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Mapping the extent of calaminarian grassland at Mwyngloddfa Cwmystwyth SSSI

C. Forster Brown
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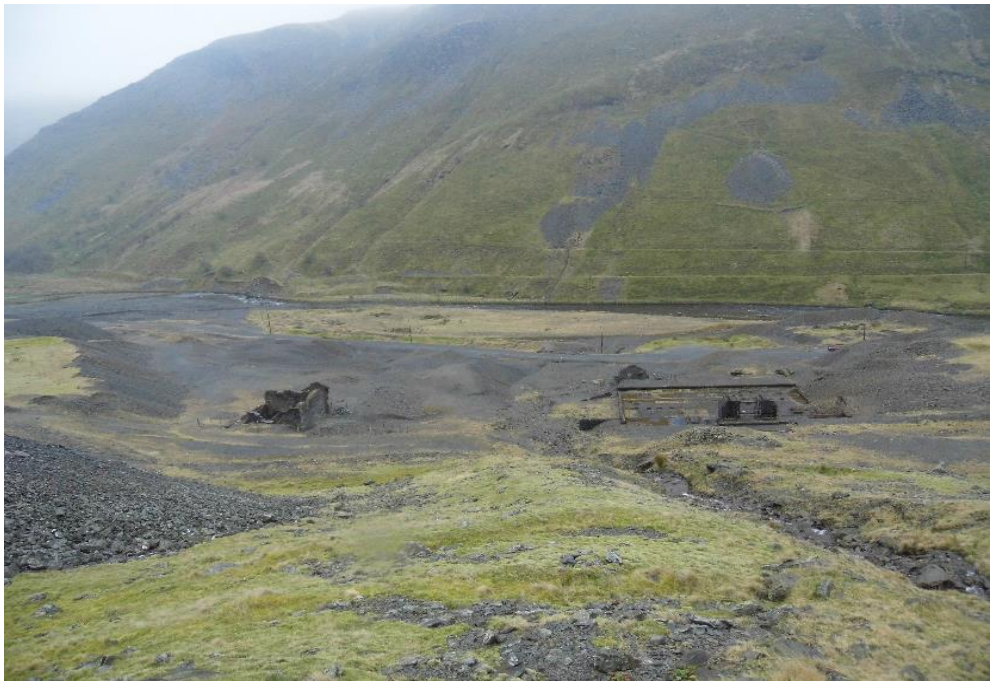
Natural Resources Wales Evidence Report No: 203



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Contents

1. Crynodeb Gweithredol

Mae gan ardal Cwmystwyth hanes hir o fwyngloddio am amrywiaeth o fetelau trwm, gan gynnwys sinc, plwm a chopr. Daeth y mwyngloddio i ben yn gynnar yn yr ugeinfed ganrif. Fodd bynnag, ers hynny mae nifer o adeiladau'r mwyngloddiau, y mynedfeydd a'r tomenni rwbel yn parhau i fod ar y safleoedd, ac ychydig o waith adfer sydd wedi'i wneud. Mae nifer o'r adeiladau'n gymharol gyfan, ar wahân i ddadfeilio graddol. Mae'r tomenni rwbel sy'n gysylltiedig â'r mwyngloddiau a'r adeiladau eu hunain yn cynnal casgliad tameidiog, ond unigryw, o gennau. Mae'r rhain, ynghyd â nifer cyfyngedig o blanhigion fasgwlaidd a bryoffytau (mwsoglau a llysiau'r afu), yn ffurfio amrywiad o'r gymuned glaswelltir calaminaraidd. Nodwedd hollbwysig y gymuned hon yw ei bod wedi datblygu ar swbstrad metelaidd, ac mae nifer o rywogaethau naill ai wedi'u cyfyngu i'r amodau hyn neu'n arwydd cryf ohonynt (metaloffytau). Ymhellach, mae glaswelltir calaminaraidd yn un o nodweddion dynodedig Ardal Cadwraeth Arbennig (ACA) Elenydd, safle Natura 2000. Cwmystwyth yw'r brif enghraifft o'r nodwedd galaminaraidd oddi mewn i'r ACA.

Aeth arolygon diweddar gan Simkin (2015) ati i fapio presenoldeb glaswelltir calaminaraidd ar draws nifer o safleoedd mwyngloddio yng nghanolbarth Cymru. Adeiladodd yr arolwg hwn ar waith blaenorol (Simkin, 2014) a geisiodd greu dosbarthiad manylach o'r cynefin yng Nghanolbarth Cymru. Dangosodd hyn fod gwahanol ffurfiau o'r cynefin wedi bodoli a'u bod wedi cael eu nodweddu mewn amrywiol ffyrdd gan rostiroedd, glaswelltiroedd a rwbel metaloffytaidd, yn ogystal ag ardaloedd a oedd, i raddau helaeth, yn noeth o lystyfiant (rwbel noeth, halogedig iawn).

Ni chynhwyswyd safle Cwmystwyth yn yr arolwg blaenorol gan ei fod yn cael ei ystyried yn gymharol adnabyddus o'i gymharu â nifer o fwyngloddiau eraill yng nghanolbarth Cymru. Yn ystod y 30 mlynedd ddiwethaf ymwelwyd â'r safle sawl tro ac fe'i harolygwyd nifer o weithiau, a chydnabyddir ei fod yn lleoliad hollbwysig i nifer o fetaloffytau anfynych a phrin. Fodd bynnag, nid oedd union ddosbarthiad yr ardaloedd metaloffytaidd wedi'i fapio o'r blaen ac nid oedd lleoliadau'r rhywogaethau nodedig wedi'u cadarnhau'n ddiweddar. Nod yr arolwg hwn oedd darparu map diweddar yn dosbarthu hyd a lled y cynefin calaminaraidd yng Nghwmystwyth a darganfod lleoliadau hollbwysig y rhywogaethau metaloffytaidd.

2. Executive Summary

The Cwmystwyth area has a long history of mining for a variety of heavy metals, including zinc, lead and copper. Active mining ceased in the early part of the twentieth century. However, since this time many of the mine buildings, adits and spoil tips have remained *in situ* and little restoration work has taken place. Several buildings remain relatively intact, save for the gradual processes of decay. The spoil tips associated with the mines and the buildings themselves support a patchy but unique assemblage of lichens. These, together with a limited number of vascular plants and bryophytes (mosses and liverworts) form a variant of the calaminarian grassland community. The key characteristic of this community is that it has developed on a metal-rich substrate and a number of species are either confined to or are highly indicative of these conditions (metallophytes). Calaminarian grassland is also one of the designated features of the Elenydd Special Area of Conservation (SAC), a Natura 2000 site. Cwmystwyth is the main example of the calaminarian feature within the SAC.

Recent surveys by Simkin (2015) mapped the presence of the calaminarian across a number of mine sites in mid Wales. This survey built on previous work (Simkin, 2014) that sought to produce a more detailed categorisation of the habitat in mid Wales. This established that different forms of the habitat existed which were variously typified by metallophyte-rich spoil, grassland and heathland, as well as areas that were largely denuded of vegetation (bare, highly contaminated spoil).

The Cwmystwyth site was excluded from this previous survey since it was considered to be relatively well-known compared with a number of the other mid Wales mines. The site had been visited and surveyed many times during the past 30 years and it was recognised that it was a key location for a number of scarce and rare metallophytes. However, the precise distribution of metallophyte-rich areas had never been mapped and the locations of noteworthy species had not been recently verified. This survey aimed to provide an up-to-date distribution map of the extent of the calaminarian habitat at Cwmystwyth and to identify key locations for metallophyte species.

3. Introduction

Mining for heavy metals (zinc, copper and lead) is inextricably linked with the landscape at Cwmystwyth. Evidence of these mining activities dominates the lower slopes of the Cwmystwyth Valley. Mining ceased completely in the 1950s and since then, aside from some minor restoration work, much of the area has been left *in situ*. Features of the site include large areas of spoil (of a variety of sizes, aspects and degree of contamination), adits and shafts and a range of buildings.

A number of lichen species are virtually confined to metal-rich micro-habitats (metallophyte lichens), and reach their maximum abundance in abandoned metal mine locations. These include species in the genera *Vezdaea*, *Thelocarpon*, *Stereocaulon* and *Lecanora* as well as many other single species from different genera. A survey of all the mine sites (including Cwmystwyth) in 1992, for the Countryside Council for Wales (CCW) and the Dyfed Wildlife Trust (Dyfed Wildlife Trust, 1992), revealed that many of them are amongst the highest quality metallophyte sites in the UK. The ecological value of the metal mine lichen assemblage has been recognised by its inclusion in the Section 7 list of species and habitats of principal importance for conservation of biological diversity in Wales in the Environment (Wales) Act (2016). As such, planning authorities and decision makers should have due regard to species and habitats that appear on the Section 7 list when making planning decisions.

As with lichens, certain bryophytes are also confined to metal-rich habitats. These are, however, fewer in number and comprise two *Cephaloziella* species – *nicholsonii* and *massalongi* (particularly in copper-rich situations), *Scopelophila cataractae* (copper-rich, often near buildings), *Grimmia atrata* (copper-rich outcrops and spoil) and *Ditrichum plumbicola* (fine waste from lead mines). These last two species have been recorded at the site, though in small quantity. Other species, such as *Weissia controversa* var. *densifolia* are found much more abundantly on metal mine and other metal-rich sites than elsewhere.

The mine sites also provide a locus for several species of ferns with a restricted distribution in mid Wales. These are largely associated with the mine buildings (e.g. Forked Spleenwort *Asplenium septentrionale*) and with short grassland adjacent to the mine buildings (e.g. Moonwort *Botrychium lunaria*). In addition, a small number of vascular plants are characteristic of the mid-Wales mine sites. These include the prostrate form of Sea Campion *Silene uniflora*, which is strongly tied to metal mine areas and is considered to be a metallophyte.

The combination of all these species forms a unique variant of the calaminarian. The calaminarian is essentially a grassland habitat that has developed on a metal-rich substrate. The habitat is recognised as of European importance and is detailed under the Habitats Directive as type H6130 calaminarian grasslands of the *Violetalia calaminariae*. In Britain, it is partly categorised under the National Vegetation Classification (NVC) as OV37 *Minuartia verna – Festuca ovina* grassland community. It takes a variety of forms across its European range and the British examples are subsumed under the EUNIS Habitat Classification as ‘heavy-metal grassland of western and central Europe’, which is regarded as Endangered on the new European Red List of Habitats. Even within Britain, the calaminarian exhibits a number of

different forms. The mid-Wales sites lack characteristic species such as Spring Sandwort *Minuartia verna* (the principal charcter species of OV37) and Alpine Pennycress *Noccaea caerulescens* but are especially rich in metallophyte lichens (and, to a lesser extent, metallophyte bryophytes).

The Cwmystywth mines area has long been recognised as an important location for this variant of the calaminarian, particularly with respect to its lichen assemblage. A long history of recording (over some 30 years) has identified this as one of the more important sites for metallophyte lichens within the mid-Wales area (and in a wider UK context). This relatively detailed knowledge of the site meant that it was left out of a recent survey of the mid-Wales mine sites. The survey, conducted by Simkin (2014) sought to categorise a large number of the mid-Wales mine sites in terms of their calaminarian. However, since this survey was conducted it has become clear that a similar classification of the Cwmystwyth site does not exist. No overall mapping of the site in terms of the calaminarian had previously taken place. Furthermore, the locations of important metallophyte species had not been recently reviewed and these locations had not been linked with the presence of the wider calaminarian habitat.

This current contract aimed to fill this gap in survey coverage. It therefore had two main objectives – to map the site in terms of the Calaminarian and to review and confirm the locations of key species of metallophytes. To meet the first objective, the site was mapped in terms of the categories provided by Simkin (2014). This will allow for a comparison with sites previously surveyed. In broad terms, survey differentiated between spoil with metallophytes, grassland with metallophytes, heathland with metallophytes and bare, highly contaminated spoil. A further category was that of bryophyte-rich areas, a 'sub-community' often associated with damp, shaded ground. These bryophyte-rich areas were also found to support a number of metallophyte lichens, and in particular *Vezdaea* species. Further sub-division was made between areas which appeared to be rich in metallophytes (i.e. abundant presence of obvious species such as *Stereocaulon dactylophyllum and S. condensatum*) and those which appeared to be largely poor (i.e. obvious metallophytes very patchy). Maps showing the extent of these habitats are found in Appendix 1 (and supplied in separate ARC GIS Shape files).

During the course of the survey, key locations for metallophytes were recorded and existing locations reviewed and confirmed. The survey established that a number of areas of the site were rather poor for metallophytes and could not be described as good areas of calaminarian. These areas included widespread, largely bare spoil, areas in which grassland had become too dense to support metallophytes, areas that had been re-profiled and mixed with non-metal-rich 'spoil' such as concrete and highly toxic bare 'sludge' and fine spoil, devoid of species. The survey also ascertained that many areas of the Cwmystwyth site continued to support good metallophyte habitat. These included areas of metal-rich spoil, a small number of bryophyte-rich areas (with associated metallophyte lichens), buildings and widespread, patchy grassland mixed with spoil. A further good metallophyte habitat, though not included in the categorisation detailed above, is that of river shingle. A large area of this was present alongside the Ystwyth. Whilst much of this 'sub-community' is the result of natural processes, it has also undoubtedly been affected by mining activities and some of the natural shingle is highly likely to be mixed with

rock derived from the mining area. The locations of several key metallophyte species were also reconfirmed and a small number of additional rare species were added to the site list. Both calaminarian habitat areas and the locations for scarce and rare species are provided on the annotated maps in Appendix 1.

Survey methodologies are outlined below.

4. Methodology

S.P. Chambers (lichenologist) and C. Forster Brown (bryologist) visited the site on 18th March and again on 24th March 2017. S.P. Chambers has been a practising lichenologist for over 20 years. He is currently an international referee (determining specimens) for the British Lichen Society (BLS) and is a former council member. He is also on the Conservation Committee of the BLS. He contributed to the revised edition of 'The Lichens of Great Britain and Ireland' providing species accounts for several genera associated with metal mine habitats, e.g. *Vezdaea*. He conducted surveys of all the metal mines in Ceredigion in 1992 – 1994 and of metal mines in north Wales in 1995. He has also carried out the survey and assessment of potential impacts on metallophyte lichen species and communities at several mine sites proposed for remediation.

C. Forster Brown MCIEEM has been a practicing ecologist for over 20 years. He has carried out numerous botanical surveys including all standard and recognised techniques (e.g., National Vegetation Classification, Phase I, extended Phase I, condition assessment). He holds IdQ examinations in vascular plants (1997) and bryophytes (2005), endorsed by the Natural History Museum. He has carried out numerous lower plant surveys, including surveys of species associated with metal mine habitats. He worked alongside S.P. Chambers to carry out the survey and assessment of lower plants on several mid-Wales metal mine sites proposed for remediation.

Background information for the survey had been provided by NRW. This included copies of previous reports by Simkin (2014, 2015), a proposed methodology and high quality, orthorectified aerial photographs of the site.

Calaminarian grassland was mapped in line with the categories defined by Simkin (2014). These were as follows:

- A Open stony ground with sparse or no vascular plant cover, on spoil, tailings or around mine buildings and other structures. The strong heavy metal influence is usually evident from the sharp delimitation of affected areas, and the contrast with the surrounding non-calaminarian vegetation.

AM Open stony ground with one or more metallophytes.

- B Open calaminarian grassland on spoil, tailings or around mine buildings and other structures, with scattered grasses and small patches of bare ground, lichens and/or bryophytes. The strong heavy metal influence is usually evident from the sharp delimitation of affected areas, and the contrast with the surrounding non-calaminarian vegetation.

BM Open grassland with one or more metallophytes

- C Closed calaminarian grassland sward of grasses and/or large pleurocarpous mosses, on spoil, tailings or around mine buildings and other structures. The heavy metal influence is usually evident from the sharp delimitation of affected areas, and the contrast with the surrounding non-calaminarian vegetation.

CM Closed swards with metallophytes

- D Damp bryophyte communities on damp, shaded, ground on spoil, tailings or around mine buildings and other structures, dominated by small mosses or leafy liverworts.

DM Bryophyte communities with one or more metallophytes

- F Buildings and other man-made structures on mine sites and likely to be impregnated with heavy-metal contaminated dust.

FM Buildings or other structures with metallophytes

- H Calaminarian heath on spoil, tailings or around mine buildings and other structures, with constant and frequent heather (cover >10%), and beneath that a fine mosaic of bare ground, lichens and/or bryophytes and scattered grasses. The strong heavy metal influence is usually evident from the sharp delimitation of affected areas, and the contrast with the surrounding non-calaminarian vegetation.

HM Calaminarian heath with one or more metallophytes

- O Other, non-calaminarian habitats, including moorland, forestry, open water and wet ground, with no evidence of heavy-metal influence on the vegetation.

Again following Simkin, and using the broader definition of calaminarian grassland, all but F, FM and O can be considered calaminarian grassland habitats. The narrower definition restricts this to AM, BM, CM, DM and HM. The current survey used these more narrowly defined categories. AM and BM categories were further sub-divided into areas of 'good' metallophyte habitat and areas of 'poor' metallophyte habitat. Habitats were mapped directly onto ortho-rectified aerial photographs. These were mapped as pure polygons where possible and to a minimum stand area of 0.02 ha.

Clean copies of the resultant mapping, categorising the whole site in terms of the calaminarian definitions, are provided in Appendix 1.

In assessing habitat quality, a wider list of species was used, including:

- metallophytes
- nationally rare or scarce in Britain
- Section 7 (Environment (Wales) Act 2016)
- taxa not yet described or in need of taxonomic review
- other lichens that are strongly associated with calaminarian grassland in Britain

Areas of high habitat quality and supporting a range of metallophyte species and/or nationally rare/scarce species and/or Section 7 species are highlighted on the aerial

maps in Appendix 1 as Target notes. These areas are also described in the results and evaluation section.

Notes on site management were compiled, including any livestock present, threats to the calaminarian grassland, any off-road vehicle activity, fly-tipping, detrimental re-profiling and scrub encroachment.

A list of species recorded in the calaminarian grassland on the site, indicating any metallophyte species used to define the habitat, is provided in Appendix 2.

Appendix 2 also identifies all records of notable metallophyte lichens and bryophytes, with population size estimates and 8- or 10-figure GPS readings, so as to allow identification of key areas for these taxa. These are also provided in a separate excel format.

Digital photographs to illustrate significant variation in the calaminarian grassland present are also provided (Appendix 3).

Based on the surveyors' experience, the following caveats apply to the survey of metallophytes:

- because metallophyte interest on metalliferous sites is typically highly dispersed and 'patchy', even on the richest sites, notable species and assemblages usually occur in patches no larger than ca. 1-10cm across. These are located within much larger areas several decimetres or more in extent, the greater part of which contain little or no identified interest. Small areas can effectively be comprehensively searched but larger areas can only be selectively searched because of the minute nature of many taxa, particularly the rare ephemeral terricoles and perennial species occupying tiny sub-centimetre niches.

- as a consequence of the dispersed and minute nature of many of the taxa, a comprehensive survey of the entire potential area is not practical.

Despite these caveats, all areas of suitable habitat for metallophytes were visited and searched. It is unlikely that important species were missed and the areas of habitat highlighted represent the key areas for metallophytes for the site as a whole.

Examples of all potential micro-habitats were surveyed within all areas likely to hold important assemblages of metallophytes. In particular, these included open, patchy grassland, slopes below collapsed (and relatively intact) buildings, spoil mounds with coarser material (i.e. larger stones) and incipient heath areas. Where possible, species were identified in the field with either a x10 or a x20 hand lens, but a number of specimens had to be collected for later determination under the microscope. The main texts used for identification were, for lichens, Dobson (2011) and Smith *et al*. (2009) and, for bryophytes, Atherton *et al.* (2010) and Paton (1999).

Taxonomy and nomenclature for lichens follows Smith *et al*. (2009) updated by changes published in the biannual bulletins of the British Lichen Society. Taxonomy and nomenclature for bryophytes follows Atherton *et al.* (2010), updated by bulletins of the British Bryological Society.

Weather conditions on the survey days were generally fine with occasional overcast spells. Weather conditions and time of year were both ideal for survey.

5. Results

Taken as a whole, the Cwmystwyth site comprises a mix of the calaminarian 'communities' defined by Simkin (2014). These are detailed on the maps in Appendix 1. Area figures for each of the calaminarian communities, including 'condition' categories (i.e. good, poor, average) are detailed in Appendix 4. It is immediately clear, however, that two of these are particularly dominant at the site – AM (open stony ground with one or more metallophytes) and BM (open grassland with one or more metallophytes). Only small areas, few in number, were categorised as HM (calaminarian heath with one or more metallophytes) or as DM (Bryophyte communities with one or more metallophytes). Examples of HM were more prevalent at the southern end of the Copa mine area where the vegetation, in places, supported an incipient form of heath with occasional heather *Calluna vulgaris* but also widespread lichens more typical of this community such as *Cetraria* species (Photographs 1 and 2, Appendix 3). DM occupied very small areas, usually in the shaded lee of buildings or close to former trackways (Photograph 3, Appendix 3). One area was found to contain the very fine damp spoil characteristic of *Ditrichum plumbicola*, and this species was recorded here (Photograph 4, Appendix 3). CM (Closed swards with metallophytes) was found towards the edges of the site and particularly the western edge. However, this area appeared to be largely non-calaminarian i.e. U4/U5 calcifugous grassland.

AM and BM were probably equally represented at the site, with large expanses of the former comprising the main spoil tips (particularly on slopes) and BM becoming more prevalent on flatter areas. These flatter areas were often adjacent to or close by the mine buildings. The very large area of 'shingle' associated with the river was found to support a small number of metallophytes and was marked as AM (Photographs 5 and 6, Appendix 3). Both AM and BM 'sub-communities' varied greatly in quality. Good examples of each were scattered throughout the site (see map in Appendix 1 and detailed notes below). Many examples were however almost devoid of metallophyte interest and in a number of areas, all vegetation (in particular AM). A large area of very species-poor AM was found in the centre of the site (Photograph 7, Appendix 3). It is presumed this area is highly contaminated and that it will take a very long time for species to establish here. An area of re-profiled spoil south of the road, whilst supporting some lichen interest, has been extensively mixed with more base-rich material (e.g. concrete) and this has had a detrimental effect on its metallophyte potential (Photograph 8, Appendix 3).

The following locations are considered to be particularly important for metallophyte species (and by extension, the calaminarian) at Cwmystwyth. Species detailed include both lichens and lichenicolous fungi. The locations are not presented in order of relative merit. It should also be noted that the list is not exhaustive. Therefore, it should not be inferred that unmentioned locations lack metallophyte interest. Accurate Global Positioning System (GPS) 10-figure Grid References (GRs) are given where known for the more recently recorded locations and species that were

re-found during the current survey. However, GPS technology was unavailable during the 1992-1994 metal mine survey when 6-fig GRs were estimated from Ordnance Survey maps. Some of these locations were not searched in detail during the current survey due to time constraints. It should be assumed, however that species interest is still present. The locations are marked on the map at Appendix 1, in accordance with the numbering below.

1. Building on road at GR22/800743. Goniocysts of *Vezdaea leprosa* at south east corner. Some slightly Fe/metal-rich ferruginous siliceous blocks in wall: *Myriospora smaragdula* and *Scoliciosporum umbrinum* along fine cleavages. Rusty spoil slope at east end: *Rhizocarpon oederi*, *Acarospora sinopica*, *Placopsis lambii* (with *Polycoccum squamarioides*). Crumbling wall at back: ledges and crevices with *Vezdaea leprosa*, *Micarea cinerea* f. *tenuispora*, *Cladonia subulata*, *Baeomyces rufus* and *Bilimbia sabuletorum* (over moss cushions).

2. Building on south side of road. Ground near south west corner with *Placynthiella hyporhoda*, discovered 1996 and re-found 2017. About 25m south west of the building at GR (GPS) 22/80121.74421, alt 235m, c. 4 small, c.2cm diam., patches of *Cladonia strepsilis* (new for the mine) on heathy-stony low wall top feature. Rainfall must be sufficient for it up here, closely associated with *C.subcervicornis* and *Baeomyces placophyllus*. Occasional *Stereocaulon condensatum* nearby. Also *Mniaecia jungermanniae* and much *Micarea cinerea* f. *tenuispora* on damp, acid-heathy metal-polluted ground and on ‘gunge lumps’ on wall below road. In 1996 *Coppinsia minutissima* and *Vezdaea cobria* were noted here, and both species were seen again in 2017. In 1996 *Vezdaea rheocarpa* and *Coppinsia minutissima* were both frequent on the flat areas near the road on the north east side of the building. Also one of only three places where *Massalongia carnosa* has been seen at the mine, firstly by Alan Fryday in 1989 then by SPC in 2011 & 2017 (Photograph 9, Appendix 3).

3. More recently dumped or moved spoil hummocks in mound-scape east from location 3 above has (in 2017) *Dibaeis baeomyces* hosting *Rhymbocarpus* (*Gelatinopsis*) *ericetorum* on top of one mound – new for the mine & third VC record. In general, this area has been greatly modified and appears to now contain much concrete and base-rich spoil. It is therefore of much reduced value for metallophytes and in no way represents an area of calaminarian.

4. Along the south side of the road, ‘gungy’ spoil-mound aprons (patches of dark ‘goo’ over flatter spoil edges etc.) immediately beside road at GR (GPS) 22 (SN)80220.74485, alt 230m, have *Gyalidea subscutellaris* (locally frequent), *Leptogium subtile*, *Vezdaea cobria*, *V.leprosa*, *Coppinsia minutissima*, *Stereocaulon condensatum* (tiny sub-centimetre tuftlets) and *Micarea cinerea* f. *tenuispora*.

5. Large shoal of metal-polluted river shingle along the north side of the Afon Ystwyth, centred on GR22(SN)803744, c. 232–234m, forming a large open expanse of ‘cobble-shingle’ south of the road, between the road and river but closer to the river than the road (Photographs 5 and 6, Appendix 3). In many ways like some of the Grogwynion/Tynbedw shingle shoals were before vegetation succession took hold, but much larger and completely open on the north side of the Afon Ystwyth. Although categorised as shingle on the map at Appendix 1, this area is beginning to

show elements of a heath-type vegetation (i.e. HM). The shoal runs west - east, in profile is gently raised, the highest central part being no more than a metre or so above the flanks. Undoubtedly of natural origin, with naturally (fluvial processes) and unnaturally (mine-source) incorporated metal-rich rock/spoil etc. The lichen flora can be usefully 'compartmentalised' between (i) terricole (spp. on fine material deposits, or on bryophytes, between the cobbles) and (ii) saxicole (growing directly on the cobbles) elements -

(i) Terricoles (= 20 taxa): *Baeomyces placophyllus* (rare), *B.rufus*, *Cetraria aculeata* (occ.), *C.muricata* (rarer), *Cladonia cervicornis* ssp. *cervicornis* (drier parts on more raised surfaces), *C.diversa*, *C.furcata* (heather-grassier area), *C.gracilis*, *C.portentosa*, *C.strepsilis* (rare, colony over area c. 2 x 3m in one place at GR (GPS) 22(SN)80352.74487), *C.subcervicornis* (squamules hosting *Diploschistes* 'aff. *muscorum*', seen a few times, but very poorly developed, new for the mine), *C.uncialis* ssp. *biuncialis* (grassier area), *Dibaeis baeomyces*, *Micarea leprosula*, *M.lignaria*, *Mniaecia jungermanniae* (on *Diplophyllum albicans* wefts), *Peltigera hymenina* (rare), *Placynthiella hyporhoda* (on metalliferous river shingle (like Grogwynion), rare (seen twice in one place) in damp saucer-like shallow depressions, again over 'mineral soil', towards the west end just near the centre crest at GR (GPS) 22(SN)80296.74462, alt 233m; third location for it at Cwmystwyth mine) and *Stereocaulon condensatum* (little tufts here & there) (Photograph 5, Appendix 3).
(ii) Cobble saxicoles (= 22 taxa): *Buellia aethalea*, *Catillaria atomarioides*, *Fuscidea lygaea*, *Lecanora polytropa*, *L.soralifera*, *Lecidea lithophila*, *Melanelixia fuliginosa* (rare on enriched block top), *Physcia tenella* (rare, ditto), *Placopsis lambii* (with *Polycoccum squamarioides*), *Porpidia cinereoatra* (rare), *P.crustulata*, *P.macrocarpa* s.l. (various morphs), *P.striata* (rare), *P.tuberculosa*, *Rhizocarpon geographicum*, *R.lavatum*, *R.oederi*, *R.reductum*, *Trapelia glebulosa* 'small', *T.glebulosa* s.s. and *T.obtegens* (rare) (Photograph 6, Appendix 3).

6. At the eastern end, the shoal grades into an area of more typical blocky-cobble mine spoil – species here are excluded from the 'eu-shingle community' detailed above. Block spoil (associated with the edges of the Nant Watcyn 'outwash area' below the road): *Stereocaulon dactylophyllum* (very locally frequent; one albino seen with all apothecia on the tuft instead of the normal dark brown instead a pure 'ghostly' pale flesh pink-white. The tuft also standing out from the others by being a 'brighter white', less grey-white. Albino forms of the species have not been noted before. Also here: *S.vesuvianum* var. *nodulosum*, *S.nanodes* (new for the mine), and, on a large spoil boulder-block, good chasmolithic *S.leucophaeopsis*.

7. At GR22(SN)805745, alt 240m, very locally frequent *Lecidea lapicida* occurs on well-lit large dark block spoil, over an area c. 5 x 8m of spoil comprising the 'outwash fan' of the Nant Watcyn just below the road here, the first VC 46 record.

8. Rusty tip slope and top flat in the central part of the mine, at GR22(SN)805746, have *Stereocaulon pileatum*, *S.leucophaeopsis*, *S.condensatum*, *Acarospora sinopica* and *Baeomyces placophyllus*. *Stereocaulon condensatum* seems to have increased significantly at the mine since c. 1992. Top edge of damp heathy-wet low wall beside track behind building has a tiny amount (dispersed micro-squamules) of *Massalongia carnosa*, only the third time it has been seen at the mine in nearly a third of a century. Heathy ground, probably metal-contaminated (as all

surfaces are to various degrees) and block spoil: *Micarea coppinsii*, *Rhizocarpon lecanorinum* (v.l.f in one area on well-lit south-facing spoil). *Stereocaulon vesuvianum* on spoil and also terricolously on ground. Spoil: *Pertusaria corallina* (with *Sclerococcum sphaerale*), *P.pseudocorallina* and *P.aspergilla*. Heathy grassy metal-polluted slope: *Cladonia ciliata* var. *ciliata* and var. *tenuis*.

9. A conspicuously rusty (central part) south-facing isolated spoil tip high on hillside at west end, GR22(SN)80030 74560, first 'discovered' in 1996 on the British Lichen Society spring field meeting, is one of the best at the mine and supports, *inter alia*, *Acarospora impressula*, *A.sinopica*, *Lecanora subaurea*, *Lecidea endomelaena*, *Miriquidica pycnocarpa* f. *sorediata*, *Rhizocarpon cinereovirens*, *Rimularia furvella*, *Stereocaulon pileatum* and *S.leucophaeopsis*. Boulders to the east of the tip have *Immersaria athroocarpa*, *Lecidea swartzioidea* and *Ophioparma ventosa* (grey f. *subfestiva* morphs).

10. South-facing spoil 'scree chute' north-west of main building, at GR22(SN)800747, has *Micarea coppinsii*, *Rhizocarpon cinereovirens* and *R.expallescens*, intermixed with *Acarospora sinopica*. Also here is *Arthrorhaphis grisea* on *Baeomyces rufus*.

11. The central flat expanse north of the road in front of the building, at GR22(SN)802745, has *Gyalidea subscutellaris* on fine toxic slimes. Extensive flats of heathy terricole habitat here have *Micarea cinerea* f. *tenuispora*, *M.lignaria*, *Hypogymnia physodes*, *Stereocaulon dactylophyllum*, *S.condensatum* (good colonies on metal-rich, fine gravelly ground), *Baeomyces placophyllus*, *Dibaeis baeomyces* and, *C.cervicornis* ssp. *verticillata*. Inside the building on the ground, scraps of *Peltigera neckeri* are present. *Sarcosagium campestre* occurs in front of building, together with *Agonimia gelatinosa* (abundant in 1996), *Coppinsia minutissima*, *Steinia geophana* and *Vezdaea aestivalis*.

12. Rocky outcrops high on the shoulder rising above the west side of Copa Hill, at GR22(SN)807751, have *Sphaerophorus fragilis*.

13. Multifarious mining features, inc. spoil tips, adit entrances, tramway walls, wheel-pit structures and old leat banks, on and up Copa Hill have *Coppinsia minutissima*, *Cryptodiscus* (*Bryophagus*) *gloeocapsa*, *Lepraria* '*incana* + parietin', *Lepraria crassissima*, *Leptogium subtile*, *Micarea subnigrata*, *Porpidia striata*, *Psilolechia leprosa*, *Steinia geophana*, *Stereocaulon leucophaeopsis*, *S.pileatum* and *S.vesuvianum* var. *nodulosum*. The main hushing channel has, on associated spoil, *Carbonea aggregantula* (on *Lecanora soralifera*).

14. Sheltered stonework inside a low, rounded adit entrance (with pendent *Asplenium adiantum-nigrum*) up Copa Hill has *Micarea lutulata*.

15. Seepage crevice on vertical face of huge open-cut at top of Copa Hill, at GR22(SN)808752, has *Dermatocarpon intestiniforme*, one of two known locations in Cards. (hb. SPC)

16. The lip of an infilled shaft north west of the crusher house, at GR22(SN)801746, had in 1994 frequent *Stereocaulon glareosum*. Though still present in 1996, it appeared much sparser.

17. A very rusty section of a steep, south-facing spoil tip on the west side of the Copa Hill stream approximately a quarter of the way up from the bottom, at GR22(SN)80837.74859, has super-abundant *Lecanora subaurea*, certainly the largest colony of this species in Britain. *L.subaurea* also grows muscicolously (over *Racomitrium lanuginosum*) and lichenicolously (over *Micarea leprosula*) here, behaviour unobserved anywhere else in Britain or in its world range. The tip supports a rich assemblage of other quality companion metallophytes, including *Acarospora sinopica*, *Polycoccum squamarioides* (on *Placopsis lambii*), *Rhizocarpon cinereovirens*, *R. furfurosum*, *R.oederi* and *Stereocaulon leucophaeopsis*. The tip just below has *Lecanora handelii* and *L.epanora*. In 2005 just to the east, a flat area of ground rich in ferroan dolomite had a tiny amount of *Placynthiella hyporhoda*. Flushed un-worked natural rockface on the east side of the stream has (2005) *Melaspilea interjecta*.

18. Wet floor of an adit on the west side of the Copa Hill stream, at GR22(SN)808752, has the rare *Ephebe hispidula* (conf. Dr B.J. Coppins; hb SPC).

Other locations recorded during the current survey that supported abundant metallophyte indicators representative of the BM ‘sub-community’ were at SN80324 74630 and SN80421 74618. Here, there were extensive mats of both *Stereocaulon dactylophyllum* and *S. glareosum*.

6. Conclusions

The Cwmystwyth mine site is clearly important for the calaminarian. As is typical for this habitat, over much of the site, the community is relatively patchily represented, depending on the degree of contamination i.e. with the most contaminated areas such as the central spoil area remaining devoid of vegetation even after some 60 to 70 years after mining ceased. Other areas, particularly flatter areas adjacent to buildings and small, damp, often bryophyte-rich areas in the lee of buildings, were much more species-rich. This is possibly due to the specific chemical make-up and mix of spoil in these areas and potentially the degree of compaction. Many spoil areas (AM) were very species-poor and lacked any evidence of metallophytes, or at least they were very sparsely represented. Other individual spoil tips were much more species-rich. These were often very isolated from the next nearest tip that supported a similarly rich assemblage of species. Again, this is probably due to the specific chemical make-up of the individual tip, its aspect and potentially other factors, such as degree of stability. The shingle area close to the Ystwyth is also worthy of mention. It does not perhaps support the diversity of metallophyte species that other areas do, but represents a further variant/’sub-community’ of the calaminarian that is important in its own right. It can be regarded as an early stage of succession of shingle heath (cf. Grogwynion). Further east, in the Copa area, areas of calaminarian are at a higher density and there are many specific locations, such that the whole area should be regarded as of high quality.

Many of the metallophyte lichen species present at Cwmystwyth are also well represented at other mid-Wales mine sites. Examples are the species of *Vezdaea* and *Stereocaulon*. The site is not outstanding with respect to these individual species, and can be regarded as typical or characteristic of the mid-Wales sites in general. What perhaps marks the site out in comparison with these other areas, is the sheer extent of the calaminarian. Whilst it is patchy, it is widespread, and also covers a large overall area due to the spread of the former workings. Key areas are outlined in the results section. The shingle area is particularly noteworthy as another 'variant' or 'sub-community' of the calaminarian, representing as it does, a specific stage in the succession from fluvial, metal-influenced shingle, to metal-rich heath. One or two individual tips towards the western end of the mined area are important for the number and extent of their metallophytes. The other area that should be regarded as outstanding and out of the ordinary compared to the other mid-Wales mines, is the Copa hill area. The influence of copper here is clearly evident in the extent of *Lecanora subaurea* and the presence of other species such as *Lecanora handelii*.

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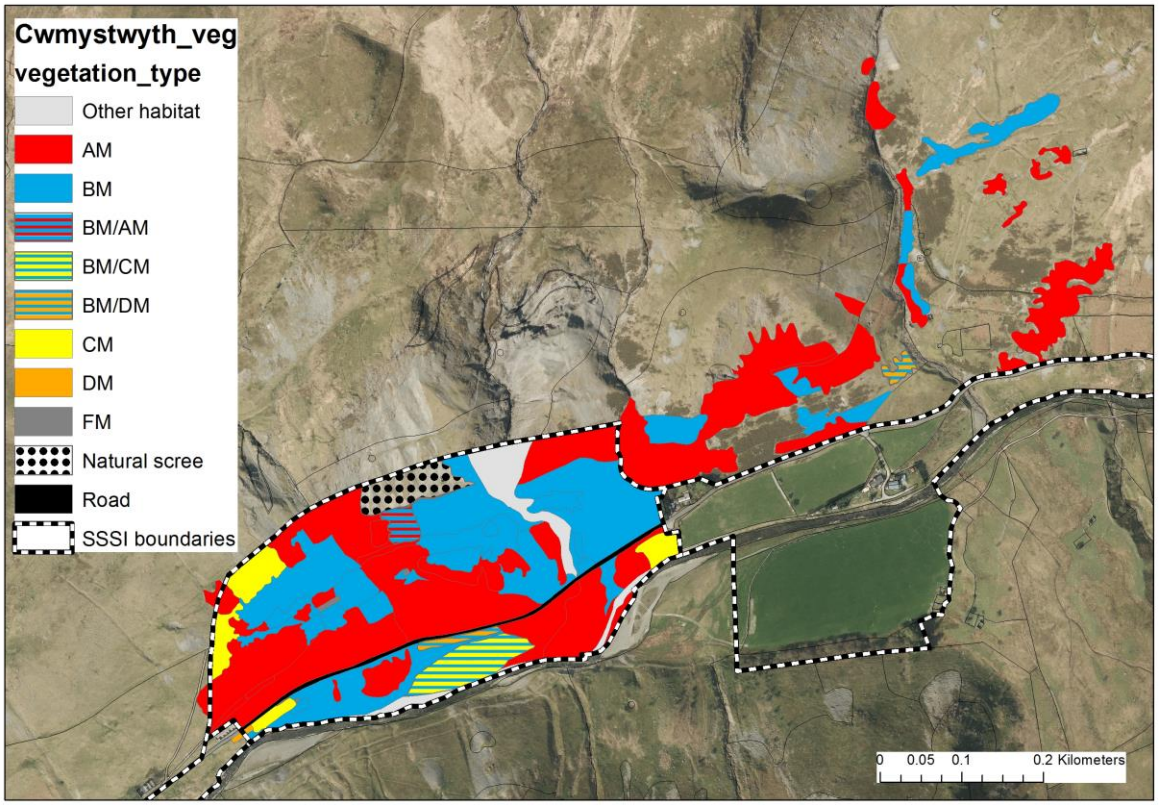
8. Appendix 1

Map showing Cwmystwyth Mine calaminarian and associated communities



9. Appendix 2

Cwmystwyth Mine - Cumulative list of lichens & lichenicolous fungi [LF] recorded since 1988.

S.P. Chambers

Over a time slice approaching 30 years, a large number of survey visits have been made to the mine by various lichenologists. The following list collating all saxicolous, terricolous and lignicolous taxa reliably reported from the mine since 1988, comprises 188 taxa. Common epiphytes, found for example on *Ulex gallii* and heathland dwarf shrubs, are excluded, as the group lacks rarities and is unimportant in respect of the key metallophytic interest. No attempt has been made here to indicate abundances or locations. Many species are known from only single spots or a few places, while others are commonplace. More precise details of distribution and population sizes are provided separately in excel spreadsheet format. Significant or noteworthy taxa (54) as defined in the context of having metalliferous ('calaminarian') affinities, i.e. obligate or facultative metallophytes (*sensu* Martin *et al*. 1994), or VC- or nationally scarce, are shown emboldened. Taxonomy follows the Lichen Flora of Britain & Ireland (2009) with some modern updates (older names bracketed).

Every visit yields new species, including the most recent (SPC & CMFB), when *Catillaria atomarioides*, *Diploschistes* 'aff. *muscorum'* (possible undescribed entity occurring on acidophillous *Cladonia* & *Stereocaulon* spp., known also from Grogwynion (SAC) and c.4 other additional VC 46 Cards localities (Chambers, unpublished), as well as Scotland), *Lecidea lapicida* s.s. (new for Cards.) & *L.swartzioidea* were added.

Survey visits in chronological order: PWJ & RGW, 30 xi 1988; AMF, ii 1989; SPC, numerous visits 1992 – 1994; British Lichen Society Spring Field Meeting, 30 iii 1996; Welsh Lichen Group (SPC, AO, RGW, ADH, CS, JR), 20 iii 2005; SPC & ADH, 18 iv 2011; SPC, 2 vi 2011; SPC, 1 viii 2012; SPC & CMFB, 18 iii 2017. Visits to peripheral workings of the mine on the S side of the Afon Ystwyth are not included.

Recorder initials: ADH = Alan Hale, AMF = Alan Fryday, CMFB = Chris Forster-Brown, CS = Cliff Smith, JR = Joy Ricketts, PWJ = Peter James, RGW = Ray Woods, SPC= Steve Chambers.

Martin *et a*l. (1994). Biological survey of the metal mines of mid-Wales. CCW Science report 92. Aberystwyth: CCW (for the Dyfed Wildlife Trust).

Acarospora fuscata
Acarospora impressula
Acarospora sinopica
Agonimia gelatinosa
Arthrorhaphis citrinella
***Arthrorhaphis grisea* [LF]**
Aspicilia contorta ssp. *contorta*
Aspicilia grisea 'simoensis'
Baeomyces placophyllus

Baeomyces rufus
Bilimbia sabuletorum
Brianaria (Micarea) bauschiana
Brianaria (Micarea) lutulata
Buellia aethalea
Buellia ocellata
Caloplaca dalmatica
Candelariella aurella
Candelariella vitellina
***Carbonea aggregantula* [LF]**
Catillaria atomarioides
Catillaria chalybeia
Cetraria aculeata
Cetraria muricata
Cladonia arbuscula
Cladonia cervicornis ssp*. cervicornis*
Cladonia cervicornis* ssp*. verticillata
Cladonia chlorophaea agg*.*
Cladonia ciliata var*. ciliata*
Cladonia ciliata var*. tenuis*
Cladonia diversa
Cladonia fimbriata
Cladonia floerkeana
Cladonia furcata
Cladonia gracilis
Cladonia macilenta
Cladonia portentosa
Cladonia pyxidata
Cladonia ramulosa
Cladonia rangiformis
Cladonia strepsilis
Cladonia subcervicornis
Cladonia subulata
Cladonia uncialis ssp*. biuncialis*
Clauzadea monticola
Coppinsia minutissima
Cryptodiscus (Bryophagus) gloeocapsa
Cystocoleus ebeneus
Dermatocarpon intestiniforme
Dibaeis baeomyces
Diploschistes scruposus
***Diploschistes 'aff. muscorum' initially* [LF]**
Enterographa zonata
Ephebe hispidula
Ephebe lanata
Flavoplaca (Caloplaca) 'citrina' (agg.)
Flavoplaca (Caloplaca) flavocitrina
Flavoplaca (Caloplaca) oasis
Fuscidea cyathoides
Fuscidea lygaea

Fuscidea praeruptorum
Fuscidea recensa
Gyalecta (Belonia) incarnata
Gyalecta jenensis
Gyalecta (Belonia) nidarosiensis
Gyalidea subscutellaris
Hypogymnia physodes
Immersaria athroocarpa
Ionaspis lacustris
Lecania erysibe f. erysibe
Lecanora albescens
Lecanora campestris
Lecanora dispersa
Lecanora epanora
Lecanora gangaleoides
Lecanora handelii
Lecanora intricata
Lecanora orosthea
Lecanora polytropa
Lecanora semipallida
Lecanora soralifera
Lecanora subaurea
Lecidea endomelaena
Lecidea fuscoatra
Lecidea lapicida s.s.
Lecidea lithophila
Lecidea swartzioidea
Lecidella scabra
Lecidella stigmatea
Lepraria caesioalba
Lepraria crassissima
Lepraria incana s.s.
Lepraria 'incana + parietin'
Lepraria vouauxii
Leptogium subtile
Lichenomphalia hudsoniana
Massalongia carnosa
Melanelixia fuliginosa
Melanelixia glabratula
Melanohalea exasperata
Melaspilea interjecta
Micarea botryoides
Micarea cinerea f. tenuispora
Micarea coppinsii
Micarea leprosula
Micarea lignaria
Micarea peliocarpa
Micarea subnigrata
Miriquidica leucophaea
Miriquidica pycnocarpa f. sorediata

Mniaecia jungermanniae [F]
Myriospora smaragdula
Ochrolechia androgyna
Opegrapha gyrocarpa
Ophioparma ventosa
Parmelia saxatilis
Peltigera hymenina
Peltigera membranacea
Peltigera neckeri
Peltigera rufescens
Pertusaria aspergilla
Pertusaria corallina
Pertusaria excludens
Pertusaria pseudocorallina
Physcia tenella
Placopsis lambii
Placynthiella hyporhoda
Placynthiella icmalea
Placynthiella uliginosa
Polycoccum squamarioides **[LF]**
Polysporina simplex
Porpidia cinereoatra
Porpidia crustulata
Porpidia macrocarpa s.l.
Porpidia striata
Porpidia tuberculosa
Protoblastenia rupestris
Protoparmelia badia
Psilolechia leprosa
Psilolechia lucida
Rhizocarpon cinereovirens
Rhizocarpon 'expallescens'
Rhizocarpon furfurosum
Rhizocarpon geographicum
Rhizocarpon lavatum
Rhizocarpon lecanorinum
Rhizocarpon oederi
Rhizocarpon petraeum
Rhizocarpon reductum
Rhymbocarpus (Gelatinopsis) ericetorum **[LF]**
Rimularia furvella
Sarcogyne regularis
Sarcosagium campestre
Schaereria cinereorufa
Sclerococcum sphaerale [LF]
Scoliciosporum umbrinum
Sphaerophorus fragilis
Steinia geophana
Stereocaulon condensatum
Stereocaulon dactylophyllum

Stereocaulon evolutum
Stereocaulon glareosum
Stereocaulon leucophaeopsis
Stereocaulon nanodes
Stereocaulon pileatum
Stereocaulon vesuvianum var. nodulosum
Stereocaulon vesuvianum var. symphycheileoides
Stereocaulon vesuvianum var. vesuvianum
***Thelocarpon epibolum* [LF]**
Trapelia coarctata
Trapelia glebulosa s.s.
Trapelia glebulosa 'small'
Trapelia obtegens
Trapelia placodioides
Trapeliopsis flexuosa
Trapeliopsis gelatinosa
Trapeliopsis granulosa
Trapeliopsis pseudogranulosa
Tremolecia atrata
Tylothallia biformigera
Varicellaria (Pertusaria) lactea
Verrucaria nigrescens
Verrucaria viridula
Vezdaea aestivalis
Vezdaea cobria
Vezdaea leprosa
Vezdaea rheocarpa
Xanthocarpia (Caloplaca) crenulatella
Xanthoparmelia conspersa

10. Appendix 3

Photo 1: *Cetraria* and *Cladonia* species associated with HM (Calaminarian heath) at southern end of Copa area

Photo 2: HM species in Copa area

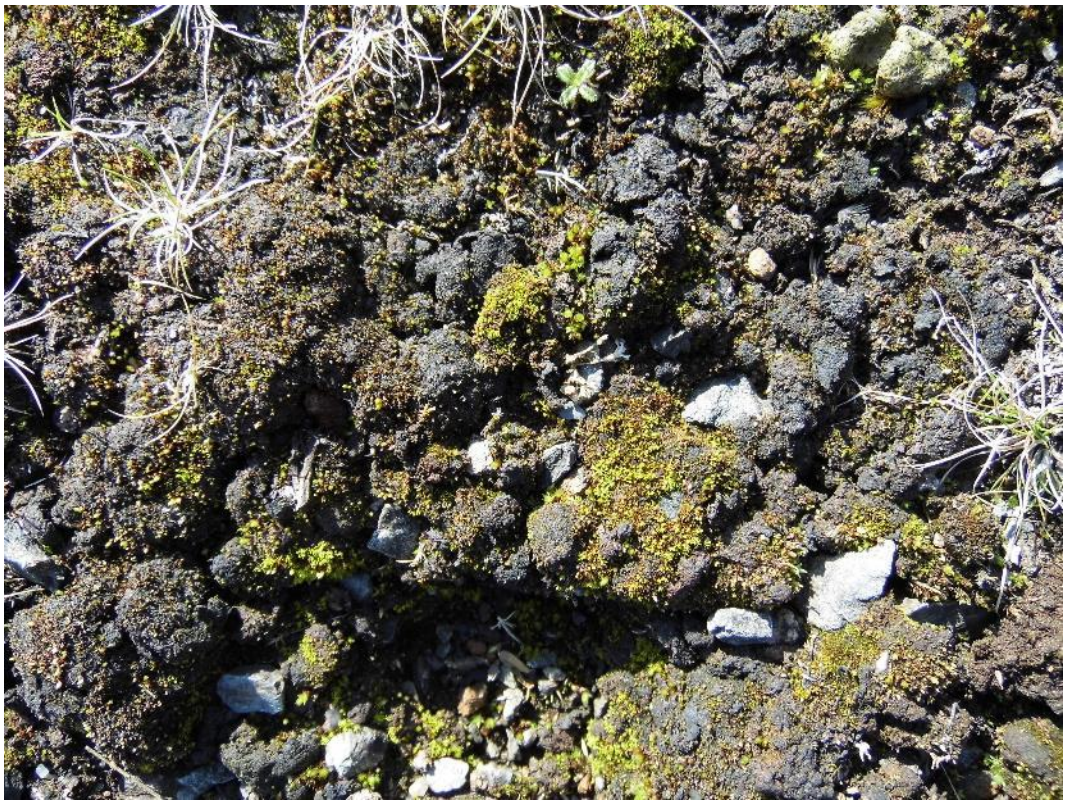


Photo 3: Close-up of DM (bryophyte communities with one or more metallophytes). Usually close to buildings and/or edges of trackways. 'Classic' habitat for *Vezdaea* species, *Steinia geophana*, *Coppinsia minutissima*, etc.

Photo 4: Damp 'sludge' with bryophytes *Scapania undulata* and *Philonotis fontana*. *Ditrichum plumbicola* is found on fine spoil above this feature

Photo 5: River shingle community – supporting ‘terricole’ species on fine deposits between grass clumps

Photo 6: River shingle ‘cobbles’ – supporting saxicole species

Photo 7: Large bare expanse of spoil in centre of photo (in front of buildings). Probably highly toxic and lacking virtually all vegetation

Photo 8: Re-profiled area containing base-rich spoil (e.g. concrete). Little metallophyte/Calaminarian interest remains here

Photo 9: Close to building at GR (GPS) 22/80121.74421 with *Placynthiella hyporhoda*, *Coppinsia minutissima* and *Vezdaea cobria*

11. Appendix 4

Table with total areas of each calaminarian (sub) community

Vegetation type	Condition	Mwyngloddfa Cwmystwyth SSSI area (ha)	Adjacent Elenydd SSSI area (ha)	Total area (ha)
AM	Good	0.2	0.82	1.02
AM	Average	1.23		1.23
AM	Poor	3.43	2.67	6.1
AM	Very poor	1.21		1.21
BM	Good	0.83	0.47	1.3
BM	Average	1.31		1.31
BM	Poor	2.87	0.57	3.44
BM/AM	Poor	0.16		0.16
BM/CM	Average	0.57		0.57
BM/DM	Good		0.08	0.08
BM/DM	Average	0.09		0.09
CM	Average	0.24		0.24
CM	Poor	0.47		0.47
DM	Poor	0.02		0.02
FM	Average	0.04		0.04
0		0.83		0.83
Natural scree	Average	0.49		0.49
Road	Average	0.26		0.26
Totals		14.25	4.61	18.86

Data Archive Appendix

Data outputs associated with this project are archived in https://cyfoethnaturiolcymru.sharepoint.com/teams/evidence/Terrestrial-Habitats/lg/Projects/Forms/NRW%20View.aspx?RootFolder=%2Fteams%2Fevidence%2FTerrestrial%2DHabitats%2Flg%2FProjects%2FCwm%20Ystwyth%20calaminarian%20survey%202017&FolderCTID=0x012000D41C18DF5B07BB4282806632D373B92B&View=%7B01D1FE05%2D6D67%2D49D3%2D8E5B%2D49F3568C7F6E%7D

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