifolium	red bog-moss		6	1	5	5		4
Sphagnum papillosum	papillose bog-moss		5	2	5		6	5
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
Cladonia portentosa	a reindeer lichen							3
Eriophorum angustifolium	common cotton-grass			2	3	3	6	3
Eriophorum vaginatum	hare's-tail cotton-grass		5	4	5	6		4
Drosera rotundifolia	common sundew						3	1
Polygala serpyllifolia	heath milkwort						3	
Sphagnum denticulatum	cow-horn bog-moss						3	
Sphagnum fallax	flat-topped bog-moss		4	2			5	
Calypogeia fissa	common pouchwort							2
Carex echinata	star sedge		2					
Deschampsia flexuosa	wavy hair-grass		4	2	3	4		
Aulacomnium palustre	bog bead-moss		2	2				
Pleurozium schreberi	red-stemmed feather-moss		2	4	4	6		1
Lophozia ventricosa	tumid notchwort		3					
Scapania sp	an earwort		3					
Plagiothecium undulatum	waved silk-moss				3			
Empetrum nigrum	cowberry							2
Sphagnum cuspidatum	feathery bog-moss						5	
number of species			26	18	18	12	16	21

6.4 Selected photographs

Photo 1. Q1. The GPS, rucksack and clipboard mark 3 of the corners of the 2m2 quadrat. Note the overwhelming cover of *Molinia.*

Photo 2. Q1, detail. 'Parted' *Molinia* showing shaded plants of *Vaccinium, Sphagnum capillifolium* and *Polytrichum commune.*

Photo 3, Q2. This quadrat is somewhat more open than Q1. *Molinia* remains abundant but a full range of M17 blanket bog species still just discernible.

Photo 4: view W from Q2. A break of slope on the horizon reveals a gentle terrace coming toward the viewer. Flatter areas like this are productive places in which to search for relict bog vegetation.

Photo 5. Active grip running through the terrace shown in photo 4.

Photo 6. Close to the grip in photo 5 a single old tussock of *Eriophorum vaginatum* with *Vaccinium* and the hypnoid moss *Pleurozium schreberi.* Notice the difficulty in picking out the *Eriophorum* from the surrounding *Molinia.*

Photo 7. A few metres from photo 6, a hummock of the red bog moss *Sphagnum capillifolium.* Such hummocks, though very scarce now on Bwlch Corog, are conspicuous where found and a good way of honing in on former blanket bog.

Photo 8. Active grips from the centre-east of the site where almost no bog indicators were found and the area was not mapped by the BGS as peatland. A thin line of dark-coloured rush picks out the grip, including a branch to the left.

Photo 9. An attractive relict of M17. Note the much greater diversity of structure and colour than in photos 1 or 12, with pink clusters of *Erica* flowers, tonal contrast of erect *Narthecium* and yellow, bristle-like *Trichophorum* leaves, and lichens bottom L.

Photo 10. Boundary fence showing effects of ten years' absence of grazing.

Photo 11. Close-up showing depth of dense *Molinia* herbage. Weatherwriter is 35cm tall.

Photo 12. Many moorland graminoids have stiff bristle-like leaves, but those of *Molinia* are long, soft and broad. When they collapse in autumn and winter they form a mattress drastically reducing light levels for any species trying to grow beneath them.

Photo 13. Q3 lies some 10m beyond the hummock with the rucksack, in the most northerly of the summit mire complexes on Bwlch Corog. As with photo 4, the mire can be recognized by the flat terrain, here being a peat-filled basin.

Photo 14. View to pasture land to the east. The underlying rocks yield a knobbly terrain where thinner soils over rocky protruberances contrast with deeper soils in hollows between. Here land-use results in gorse heaths on the former and pastureland on the latter (and, presumably consequentially, the place-name 'brithdir'). It is possible that the corresponding patterning on Bwlch Corog was once one of rocky ground holding shallower peat with wet heath, and the deeper basins in between true blanket bog, but if this is so it is no longer possible to see this pattern there.

Photo 15. The artefacts mark out three corners of Q3. Most of the species required for favourable blanket bog are there, but the area would still fail at least on excessive *Molinia* cover.

Photo 16. Young rowan emerging from thin peat and thick *Molinia* at c 360m close to Q3. This was the commonest tree species encountered, but still scarce. Bird-sown, and perhaps not surprisingly often seen in the vicinity of rocky outcrops.

Photo 17. The main saddle-mire complex seen from a low knoll with the summit of Bwlch Corog mid-field right. The flat basins of peat are very obvious here and could form a dramatic contrast to a partially re-wooded landscape.

Photo 18. Erosion scar (thought very recent) midway along the north-west facing slopes of Bwlch Corog. The area was formerly site of a natural M6 flush but grips from the bog above were directed into it many decades ago causing scour of the channel and undermining of peat. Perhaps during a recent storm episode the weakened peat has failed en masse and slipped revealing the underlying mudstones, themselves also now considerably eroded. Note the peat on the opposite bank, 50-75cm deep, even though this area was not mapped by the BGS as holding peat and the slopes themselves are rather steep. This suggests blanked bog may once have covered the whole massif.

Photo 19, looking downstream from the same point as photo 18. Large cubic masses of oxidized peat, with rush and *Molinia.* One end-product of abused land.

Photo 20. Part view of the large mire on the western edge of the site. The mire is heavily gripped but still holds a few bog species. It has a rather uneven surface and probably represents more than one mire which subsequently coalesced. At 73209561 it appears to have been cut for turf.

Photo 21. Detail of the grip in the centre of the mire shown in photo 20. Scour has taken the grip down to the bedrock. It is now c 1m deep with 30cm water running noisily after heavy rain.

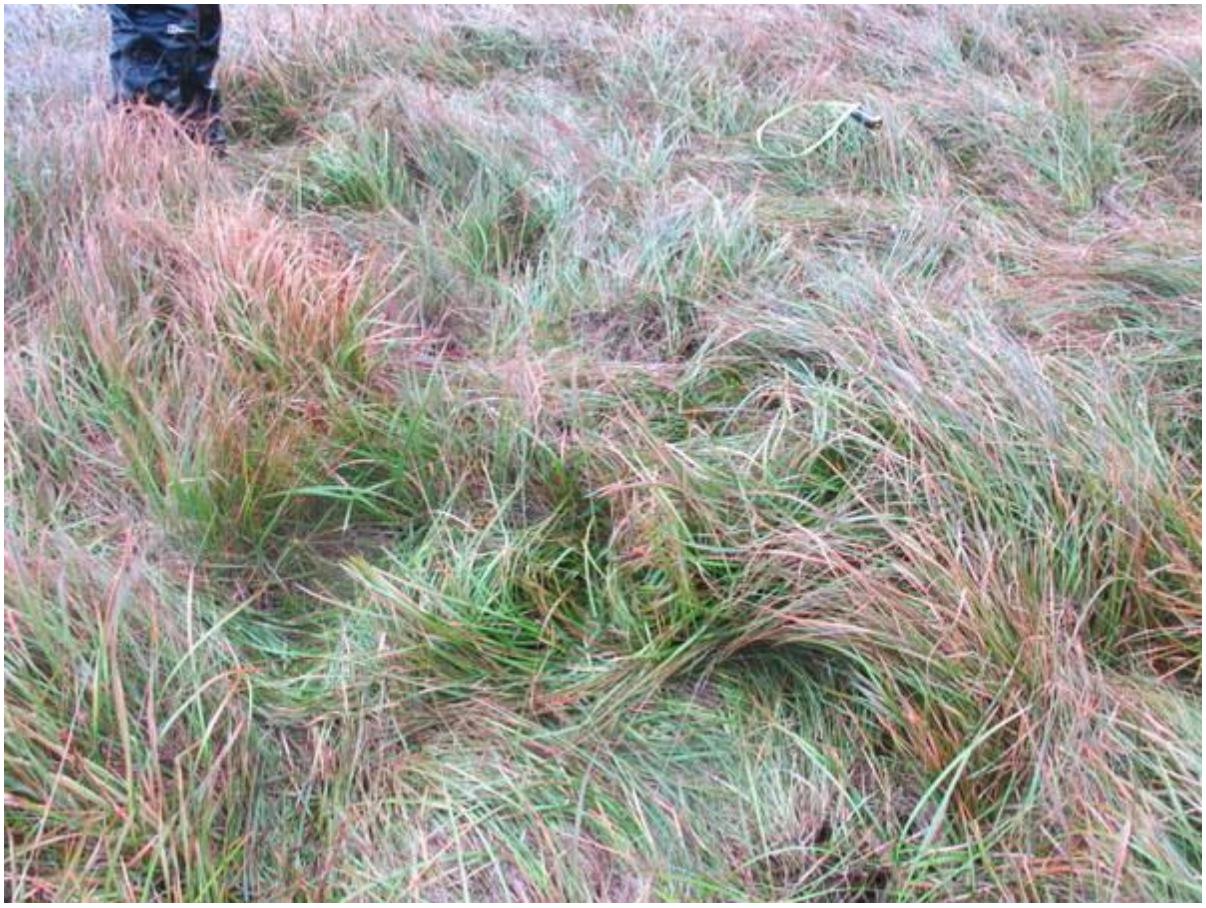


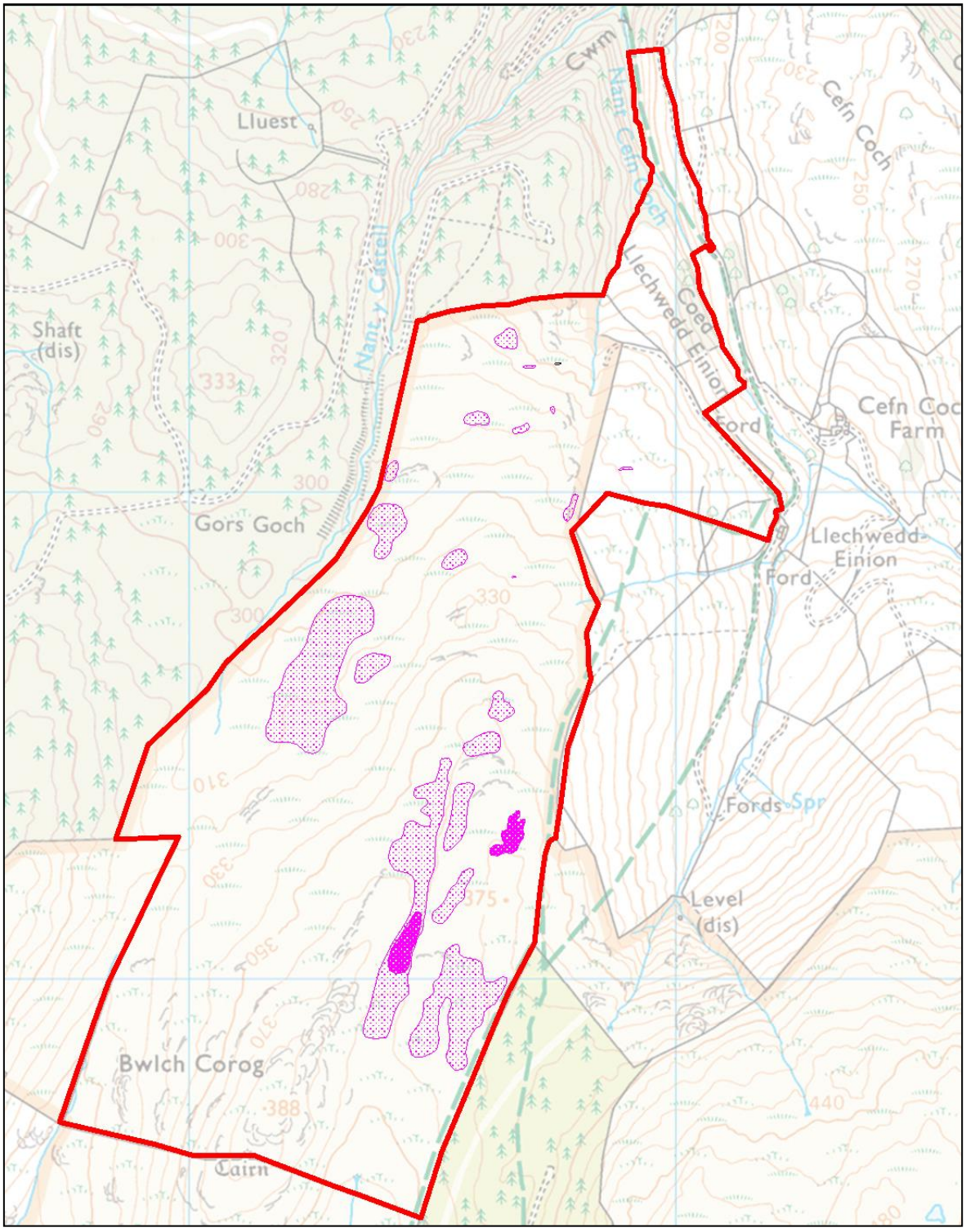
Photo 22. Quadrat 4.

Photo 23. Area close to Q5, showing bog surface patterning. The centre of the picture has a lawn of bright green *Sphagnum fallax* (NVC M2) and is surrounded by M17. Surface patterns indicate extreme wetness, and may be indicative of quality bogs, but the phenomenon is rare on Bwlch Corog.

Photo 24. The main saddle mire from near the summit. Twin grips are visible.

Photo 25. The south-eastern slopes of the side from near the summit. Again grips are visible.

6.5 Mire condition



Condition of bog vegetation at Bwlch Corog (not based on systematic sampling). Dark pink = favourable, or probably so. Pale pink = unfavourable declining.