Cyfoeth Naturiol Cymru
Natural Resources Wales

Survey of Upland Saxicolous Lichens & Lichenicolous Fungi at Carn Owen/Cerrig yr Hafan, Ceredigion (VC 46 Cardiganshire)

John R. Douglass & Steve P. Chambers
2021

Evidence Report No 561

About Natural Resources Wales

Natural Resources Wales is the organisation responsible for the work carried out by the three former organisations, the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales. It is also responsible for some functions previously undertaken by Welsh Government.

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.

Evidence at Natural Resources Wales

Natural Resources Wales is an evidence based organisation. We seek to ensure that our strategy, decisions, operations and advice to Welsh Government and others are underpinned by sound and quality-assured evidence. We recognise that it is critically important to have a good understanding of our changing environment.

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 be attributed to NRW.

Report series:	NRW Evidence Reports
Report number:	561
Publication date:	October 2021
Contractor:	J.R. Douglass
Title:	Survey of Upland Saxicolous Lichens & Lichenicolous Fungi at Carn Owen/Cerrig yr Hafan, Ceredigion (VC 46 Cardiganshire)
Author(s):	J.R. Douglass & S.P. Chambers
Peer Reviewer(s):	Sam Bosanquet
Approved By:	Dr Carol Fielding
Series Editor(s):	
Restrictions:	None

Distribution List (core)

NRW Library, Bangor

National Library of Wales

British Library

Welsh Government Library

Scottish Natural Heritage Library

Natural England Library

Distribution List (additional)

NRW Environment Team Ceredigion

Bob Matthews

John Douglass

Steve Chambers

British Lichen Society Library

Recommended citation for this report: Douglass JR & Chambers SP. 2021. Survey of Upland Saxicolous Lichens & Lichenicolous Fungi at Carn Owen/Cerrig yr Hafan, Ceredigion (VC 46 Cardiganshire). Natural Resources Wales Evidence Report 561: 66pp.

Table of Contents

1. Crynodeb Gweithredol

Comisiynwyd yr arolwg cennau hwn gan Cyfoeth Naturiol Cymru er mwyn llywio rheolaeth tir Carn Owen a'r ardal o'i amgylch yn y dyfodol. Y Safle Daearegol Pwysig Rhanbarthol (RIGS) oedd yr ardal y canolbwyntiwyd arni'n bennaf, ynghyd ag asesiad cychwynnol o'r ardal ehangach.

Gwnaed gwerthusiad o gasgliadau creigdrig ar gyfer creigiau asidig nad ydynt yn fynyddig, ynghyd â'r casgliadau metelaidd a dyfrol, gan ddefnyddio mynegeion dethol SoDdGA a ddatblygwyd gan Sanderson ac eraill (2018). Mae'r asesiad hwn yn dangos yn gryf y dylid ystyried Carn Owen ar gyfer dynodiad SoDdGA ar sail y creigiau asidig nad ydynt yn fynyddig a'r fflora cennau metelaidd.

Dangosodd arolygon cychwynnol gan Steve Chambers ac Alan Fryday fod y safle wedi pasio'r trothwy ar gyfer ei ddethol fel SoDdGA ar gyfer creigiau asidig nad ydynt yn fynyddig a chasgliadau metelaidd (Chambers 2017 a 2020). Fodd bynnag, nid oedd toreithrwydd a dosbarthiad y rhywogaethau sgorio yn hysbys ac nid oedd yn bosibl gosod ffin SoDdGA. Mae Carn Owen yn SoDdGA ymgeisiol am ei ddaeareg ac mae'r ffin bresennol yn dilyn ffin y Safle Daearegol Pwysig Rhanbarthol (RIGS).

Sgôr y casgliad cennau ar gyfer creigiau asidig nad ydynt yn fynyddig yw 58. Y mynegai cynefinoedd metelaidd yw 18. Y sgôr trothwy ar gyfer ystyriaeth i fod yn SoDdGA ar gyfer y ddau fynegai yw 10 (Sanderson ac eraill 2018). Sgôr y Mynegai Ansawdd Cyrsiau Dŵr Asidig (AQUI) yw 7 (trothwy = 11). Y sgôr creigiau asidig nad ydynt yn fynyddig yw'r uchaf a gofnodwyd yn Ardal Chwilio Ceredigion, er nad oes gan CNC ddata ar y mwyafrif helaeth o safleoedd yng Ngheredigion. Fodd bynnag,

mae’r sgôr hon yn uwch na llawer o Safleoedd o Ddiddordeb Gwyddonol Arbennig yng Nghymru. Mae sgorau uwch ar gyfer SoDdGA Cadair Idris a SoDdGA Eryri yn rhannol oherwydd eu maint llawer mwy.

Ymhlith y cofnodion newydd ar gyfer y safle mae'r canlynol: 21 rhywogaeth sy’n anfynych yn genedlaethol, deg rhywogaeth sy’n brin yn genedlaethol, dwy rywogaeth sydd dan beth bygythiad, un rywogaeth sydd dan fygythiad, un rywogaeth sydd mewn perygl, saith rhywogaeth sydd â diffyg data, a dwy rywogaeth y mae gan y DU gyfrifoldeb rhyngwladol amdanynt. Mae dau dacson yn newydd i Gymru: *Lecidea sarcogynoides* (yn brin yn genedlaethol, dan fygythiad yn ôl y Llyfr Data Coch) a'r ffwng parasitig *Polycoccum microcarpum* (yn brin yn genedlaethol) sy'n tyfu ar y cen *Cladonia gracilis*. Cafodd chwe tacson eu cofnodi fel rhai sy’n newydd i Geredigion (VC 46), gan gynnwys y canlynol: *Micarea lignaria* var. *endoleuca* (yn anfynych yn genedlaethol, â chyfrifoldeb rhyngwladol), *Rhizocarpon sublavatum* (yn brin yn genedlaethol), a’r ffyngau parasitig sy'n brin yn genedlaethol *Sphaerellothecium araneosum* a *Cercidospora cladoniicola* sy’n byw ar y cennau *Ochrolechia androgyna* a *Cladonia ciliata* var. *ciliata* yn y drefn honno. Gwnaed ail gofnodion VC 46 ar gyfer *Fuscidea gothoburgensis* (yn anfynych yn genedlaethol) a *Lepra* (*Pertusaria*) *melanochlora* (yn brin yn genedlaethol, mewn perygl). Yn ogystal â hyn, mae'r safle'n cynnal nifer o rywogaethau y mae’n bosib nad ydynt wedi eu disgrifio hyd yma (Chambers, heb ei gyhoeddi).

Mae'n ymddangos bod llygryddion nitrogenaidd (h.y. cyfansoddion NOx a/neu amonia a deilliadau ohonynt) yn effeithio'n negyddol ar y safle hwn, o ddyddodiad drwy'r awyr ac o dorthau mwynau a gyflwynwyd.

Argymhellir yn gryf y dylid monitro rhywogaethau a chymunedau cennau pwysig, er mwyn helpu i lywio penderfyniadau rheoli.

Mae nodiadau targed darluniadol yn manylu ar rai o'r rhywogaethau prinnaf a'u cynefinoedd cysylltiedig. Darperir rhestr lawn o rywogaethau ar ffurf taenlen Cymdeithas Cennau Prydain, a fydd yn cael ei lledaenu i'r Rhwydwaith Bioamrywiaeth Cenedlaethol.

2. Executive Summary

This lichen survey was commissioned by Natural Resources Wales in order to inform the future land management of Carn Owen and its surroundings. The RIGS (Regionally Important Geological Site) was the main focus area, together with an initial assessment of the wider area.

An evaluation was made on saxicolous (rock dwelling) assemblages for non-montane acid rock, together with the metalliferous and aquatic assemblages using SSSI (Site of Special Scientific Interest) selection indices developed by Sanderson *et al*. (2018). This assessment strongly indicates that Carn Owen should be considered for SSSI designation for both the non-montane acid rock and the metalliferous lichen flora.

Initial surveys by Steve Chambers and Alan Fryday indicated that the site passed the threshold for SSSI selection for non-montane acid rock and metalliferous assemblages (Chambers 2017 & 2020). However, abundance and distribution of the scoring species was unknown and it was not possible to set a SSSI boundary. Carn Owen is a candidate SSSI for its geology and the current boundary follows that of the RIGS (Regionally Important Geological Site).

The lichen assemblage score for non-montane acid rock is 58. The metalliferous Habitat Index is 18. The threshold score for SSSI consideration for both indices is 10 (Sanderson *et al*. 2018). The Acid Watercourse Quality Index (AQUI) score is 7 (threshold =11). The non-montane acid rock score is the highest recorded in Ceredigion Area of Search, although NRW do not have data on the great majority of

Ceredigion sites. However, this score exceeds many SSSI's in Wales. Higher scores for Cadair Idris SSSI and Eryri SSSI are partly due to their far larger extent.

New records for the site include: 21 Nationally Scarce, 10 Nationally Rare, 2 Near Threatened, 1 Vulnerable; 1 Endangered, 7 Data Deficient and 2 species for which the UK has an International Responsibility. Two taxa are New for Wales: *Lecidea sarcogynoides* (Nationally Rare, RDB Vulnerable) and the lichenicolous fungus *Polycoccum microcarpum* (Nationally Rare) growing on *Cladonia gracilis*. In total six taxa were recorded as new to Cardiganshire (VC 46) including: *Micarea lignaria* var. *endoleuca* (Nationally Scarce, International Responsibility), *Rhizocarpon sublavatum* (Nationally Rare) and the Nationally Rare lichenicolous fungi *Sphaerellothecium araneosum* on *Ochrolechia androgyna* & *Cercidospora cladoniicola* on *Cladonia ciliata* var. *ciliata*. 2nd VC 46 records were made for *Fuscidea gothoburgensis* (Nationally Scarce) and *Lepra (Pertusaria) melanochlora* (Nationally Rare, Endangered). In addition, the site supports a number of as yet possibly undescribed species (Chambers, unpublished).

Nitrogenous pollutants (i.e. NOx and/or ammonia compounds and their derivatives) appear to be negatively affecting this site, from both airbourne deposition and from introduced mineral licks.

It is highly recommended that important lichen species and communities are monitored, in order to help inform management decisions.

Illustrated target notes detail some of the rarer species and their associated habitats. A full species list is provided in Table 1 (below), and the underlying records

will be disseminated to the National Biodiversity Network (NBN), British Lichen Society (BLS) and Local Environmental Records Centre (LERC).

3. Background

Carn Owen (Cerrig yr Hafan) is situated c. 15km east of Aberystwyth, Cardiganshire (VC 46) and is owned by Natural Resources Wales. The bedrock comprises thickly bedded Ordovician quartzose sandstones (gritstones) of the Pencerrigtewion Member and fossiliferous (graptolites) basal Silurian (Cwmere Formation) mudstones. The site includes sheer cliff faces, crags, rock outcrops, boulders (of a range of sizes), rock slabs, scree (mostly from previously quarried exposures) and upland heathland with adjoining conifer plantations to the north and east. The site includes old metal mine workings (Hafan mine), which were mined for lead and zinc and old stone quarries (Hafan quarry & Setts Quarry) all of which operated in the 19th century.

The lichens of Carn Owen were first studied in 1993 by Alan Fryday and Steve Chambers. They discovered a remarkably rich assemblage of saxicolous species, including several (at the time) unknown outside Scotland (Chambers 2017 & 2020).

The current project assesses the site for its Non-montane acid rock, Metalliferous and aquatic assemblages (Sanderson *et al*. 2018). The site was known to support 'one of the finest assemblages of oceanic upland-submontane lichens in mid-Wales" (Chambers 2017).

This survey focused on the RIGS area (Map 1 area A, cross-hatched in blue), which received 4 days of fieldwork, with areas B (Cerrig Llwynog) and C (Craig yr Allt-ddu) receiving one day each.

4. Methods

Ten figure GPS readings were recorded for species of conservation importance. Location photographs for some species of conservation were taken. DAFOR abundance was recorded. A BLS spreadsheet was also produced of all lichens recorded in each of the 1km squares visited.

In some instances, specimens were collected to confirm identification.

Key to abbreviations

A = Abundant
AQUI = The Acid Watercourses Quality Index (Sanderson 2018)
BLS = British Lichen Society
DD = Data Deficient
DMP = Direct Monitoring Plot
EN = IUCN red list Endangered
F = Frequent
G = Graphidion community species
IR = Species for which the UK has an International Responsibility (Woods and Coppins 2012)
IUCN = International Union for the Conservation of Nature and natural resources
L = Lobarion community species
LF = Lichenicolous Fungus
MHI = Metalliferous Habitats Index (Sanderson 2018)
NBN = National Biodiversity Network
NR = Nationally Rare
NS = Nationally Scarce
NT = IUCN red list Near Threatened
O = Occasional
SOWI = Southern Oceanic Woodland index
TBC = Species ID to be confirmed by specialist
TLC = Thin Layer Chromatography
VU = IUCN red list Vulnerable

DAFOR Codes

D = Dominant
A = Abundant
F = Frequent
O = Occasional
R = Rare
LF = Locally Frequent
LA = Locally Abundant

Nomenclature follows Smith *et al.* (2009) and the BLS super dictionary (BLS website).

4.1. Timing and personnel

The surveys took place between 6th and 10th December 2020 with John Douglass being joined by Steve Chambers on 7th, 8th and 9th. Steve Chambers also visited the site on on 3 February 2021 to survey Craig yr Allt-ddu in area C.

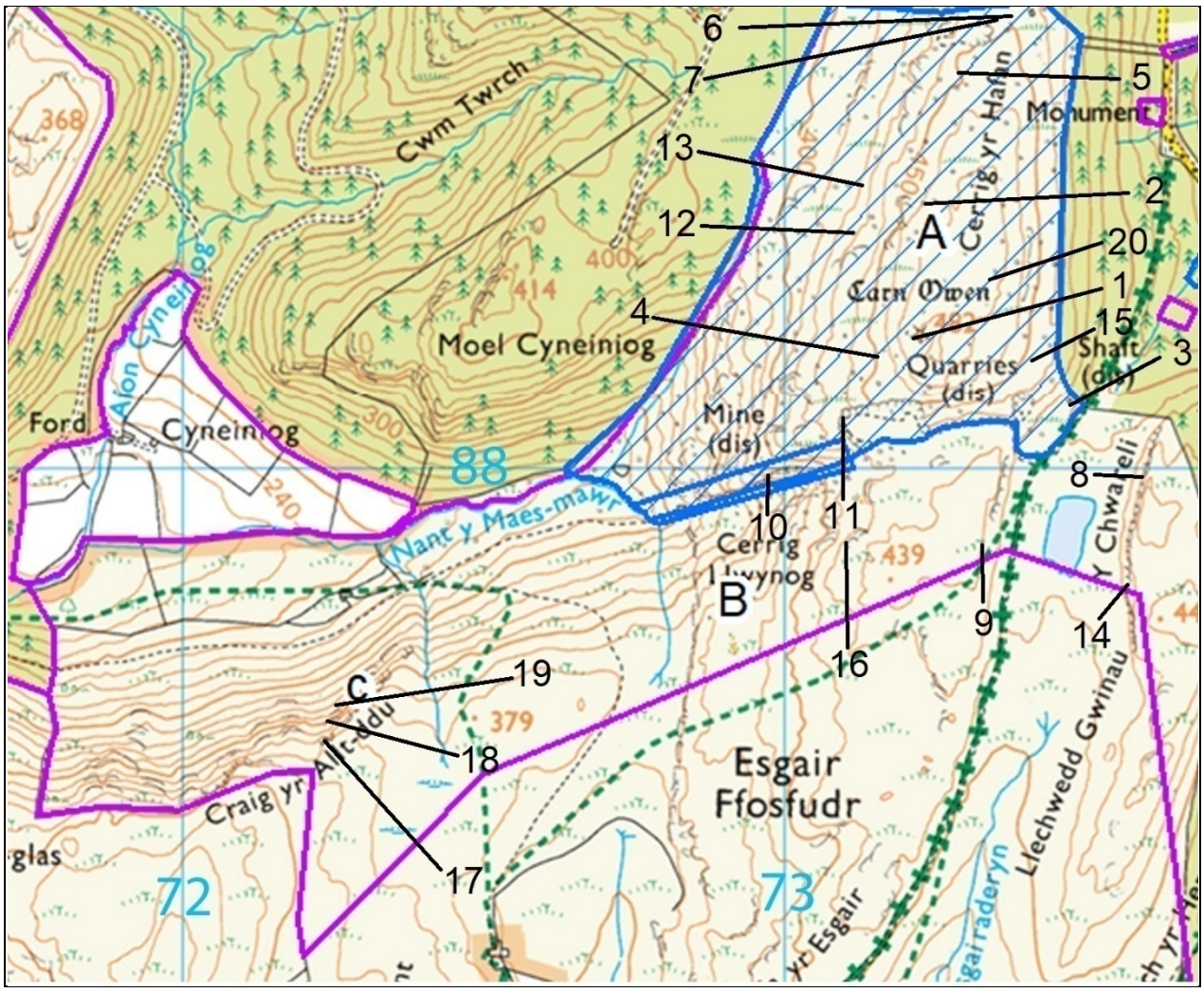
4.2. Survey constraints

There was insufficient time to undertake a complete survey of all locations supporting lichens within the site. The complexity of montane saxicolous lichen habitats and the small size of most lichen species mean a complete survey is unachievable. Certain areas not studied in detail but which may prove productive include the North side of the south facing cliffs at c. SN 729 880 and the quarry area (Site 7 on Map 1).

5. Results

Map 1 below shows the locations of lichen hotspots. The map is followed by tables of notable species. Table 3 shows comparisons with other similar lichen assemblages in Wales (compiled by Sam Bosanquet with updated results for Carn Owen and Cadair Idris). Illustrated target notes are detailed in Appendix I. Species portraits are provided in Appendix II. A full species list is provided separately as a BLS spreadsheet which will be disseminated to the NBN.

Map 1. Showing positions of 'lichen hotspots' at Carn Owen, with purple indicating management boundaries and blue highlighting the principal survey area.



1 = Summit cairn with boulders and low outcrops supporting *Fuscidea cyathoides* var. *sorediata*, *Lasallia pustulata, Micarea coppinsii, M. subnigrata, Stereocaulon vesuvianum* var. *nodulosum* and *Umbilicaria torrefacta.*

2 = Slabs and low flushed outcrops on east facing hill supporting *Calvitimela aglaea, Coenogonium luteum, Fuscidea cyathoides* var. *sorediata* (occasional to locally frequent)*, Halecania spodomela*, *Lasallia pustulata* (locally abundant)*, Lecidella 'subcarpathica' Micarea coppinsii, Miriquidica pycnocarpa* f. *pycnocarpa, Mycoblastus sanguinarius, Miriquidica pycnocarpa* f. *sorediata, Rimularia badioatra, R. intercedens, Stereocaulon vesuvianum* var. *nodulosum, Umbilicaria polyrrhiza* and *U. torrefacta* (locally abundant)*.*

3 = Hafan mine (SPC records, 1992-2010). *Acarospora sinopica, Baeomyces placophyllus, Coppinsia minutissima, Cryptodiscus gloeocapsa, Gyalidea subscutellaris, Lecanora stenotropa, Placopsis lambii, Rhizocarpon furfurosum* (fertile inside shaft entrance), *R. oederi, S. dactylophyllum, S. leucophaeopsis, S. pileatum, Thrombium epigaeum, Vezdaea aestivalis, V. cobria*, *V. leprosa* & *V. retigera.* *Stereocaulon condensatum* was added to the list in 2020 from sloping ground just SE of the mine shaft.

4 = Outcrops and boulders supporting *Cladonia luteoalba, Fuscidea kochiana, Halecania spodomela*, *Lasallia pustulata*, *Lecidea sarcogynoides* (New to Wales)*, Polycoccum microstictum* (LF on *Acarospora fuscata*)*, Porina lectissima* (small patch of flushed outcrop), *Porpidia melinodes, Sphaerophorus fragilis* and *Rhizocarpon subgeminatum.*

5 = *Umbilicaria polyrrhiza* on slab on east facing slope.

6 = *Porpidia striata* on mine spoil heap.

7 = Stone quarry spoil heap containing massive blocks supporting: *Micarea lignaria* var. *endoleuca* (var. new to VC)*, Miriquidica pycnocarpa* f. *pycnocarpa, Placopsis lambii* (with *Polycoccum squamarioides, Porpidia melinodes, P. soredizodes* (with *Endococcus* sp.)*, Rhizocarpon sublavatum* (on rock at top of heap, new to the VC)*, R. subgeminatum, Scoliciosporum intrusum* (on large boulder nr. base of heap), *Stereocaulon leucophaeopsis* and *S. pileatum*.

8 = West facing crags supporting: *Bryoria fuscescens* (several tassels/stands in 3 separate locations), *Catillaria atomarioides, Cetraria aculeata, Cladonia cyathomorpha, Lecanactis* (*Psoronactis*) *dilleniana, Lecidea swartzioidea, Micarea coppinsii, Opegrapha* (*Gyrographa*) *saxigena*, *Pertusaria pseudocorallina, Porpidia melinodes* (fertile) and *Sphaerophorus fragilis* (lowest altitudinal limit for VC).

9 = Low flushed boulders supporting *Collemopsidium* sp., *Epigloea soleiformis* and heathland with *Polycoccum microcarpum* (New to Wales) (LF on *Cladonia gracilis*) and *Cercidospora cladoniicola* (new VC record) on *Cladonia ciliata* var. *ciliata.*

10 = South facing cliffs and boulders supporting *Fuscidea gothoburgensis* (2nd VC record; only otherwise known in the VC from near the summit of Pumlumon Fawr), *Lasallia pustulata* (large sheets, including very large thalli), *Lepraria membranacea, Micarea coppinsii, Parmelia discordans* (on boulder below cliffs), *Pertusaria excludens, Porpidia melinodes* and *Rhizocarpon infernulum* f. *sylvaticum*.

11 = West facing rocky ridge and outcrops supporting *Clauzadeana macula, Fuscidea cyathoides* var. *sorediata*, *Lasallia pustulata*, *Rhizocarpon subgeminatum, Micarea subnigrata, Mycoblastus sanguinarius, Miriquidica pycnocarpa* f. *sorediata, Scoliciosporum*

intrusum, Stereocaulon vesuvianum var. *nodulosum, Umbilicaria polyphylla* and *Pyrenidium actinellum* (LF on *Baeomyces rufus*, associated with *Placynthiella icmalea*).

12 = Large boulder and smaller boulders supporting *Micarea coppinsii, Mycoblastus sanguinarius, Parmelia discordans, Rhizocarpon subgeminatum, Sphaerophorus globosus*, *Umbilicaria torrefacta and Marchandiomyces corallinus* on *Fuscidea cyathoides, Ochrolechia androgyna* and *Parmelia saxatilis.*

13 = Outcrops and boulders supporting *Clauzadeana macula*, *Fuscidea cyathoides* f. *sorediata, Halecania spodomela, Lasallia pustulata, Parmelia discordans, Pertusaria lactescens*, *Umbilicaria polyphylla* and *U. torrefacta*.

14 = Quarry spoil slabs supporting large colonies of *Lecidea swartzioidea*.

15 = Boulders supporting: *Clauzadeana macula, Lecidea phaeops, Miriquidica pycnocarpa* f. *pycnocarpa, Mycoblastus sanguinarius, Porpidia contraponenda, P. melinodes, Rhizocarpon subgeminatum, Sphaerophorus fragilis*, *Thelocarpon laureri* (on a large table-top boulder) and *Umbilicaria torrefacta*.

16 = Outcrops and boulders supporting *Fuscidea cyathoides* var. *sorediata*, *Lasallia pustulata, Parmelia discordans*, *Porpidia melinodes, Rhizocarpon subgeminatum, Umbilicaria polyphylla* and *U. torrefacta.*

17 = NW facing crags supporting *Arthrorhaphis aeruginosa* on *C. polydactyla, Catillaria atomarioides, Cecidonia xenophana* on *P. cinereoatra, Endococcus propinquus on P. tuberculosa, Lecanora barkmaniana* on rowan*, Lecidea herteliana, Leimonis (Micarea) erratica, Melaspilea interjecta, Micarea angulosa, M. botryoides, M. ternaria, Mycoporum antecellens* on rowan*, Porina guentheri* var. *guentheri, Porpidia contraponenda, P. striata, Sphaerophorus fragilis* and *Stereocaulon vesuvianum* var. *nodulosum.*

18 = NW facing crags supporting *Amygdalaria pelobotryon, Lepra (Pertusaria) melanochlora*, *Pilophorus strumaticus* and *Sphaerophorus fragilis.*

19 = NW facing crags supporting *Pronectria oligospora* on *Punctelia subrudecta* on hawthorn.

20 = Slabs and low flushed outcrops on east facing hill supporting *Calvitimela aglaea, Coenogonium luteum, Fuscidea cyathoides* var. *sorediata* (occasional to locally frequent)*, Lasallia pustulata* (locally abundant)*, Lecidella 'subcarpathica', Rimularia badioatra, R. intercedens, Stereocaulon vesuvianum* var. *nodulosum* and *U. torrefacta* (locally abundant

Tables 1 & 2 were removed because they are impossible to format in a way which meets Accessibility legislation without compromising their interpretability. They can be found in the full PDF version available from the Natural Resources Wales Library.

Table 3. Updated comparison table of Non-montane Acid Rock TNTN scores for selected sites in Wales (modified from Bosanquet 2020)

Site	Area of Search	Non-montane Acid Rock TNTN
Eryri SSSI	West Gwynedd	108
Cadair Idris SSSI	East Gwynedd	59
Carn Owen cSSSI	Ceredigion	58
Elenydd SSSI	Brecknock/Ceredigion	56
Marcheini Uplands, Gilfach Farm &Gamallt SSSI	Radnor	48
Rhinog SSSI	East Gwynedd	20
Carn Ingli SSSI	Preseli & South Pembrokeshire	12
Migneint – Arenig – Dduallt SSSI	East Gwynedd	12
Brecon Beacons SSSI	Brecknock	11
Berwyn SSSI	East Gwynedd/Montgomeryshire	10
Afon Eden - Cors Goch Trawsfynydd SSSI	East Gwynedd	9
Coedydd a Cheunant Rheidol (Rheidol Woods & Gorge) SSSI	Ceredigion	9
Black Mountains SSSI	Brecknock	8
Mynydd Du (Black Mountain) SSSI	Carmarthen & Dinefwr	7

6. Conclusions and Discussion

Despite its modest size compared with, for example, very extensive high ground areas in north Wales, Carn Owen is of high conservation importance with scores well above the thresholds for SSSI site selection. This assessment strongly indicates that Carn Owen should be considered for SSSI designation for its non-montane acid rock and metalliferous lichen assemblages.

Several nationally and locally rare taxa were newly discovered for the site during the survey, the most notable of which were *Calvitimela aglaea* (NS; 4th VCR), *Cercidospora cladoniicola* (NR; LF on *Cladonia ciliata* var. *ciliata*; 1st VCR), *Fuscidea gothoburgensis* (NS; 2nd VCR), *Lecidea herteliana* (NR; 4th VCR), *Lecidea sarcogynoides* (NR, RDB Vulnerable; new to Wales), *Lepra* (*Pertusaria*) *melanochlora* (RDB En B, NR; 2nd VCR), *Melaspilea interjecta* (RDB, IR, DD, NR), *Micarea angulosa ad int.* (2nd VCR from a near-natural habitat), *Micarea lignaria* var. *endoleuca* (NS IR; 1st VCR for the var.), *Micarea ternaria* (NR; 3rd VCR), *Polycoccum microcarpum* (NR; LF on *Cladonia gracilis*; new to Wales), *Rhizocarpon sublavatum* (NR; 1st VCR), *Scoliciosporum intrusum* (NR; 3rd VCR) & *Sphaerellothecium araneosum* (NR; LF on *Ochrolechia androgyna*; 1st VCR). In addition, the site supports a number of as yet possibly undescribed species (Chambers, unpublished).

Management guidelines should inform decisions to conserve and enhance these features. Conifer regeneration should be removed as soon as possible to prevent shading of rocks and outcrops. Grazing levels appear to be keeping vegetation from growing over rocks. However, supplementary feeding of livestock (sheep) in the form of mineral licks (provided in red plastic containers) is of concern as these are undoubtedly importing nitrogen compounds, which are adversely impacting the

ecology of the site and in particular the saxicolous lichens. Reduced nitrogen, particularly in the form of ammonia from livestock manures together with organic and inorganic fertilizers causes hypereutrophication which can seriously damage habitat features including lichen communities. Large areas of the UK and Ireland have nitrogen concentration levels above critical loads which will have a damaging affect on the habitat in question. The Air Pollution Information system website (APIS 2021) gives modelled Ammonia concentrations of just 0.6ug/m3 (well below the 1ug/m3 Critical Level for lichen-rich ecosystems), but N-deposition of nearly 12kgN/ha/yr (above the 10kgN/ha/yr Critical Load for lichen-rich montane rock ecosystems). Source attribution plots from the Nitrogen Futures project (Nitrogen Futures 2021) also show high N-deposition across much of the Cambrian Mountains.

Reactive nitrogen, which includes oxidised nitrogen (e.g. nitrogen dioxide) and reduced nitrogen (e.g. ammonia) is also known to acidify habitats (Plantlife 2017). These effects are most acute in areas of high rainfall in acid habitats e.g. siliceous rocks and soils in upland and montane situations which cannot buffer against the effects of increased acididty for rain, snow and occult precipitation.

Sheep are known to excrete c. 80% of the nitrogen in their diet in their dung and urine, which is then released into the ecosystem. The semi-natural grass-heath vegetation on the hill is naturally low in N-compounds and the use of supplementary feedstuffs, such as sheep lick formulations, artificially elevate the total loading of N-compounds on the system. Simplistic measurements of grazing pressure/levels on upland vegetation based on calculations of livestock units per area do not take into account the impact of nitrogen loading from dietary sources, including off-site on-farm feeding practices and the now routine provision of on-site feedstuffs, especially

modern mineral lick substances which comprise mostly urea, a substance that is very high in N-compounds.

Hormidiopsis (*Klebsormidium*) *crenulata* (a green alga) was occasional to locally frequent on rock and lichens at Carn Owen. This alga is associated with excess nitrogen input from both diffuse atmospheric sources and from point concentrated local sources e.g. sheep excretion. The alga was not seen (SPC pers. obv.) on rock faces or lichens at Carn Owen during surveys between 1993 - 2010. This species appears to be increasing, particularly in upland areas, in response to increased Nitrogen deposition (Douglass 2020a & b). Monitoring should be initiated at Carn Owen on colonies of *Hormidiopsis crenulata*. This should form part of the management plan to help inform future management decisions at this site.

Bryoria fuscescens is a species known to be sensitive to excess nitrogen input from human activities. A new population of this lichen was found during the survey in a tetrad in which it had previously not been recorded. It would also be worth initiating monitoring for this and for other species of conservation importance e.g. *Lecidea sarcogynoides, Lepra melanochlora, Fuscidea gothoburgensis* and *Rhizocarpon subgeminatum*.

Increased rainfall due to climate change is likely to favor vascular plant and bryophyte growth. This will negatively affect the slower growing lichen assemblages which will become over shaded and eventually shaded out of saxicolous (rock) and terricolous (ground) habitats.

During the survey it became apparent that *Marchandiomyces corallinus* was present on 7 different host lichens (*Fuscidea cyathoides, Ochrolechia androgyna,*

Parmelia omphalodes, P. saxatilis, P. sulcata, Mycoblastus sanguinarius & *Rhizocarpon geographicum*) giving it the greatest host diversity for this lichenicolous fungus at any site to-date in the Vice County.

There was not enough time to undertake a complete survey of the site. Areas not looked at but looking promising include the North side of the south facing cliffs at c. SN 729 880 and the quarry area (Site 7 on map 1). Both areas should be examined in more detail during any follow up surveys or monitoring at this site.

Acknowledgements

Special thanks to Sam Bosanquet and Carol Fielding for their help and support.

References and Further Reading

Air Pollution Information system website (APIS). Air Pollution Information System | Air Pollution Information System (apis.ac.uk) [Accessed February 2nd 2021].

Bosanquet, SDS. 2020. Project Specification. Carn Owen saxicolous lichens.

GBV. 2019. Geology of Britain Viewer. British Geological Survey. Natural

Research Council. Available from: http://mapapps.bgs.ac.uk/geologyofbritain/home.html. [Accessed 15th Dec 2019].

Chamber SP. 2017. File notes on Carn Owen's Lichen assemblages by Steve Chambers to Sam Bosanquet.

Chambers SP. 2020. Cairn Owen (Cerrig yr Hafan), centred on GR22(SN)734883, Tetrad J, Alt 430-482m, VC 46 Cards.

Church JM, Coppins BJ, Gilbert OL, James PW, Stewart NF. 1996. *Red Data Books of Britain and Ireland: Lichens*. Volume 1: Britain. JNCC. ISBN: 1 86107 4123.

Douglass, JR. 2020a. *Survey and Monitoring of Upland Saxicolous Lichens in Yr Wyddfa, Cadair Idris and Rhinog NNR's*. Report for NRW.

Douglass, JR. 2020b. *Lichen Monitoring in relation to Nitrogen Deposition in Northern Ireland*. Report for NMNI and NIEA.

Nitrogen Futures Project. https://jncc.gov.uk/news/nitrogen-futures-project-reports-published/ [Accessed 2nd Feb 2021].

Orange A. 2013. *British and Other Pyrenocarpous Lichens*. Version 2. Cardiff: National Museum of Wales.

Orange A. 2014. *Porpidia irrigua*, a new species related to *P. contraponenda*. *The Lichenologist* 46 (3), 269-284.

Orange A. 2018. A new species-level taxonomy for Trapelia (Trapeliaceae, Ostropomycetidae), with special reference to Great Britain and the Falkland Islands. *The Lichenologist* 50(1): 3 - 43.

Sanderson N, Wilkins T. Bosanquet S, Genney D. (2018). *JNCC, Guidelines for the Selection of Biological SSSIs*. Part 2: Detailed Guidelines for Habitats and Species Group. Chapter 13 Lichens and associated microfungi. JNCC incl: Guidelines for Biological SSSI's Lichens TNTN Thresholds and assemblages.

Smith CW, Aptroot A., Coppins BJ, Fletcher A, Gilbert OL, James PW, Wolseley PA. 2009. *The Lichens of Great Britain and Ireland*. London: The British Lichen Society.

Woods R. 2003. *Lichen Flora of Brecknock*. British Lichen Society.

Woods R. 2010. *A Lichen Red Data List for Wales*. Plantlife. Salisbury.

Woods RG, Coppins BJ. 2012. *A Conservation Evaluation of British Lichens and Lichenicolous fungi*. London. Species status 13. JNCC.

Appendix I. Illustrated Target Notes

All photographs taken by John Douglass unless otherwise stated.

Figure 1. Position of *Umbilicaria polyrrhiza* on boulder. SN 73357 88337. View direction SE.

Figure 2. Position of *Umbilicaria polyrrhiza* colonies on boulder. SN 73384 88626. View direction SW.

Figure 3. *Umbilicaria polyrrhiza* colonies on boulder in fig. 2. SN 73384 88626. View direction SW.

Figure 4. *Umbilicaria polyrrhiza.*

Figure 5. Positions of *Rhizocarpon subgeminatum* (red arrow) and *Micarea subnigrata* (yellow arrow). NY 73102 88059. View direction N.

Figure 6. Large patch of *Hormidiopsis crenulata*. This species of green alga is occasional to frequent throughout the site and is thought to be related to increased nitrogen deposition. This alga is able to grow on bare rock or over the top of lichens. *Umbilicaria polyphylla* occurs on the top of this boulder. NY 7310 8805. View direction NW.

Figure 7. Upper section of boulder in photo above with *Hormidiopsis crenulata, Hypogymnia physodes* and *Lasallia pustulata*. View direction NW.

Figure 8. These SW facing outcrops support species including *Clauzadeana macula, Fuscidea cyathoides, Micarea peliocarpa, Lecidea fuscoatra, Lepraria caesioalba, Miriquidica pycnocarpa* f. *sorediata, Rhizocarpon geographicum, R. subgeminatum*, *Schaereria fuscocinerea, Stereocaulon evolutum, Trapelia obtegens, Umbilicaria polyphylla, U. torrefacta* and *Xanthoparmelia conspersa.* NY 7310 8806. View direction NW.

Figure 9. Position of *Miriquidica pycnocarpa* f. *sorediata*. NY 73101 88063. View direction NW.

Figure 10. *Miriquidica pycnocarpa* f. *sorediata* following a small crevice in the rock.

Figure 11. Positions of *Halecania spodomela*. SN 73136 88223. View direction NW.

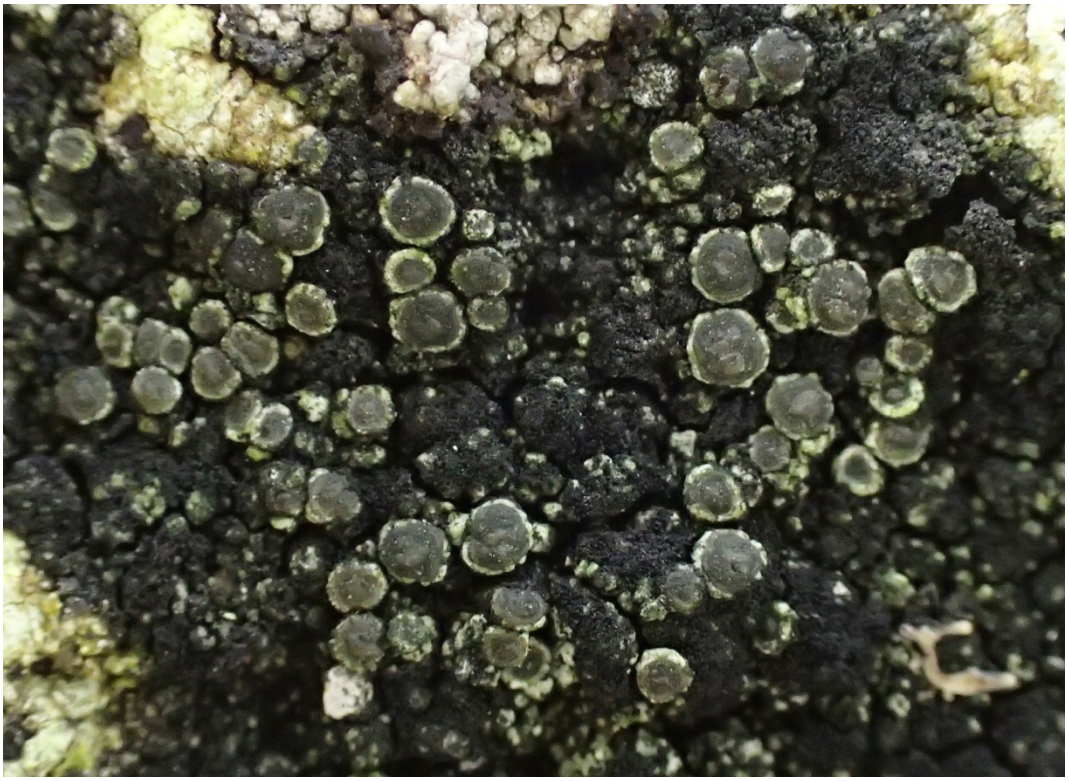


Figure 12. *Halecania spodomela*. SN 73136 88223. View direction NW.

Figure 13. Steve Chambers pointing out the position of *Lecidea sarcogynoides* (new for Wales). SN 73133 88227. View direction NW.

Figure 14. Section of outcrop supporting *Lecidea sarcogynoides*. Associated species include: *Cladonia bellidiflora, C. polydactyla, C. subcervicornis, Fuscidea cyathoides, Micarea leprosa, Pertusaria corallina, Porpidia macrocarpa, Rhizocarpon geographicum, Schaereria fuscocinerea* and *Sphaerophorus fragilis*. SN 73133 88227. View direction E.

Figure 15. Upper section of outcrop supporting *Lecidea sarcogynoides*. SN 73133 88227.

Figure 16. *Lecidea sarcogynoides*. SN 73133 88227.

Figure 17. *Lecidea sarcogynoides*. SN 73133 88227.

Figure 18. Outcrop supporting *Rhizocarpon subgeminatum* and *Miriquidica pycnocarpa* f. *pycnocarpa*. SN 73145 88229. View direction NW.

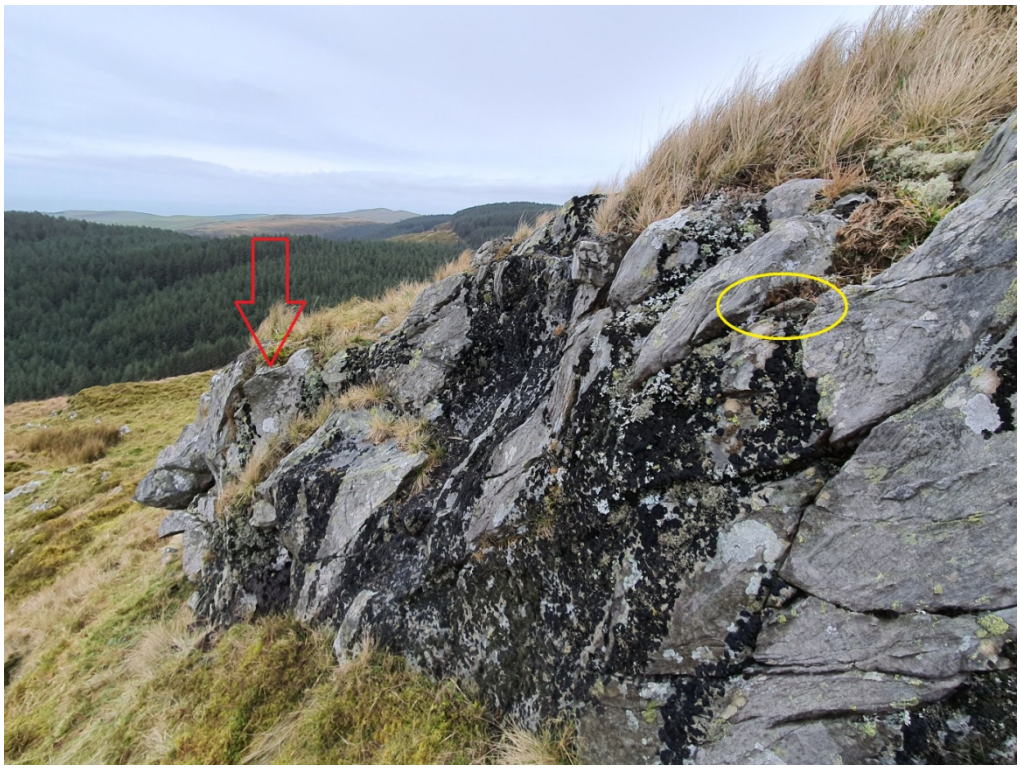


Figure 19. *Rhizocarpon subgeminatum* at red arrow and *Miriquidica pycnocarpa* f. *pycnocarpa* circled in at yellow on outcrop in photo above. SN 73145 88229. View direction NW.

Figure 20. *Rhizocarpon subgeminatum* on outcrop in fig. 19.

Figure 21. *Rhizocarpon subgeminatum* on outcrop fig. 20.

Figure 22. Large boulder supporting species including with *Mycoblastus sanguinarius*, *Ochrolechia androgyna, Rhizocarpon subgeminatum, Sphaerophorus globosus, Umbilicaria*

torrefacta. A rock below this large boulder supports *Parmelia discordans*. SN 73183 88358. View direction NW.

Figure 23. Detail of large boulder large in photo above with *Marchandiomyces corallinus* on *Fuscidea cyathoides, Ochrolechia androgyna* and *Parmelia saxatilis*. This lichenicolous fungus has largest number of host lichens for any site in VC 46 including: *Fuscidea cyathoides, Ochrolechia androgyna, Parmelia omphalodes, P. saxatilis, P. sulcata, Mycoblastus sanguinarius* & *Rhizocarpon geographicum*.

Figure 24. Tub of sheep lick among boulder scree. Sheep excrete a large proportion of the nitrogen they take in, contributing to hypereutrophication. SN 731 884. View direction E.

Figure 25. *Hormidiopsis crenulatum* growing with *Micarea coppinsii* (e.g. in circled area). These species are associated with excess reactive nitrogen input which is enhanced by the use of sheep lick supplements and other introduced food sources as well as airbourne nitrogen deposition.

Figure. 26 *Stereocaulon condensatum* (whiteish patches) in area c.8 x 3m, on gravelly ground just west of the gate. The mine adit in fig. 27 is visible in the background. SN 73502 88111. View direction E.

Figure 27. Area with *Stereocaulon condensatum* fig. 26. The mine adit in the photo below is fenced off (centre, left). SN 73502 88111. View direction W.

Figure 28. Mine adit in fig. 27. A number of Metallophytes have been found at Carn Owen (Steve Chambers 1992-2010). Some were re-found during this survey and some added e.g. *Stereocaulon condensatum*. These include: *Acarospora sinopica, Baeomyces placophyllus,*

Coppinsia minutissima, Cryptodiscus gloeocapsa, Gyalidea subscutellaris, Lecanora stenotropa, Placopsis lambii, Rhizocarpon furfurosum (fertile inside shaft entrance), *R. oederi*, *S. dactylophyllum, S. leucophaeopsis*, *S. pileatum,Thrombium epigaeum, Vezdaea aestival, V. cobria*, *V. leprosa* & *V. retigera.* SN 7349 8810. View direction NW.

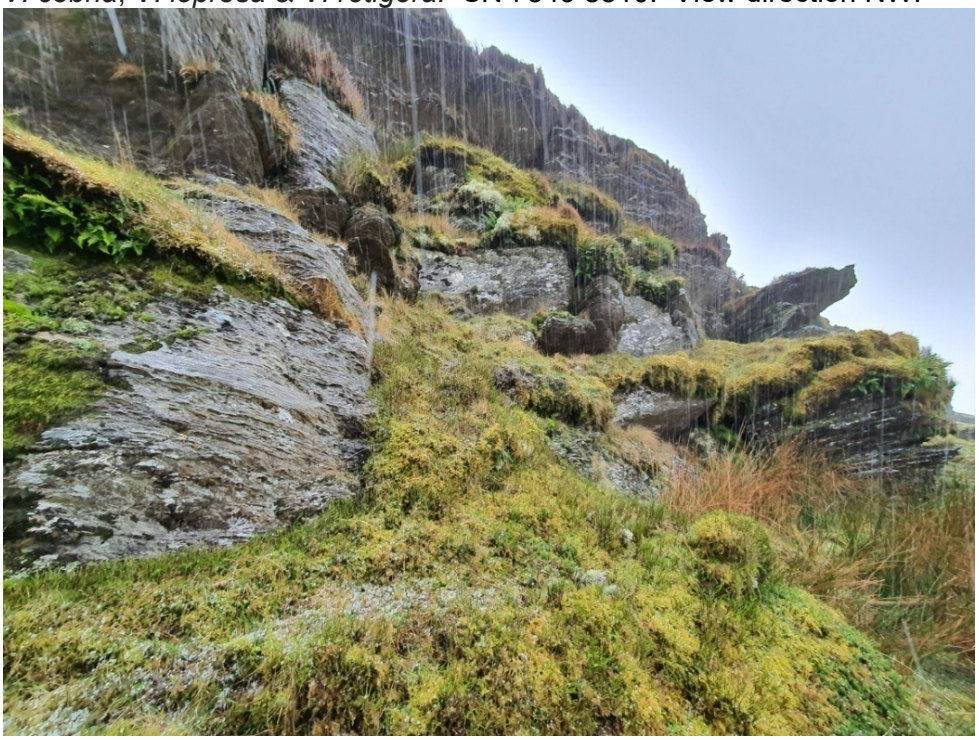


Figure 29. West facing crags served during heavy rain/hail supporting species including: *Bryoria fuscescens, Cetraria aculeata, Lecanactis dilleniana, Lecanora gangaleoides, Opegrapha saxigena, Pertusaria pseudocorallina, Sphaerophorus fragilis* and *Usnea flammea*. Patches of *Hormidiopsis crenulata* are occasional on these crags. SN 7358 8795. View direction NE.

Figure 30. Position of *Bryoria fuscescens* of west facing crags. SN 73589 87959. View direction SE.

Figure 31. *Bryoria fuscescens* of west facing crags in photo above. SN 73589 87959. View direction SE.

Figure 32. *Bryoria fuscescens* of west facing crags in photo above. SN 73589 87959. View direction SE.

Figure 33. Upper patches of *Bryoria fuscescens* of west facing crags. SN 73589 87959. View direction SE.

Figure 34. Quarry slabs supporting *Lecidea swartzioidea*. SN 73552 87775. View direction N.

Figure 35. *Lecidea swartzioidea* on quarry slabs in photo above. SN 73552 87775.

Figure 36. Position of *Thelocarpon laureri* and *Rhizocarpon subgeminatum* on large table boulder. SN 73338 88261. View direction W.

Figure 37. *Rhizocarpon subgeminatum* on large table boulder. SN 73338 88261. View direction W.

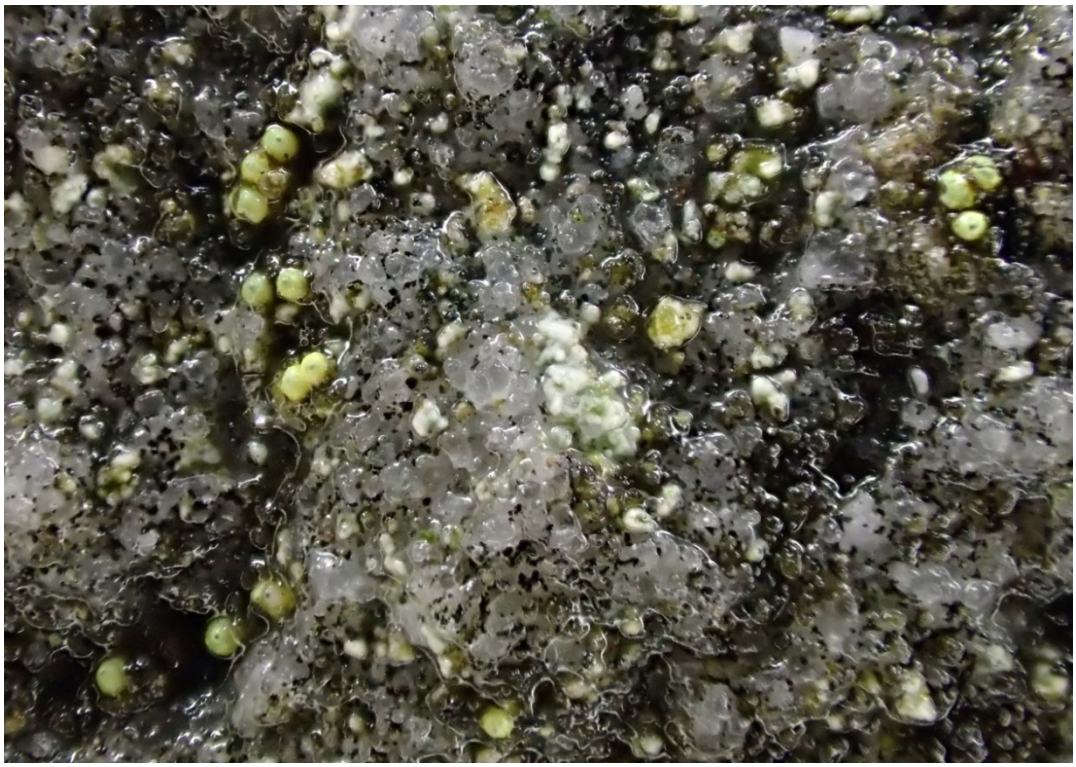


Figure 38. Position of *Thelocarpon laureri* on large table boulder in fig. 37.

Figure 39. Position of *Miriquidica pycnocarpa* f. *pycnocarpa.* SN 73169 88210. View direction NE.

Figure 40. Position of *Miriquidica pycnocarpa* f. *pycnocarpa* on loose stones and boulder in photo above. SN 73169 88210. View direction N.

Figure 41. Position of *Miriquidica pycnocarpa* f. *pycnocarpa* on loose stones and boulder in fig. 40. SN 73169 88210. View direction N.

Figure 42. Position of *Porpidia contraponenda*. SN 73164 88217. View direction NE.

Figure 43. Position of *Porpidia contraponenda*. SN 73164 88217. View direction SW.

Figure 44. Quarry heap supporting, *Lecanora soralifera, Micarea leprosula, Micarea lignaria* var. *lignaria, Miriquidica pycnocarpa* f. *pycnocarpa, Placopsis lambii* with *Polycoccum squaraoides, Porpidia macrocarpa* f. *macrocarpa, P. melinodes, P. soredizodes* with *Endococcus* sp. *Rhizocarpon lavatum, R. reductum, R. subgeminatum, Scoliciosporum intrusum, Stereocaulon leucophaeopsis, S. pileatum*. SN 73274 88728. View direction W.

Figure 45. Rough position of *Rhizocarpon sublavatum* on upper ridge of spoil heap. SN 73277 88711. View direction SE.

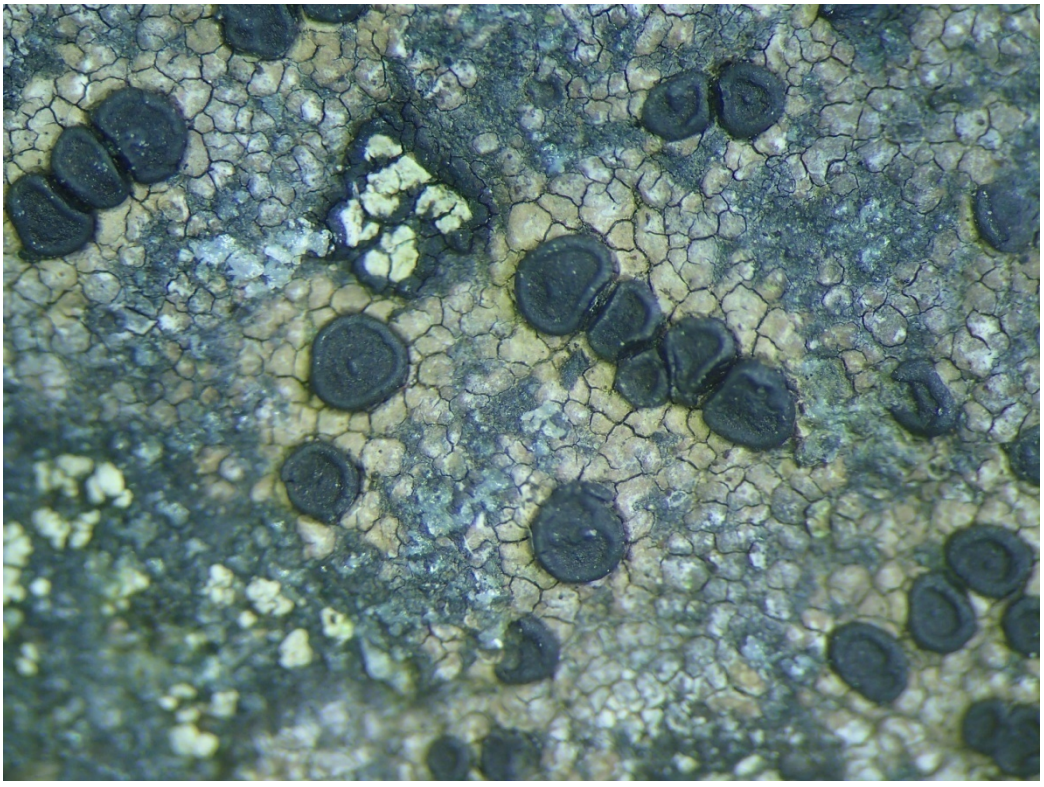


Figure 46. *Rhizocarpon sublavatum* on upper ridge of spoil heap in photo above. SN 73277 88711. View direction SE.

Figure 47. Position of *Xanthoparmelia mougeotii*. The only time this species was found at this site. SN 73359 88175. View direction SSE.

Figure 48. Extent of *Xanthoparmelia mougeotii* colony. SN 73359 88175. View direction NE.

Figure 49. *Xanthoparmelia mougeotii*. SN 73359 88175.

Figure 50. South facing cliffs (Hafan quarry incline) supporting *Fuscidea gothoburgensis* and *Pertusaria excludens*.

Figure 51. View of the W-side of Carn Owen, the Hafan quarry incline and the Hafan mine wheel-pit (visible at the bottom of the incline) looking ENE from SN 72516 87644, alt 365m, at the E-end of Craig yr Allt-ddu, 3 February 2021. ©S.P. Chambers.

Figure 52. Position of *Fuscidea gothoburgensis*. SN 72973 87985. View direction E.

Figure 53. *Fuscidea gothoburgensis* under UV light on outcrop in photo above. New site record.

Figure 54. Position of *Pertusaria excludens* on south facing cliffs. SN 72963 87984.

Figure 55. Position of *Pertusaria excludens* on south facing cliffs in photo above. The K+ yellow to blood red reaction with the punctiform soralia are diagnostic. SN 72963 87984.

Appendix II. Species portraits

Figure 56. *Clauzadeana macula*. Occasional.

Figure 57. *Cladonia floerkeana*. Occasional.

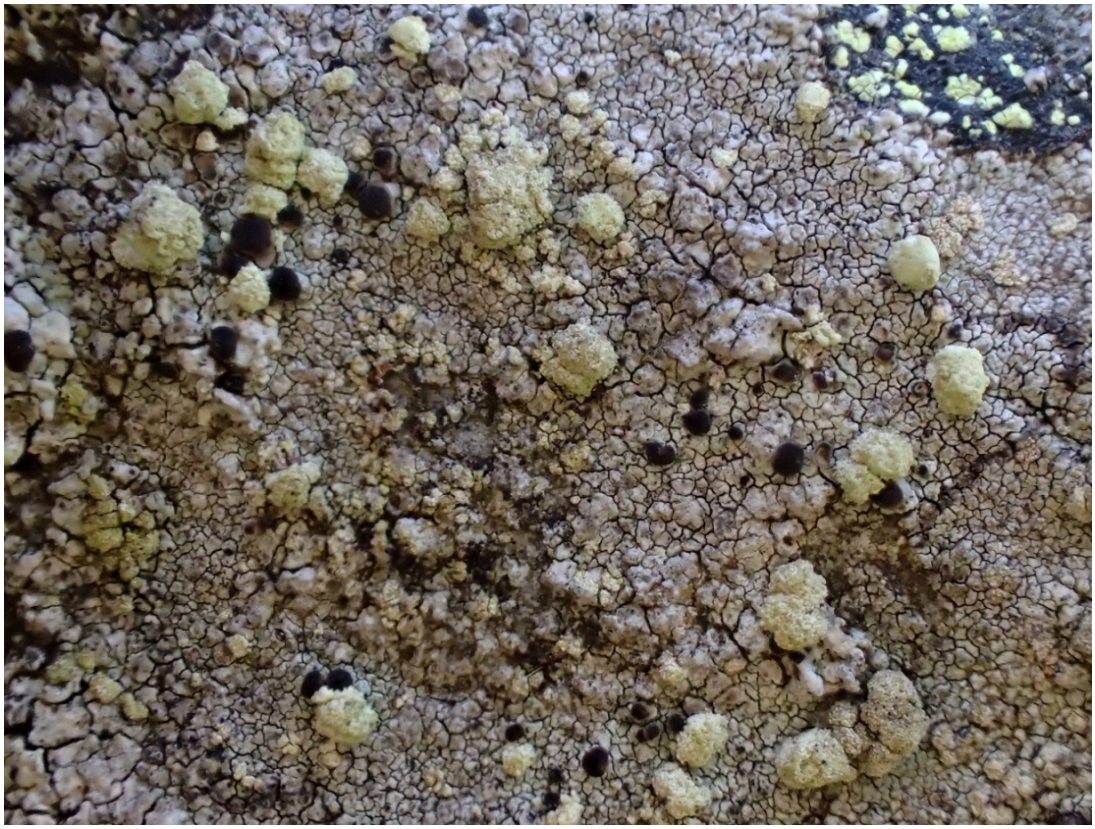


Figure 58. *Fuscidea cyathoides* var. *sorediata*. Occasional to locally frequent.

Figure 59. *Lasallia pustulata*. Occasional to locally abundant.

Figure 60. *Lasallia pustulata*. Occasional to locally abundant.

Figure 61. *Lecidea phaeops*. Rare.

Figure 62. *Micarea subnigrata*. Occasional.

Figure 63. *Mycoblastus sanguinarius*. Occasional.

Figure 64. *Ophioparma ventosa*. Occasional.

Figure 65. Fertile *Pertusaria corallina* (frequent at Carn Owen and occasionally found fertile).

Figure 66. *Porpidia melinodes*. Occasional.

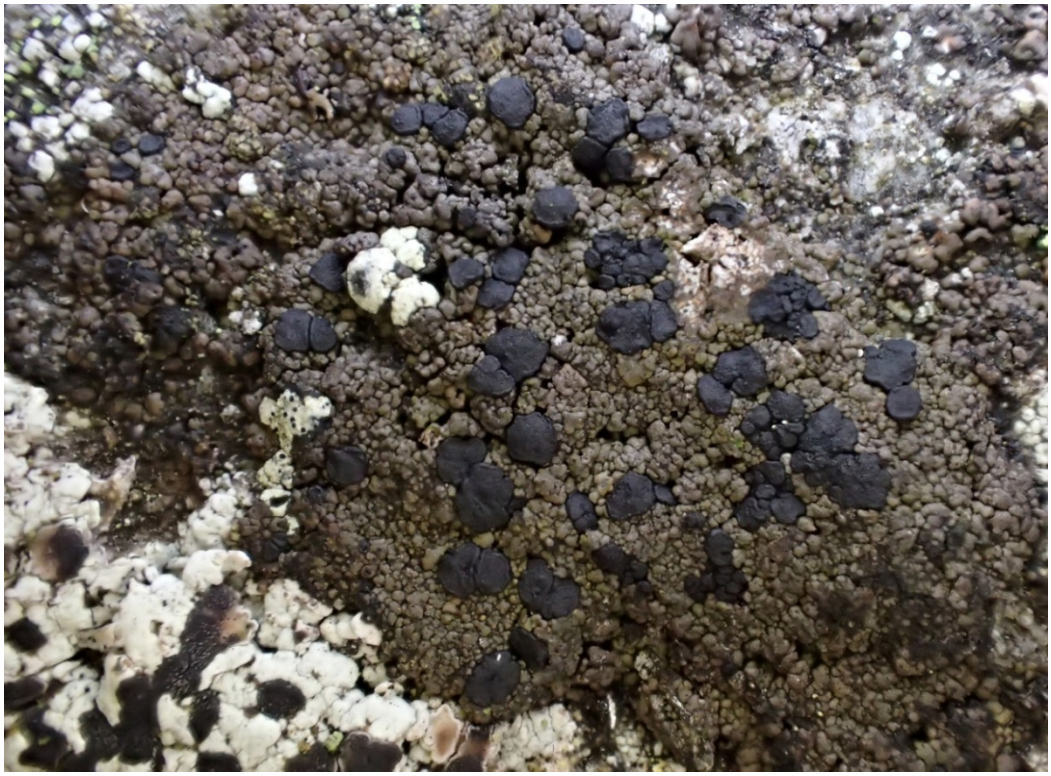


Figure 67. *Schaereria cinereorufa*. Frequent.

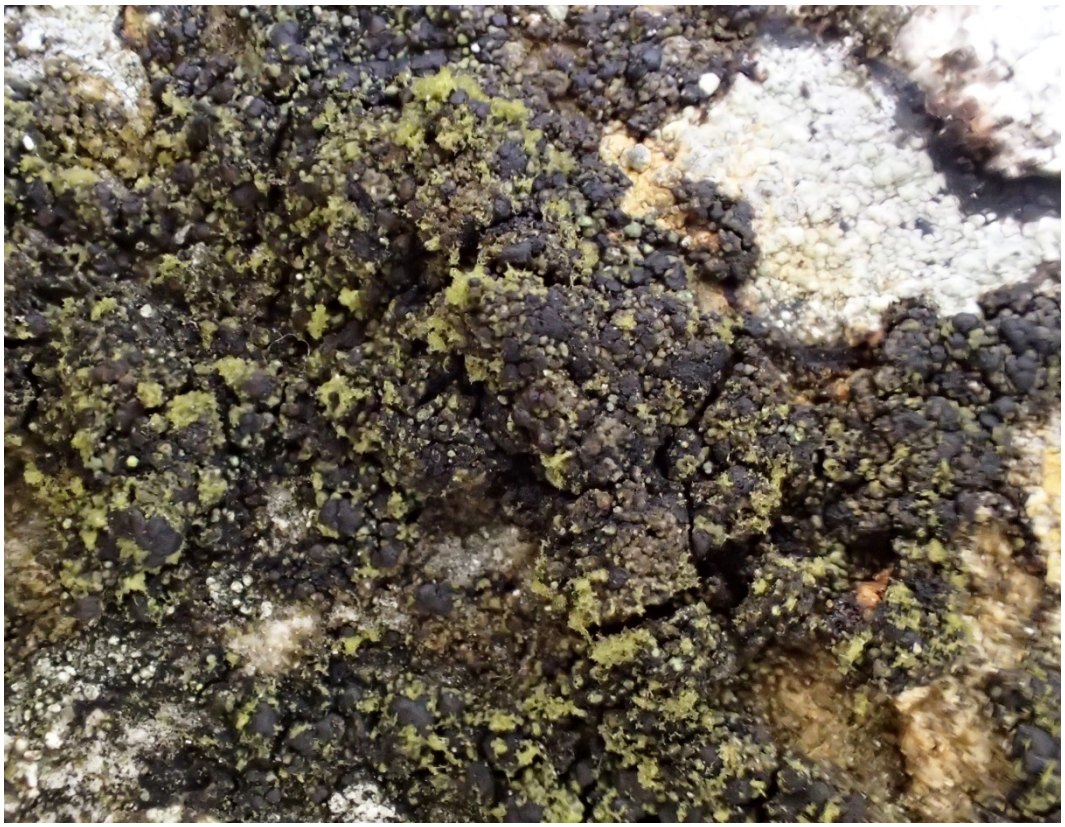


Figure 68. *Scoliciosporum intrusum* with *Hormidiopsis crenulata*. Occasional.

Figure 69. *Sphaerophorus fragilis* found at its lowest altitudinal limit in VC 46 at Carn Owen. Occasional.

Figure 70. *Stereocaulon evolutum* and *Cladonia subcervicornis*. Both species were frequent at Carn Owen.

Figure 71. *Stereocaulon vesuvianum* var. *nodulosum*. Frequent.

Figure 72. *Trapeliopsis granulosa* growing directly on damp rock. Rare.

Figure 73. *Umbilicaria polyrrhiza*. Rare on east two boulders on E. facing slopes, NE of summit cairn.

Figure 74. *Umbilicaria torrefacta* with *Hormidiopsis crenulata*. This alga is associated with nitrogen deposition and was occasionally found growing over a variety of lichens and forming extensive sheets on rocks.