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Defining and mapping calaminarian grassland in mid- Wales

Dr Janet Simkin, CIEEM

Natural Resources Wales Evidence Report No: 024



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¹ 41 North Road, Ponteland, Newcastle upon Tyne NE20 9UN

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1. Crynodeb Gweithredol

Pob chwe blynedd, rhaid i'r gwladwriaethau sy'n aelodau o'r Undeb Ewropeaidd roi gwybod am weithredu'r Gyfarwyddeb Cynefinoedd (yn unol ag Erthygl 17 y Gyfarwyddeb). Datgelodd adroddiadau 2012/13 ddiffyg data hanfodol yng Nghymru ynghylch sawl cynefin a rhywogaeth, gan gynnwys math Atodiad 1 "H6130 Glaswelltiroedd calaminaraidd *Violetalia calaminariae*", sef yn gyffredinol, glaswelltir calaminaraidd. Yn neilltuol, canfuwyd fod angen gwell nodweddu ar enghreifftiau o'r cynefin a ddiffinnir gan rywogaethau planhigion fasgwlaidd (yn enwedig cennau metaloffytig), a chasglu data ardal yn ei gylch. Mae'r mwyafrif o'r math hwn o gynefin yn y canolbarth, yn enwedig Ceredigion, ar safleoedd mwyngloddiau gadawedig.

Mae'r gwaith presennol yn astudiaeth ragarweiniol, yn amcanu diffinio'n well ffurfiau o laswelltir calaminaraidd yng Nghymru sy'n cynnal llawer o gennau, gan amcanu cael gwybodaeth am eu hyd a'u lled yn y dyfodol. Mae'r adroddiad yn gosod cynefinoedd calaminaraidd y canolbarth mewn cyd-destun Prydeinig ac Ewropeaidd, hefyd.

Ymwelwyd â chyfanswm o naw safle yng ngogledd Ceredigion rhwng y 3ydd a'r 5ed o Ragfyr 2013: saith safle mwynglawdd gadawedig, a dau farian afon llygredig. Gwelwyd amrywiaeth fawr yng nghymeriad y cynefin calaminaraidd, gan gynnwys rhai a oedd yn laswellt yn bennaf, gweundir lle ceid llawr o fetalophytau, a thir moel, gan fwyaf, a hynod lygredig. Barnwyd fod peth o'r llystyfiant yn nodweddiadol, yng nghyd-destun Prydeinig ac Ewropeaidd fel ei gilydd. Cofnodwyd cyfanswm o 69 rhywogaeth gen, gan gynnwys 15 o ddiddordeb cadwraeth natur. Cyflwynwyd dosbarthau mathau cynefinoedd calaminaraidd darpariaethol yn y canolbarth, er mwyn hwyluso mapio'r cynefin yn y dyfodol.

Executive Summary

Every six years, Member States of the European Union are required to report on implementation of the Habitats Directive (by Article 17 of the Directive). The 2012/13 reporting round revealed a lack of essential data in Wales for a number of habitats and species, including the Annex 1 type 'H6130 Calaminarian grasslands of the *Violetalia calaminariae*', known generally as calaminarian grassland. A particular need was identified to better characterise, and to compile area data for, examples of the habitat defined by non-vascular plant species (especially metallophyte lichens). Examples of this form of the habitat in Wales are concentrated in mid-Wales, particularly Ceredigion, on abandoned mine sites.

The current work is a preliminary study, aiming to better define lichen-rich forms of calaminarian grassland in mid-Wales with a view to obtaining information on extent in the future. The report also sets the mid-Wales calaminarian habitats into a British and European context.

A total of nine sites in north Ceredigion were visited between 3rd and 5th December 2013: seven abandoned mine sites and two contaminated river shingles. A wide variation in the character of calaminarian habitat was observed, including grass-dominated examples, metallophyte-rich heathland and largely bare, highly contaminated land. Some of the vegetation was considered distinctive in both a British and European context. A total of 69 lichen species were recorded, including 15 of nature conservation concern. Provisional categories of calaminarian habitat types in mid Wales are presented, to facilitate future mapping of the habitat.

3. Introduction

Natural Resources Wales (NRW) need to determine the extent of calaminarian grassland on sites in mid-Wales, but there is some uncertainty as to what habitats should be included and how they can be easily identified and mapped on the ground. The initial proposal was to limit the definition to those areas with the species of plants, lichens or bryophytes that are considered to be metallophytes, but there are difficulties with this and other options need to be considered.

This report sets the mid-Wales calaminarian habitats into the British and European context and considers how they might most usefully be defined. It is based on discussions that took place during and following the site visits on 3-5th December 2013, attended by myself, Stuart Smith (NRW), Alan Hale (NRW), Dave Reed (NRW), Sam Bosanquet (NRW), and Ray Woods. Steve Chambers (Welsh Government) was also invited but was unable to attend.

Seven mid-Wales abandoned mine sites and two river gravels were visited briefly in the period 3-5th December 2013, to assess the variation and distinctiveness of the calaminarian plant and lichen communities. Sites were selected for their accessibility and also to represent the full range of contamination levels, disturbance and grazing history that affect the vegetation. The locations are shown in the table and on the map below.

Site	Grid ref.	Date
Cwmystwyth Mine and river gravels	SN803747	3 rd Dec (JS)
Lisburn Mine (wall)	SN738722	3 rd Dec (JS) and 5 th Dec (JS, AH)
Grogwynion river gravels	SN695717	3 rd Dec (JS)
Nant y Cagl mine	SN736893	4 th Dec (all)
Esgair Fraith mine	SN740913	4 th Dec (all)
Wemyss mine	SN716742	5 th Dec (JS, AH)
Frongoch mine (viewed from above)	SN723743	5 th Dec (JS, AH)
Grogwynion mine	SN714721	5 th Dec (JS, AH)

Table 1. Sites visited for this study

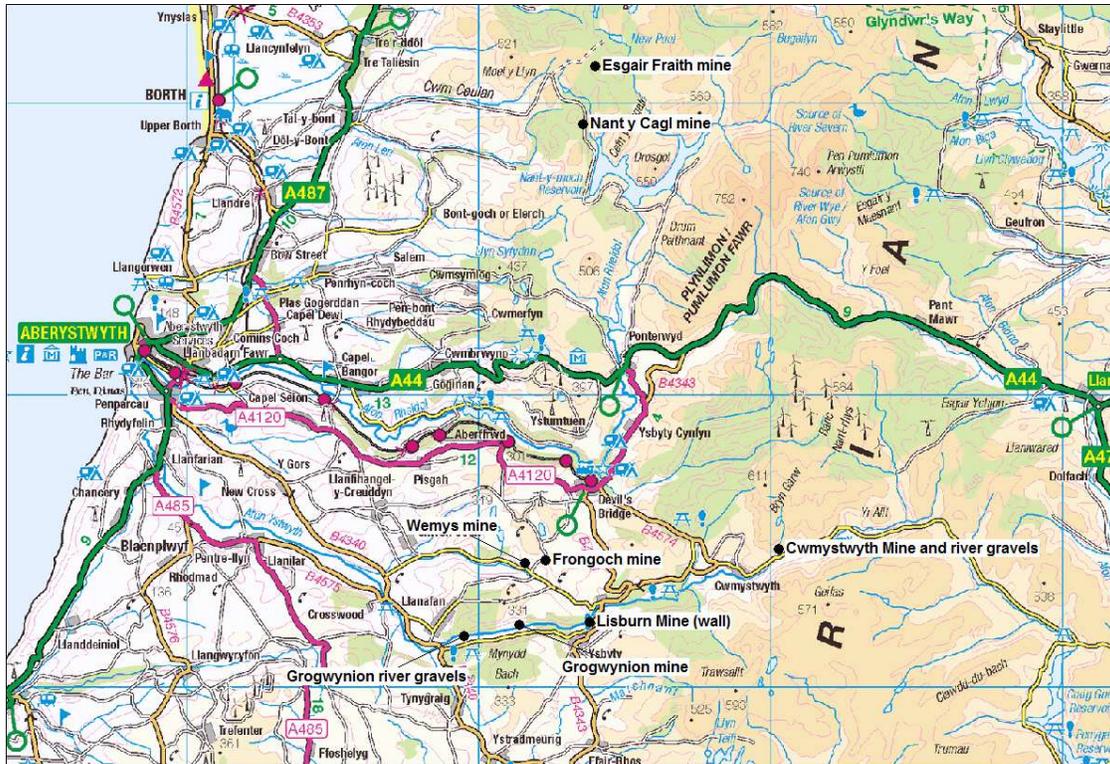


Figure 1. Location of sites visited for this study. © Crown Copyright. All rights reserved. NRW. Licence no. 100019741

It was not possible to survey any of the sites in detail in the time available, and weather conditions were mostly poor, but the lichens and a few plants and bryophytes noted during the visit are recorded in Appendix C. The lichen records have been submitted directly to the British Lichen Society database. A list of the bryophytes recorded at Nant y Cagl was sent to the British Bryological Society database by Sam Bosanquet.

4. Calaminarian habitats

Calaminarian grassland is the habitat described for Europe as type H6130 Calaminarian grasslands of the *Violetalia calaminariae*, and in Britain as National Vegetation Classification (NVC) community OV37 *Minuartia verna* – *Festuca ovina* grassland. It is found on sites with high levels of lead, zinc, copper, tin or other heavy metals in the soils. There are now very few natural sites in Britain as any easily accessible metal ores have been mined, but those mining operations created new areas of heavy-metal contaminated deposits which have been colonised by what is assumed to be similar vegetation. Calaminarian habitats include mine wastes, areas affected by mine dust and smelter fume, and also metalliferous alluvial deposits in the rivers and streams downstream of the mines. Contaminated ground on other industrial sites may have a similar vegetation.

In mid-Wales there is also a form of calaminarian grassland in which the shorter grasses are largely replaced by heather *Calluna vulgaris* and scattered purple moor-grass *Molinia caerulea*, to form a heathy community with areas of bare and stony

ground that can be rich in lichens and bryophytes. This is sometimes referred to as shingle heath or calaminarian heath.

These are all anthropogenic communities, created as a result of what would now be considered severe pollution of the environment. As such, an important consideration in their conservation is the process of succession. While mining continued, the successional communities were continually being replaced as new habitat was created, but mining has now ceased and this is no longer the case. If calaminarian grassland communities are to persist they must now be maintained as plagioclimax communities.

Early mining was on a small scale, with strong but very local environmental effect. Most of the larger calaminarian sites date from the 18-19th centuries when the mines were much larger and mechanised and water-based ore-dressing methods produced large quantities of contaminated waste. As well as spoil heaps, dressing floors, smelter waste, settling ponds and tailings dams from this period are often highly contaminated, as are the remains of buildings and other structures affected by wind-blown dust or smelter fume. However, the features that are often most conspicuous in the landscape, hushes and the large dumps of country rock, are relatively uncontaminated and generally do not support calaminarian grassland.

Weathering and leaching are gradually reducing metal concentrations at the surface, but the effect is patchy and metalliferous sites are characterised by variation in soil conditions and the vegetation on a fine scale. The mosaic of habitats produced can be difficult to categorise but it contributes to the species richness of the site and also to its long term viability.

Areas of calaminarian vegetation are often sharply delimited as they lack the deeper soils that have developed on surrounding areas. There is often no soil or litter layer at all.

Factors controlling the species composition include low nitrogen and phosphorus availability, exposure to wind and frost, summer drought, winter water-logging and grazing, as well as heavy metal levels (Simkin, 2007). Zinc, cadmium and copper are the most phytotoxic of the metals present on these sites, with lead rather less so, but the soil chemistry that determines their bioavailability is complex and can vary over short distances across a site covered by spoil and tailings of different ages and origins. The topography and hydrology of the lead mines is also complex, with a mosaic of heaps, banks and flat ground, some wet and some dry. The patches with lichen and bryophyte species of interest may be only a few square metres in size.

4.1 The European context

For reasons of geology, climate and vegetation history, the forms of calaminarian grassland found in Britain are distinctly different in their flora to those found elsewhere in Europe. The most similar communities are found in Ireland, Belgium, Germany and the Netherlands.

- The Irish form, found on the Burren, has spring sandwort *Minuartia verna* but lacks our other typical species, such as common bent *Agrostis capillaris*, sheep's fescue *Festuca ovina*, alpine pennycress *Noccaea* (formerly *Thlaspi*) *caerulescens*, sea campion *Silene uniflora* and thrift *Armeria maritima*.

- In Belgium, Germany and the Netherlands there are communities that appear similar but have different plant species, such as the zinc pansy *Viola calaminaria* rather than mountain pansy *V. lutea*, a different subspecies of thrift *Armeria maritima* subsp. *halleri* rather than subsp. *maritima*, and a different species of thyme, *Thymus pulegioides* rather than *T. polytrichus*.

So far as we know the calaminarian heath community is also unique as it is not included in any European classification, however if it is present it may be described as a type of heath.

The EUNIS Habitat Classification recognises this, putting the British forms together with the Irish into Atlantic heavy-metal grasslands:

- E1.B1** Atlantic heavy-metal grasslands
 - E1.B11** British heavy metal grasslands
 - E1.B12** Irish heavy metal grasslands
- E1.B2** Calaminarian grassland
 - E1.B21** *Viola calaminaria* grasslands
 - E1.B22** *Viola guesphalica* grasslands
 - E1.B23** Western calaminarian thrift grasslands
 - E1.B24** Calaminarian pennycress grasslands
- E1.B3** Central European heavy-metal grassland
- E1.B4** Calaminarian *Silene vulgaris* grassland
- E1.B5** Alpine heavy-metal grassland

4.2 The British context

Even within Britain there is considerable variation between calaminarian grasslands in Wales, the Pennines, Cumbria, Cornwall and Scotland. The metalliferous soils of these areas fall into two distinct groups, determined by the nature of the country rock in which mineralisation occurred. Siliceous rocks have formed soils of low pH in Scotland, the Lake District, Mid-Wales and the Isle of Man, while the mineralised limestones of North Wales, the North and South Pennines and the Mendips have given rise to soils that are pH neutral or slightly basic. In Cornwall the geology is more complex with both acidic and basic environments present.

Some of these areas themselves have several very distinct forms of calaminarian grassland associated with more or less contaminated ground and with low and high altitudes. Not all have the appearance of grasslands, for instance the Welsh calaminarian heath in which the grass is largely replaced by heather *Calluna vulgaris*. Similarly heathy communities occur on Shetland and in Cornwall, but their species composition is rather different to the Welsh communities.

On the most contaminated ground in all areas there are expanses of bare and stony ground supporting a great variety of lichens and bryophytes but very little grass and these are often among the most important in terms of biodiversity and rare species. The published description of OV37 (Rodwell, 2000) only covers three of the British variants, described from Derbyshire and the Mendips. Some of the others have been described elsewhere (e.g. Swain et al, 2005; Simkin, 2007), but there has been no opportunity yet to propose them for inclusion in a revised NVC.

Because of this variation, and the fact that many of the most interesting forms of this vegetation are not dominated by grasslands, the terms “calaminarian” and “calaminarian habitats” are now often used in preference to the rather misleading “calaminarian grassland”.

4.3 Calaminarian habitats in mid-Wales

The mid-Wales calaminarian plant communities do not fit well into NVC community OV37, which was described only from samples from the limestone areas of the southern Pennines and Mendips. The grasses are largely the same, mainly sheep’s fescue *Festuca ovina* and common bent *Agrostis capillaris*, with purple moor-grass *Molinia caerulea* on wetter ground, and the lichen and bryophyte floras are similar although with some species more or less abundant, but they generally don’t have the metallophytes spring sandwort *Minuartia verna*, alpine pennycress *Noccaea caerulescens*, thrift *Armeria maritima*, Pyrenean scurvy-grass *Cochlearia pyrenaica*, or mountain pansy *Viola lutea* (in the north Pennines this is probably actually a hybrid between *V. lutea* and *V. tricolor*), or calcicoles such as thyme *Thymus polytrichus*. However, they do often have sheep’s-bit *Jasione montana*, which is not found in the other areas, and sea campion *Silene uniflora* (probably actually another hybrid) is much more common on the mid-Wales sites than in the Pennines. They may also include scattered plants of heather and look more like a heathland than grassland.

The site visits were useful in confirming the range of variation of calaminarian habitats present in mid-Wales. These include:

- Open vegetation on mine waste and tailings, with occasional grasses and other plants. Small patches of this form can also be found on the river gravels. Depending on their history and levels of disturbance the open communities may be rich in lichens and small bryophytes, or they may not. The lichens may be saxicolous, growing directly on stone fragments, or terricolous, growing on the gravelly substrate. Saxicolous species include *Stereocaulon vesuvianum*, *S. dactylophyllum*, *Placopsis lambii*, *Gyalideopsis crenulata*, *Rhizocarpon oederi*, *Acarospora sinopica*, *Lecanora handellii*, *L. epanora*, etc., but these more interesting species will be part of a much more diverse community that also includes common upland species from the area. The terricolous lichens are mostly species of *Cladonia*, *Cetraria* and *Stereocaulon*, including *S. condensatum*.
- Short grassland on mine waste and tailings, dominated by grasses and larger mosses. In other parts of Britain this community would be rich in the metallophyte plants mentioned above, but here the species are less specialised although there may be metal-tolerant ecotypes. This community also occurs as small patches on some of the river gravels.
- Heathy vegetation, with scattered or dominant heather *Calluna vulgaris*, tussocks of purple moor-grass *Molinia caerulea* and/or common bent *Agrostis capillaris*, and patches of open stony ground with lichens and bryophytes. The greatest extent of this is found on the river gravels of the Ystwyth and Rheidol, but it also occurs in smaller areas on mine wastes.
- Damp, and sometimes shaded, ground dominated by small mosses and/or leafy liverworts. These may include the lead moss *Ditrichum plumbicola*, and

more commonly of *Solenostoma gracillimum*, *Cephaloziella* species including *C. stellulifera* and *C. nicholsonii*, *Dicranella rufescens* and *D. varia*, and on the river gravels sometimes *Marsupella emarginata*.

- Buildings and other structures which have been impregnated with metalliferous dust or fume. Occasionally these support large populations of lichens such as *Lecanora epanora* and *Acarospora sinopica*.

69 lichen taxa were recorded. None were seen on all nine sites recorded, however conditions were difficult and recording on most of the sites was very incomplete. The most constant species were generally common upland species in the area, but two, *Stereocaulon dactylophyllum* and *Placopsis lambii*, are particularly associated with lead mines.

The importance of these sites for lichens is supported by the high proportion, 15 taxa (22%), of particular conservation interest. Of these, 3 have a conservation status of near-threatened (NT), 7 are nationally rare (NR) or nationally scarce (NS), and 14 are considered to be metallophytes:

<i>Acarospora sinopica</i>		metallophyte
<i>Baeomyces placophyllus</i>		metallophyte
<i>Cladonia uncialis subsp. uncialis</i>	NT NS	
<i>Epilichen scabrosus</i>	NS	metallophyte
<i>Gyalideopsis crenulata</i>	NR	metallophyte
<i>Lecanora epanora</i>		metallophyte
<i>Lecanora handellii</i>	NT NS	metallophyte
<i>Placopsis lambii</i>		metallophyte
<i>Rhizocarpon furfurosum</i>	NT NS	metallophyte
<i>Rhizocarpon oederi</i>		metallophyte
<i>Stereocaulon condensatum</i>	NS	metallophyte
<i>Stereocaulon dactylophyllum</i>		metallophyte
<i>Stereocaulon leucophaeopsis</i>	NS	metallophyte
<i>Stereocaulon nanodes</i>	NS	metallophyte
<i>Stereocaulon pileatum</i>		metallophyte

5. Definitions of calaminarian habitat

5.1 Using metallophytes as indicators

In other parts of Britain and Europe, definitions of calaminarian grassland make use of the presence of indicator species, particularly the vascular plants spring sandwort *Minuartia verna* and alpine pennycress *Noccaea caerulea* in much of Britain, and the zinc pansy *Viola calaminaria* in parts of mainland Europe. This works well in areas such as the North Pennines, Derbyshire and north-east Wales, where spring sandwort is widely distributed and easily identified in the field, but there are several problems with using this approach in mid-Wales:

- spring sandwort and the other indicators are very scarce in mid-Wales (the BSBI tetrad map shows just one record for spring sandwort and three for alpine pennycress).

- the lichens and bryophytes which can be considered as metallophytes and used in the same way, are also very sparsely distributed in mid-Wales, and many are small and/or seasonal and so are easily overlooked.
- the lichen and plant indicators are mostly facultative rather than obligate metallophytes, so they are not strictly restricted to metalliferous sites and their presence alone does not confirm the plant community as calaminarian. An association of several indicator species is required, but this is rarely found.
- areas where the vegetation is most strongly influenced by heavy metals are still at an early stage of succession and may not yet have any of the indicators.

In this area a definition of calaminarian habitat that is based only on the presence of metallophyte indicators will result in a very narrow classification that would exclude most of what is recorded as calaminarian habitat elsewhere in Britain and Europe. It would, however, identify the “best” areas that should be a priority for conservation.

5.2 Broader definitions

A broader definition of calaminarian habitat, to avoid the use of indicator species, could be “vegetation affected by phytotoxic levels of heavy metals in the soil and groundwater”. This would include all the categories described in 2.3 above for mid-Wales, and areas could be identified from:

- the presence of bare and stony ground (other than that kept open by other causes such as recent disturbance).
- the overall species composition of plants, lichens and bryophytes, including common species as well as rarities.

the scarcity of metal and drought-sensitive species that are common in the surrounding vegetation (a negative indicator that can be obvious on the ground and in satellite images).

6. Mapping and recording

6.1 Vegetation compartments

Areas of calaminarian vegetation are usually sharply delimited, but the sites are complex and it can be difficult to know where you are on the ground. The easiest way to map the vegetation compartments is to mark up a satellite image first, and then classify the compartments on the ground, to one of five broad categories:

- A Open stony ground with sparse or no vascular plant cover
- B Open grassland, with scattered grasses and small patches of bare ground, lichens and/or bryophytes between
- C Heath with scattered or dominant heather, and beneath that a patchwork of bare ground, lichens and/or bryophytes and scattered grasses
- D Damp, sometimes shaded, ground dominated by small mosses or leafy liverworts
- E Closed sward of grasses and/or large pleurocarpous mosses

If the mapping is being done by an experienced botanist and lichenologist, or if precisely localised data from a previous survey is available, another five categories can also be used:

- AM Open stony ground with one or more metallophytes
- BM Open grassland with one or more metallophytes
- CM Heath with one or more metallophytes
- DM Damp shaded ground with one or more metallophytes
- FM Buildings or other structures with metallophytes

The appropriate scale of recording will vary from site to site, but for some areas it will be necessary to map down to compartments 2- 3m long, especially if the metallophyte survey is being done at the same time.

6.2 Botanical and lichen assessment

The following can be recorded by surveyors with some botanical knowledge and a half day of on-site training:

- vascular plants of interest - sea campion *Silene uniflora* or its hybrid, and sheep's-bit *Jasione montana*.
- Lichen assemblages – species-rich communities typical of stable mine spoil and contaminated gravels. Which species are conspicuous will vary through the year, but any significant populations of lichens on soil or rock, including the very small crustose species in the biotic crust over the soil, can be taken as indicators of habitat quality for this purpose. Most noticeable will be *Dibaeis baeomyces*, *Placopsis lambii*, and species of *Stereocaulon*, *Cetraria* and *Cladonia*. The typical heathland assemblage, dominated by *Micarea lignaria*, *Cladonia portentosa*, *C. ciliata* (either subspecies), *C. arbuscula* subsp. *squarrosa* and/or *C. uncialis* subsp. *biuncialis*, should not be recorded here, but populations of the similar *Cladonia rangiformis* should.
- Bryophyte associations - populations of small acrocarpous mosses and leafy liverworts. The most conspicuous mosses on spoil are often *Polytrichum juniperinum* or *P. piliferum*, but there may also be bryophyte interest such as *Ditrichum plumbicola* on wet ground, very fine spoil, or shaded banks where there is no lichen interest. The more competitive species that are common in heathland or grassland, particularly the larger pleurocarpous mosses such as *Pleurozium schreberi*, *Rhytidiadelphus squarrosus* and *Hypnum jutlandicum*, should not be recorded.
- Invasive species – a quick assessment should also be made for the presence within the compartment or nearby of invasive plant species that would encourage soil development and so make the substrate less suitable for the species of conservation interest, particularly gorse *Ulex* sp., birch *Betula* sp., and purple moor-grass *Molinia caerulea*. It is important to note that these are native species: this is not an assessment of Invasive Non-Native Species (INNS).

Further, more detailed, survey by specialists will then be needed to determine whether there are rare or metallophyte lichens or bryophytes present. This survey

can be targeted on the areas already identified as having significant lichen or bryophyte communities, making the best use of the specialist's time.

A simple record sheet to capture these assessments for each compartment is included as Appendix A.

6.3 GIS

Collecting the data in this way makes it suitable for use in a GIS. The compartments can be drawn as polygons on the georeferenced satellite image, and linked to an attribute table containing the data from the record sheet. It will then be simple to produce maps showing all the calaminarian or just the areas of particular interest, and to measure their area.

7. References

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Swain CH, Brewer, PA, Macklin MG, Simkin JM. 2005. *The ecological, geomorphological and geochemical controls on river shingle heath development on the Afon Rheidol and Afon Ystwyth, Ceredigion*. University of Wales, Aberystwyth. CCW Contract Report No. RE0.92

FM Buildings or other structures with metallophytes
Species: use abbreviated latin names

Appendix B: Potential sites for mapping and survey

Site name	County	Site area (ha) (approx)	Open country	PRoW	NRW	Walking distance to public road
Dylife Mine SSSI	Montgomerys hire	39.0	Mainly Open	Yes		Next to
Frongoch (part SSSI)	Ceredigion	27.0	No	Partly		Next to
Ystumtuen	Ceredigion	16.7	No	Yes		Next to
Pen Glog-fawr	Ceredigion	16.0	No	Yes		0.2 km
Pant y Gwaith	Ceredigion	12.8	No	Yes		0.3 km
Cerrig Lwynog	Ceredigion	9.5	Open	Yes	NRW owned	0.3 km
Mwyngloddfa Castell SSSI	Ceredigion	7.7	No	Yes		Next to
Afon Tarennig	Ceredigion	3.8	No	Yes (to site edge)		1.7 km
Nant y Creuau	Ceredigion	3.3	No	Yes	NRW owned	2.2 km
Cwmsymlog SSSI	Ceredigion	7.7	No	Yes		Next to
Llain Cottage	Ceredigion	6.8	No	Yes		Next to
Ochr Lwyd	Ceredigion	5.4	Open			Next to
Mwyngloddfa Nant-y-cagl SSSI	Ceredigion	4.7	Open		NRW owned	Next to
Mwyngloddfa Cwmbwyno SSSI	Ceredigion	4.2	No	Yes		Next to
Mwyngloddfeydd	Ceredigion	3.6	Open	Yes	part NRW owned	1 km
Esgair Hir (SSSI)						
Mwyngloddfa Llety Ifan Hen SSSI	Ceredigion	3.2	No	Yes (to site edge)		0.5 km
Trawsnant	Ceredigion	2.0	Open	Nearby		0.5 km
Llawr-y-cwm-bach	Ceredigion	1.6	Part Open	Yes		1.6 km
Tre Taliesin	Ceredigion	1.4	No	Yes		0.5 km
Ystrad Einion	Ceredigion	1.1	Open			Next to
Rheidol Woods (SSSI)	Ceredigion	0.4	No	Nearby		0.5 km

Appendix C: Records made during this visit

Key

Sites:	CG	Cwmystwyth river gravels	3 rd Dec (JS)
	CM	Cwmystwyth Mine and river gravels	3 rd Dec (JS)
	EFM	Esgair Fraith mine	4 th Dec (all*)
	FM	Frongoch mine (viewed from above)	5 th Dec (JS, AH)
	GG	Grogwynion river gravels	3 rd Dec (JS)
	GM	Grogwynion mine	5 th Dec (JS, AH)
	LM	Lisburn Mine (wall)	3 rd Dec (JS) & 5 th Dec (JS, AH)
	NCE	Nant y Cagl mine - east	4 th Dec (all*)
	NCF	Nant y Cagl mine - west	4 th Dec (all*)
	WM	Wemys mine	5 th Dec (JS, AH)

*All = JS, AH, Stuart Smith, Sam Bosanquet, Dave Reed, Ray Woods

Conservation status:	LC	least concern
	NR	nationally rare
	NS	nationally scarce
	NT	near-threatened

Metallophytes: M* metallophyte

Species	Status	CG	CM	EF	GG	GM	LM	NE	NW	WM	Sites
Vascular plants											
<i>Agrostis capillaris</i>			x	x							2
<i>Calluna vulgaris</i>			x	x							2
<i>Festuca ovina</i>			x	x							2
<i>Jasione montana</i>		x			x						2
<i>Silene uniflora</i>		x			x	x					3
<i>Vaccinium myrtillus</i>				x							1
Clubmosses											
<i>Huperzia selago</i>				x				x			2
Bryophytes											
<i>Barbilophozia floerkei</i>		x									1
<i>Dicranella varia</i>			x								1
<i>Dicranum scoparium</i>		x	x								2
<i>Ditrichum plumbicola</i>	M*							x			1
<i>Hypnum jutlandicum</i>		x	x								2
<i>Philonotis fontana</i>			x						x		2
<i>Pleurozium schreberi</i>		x	x	x				x			4
<i>Pohlia annotina</i>								x			1
<i>Pogonatum aloides</i>			x								1
<i>Polytrichum piliferum</i>		x	x								2
<i>Racomitrium ericoides</i>			x	x	x						3
<i>Racomitrium lanuginosum</i>			x	x	x						3
Lichens											
<i>Acarospora sinopica</i>	LC M*			x				x			2

<i>Amandinea punctata</i>	LC							x				1
<i>Aspicilia contorta</i> subsp. <i>contorta</i>	LC		x									1
<i>Baeomyces placophyllus</i>	LC M*		x						x			2
<i>Baeomyces rufus</i>	LC	x	x	x						x		4
<i>Buellia griseovirens</i>	LC							x				1
<i>Cetraria aculeata</i>	LC	x	x									2
<i>Cladonia arbuscula</i> subsp. <i>squarrosa</i>	LC		x		x						x	3
<i>Cladonia cervicornis</i> subsp. <i>cervicornis</i>	LC	x	x		x				x			4
<i>Cladonia cervicornis</i> subsp. <i>verticillata</i>	LC								x			1
<i>Cladonia chlorophaea</i> s. <i>lat.</i>	LC		x	x		x			x			4
<i>Cladonia ciliata</i> var. <i>ciliata</i>	LC		x		x						x	3
<i>Cladonia ciliata</i> var. <i>tenuis</i>	LC	x	x	x	x	x					x	6
<i>Cladonia diversa</i>	LC	x		x				x	x			4
<i>Cladonia furcata</i> subsp. <i>furcata</i>	LC	x	x	x	x	x			x		x	7
<i>Cladonia gracilis</i>	LC	x			x							2
<i>Cladonia macilenta</i>	LC	x						x	x			3
<i>Cladonia portentosa</i>	LC	x	x	x	x	x			x		x	7
<i>Cladonia ramulosa</i>	LC	x	x	x								3
<i>Cladonia rangiformis</i>	LC				x						x	2
<i>Cladonia squamosa</i> s. <i>lat.</i>		x	x					x		x		4
<i>Cladonia subcervicornis</i>	LC	x										1
<i>Cladonia subulata</i>	LC					x		x	x			3
<i>Cladonia uncialis</i> subsp. <i>biuncialis</i>	LC	x	x		x							3
<i>Cladonia uncialis</i> subsp. <i>uncialis</i>	NT NS				x							1
<i>Dibaeis baeomyces</i>	LC	x	x	x	x				x			5
<i>Diploschistes scruposus</i>	LC		x									1
<i>Epilichen scabrosus</i>	LC NS M*										x	1
<i>Evernia prunastri</i>	LC							x				1
<i>Fuscidea cyathoides</i> var. <i>cyathoides</i>	LC	x	x	x							x	4
<i>Fuscidea lygaea</i>	LC	x	x	x								3
<i>Gyalideopsis crenulata</i>	LC NR M*								x	x		2
<i>Hypogymnia physodes</i>	LC	x	x					x				3
<i>Ionaspis lacustris</i>	LC								x			1
<i>Lecanora epanora</i>	LC M*							x				1
<i>Lecanora handelii</i>	NT NS		x	x								2

	M*								
<i>Lecanora polytropa</i>	LC	x	x						2
<i>Lecanora soralifera</i>	LC	x	x	x					3
<i>Lecidea lithophila</i>	LC	x	x	x	x			x	5
<i>Lecidella stigmatea</i>	LC		x						1
<i>Lepraria incana s. lat.</i>							x		1
<i>Micarea leprosula</i>	LC		x						1
<i>Micarea lignaria var. lignaria</i>	LC	x	x	x	x		x	x	6
<i>Peltigera hymenina</i>	LC	x	x		x				3
<i>Peltigera membranacea</i>	LC	x							1
<i>Placopsis lambii</i>	LC M*	x	x	x		x	x	x	6
<i>Platismatia glauca</i>	LC						x		1
<i>Porpidia crustulata</i>	LC	x	x	x		x		x	6
<i>Porpidia hydrophila</i>	LC		x					x	2
<i>Porpidia macrocarpa f. macrocarpa</i>	LC		x	x		x	x		4
<i>Porpidia soredizodes</i>	LC	x	x	x		x	x		5
<i>Porpidia tuberculosa</i>	LC	x	x	x	x		x	x	6
<i>Protoblastenia rupestris</i>	LC		x						1
<i>Rhizocarpon furfurosum</i>	NT NS M*		x				x	x	3
<i>Rhizocarpon geographicum</i>	LC	x	x				x		3
<i>Rhizocarpon oederi</i>	LC M*	x	x			x		x	4
<i>Rhizocarpon reductum</i>	LC	x	x	x	x	x	x		7
<i>Scoliciosporum umbrinum</i>	LC		x			x			2
<i>Stereocaulon condensatum</i>	LC NS M*		x						1
<i>Stereocaulon dactylophyllum var. dactylophyllum</i>	LC M*	x	x	x		x	x	x	7
<i>Stereocaulon evolutum</i>	LC	x	x				x	x	4
<i>Stereocaulon leucophaeopsis</i>	LC NS M*	x	x	x			x	x	5
<i>Stereocaulon nanodes</i>	LC NS M*			x					1
<i>Stereocaulon pileatum</i>	LC M*		x				x		2
<i>Stereocaulon vesuvianum var. vesuvianum</i>	LC	x	x	x			x	x	5
<i>Trapelia coarctata</i>	LC						x		1
<i>Trapelia placodioides</i>	LC	x	x						2
<i>Trapeliopsis pseudogranulosa</i>	LC				x				1
<i>Usnea subfloridana</i>	LC						x		1

Data Archive Appendix

Data outputs associated with this project are archived at Ffynnon reference: NRW-14-003465 on server-based storage at Natural Resources Wales.

The data archive contains:

The final report in Microsoft Word and Adobe PDF formats.

A spreadsheet in Microsoft Excel format.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue <http://194.83.155.90/olibcgi> by searching 'Dataset Titles'. The metadata is held as record no NRW-14-118748 (Ffynnon)



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