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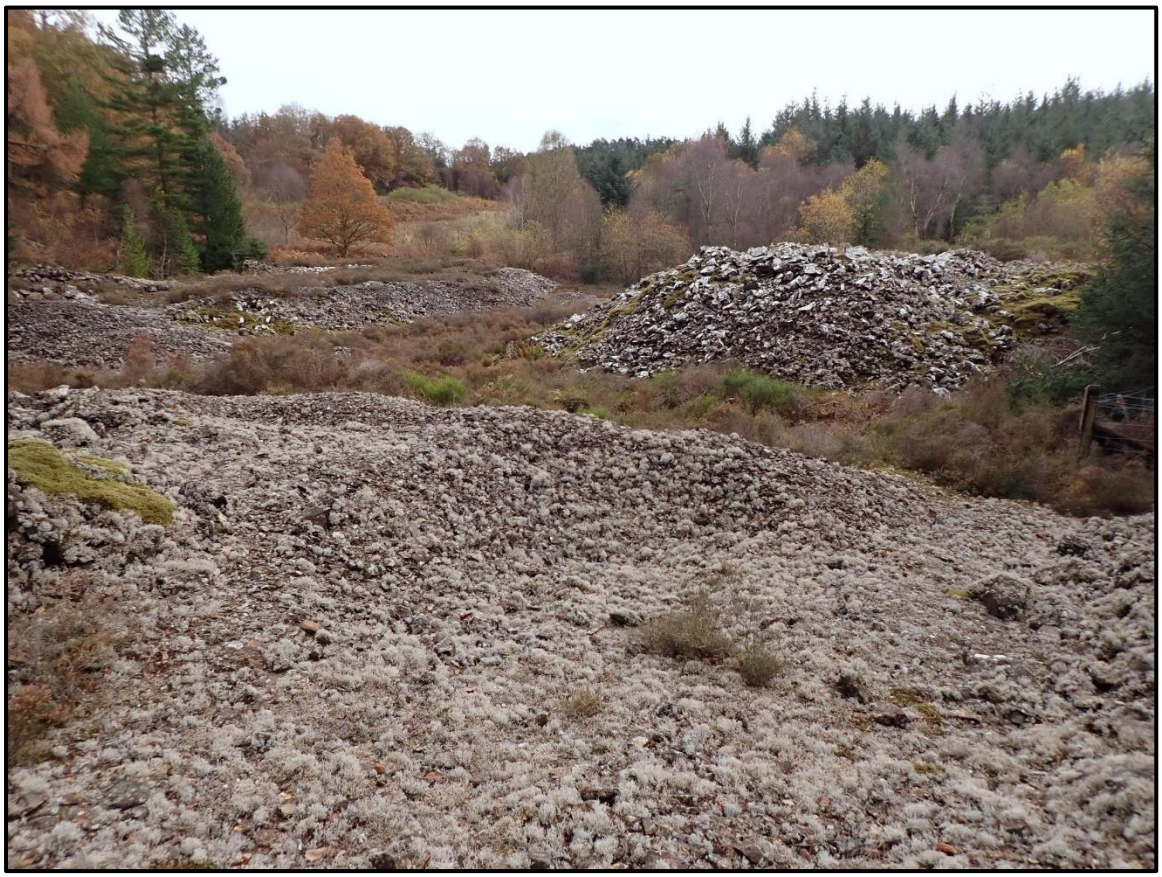
A Lichen Survey of the Gwydyr Forest Mines



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Evidence Report No 600

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Our purpose is to ensure that the natural resources of Wales are sustainably maintained, used and enhanced, now and in the future.

We work for the communities of Wales to protect people and their homes as much as possible from environmental incidents like flooding and pollution. We provide opportunities for people to learn, use and benefit from Wales' natural resources.

We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

We work to maintain and improve the quality of the environment for everyone and we work towards making the environment and our natural resources more resilient to climate change and other pressures.

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We will realise this vision by:

- Maintaining and developing the technical specialist skills of our staff;
- Securing our data and information;
- Having a well resourced proactive programme of evidence work;
- Continuing to review and add to our evidence to ensure it is fit for the challenges facing us; and
- Communicating our evidence in an open and transparent way.

This Evidence Report series serves as a record of work carried out or commissioned by Natural Resources Wales. It also helps us to share and promote use of our evidence by others and develop future collaborations. However, the views and recommendations presented in this report are not necessarily those of NRW and should, therefore, not necessarily be attributed to NRW.

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Contents

1. Crynodeb Gweithredol

Ymwelwyd â 23 o unedau SoDdGA ac un safle ychwanegol. Canfuwyd deunaw o rywogaethau'r Mynegai Cynefinoedd Metaloffyt (y Mynegai), gyda safleoedd unigol yn cefnogi rhwng 0 a 12 o rywogaethau'r Mynegai. Gan gynnwys chwe rhywogaeth ychwanegol a gofnodwyd gan Steve Chambers ym 1994, y Mynegai ar gyfer y SoDdGA yw 24, sy'n llawer uwch na'r trothwy ar gyfer ystyried safle yn SoDdGA. Fodd bynnag, canfuwyd rhai rhywogaethau metaloffyt mewn symiau bach iawn, ac roedd rhai wedi'u cyfyngu i safleoedd unigol. Nid oes unrhyw un safle yn cynnwys yr holl rywogaethau, ac mae'n rhaid ystyried fflora'r SoDdGA yn ei gyfanrwydd. Mae'r cyfoeth o rywogaethau metaloffyt wedi'i gyfyngu'n aml gan y symiau cymharol fach o rwbel sydd ar gael, prinder blociau mwy, prinder arwynebau sydd wedi eu cysgodi rhag glaw, a gwaith ailbwyntio trwm ar adeiladau adfeiliedig gyda morter sment, sy'n creu is-haen sy'n anaddas ar gyfer metaloffytau ac ar gyfer y rhan fwyaf o gennau. Y bygythiad mwyaf i'r metaloffytau hyn yw planhigion fasgwlaidd sy'n cytrefu, yn enwedig coed conwydd, er bod glaswellt, *Calluna* ac *Ulex* hefyd yn rhywogaethau goresgynnol. Ni nodwyd bod aflonyddwch oherwydd gweithgareddau hamdden yn fygythiad sylweddol.

Yn ogystal â metaloffytau, canfuwyd nifer o rywogaethau Cenedlaethol Anfynych a Chenedlaethol Brin. Cofnodwyd *Rhizocarpon rubescens* a *Thelidium submethorium* fel rhywogaethau newydd i Brydain Fawr, a chanfuwyd dwy rywogaeth heb eu disgrifio, un (*Porpidia* 'Blagill A) y mae ei phresenoldeb hefyd yn hysbys mewn safle sy'n gyfoethog o ran metel yn y Pennines, a'r llall (*Lecidea* 'Gwydyr A') yn rhywogaeth nad oedd wedi'i gweld o'r blaen.

2. Executive Summary

Twenty-three SSSI units and one additional site were visited. Eighteen species from the Metallophyte Habitats Index (MHI) were found, with individual sites having from 0 to 12 MHI species. Including an additional six species recorded by Steve Chambers in 1994, the MHI for the SSSI is 24, well above the threshold for SSSI consideration. However, some metallophyte species were found in very small quantities, and a few were confined to individual sites. No one site contains all the interest, and the flora of the SSSI has to be considered as a whole. The metallophyte richness is limited by the often relatively small amounts of spoil available, the scarcity of larger blocks, the scarcity of rain-sheltered surfaces, and heavy repointing of derelict buildings with cement mortar, which creates a substratum unsuitable for metallophytes and for most lichens. The greatest threat to the metallophyte interest is colonisation by vascular plants, particularly conifers, though grass, *Calluna* and *Ulex* are also invasive. Disturbance by recreational activities was not noted as a significant threat.

In addition to metallophytes, a number of Nationally Rare and Nationally Scarce species were found. *Rhizocarpon rubescens* and *Thelidium submethorium* were recorded as new to Great Britain, and two undescribed species were found, one (*Porpidia* ‘Blagill A) known also from a metal-rich site in the Pennines, the other (*Lecidea* ‘Gwydyr A’) not previously seen.

3. Introduction

All the sites studied, with one exception, are within Mwyngloddiau a Chreigiau Gwydr SSSI, important for Calaminarian grassland, bat roosts, and geological features. The area lies between Betws-y-coed in the south and Trefriw in the north, and is mainly within the botanical vice-county of Caernarvonshire (V.C. 49), with two small sites east of Betws-y-coed in Denbighshire (V.C. 50). There was extensive mining for lead and zinc in the eighteenth century, and this continued at some sites until the 1960s. Afforestation with exotic conifers began in the 1920s, and the area now comprises the Gwydyr Forest Park.

The mines at Aberllyn (Unit 41) and Coed Mawr Pool were surveyed for lichens in 1994 by Steve Chambers (Williams and Chambers 1995). Possibly other sites were surveyed, but the full report was not available. Parc Mine was surveyed by Orange (2021) and consequently was not included in the present survey. A request for records for the area from the British Lichen Society database returned no records from mine sites.

4. Methods

Twenty-three SSSI units and one additional small unit were listed for lichen survey (Fig. 1). A few sites were excluded as permission to survey was not forthcoming (Units 28, 30, 36). The remaining SSSI units are considered to have no extant metallophyte lichen habitat.

Sites were visited on 11 days on 9–12 and 14–20 November 2021, in mostly dry, occasionally drizzly weather. Lichen recording was restricted mainly to species listed on the Metallophyte Habitat Index (MHI) (Sanderson *et al*. 2018). Additional species were recorded if they were readily identified in the field, if they were Red Data Book or Notable species (Sanderson *et al*. 2018 and associated spreadsheet), or if they were of taxonomic interest. Complete species lists were not attempted for any site.

A number of specimens were collected for examination by microscopy or thin-layer chromatography (TLC). For some critical taxa, the internal transcribed spacer region (ITS) of the nuclear ribosomal DNA was sequenced.

Non-lichen metallophytes were noted when seen, but were not searched for.

5. Results

A total of 105 taxa was recorded (Table 1). Of these, 18 species occur on the Metallophyte Habitat Index, and a number of additional species were considered to be of conservation concern (Table 2). Localities where notes or records were made were given a number; the localities are listed in Table 4. Accounts and species lists for individual sites are given in Appendix I. In the species tables for each site, all

localities were listed for MHI species when possible, but locations of other species are incomplete, usually included only as an example of a precise location. In addition to species with a conservation grading, there were a few species not evaluated in Sanderson *et al*. (2018), but which are probably rare. These are *Rhizocarpon rubescens* and *Thelidium methorium*, new to Britain; *Porpidia thomsonii*, a poorly-understood species, and two apparently undescribed species *Lecidea* 'Gwydyr A', and *Porpidia* 'Blagill A' (see Taxonomic Notes below).

The number of MHI species found at individual SSSI Units varied from 0 to 12 (Table 3). The metallophytes *Rhizocarpon oederi* and *Stereocaulon dactylophyllum* were found at all but three sites, where there was no lichen habitat. Other frequent metallophytes were *Stereocaulon leucophaeopsis* (17 sites), *Porpidia melinodes* (12 sites) and *Placopsis lambii* (11 sites). None of these five species are restricted to rocks containing high concentrations of heavy metals, though a few require at least some iron in the rock. Other metallophytes were found in only a minority of sites.

Considering the extent of mining, visible spoil often seemed limited in extent. It is likely that much has already become vegetated, and unless there is an obvious outline of a tip, it may go unnoticed. Unstable ground hidden by grass or moss, detected while walking across an area may be the only indication of a tip.

Relatively coarse spoil was very limited in extent, and very rarely included sizeable blocks. It seems likely that much of the coarser spoil seen comprised non-mineralised rock, and it sometimes supported non-metallophytes including the conspicuous yellow *Rhizocarpon geographicum*, or rarely the extensive white thalli of *Pertusaria corallina*. Such tips tended to be colonised by the moss *Racomitrium lanuginosum*, forming a mat that excludes all lichens. *R. geographicum* is probly an indicator of low toxicity, however it also avoids damp rocks and small stones, so would rarely be present on the types of spoil described below.

Some tips comprised rock that was not particularly coarse, but which apparently included relatively little fine material, so that stones were not in contact with very fine tailings or soil. Individual stones are less damp than when lying on fine material. A tip at Cyffty mine was like this, and was the only place in the survey to support *Lecanora handelii* and *L. subaurea*, though this could have been due to some other factor, such as different mineralisation.

Many sites had a lot of sloping or level stony ground where although stones are abundant at the surface, the deposit comprises stones mixed with fine tailings, so that stones are relatively damp from contact with the fine material. Sometimes the fine material is dominant, with scattered stones at the surface. This type of spoil was often more productive than coarser material. Some species probably require the damper conditions provided by proximity to fine material, for instance *Gyalideopsis crenulata*, which preferred rather flat stones lying on fine material, with few or no associated species.

Habitat for terricolous lichens occurs where there is a thin layer of soil or fine tailings over stones, or where there is extensive soft fine material. Here a soil crust of algae, cyanobacteria and the moss *Weissia controversa* can build up, forming a yellow-green turf (*Weissia*) or a dull dark green crust of algae and/or *Cephaloziella* spp.,

sometimes over old *Weissia* mats which are invisible from the surface, but sometimes directly over soil. This is the habitat for *Vezdaea* spp., and in one case *Agonimia repleta*. *Vezdaea* species were sparse at all sites except Aberllyn, and the impression was gained that the soil was often too damp for these species, and that they may prefer the better-drained conditions on sloping ground. These species are probably rather mobile, and are also often undetectable in the drier months of the year. It is possibly more important to look for suitable habitat, than to rely on individual records of these genera when assessing a site. On sloping ground the soil crusts are very easily destroyed by trampling, exposing bare soil. It is unknown how rapidly a suitable crust can build up again on bare soil.

Most of the spoil seen provided only very small areas of rain-sheltered rock, due to the small size of the stones. At some mine sites in Britain, old buildings and retaining walls are a valuable source of such a microhabitat, especially where mineral-rich blocks have been incorporated into walls. However, at most of the sites in the present survey, old buildings have been very heavily repointed with cement mortar after becoming derelict (Figs. 34, 43). The mortar often covers much of the face of the blocks as well as the joints between them. The calcareous surface, and calcareous run-off, make the repointed walls completely unsuitable for metallophytes, and poor for lichens in general. At two of its sites *Lecanora epanora* was found only on unmortared retaining walls. At another site it occurred only in small quantity on a block in a mortared wall, either because calcareous run-off is less on this block, or perhaps because iron compounds create an acidic environment here. *Lecanora handelii* is another species that favours rain-sheltered surfaces, and at its only site in the survey (Cyffty), one colony was growing on a slightly sheltered face of a stone on spoil.

Shafts and adits were usually too dangerous to examine, but it is likely that the sides are often too wet or too bryophyte-dominated to support many lichens.

6. Taxonomic notes

Lecidea ‘Gwydyr A’

An unidentified *Lecidea*, possibly undescribed, with a pale grey, cracked thallus with no detectable substances or with stictic acid by TLC. Apothecia mostly immersed or semi-immersed in the thallus. Ascospores 11.5–12.5 × 4.5–5 µm. BLAST searches of ITS sequences return *Lecidea* species, but nothing closely related. Two specimens collected during the survey, both on small stones in probably contaminated areas, one with no associated species, the other with *Micarea lignaria*. Vouchers: *Orange* 25816, 25898.

Fig. 1. *Lecidea* Gwydyr A. Scale = 1 mm.

Porpidia 'Blagill A'

A distinct, but undescribed, species which is basal to *Porpidia macrocarpa*, *P. crustulata*, *P. flavocruenta* and others in the phylogenetic tree. So far known only from Gwydyr Forest and from metal-rich river gravels at Blagill in the North Pennines. Not easily identified in the field, with the thallus varying from grey to rusty orange, but the apothecia are smaller than in *P. macrocarpa*. The thallus contains stictic acid (often weak), or has no substances detectable by TLC. Rusty material could be mistaken in the field for *P. flavocruenta*, but in the lab the apothecia lack the K + purple pigment found in that species. Collections on small stones which are probably in metal-rich areas. Vouchers: *Orange* 25814, 25826, 25828, 25861, 25872, 25878.

Fig. 2. *Porpidia* Blagill A. Scale = 2 mm.

Porpidia thomsonii

A poorly understood species in Britain, with only three records in the BLS database, all from western Scotland. The species was described from North America and the identity of European and American specimens has not yet been confirmed by DNA data. Sequenced specimens seen from Helvellyn, and herbarium specimens which may belong here have been seen from montane sites in Scotland and Cadair Idris. Two collections at Gwydyr, on small stones in probably contaminated areas. Vouchers: *Orange* 25893, 25913.

Fig. 3. *Porpidia thomsonii*. Scale = 2 mm.

Rhizocarpon rubescens

One collection, from a probably not- or weakly contaminated stone on spoil. First confirmed British record of this species, which is said to occur in Scandinavia and the Alps. Voucher: *Orange* 25925.

Fig. 4. *Rhizocarpon rubescens*. Scale = 1 mm.

Thelidium submethorium

One collection, on stones in flushed area. First British record, known from few collections from NE Russia (type), and montane areas of Germany and Italy. It is possible that the type is a different species to the Central European collections Thüs & Nascimbene (2008) and to the Gwydyr collection, which may be undescribed. The collection has a dark brown epilithic thallus, and prominent perithecial projections 250–335 µm diameter, ascospores 1-septate, 25.5–28.5 µm. An ITS sequence from Gwydyr Forest is close to the single publicly available sequences of *T. submethorium* (Italy) and *T. aethioboloides*, but has small differences from both. *T. aethioboloides* is said to differ in the 2–3-septate ascospores and habitat on limestone (Thüs & Nascimbene 2008). Voucher: *Orange* 25832.

Fig. 5. *Thelidium submethorium*.

7. Discussion

The SSSI as a whole has 18 MHI species, over the threshold of 10 for consideration of SSSI status (Sanderson *et al*. 2018). However, individual sites were mostly under this threshold. Sites often had only small quantities of certain metallophytes, which scarcely form viable populations, for instance *Acarospora sinopica* (four sites, very rare to rare/occasional), *Epilichen scabrosus* (two sites, very rare and rare), *Lecanora handelii* (one site, very rare), *L. subaurea* (one site, rare), *Stereocaulon nanodes* (three sites, rare). Even the best-scoring sites lacked species found elsewhere, for instance Unit 14 had the highest score of 12 on the MHI, but apparently lacked *Baeomyces placophyllus*, *Gyalideopsis crenulata* and other rarer species, and Unit 27, the only site to support *Lecanora handelii* and *L. subaurea*, lacked *Baeomyces placophyllus*, *Epilichen scabrosus*, *Gyalideopsis crenulata* and others. Clearly no single site can support the full range of metallophytes, and each site contributes to the metallophyte resource of the SSSI as a whole. The MHI is inteneded to give a rough indication of the potential interest of a mine site, but does not include every metallophyte lichen (*Psilolechia leprosa* is not included, and it is likely that *Porpidia* Blagill A is also a metallophyte). The identification of a lichen secies as a ‘metallophyte’ is not simple, as many species found at mine sites may be present because of open ground and reduced competition from other species, rather than presence of metal as such, and some species on the MHI can be found in localities with no heavy metal enrichment.

Some additional MHI species were found in the SSSI by Steve Chambers in 1994:

Belonia incarnata (Unit 37, 41)
Coppinsia minutissima (Unit 37, 41)
Gyalidea subscutellaris (Unit 41)
Rhizocarpon cinereovirens (Unit 37)
Rhizocarpon expallescens (Unit 37)

Vezdaea rheocarpa (Unit 41)

These bring the MHI total for the SSSI to 24. It is likely that these species are still present.

Many of the Gwydyr mines are closely associated with conifer plantation. In many cases conifers have probably been planted as close as possible to old workings. The proximity of conifers provides an abundant source of seed, and old spoil is often being invaded by a variety of young conifer species, including *Larix*, *Picea sitchensis* and *Tsuga heterophylla*. Birch is invading in some places, but is a lot less important than conifers. Deciduous trees in general are scarce in the Gwydyr Forest. In addition, where trees are close to spoil, the shed needles can locally directly smother some of the spoil, and in the long term help to build up a humus layer which encourages further colonisation. The speed of colonisation is difficult to judge. Doubtless some spoil has already been lost, but once low areas of spoil are vegetated, it is be difficult to detect them unless they show a very clear profile of a spoil heap. At Parc Mine, surveyed before this project (Orange 2021), some spoil was so toxic that although Sitka Spruce seedlings were abundant, they inevitably died after a year or two, leaving numerous matchstick-like remains. This phenomenon has not been seen at the other Gwydyr sites. Toxicity must be slowing colonisation at many sites, but the fate of individual seedlings is difficult to predict. Some spoil heaps of relatively coarse stones, rather than fine material, are being effectively colonised by the moss *Racomitrium lanuginosum*, which creates a mat which excludes all lichens. It seems possible that this species is also an indicator of low metal content.

Grazing seems to be almost absent on sites within conifer plantations. Even stray sheep seem to be absent from the Gwydyr Forest, and there was no sign of deer. In any case, fences have usually been erected around old shafts, and whole sites have sometimes been fenced, in some cases perhaps to avoid disturbance from recreation, but mostly for safety.

Recent disturbance was not observed on the sites. Disturbance from recreational activities could easily disrupt spoil and soil crusts, but would do little to reverse colonisation by vascular plants.

Small conifers have been cut at Unit 37, apparently for conservation reasons. Cutting of young trees and saplings would help to avoid shading and needle-fall, but cannot return the spot to bare spoil. At some sites it might be beneficial to create an open belt around the mine by removing mature trees; this would reduce but not eliminate the supply of seed, and would reduce needle fall. However, in the short term this would not be visually attractive, and it must be admitted that mines lost among the trees have a romantic appearance. In the very long term it may be necessary to consider wholesale disturbance, by reworking some of the spoil heaps to re-expose stones. However, this would damage the archaeology of the site. Fortunately, this option is probably not yet needed. If the conifers are ever harvested for timber at some sites, then the disturbance that this creates could be used to justify exposing some spoil, removing brash, and avoiding replanting.

8. References

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Appendix 1. Species tables

The Appendices have been removed to comply with Accessibility legislation because they comprise complex multi-entry data tables with numerous blanks cells and/or photographs for use during on-site monitoring. They are available in full from the NRW Library.