Cyfoeth Naturiol Cymru
Natural Resources Wales

Monitoring of the Atlantic woodland bryophyte assemblage of Coed Ganllwyd, Meirionnydd

Sematophyllum demissum

Des Callaghan (Bryophyte Surveys Ltd)

Evidence Report No 960

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1. Crynodeb gweithredol

Mae safle'r astudiaeth bresennol (38 ha) yn cynnwys pob rhan o Warchodfa Natur Genedlaethol (GNG) Coed Ganllwyd, ynghyd â thir cyfagos ychwanegol sydd o fewn Safle o Ddiddordeb Gwyddonol Arbennig (SoDdGA) Ganllwyd ac Ardal Cadwraeth Arbennig (ACA) Coedydd Derw a Safleoedd Ystlumod Meirionnydd. Mae'r safle'n cynnwys ardal o goetir cefnforol o werth cadwraeth mawr iawn, a dyma'r safle gorau yng Nghymru ar gyfer bryoffytau'r lwerydd. Sefydlwyd gwaith monitro sylfaenol o'r casgliad bryoffytau coetir yr lwerydd trwy fapio'r rhywogaethau ar grid a thrwy sefydlu plotiau ffotograffig pwynt sefydlog yn 2015, ac ailadroddwyd hyn am y tro cyntaf yn ystod yr arolwg presennol. Mae'r canlyniadau'n dangos bod casgliad bryoffytau coetir yr lwerydd yng Nghoed Ganllwyd, ar y cyfan, mewn cyflwr ffafriol, gyda chynnydd o 14% yn nifer agregedig y deuddeg rhywogaeth fwyaf nodedig rhwng 2015 a 2025. Yr ardal bwysicaf yn y safle o hyd, ac o bell ffordd, yw'r cynefin ar hyd coridor Afon Gamlan, gyda swbstradau creigiog agored a boncyffion coed yn cynnal y rhan fwyaf o'r diddordeb. O fewn y duedd ffafriol yn gyffredinol, mae'r newidiadau mwyaf nodedig sy'n benodol i rywogaethau yn ymwneud â chynnydd dramatig mewn *Drepanolejeunea hamatifolia*, ailgytrefu'r safle gan *Radula voluta* yn dilyn ei ddifodiant yn lleol, a dirywiad *Sematophyllum demissum*. Trafodir rhesymau posibl dros y newidiadau hyn.

2. Executive summary

The present study site (38 ha) comprises all of Coed Ganllwyd National Nature Reserve (NNR), plus additional adjacent land that is within Ganllwyd Site of Special Scientific Interest (SSSI) and Meirionnydd Oakwoods and Bat Sites Special Area of Conservation (SAC). The site comprises an area of oceanic woodland of very high conservation value, and is the best site in Wales for Atlantic bryophytes. Baseline monitoring of the Atlantic woodland bryophyte assemblage by the grid-mapping of species and by the establishment of fixed-point photographic plots was established in 2015, which was repeated for the first time during the present survey. Results show that the Atlantic woodland bryophyte assemblage of Coed Ganllwyd is, overall, in favourable condition, with a 14% increase in the aggregated abundance of the twelve most notable species between 2015 and 2025. The most important area of the site remains, by far, habitat along the corridor of the Afon Gamlan, with open rock substrates and tree trunks supporting most of the interest. Within the generally favourable trend, the most notable species-specific changes concern a dramatic increase in *Drepanolejeunea hamatifolia*, the recolonisation of the site by *Radula voluta* following its local extinction, and a decline in *Sematophyllum demissum*. Possible reasons for these changes are discussed.

3. Background

Bryophytes comprise a diverse group of organisms that are sensitive indicators of the state of the environment. Desiccation tolerance varies greatly between species, and some of the most sensitive species are limited to highly oceanic climates. Atlantic (or oceanic) bryophytes are more strongly represented in the British Isles than in any other part of Europe and, due to their general rarity and phytogeographic interest, have received much attention from bryologists and conservationists. The most diverse Atlantic communities are found in sheltered lowland ravines along streams and rivers in woodland in west Scotland, north-west Wales (Snowdonia), north-west England (the English Lake District) and west Ireland. The best assemblages trigger the selection of Sites of Special Scientific Interest (SSSI) in Britain (Bosanquet et al. 2018) and are of principal importance for conservation under Section 7 of The Environment (Wales) Act 2016.

Coed Ganllwyd (Figure 1), which is owned and managed by The National Trust, comprises an area of oceanic woodland of very high conservation value, and is specially protected by three main designations, Coed Ganllwyd National Nature Reserve (NNR), Ganllwyd Site of Special Scientific Interest (SSSI) and Meirionnydd Oakwoods and Bat Sites Special Area of Conservation (SAC). One of the key features of conservation interest is the exceptional Atlantic bryophyte flora, which has been surveyed very well. According to the bryophyte selection criteria for SSSIs in Britain (Bosanquet et al. 2018), the 'Atlantic woodland bryophyte assemblage' of the site scores 34 points, well above the SSSI selection threshold of 12 points. The assemblage comprises 20 scoring species: *Breutelia chrysocoma* (1 point), *Campylopus setifolius* (3), *Cololejeunea microscopica* (1), *Colura calyptrifolia* (1), *Drepanolejeunea hamatifolia* (1), *Harpalejeunea molleri* (1), *Heterocladium wulfsbergii* (3), *Jubula hutchinsiae* (1), *Lejeunea lamacerina* (1), *Lejeunea patens* (1), *Lepidozia pearsonii* (1), *Leptoscyphus cuneifolius* (1), *Plagiochila bifaria* (1), *Plagiochila exigua* (1), *Plagiochila punctata* (1), *Plagiochila spinulosa* (1), *Pseudomarsupidium decipiens* (1), *Radula voluta* (3), *Scapania gracilis* (1), and *Sematophyllum demissum* (9).

Utilising a grid-mapping methodology (Callaghan 2013), baseline monitoring of *Sematophyllum demissum* in Coed Ganllwyd was undertaken by Callaghan (2014) and the remaining Atlantic species of principal interest were grid-mapped the following year (Callaghan 2015). The aim of this study is to undertake the first repeat monitoring, and to assess what population changes may have occurred.

Figure 1 View across part of Coed Ganllwyd, with the Afon Gamlan in spate flow.

4. Methods

4.1. Taxonomy

Taxonomy follows Blockeel et al. (2021).

4.2. Study area

The study area (38 ha) comprises all of Coed Ganllwyd NNR, plus additional adjacent land that is within Ganllwyd SSSI and Meirionnydd Oakwoods and Bat Sites SAC (Figure 2).

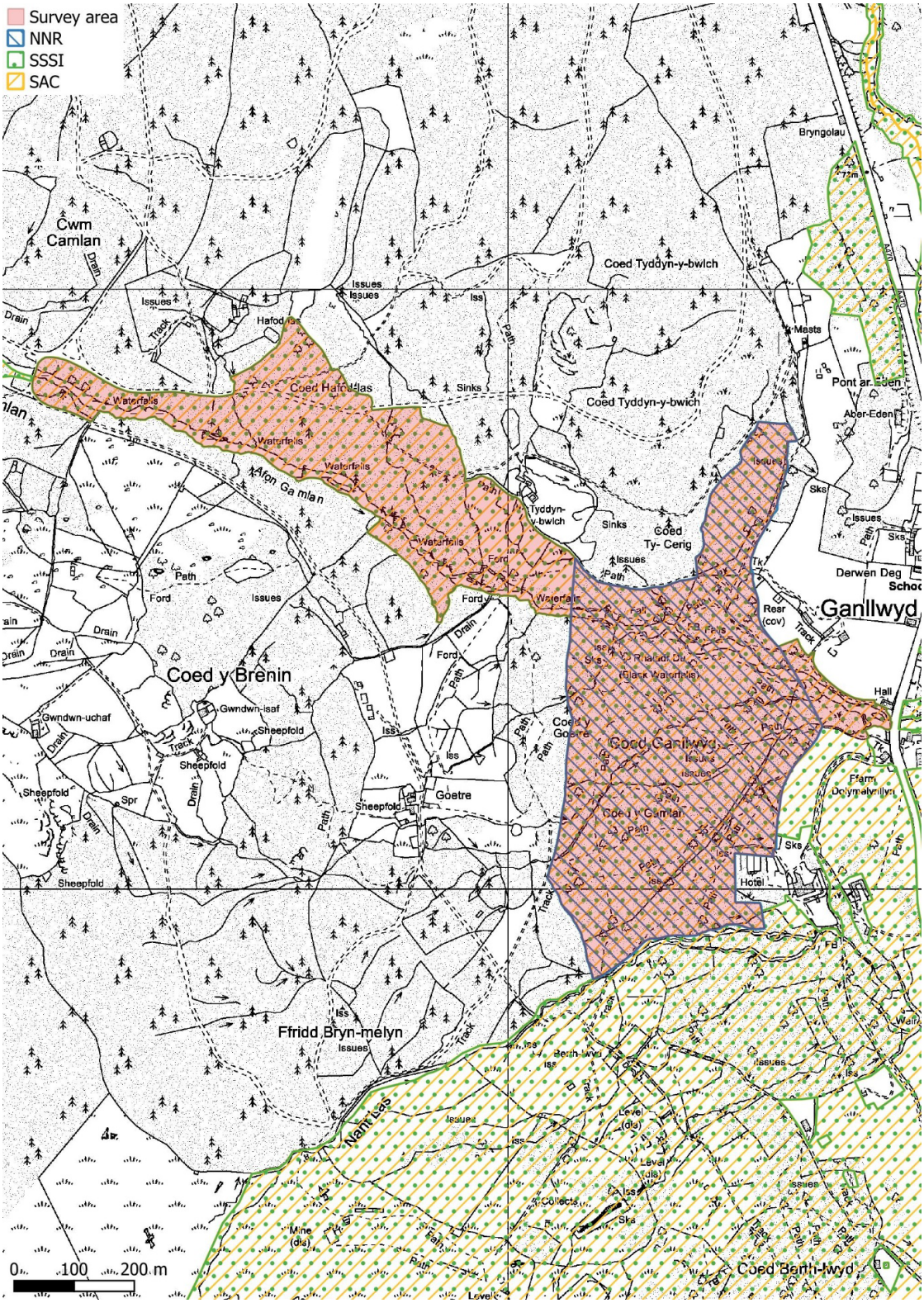

Figure 2 Location of the study area and the associated protected areas of Coed Ganllwyd National Nature Reserve NNR, Ganllwyd SSSI, and Meirionnydd Oakwoods and Bat Sites SAC.

4.3. Grid-mapping of species

The present survey, undertaken during 8–13 December 2025, repeated the baseline monitoring method of Callaghan (2015). This included following the original survey route via a hand-held GPS, which provided comprehensive coverage of the site and visits to the best areas of habitat for oceanic bryophytes. In total, this included visits to 2137 Ordnance Survey (OS) 10 m grid cells, which represents 51% of the total that overlap the entire site. Of the species that comprise the Atlantic woodland bryophyte assemblage at Coed Ganllwyd, GPS waypoints were recorded for locations occupied by the most notable species, including *Campylopus setifolius*, *Cololejeunea microscopica*, *Colura calyptrifolia*, *Drepanolejeunea hamatifolia*, *Harpalejeunea molleri, Jubula hutchinsiae, Lepidozia pearsonii, Leptoscyphus cuneifolius, Plagiochila exigua, Pseudomarsupidium decipiens, Radula voluta* and *Sematophyllum demissum*. The waypoints were loaded into GIS to produce maps of OS 10 m grid cells occupied by each species and a count of the number of grid cells occupied, the latter providing a standardised proxy measure of population size (Callaghan 2013).

4.4. Population change

Percentage change in the number of occupied 10 m grid cells between 2015 and 2025 was calculated separately for each of the target species. In addition, all of the target species were combined into an aggregate Atlantic bryophyte assemblage, and percentage change in the assemblage was similarly calculated.

4.5. Fixed-point photographic plots

Five fixed-point photographic monitoring plots that feature species of the Atlantic woodland bryophyte assemblage and which were established in 2015, were revisited to assess what change may have occurred in habitat conditions and species abundance. In addition, 13 new plots were established.

5. Results

5.1. GPS data

GPS data collected during the present survey are provided in Appendix 1. All data have been submitted to iRecord (irecord.org.uk).

5.2. Grid-mapping of species

An aggregate grid-map of the twelve species that were grid-mapped from the Atlantic woodland bryophyte assemblage is provided in Appendix 2, followed by grid-maps showing each species separately.

5.3. Population change

Table 1 and Figure 2 show counts and percentage change of occupied 10 m grid cells of each species that was grid-mapped plus the aggregate Atlantic species assemblage.

5.4. Fixed-point photographic plots

Images of the fixed-point photographic monitoring plots are provided in Appendix 3.

Table 1 Counts of OS 10 m grid cells occupied by Atlantic bryophyte species in the study area in 2015 and 2025.

Species	Count of occupied 10m grid cells 2015	Count of occupied 10m grid cells 2025	% change
Campylopus setifolius	7	13	+86%
Cololejeunea microscopica	4	4	0%
Colura calyptrifolia	7	23	+229%
Drepanolejeunea hamatifolia	34	75	+121%
Harpalejeunea molleri	46	47	+2%
Jubula hutchinsiae	3	3	0%
Lepidozia pearsonii	1	0	-100%
Leptoscyphus cuneifolius	1	1	0%
Plagiochila exigua	26	31	+19%
Pseudomarsupidium decipiens	73	85	+16%
Radula voluta	0	1	n/a
Sematophyllum demissum	138	106	-23%
Atlantic woodland assemblage[1]	340	389	+14%

[1]Sum of counts for the twelve target species.

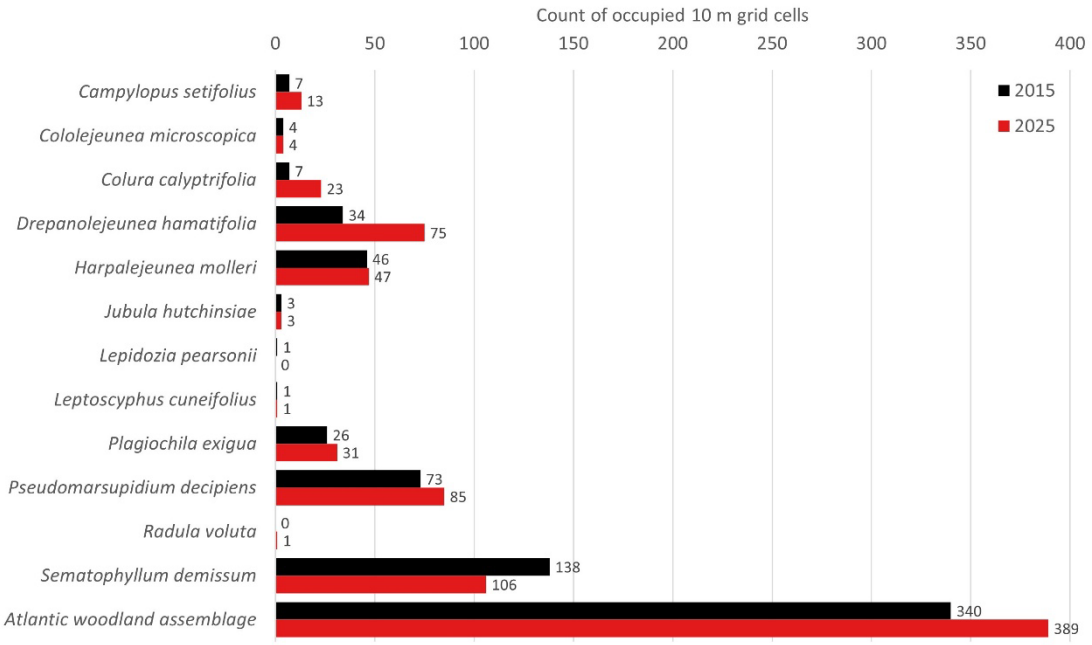

Figure 2 Counts of OS 10 m grid cells occupied by Atlantic bryophyte species in the study area in 2015 and 2025. Data for the 'Atlantic woodland assemblage' comprises a sum of the counts for the twelve target species.

6. Discussion

Results of this survey show that the Atlantic woodland bryophyte assemblage of Coed Ganllwyd is, overall, in favourable condition, with a 14% increase in the aggregated abundance of the twelve most notable species between 2015 and 2025. The most important area of the site remains, by far, habitat along the corridor of the Afon Gamlan, with open rock substrates and tree trunks supporting most of the interest. Within the generally favourable trend, the most notable species-specific change concerns *Drepanolejeunea hamatifolia*, which has undergone a dramatic increase, more than doubling in abundance, especially along the upper corridor of the Afon Gamlan, above the NNR. Of the photographic monitoring plots established in 2015 and re-visited during the present survey, this species increased in Plot 1 and colonised Plot 2 (see Appendix 3). Recent grid-mapping at two other high-quality oceanic woodlands in Snowdonia, Coed Crafnant (Callaghan 2025) and Coed Graig Uchaf (Callaghan 2024), shows that *D. hamatifolia* colonised both of these sites between 2014 and 2025, which combined with the current data suggest the species has been undergoing a general increase in the local region. There is also some limited evidence from casual bryophyte recording in Britain and Ireland, that the liverwort has been expanding its range elsewhere (Blockeel et al. 2014; Hodgetts 2024).

Drepanolejeunea hamatifolia shares a similar niche to three other small, hyperoceanic liverworts which often co-occur in the same microhabitats and which were also the focus of the current monitoring, *Colura calyptrifolia*, *Cololejeunea microscopica,* and *Harpalejeunea molleri*. Of these, *C. calyptrifolia* is much rarer at Coed Ganllwyd than *D. hamatifolia*, but shows a very similar trend, more than doubling its population size and with a marked increase in the upper river corridor. *Harpalejeunea molleri* similarly shows a marked increase along the upper corridor of the river, but appears to have declined within the NNR, the net result being that its population size across the site has remained broadly similar. Whilst *Cololejeunea microscopica* remains inexplicably rare within Coed Ganllwyd, it has also increased within the upper river corridor, from where it was absent in 2015.

Another particularly notable change detected by the current monitoring, is the re-colonisation of Coed Ganllwyd by *Radula voluta*. This rare hyperoceanic and semi-aquatic liverwort, which is categorised as 'Endangered' on the Wales Red List (Bosanquet and Dines 2011), has been recorded from the site only twice previously, sometime before 1900 by W.H. Pearson (1849–1923), and in 1966 by H.J.B. Birks. Various detailed bryophyte surveys of Coed Ganllwyd since the 1990s have failed to find *R. voluta*, and it has been considered extinct within the site. The presence of the species on several boulders along a short stretch (ca. 8 m) of a small seasonal stream (see Plot 18 of Appendix 3), is therefore noteworthy and encouraging. This stream was surveyed by the author not only in 2015 during the baseline monitoring, but also in 2019, so the re-colonisation of Coed Ganllwyd by *R. voluta* appears to be very recent. Elsewhere, information on trends in the population of this species is very limited, but grid-mapping at Coed Graig Uchaf showed that it more than doubled its population during 2014–2024 (Callaghan 2024), perhaps suggesting a more general positive trend across the region.

A final, and worrying, noticeable change detected by the current monitoring is the decline in *Sematophyllum demissum*, by 23%. This species is categorised as 'Vulnerable' on the Wales Red List (Bosanquet and Dines 2011). It is known from only nine sites in Britain, including eight oceanic woodlands in Snowdonia (Callaghan 2014) and a recently discovered site in Cornall. In 2014, Coed Ganllwyd supported most (68%) of the British population (Callaghan 2014), so its apparent decline is a particular concern. Reasons are unclear, as general habitat conditions within its core areas at Coed Ganllwyd do not appear to have changed significantly. As in 2015, it remains locally frequent in two particular areas, where diffuse passage by pedestrians across low rock outcrops prevent their overgrowth by more competitive species, and maintain open rock substrate favoured by the moss (see Plots 7 and 12 in Appendix 3). It is possible that the population change detected across the site is within the bounds of natural population dynamics, which would require more regular monitoring to

understand adequately. Given the importance of Coed Ganllwyd for this rare species and its apparent decline, monitoring of the species every 5 years should be considered.

The various changes detected by the current monitoring do not appear to be the result of any habitat changes within the site, as conditions in 2015 are broadly similar to those in 2025. The recent introduction of cattle-grazing in parts of the NNR does not seem to have changed habitat conditions for Atlantic bryophytes substantially. It seems most likely that an important driver of change is the warming macroclimate, with warmer winters likely to be especially favourable to frost-intolerant Atlantic bryophytes, particularly the small, hyperoceanic liverworts such as *Drepanolejeunea hamatifolia*. With regards to management of the site, the current regime appears to be favourable, and no new special measures need to be implemented to conserve the Atlantic bryophyte assemblage.

As with the results from comparable monitoring at Coed Crafnant (Callaghan 2025) and Coed Graig Uchaf (Callaghan 2024), this study demonstrates the value of data derived from the grid-mapping of species within sites, allowing population change to be detected and quantified. It also demonstrates the value of fixed-point photographic plots for helping to understand the causes of any change detected, and the two methods combined provide a useful approach to better understanding the status of bryophyte populations within and between sites.

7. Acknowledgements

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8. References

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9. Appendices

9.1. Appendix 1: GPS data

Species	Spatial reference
Anastrophyllum hellerianum	SH7227824451
Anastrophyllum hellerianum	SH7223424425
Bazzania tricrenata	SH7189424595
Blindiadelphus recurvatus	SH7208924079
Breutelia chrysocoma	SH7236124416
Campylopus setifolius	SH7221424441
Campylopus setifolius	SH7221124429
Campylopus setifolius	SH7219824427
Campylopus setifolius	SH7204324489
Campylopus setifolius	SH7203124497
Campylopus setifolius	SH7193824523
Campylopus setifolius	SH7193424523
Campylopus setifolius	SH7192024522
Campylopus setifolius	SH7191124528
Campylopus setifolius	SH7190924530
Campylopus setifolius	SH7186124573
Campylopus setifolius	SH7183124606
Campylopus setifolius	SH7164224709
Campylopus setifolius	SH7149924763
Cephalozia catenulata	SH7211924472
Cephalozia catenulata	SH7210524180
Cololejeunea microscopica	SH7223324434
Cololejeunea microscopica	SH7197824531
Cololejeunea microscopica	SH7184324594
Cololejeunea microscopica	SH7139124784
Colura calyptrifolia	SH7244924351
Colura calyptrifolia	SH7237424400
Colura calyptrifolia	SH7189824517
Colura calyptrifolia	SH7209724477
Colura calyptrifolia	SH7208524474
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Colura calyptrifolia	SH7205324481
Colura calyptrifolia	SH7203124497
Colura calyptrifolia	SH7198224524
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Colura calyptrifolia	SH7190424544
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Species	Spatial reference
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Drepanolejeunea hamatifolia	SH7244624368
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Species	Spatial reference
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Drepanolejeunea hamatifolia	SH7211724472
Drepanolejeunea hamatifolia	SH7211424472
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Drepanolejeunea hamatifolia	SH7183424605
Drepanolejeunea hamatifolia	SH7151724760
Drepanolejeunea hamatifolia	SH7155424735
Drepanolejeunea hamatifolia	SH7168624688
Drepanolejeunea hamatifolia	SH7171724672
Drepanolejeunea hamatifolia	SH7173024666
Drepanolejeunea hamatifolia	SH7174124662
Drepanolejeunea hamatifolia	SH7176024648
Drepanolejeunea hamatifolia	SH7176524647
Drepanolejeunea hamatifolia	SH7176924648

Species	Spatial reference
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Drepanolejeunea hamatifolia	SH7194924539
Drepanolejeunea hamatifolia	SH7194824538
Drepanolejeunea hamatifolia	SH7183224651
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Harpalejeunea molleri	SH7240224405
Harpalejeunea molleri	SH7241224370
Harpalejeunea molleri	SH7238924386
Harpalejeunea molleri	SH7234624402
Harpalejeunea molleri	SH7233324398
Harpalejeunea molleri	SH7233024388
Harpalejeunea molleri	SH7215524431
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Harpalejeunea molleri	SH7207924462
Harpalejeunea molleri	SH7204524467
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Harpalejeunea molleri	SH7200224485
Harpalejeunea molleri	SH7189924515
Harpalejeunea molleri	SH7189424519
Harpalejeunea molleri	SH7215724402
Harpalejeunea molleri	SH7215724467
Harpalejeunea molleri	SH7216524466
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Harpalejeunea molleri	SH7215524466
Harpalejeunea molleri	SH7214324473
Harpalejeunea molleri	SH7213824471
Harpalejeunea molleri	SH7213724472
Harpalejeunea molleri	SH7213424473
Harpalejeunea molleri	SH7211724471
Harpalejeunea molleri	SH7211424472
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Harpalejeunea molleri	SH7205424481
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Harpalejeunea molleri	SH7193624519
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Harpalejeunea molleri	SH7192924525
Harpalejeunea molleri	SH7188524554
Harpalejeunea molleri	SH7187524559
Harpalejeunea molleri	SH7186224573
Harpalejeunea molleri	SH7183724603
Harpalejeunea molleri	SH7183424605
Harpalejeunea molleri	SH7181924613

Species	Spatial reference
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Harpalejeunea molleri	SH7166924710
Harpalejeunea molleri	SH7165524711
Harpalejeunea molleri	SH7164224709
Harpalejeunea molleri	SH7132524796
Harpalejeunea molleri	SH7192924565
Harpalejeunea molleri	SH7186724649
Harpalejeunea molleri	SH7186724712
Harpalejeunea molleri	SH7192124597
Harpalejeunea molleri	SH7221224223
Harpalejeunea molleri	SH7218924208
Hylocomiastrum umbratum	SH7223424423
Jubula hutchinsiae	SH7250324355
Jubula hutchinsiae	SH7223024430
Jubula hutchinsiae	SH7226124450
Jubula hutchinsiae	SH7225924452
Jubula hutchinsiae	SH7225724456
Leptoscyphus cuneifolius	SH7207524458
Plagiochila bifaria	SH7260924299
Plagiochila bifaria	SH7259324306
Plagiochila bifaria	SH7255524315
Plagiochila bifaria	SH7251324349
Plagiochila bifaria	SH7248024369
Plagiochila bifaria	SH7236124417
Plagiochila bifaria	SH7228924456
Plagiochila exigua	SH7227824419
Plagiochila exigua	SH7226824431
Plagiochila exigua	SH7246424357
Plagiochila exigua	SH7241324371
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Plagiochila exigua	SH7223724425
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Plagiochila exigua	SH7210824474
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Plagiochila exigua	SH7203124497
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Plagiochila exigua	SH7130624831
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Plagiochila exigua	SH7193224562

Species	Spatial reference
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Plagiochila exigua	SH7191624704
Plagiochila exigua	SH7192024597
Plagiochila exigua	SH7195124548
Plagiochila exigua	SH7227424286
Plagiochila exigua	SH7225724284
Plagiochila punctata	SH7187424561
Plagiochila spinulosa	SH7245824374
Pohlia elongata var. elongata	SH7234724416
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Pseudomarsupidium decipiens	SH7245024381
Pseudomarsupidium decipiens	SH7244924379
Pseudomarsupidium decipiens	SH7244724378
Pseudomarsupidium decipiens	SH7244624379
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Pseudomarsupidium decipiens	SH7240324406
Pseudomarsupidium decipiens	SH7239524411
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Pseudomarsupidium decipiens	SH7234124424
Pseudomarsupidium decipiens	SH7234224428
Pseudomarsupidium decipiens	SH7233124429
Pseudomarsupidium decipiens	SH7233024429
Pseudomarsupidium decipiens	SH7232924430
Pseudomarsupidium decipiens	SH7232024427
Pseudomarsupidium decipiens	SH7232124429
Pseudomarsupidium decipiens	SH7232024433
Pseudomarsupidium decipiens	SH7232024439
Pseudomarsupidium decipiens	SH7232124439
Pseudomarsupidium decipiens	SH7232224441
Pseudomarsupidium decipiens	SH7231724449
Pseudomarsupidium decipiens	SH7231024430
Pseudomarsupidium decipiens	SH7234924446
Pseudomarsupidium decipiens	SH7232924448
Pseudomarsupidium decipiens	SH7233224452
Pseudomarsupidium decipiens	SH7233424454
Pseudomarsupidium decipiens	SH7233024457
Pseudomarsupidium decipiens	SH7233024458
Pseudomarsupidium decipiens	SH7232924461
Pseudomarsupidium decipiens	SH7232524462
Pseudomarsupidium decipiens	SH7232324465
Pseudomarsupidium decipiens	SH7231924465
Pseudomarsupidium decipiens	SH7231724456
Pseudomarsupidium decipiens	SH7234924454
Pseudomarsupidium decipiens	SH7235624461
Pseudomarsupidium decipiens	SH7235224465
Pseudomarsupidium decipiens	SH7234724470
Pseudomarsupidium decipiens	SH7234324470
Pseudomarsupidium decipiens	SH7234124469
Pseudomarsupidium decipiens	SH7233024470
Pseudomarsupidium decipiens	SH7232724467

Species	Spatial reference
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Pseudomarsupidium decipiens	SH7229124436
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Pseudomarsupidium decipiens	SH7228824434
Pseudomarsupidium decipiens	SH7228824438
Pseudomarsupidium decipiens	SH7228824440
Pseudomarsupidium decipiens	SH7228724448
Pseudomarsupidium decipiens	SH7228424448
Pseudomarsupidium decipiens	SH7229624465
Pseudomarsupidium decipiens	SH7229424470
Pseudomarsupidium decipiens	SH7229724473
Pseudomarsupidium decipiens	SH7233424504
Pseudomarsupidium decipiens	SH7233024479
Pseudomarsupidium decipiens	SH7232624480
Pseudomarsupidium decipiens	SH7232124478
Pseudomarsupidium decipiens	SH7231524476
Pseudomarsupidium decipiens	SH7232624609
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Pseudomarsupidium decipiens	SH7236024622
Pseudomarsupidium decipiens	SH7241924677
Pseudomarsupidium decipiens	SH7241624677
Pseudomarsupidium decipiens	SH7240924679
Pseudomarsupidium decipiens	SH7242624687
Pseudomarsupidium decipiens	SH7241924667
Pseudomarsupidium decipiens	SH7241524666
Pseudomarsupidium decipiens	SH7241424665
Pseudomarsupidium decipiens	SH7242024622
Pseudomarsupidium decipiens	SH7235424646
Pseudomarsupidium decipiens	SH7233324628
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Pseudomarsupidium decipiens	SH7226124431
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Pseudomarsupidium decipiens	SH7244324348
Pseudomarsupidium decipiens	SH7237124396
Pseudomarsupidium decipiens	SH7234024402
Pseudomarsupidium decipiens	SH7230124396
Pseudomarsupidium decipiens	SH7222324434
Pseudomarsupidium decipiens	SH7222224435
Pseudomarsupidium decipiens	SH7216724424
Pseudomarsupidium decipiens	SH7216524423
Pseudomarsupidium decipiens	SH7213224457
Pseudomarsupidium decipiens	SH7212724455
Pseudomarsupidium decipiens	SH7218024472
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Pseudomarsupidium decipiens	SH7197924534
Pseudomarsupidium decipiens	SH7198224535

Species	Spatial reference
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Pseudomarsupidium decipiens	SH7198324540
Pseudomarsupidium decipiens	SH7198324541
Pseudomarsupidium decipiens	SH7198224542
Pseudomarsupidium decipiens	SH7197924555
Pseudomarsupidium decipiens	SH7196824557
Pseudomarsupidium decipiens	SH7196724557
Pseudomarsupidium decipiens	SH7197224547
Pseudomarsupidium decipiens	SH7196724548
Pseudomarsupidium decipiens	SH7196724551
Pseudomarsupidium decipiens	SH7196724553
Pseudomarsupidium decipiens	SH7196724555
Pseudomarsupidium decipiens	SH7196524559
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Pseudomarsupidium decipiens	SH7194724538
Pseudomarsupidium decipiens	SH7194724539
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Pseudomarsupidium decipiens	SH7190524616
Pseudomarsupidium decipiens	SH7189024618
Pseudomarsupidium decipiens	SH7187224643
Pseudomarsupidium decipiens	SH7187824640
Pseudomarsupidium decipiens	SH7189224635
Pseudomarsupidium decipiens	SH7186524730
Pseudomarsupidium decipiens	SH7189624672
Pseudomarsupidium decipiens	SH7189524672
Pseudomarsupidium decipiens	SH7189024663
Pseudomarsupidium decipiens	SH7192024599
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Pseudomarsupidium decipiens	SH7191924600
Pseudomarsupidium decipiens	SH7191724598
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Pseudomarsupidium decipiens	SH7236823949
Pseudomarsupidium decipiens	SH7216223918
Pseudomarsupidium decipiens	SH7213023993
Radula voluta	SH7239723947
Radula voluta	SH7239323949
Radula voluta	SH7239023949
Scapania gracilis	SH7245824382
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Sematophyllum demissum	SH7244324369
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Sematophyllum demissum	SH7235124416
Sematophyllum demissum	SH7234924416
Sematophyllum demissum	SH7234524418
Sematophyllum demissum	SH7233824419
Sematophyllum demissum	SH7233824418
Sematophyllum demissum	SH7233624419
Sematophyllum demissum	SH7233024423
Sematophyllum demissum	SH7232924424

Species	Spatial reference
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Sematophyllum demissum	SH7234224421
Sematophyllum demissum	SH7233124429
Sematophyllum demissum	SH7233024429
Sematophyllum demissum	SH7232924430
Sematophyllum demissum	SH7231924427
Sematophyllum demissum	SH7232124429
Sematophyllum demissum	SH7231924432
Sematophyllum demissum	SH7232024433
Sematophyllum demissum	SH7232024439
Sematophyllum demissum	SH7232124439
Sematophyllum demissum	SH7231524450
Sematophyllum demissum	SH7231024431
Sematophyllum demissum	SH7231124433
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Sematophyllum demissum	SH7230924431
Sematophyllum demissum	SH7230924427
Sematophyllum demissum	SH7231024423
Sematophyllum demissum	SH7234024447
Sematophyllum demissum	SH7233524448
Sematophyllum demissum	SH7232224436
Sematophyllum demissum	SH7231924467
Sematophyllum demissum	SH7231824455
Sematophyllum demissum	SH7231524453
Sematophyllum demissum	SH7234224458
Sematophyllum demissum	SH7231224435
Sematophyllum demissum	SH7231224437
Sematophyllum demissum	SH7231124436
Sematophyllum demissum	SH7230824437
Sematophyllum demissum	SH7229924438
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Sematophyllum demissum	SH7230124448
Sematophyllum demissum	SH7230624453
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Sematophyllum demissum	SH7229624473
Sematophyllum demissum	SH7229724474
Sematophyllum demissum	SH7229824478
Sematophyllum demissum	SH7234224506
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Sematophyllum demissum	SH7228724424
Sematophyllum demissum	SH7228724416
Sematophyllum demissum	SH7228024419
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Sematophyllum demissum	SH7225024427
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Sematophyllum demissum	SH7249224352
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Species	Spatial reference
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Sematophyllum demissum	SH7245224355
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Sematophyllum demissum	SH7241924363
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Sematophyllum demissum	SH7239424382
Sematophyllum demissum	SH7239024385
Sematophyllum demissum	SH7234424403
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Sematophyllum demissum	SH7217824418
Sematophyllum demissum	SH7217724421
Sematophyllum demissum	SH7216924427
Sematophyllum demissum	SH7216824428
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Sematophyllum demissum	SH7215224431
Sematophyllum demissum	SH7213924445
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Sematophyllum demissum	SH7211024459
Sematophyllum demissum	SH7210924460
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Species	Spatial reference
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Sematophyllum demissum	SH7204624462
Sematophyllum demissum	SH7204424463
Sematophyllum demissum	SH7204624468
Sematophyllum demissum	SH7204724470
Sematophyllum demissum	SH7203724477
Sematophyllum demissum	SH7202724479
Sematophyllum demissum	SH7202224480
Sematophyllum demissum	SH7201924480
Sematophyllum demissum	SH7201224483
Sematophyllum demissum	SH7200824484
Sematophyllum demissum	SH7200724484
Sematophyllum demissum	SH7200124485
Sematophyllum demissum	SH7200024484
Sematophyllum demissum	SH7199324483
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Sematophyllum demissum	SH7210324355
Sematophyllum demissum	SH7216124465
Sematophyllum demissum	SH7216624467
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Sematophyllum demissum	SH7215724470
Sematophyllum demissum	SH7211524471
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Sematophyllum demissum	SH7207424473
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Sematophyllum demissum	SH7194024523
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Sematophyllum demissum	SH7192924526
Sematophyllum demissum	SH7188824553
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Sematophyllum demissum	SH7183824601
Sematophyllum demissum	SH7183324607
Sematophyllum demissum	SH7175624674
Sematophyllum demissum	SH7174024689
Sematophyllum demissum	SH7147024786
Sematophyllum demissum	SH7145124810

Species	Spatial reference
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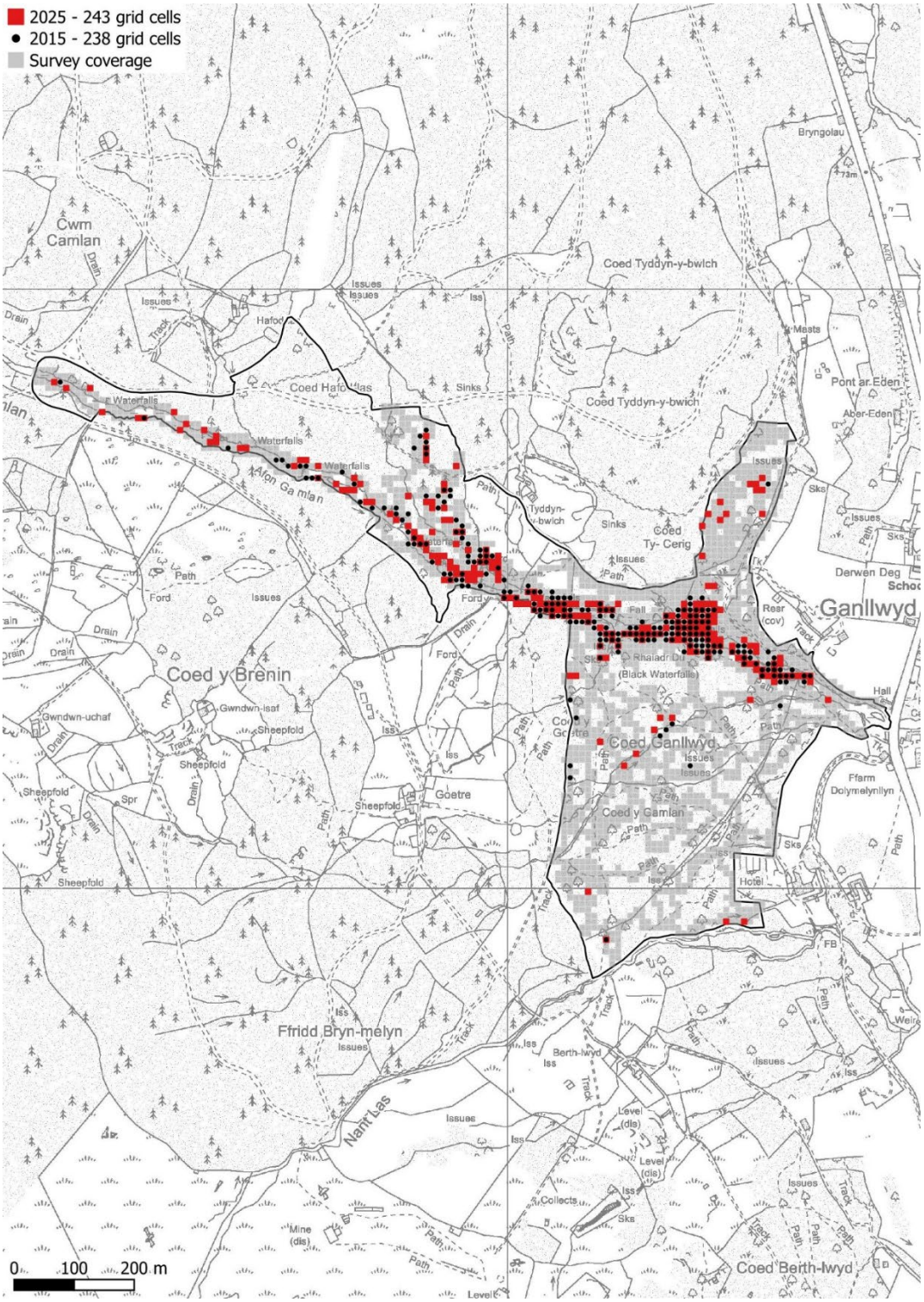
Sematophyllum demissum	SH7126524839
Sematophyllum demissum	SH7139724786
Sematophyllum demissum	SH7176724647
Sematophyllum demissum	SH7176924648
Sematophyllum demissum	SH7177124648
Sematophyllum demissum	SH7183924656
Sematophyllum demissum	SH7183224653
Sematophyllum demissum	SH7186524725
Sematophyllum demissum	SH7186424732
Sematophyllum demissum	SH7186624755
Sematophyllum demissum	SH7189524672
Sematophyllum demissum	SH7195024549
Sematophyllum demissum	SH7240424313
Sphagnum affine	SH7241924383
Sphagnum affine	SH7241924386
Sphagnum affine	SH7241824390
Sphagnum affine	SH7240524405
Sphagnum affine	SH7240024408
Sphagnum affine	SH7239524411
Sphagnum affine	SH7236124416
Sphagnum angustifolium	SH7213123932
Syzygiella autumnalis	SH7209124472
Syzygiella autumnalis	SH7133524812
Ulota hutchinsiae	SH7240324401
Ulota hutchinsiae	SH7240224405
Ulota hutchinsiae	SH7240024407
Ulota hutchinsiae	SH7234324403
Ulota hutchinsiae	SH7234024401

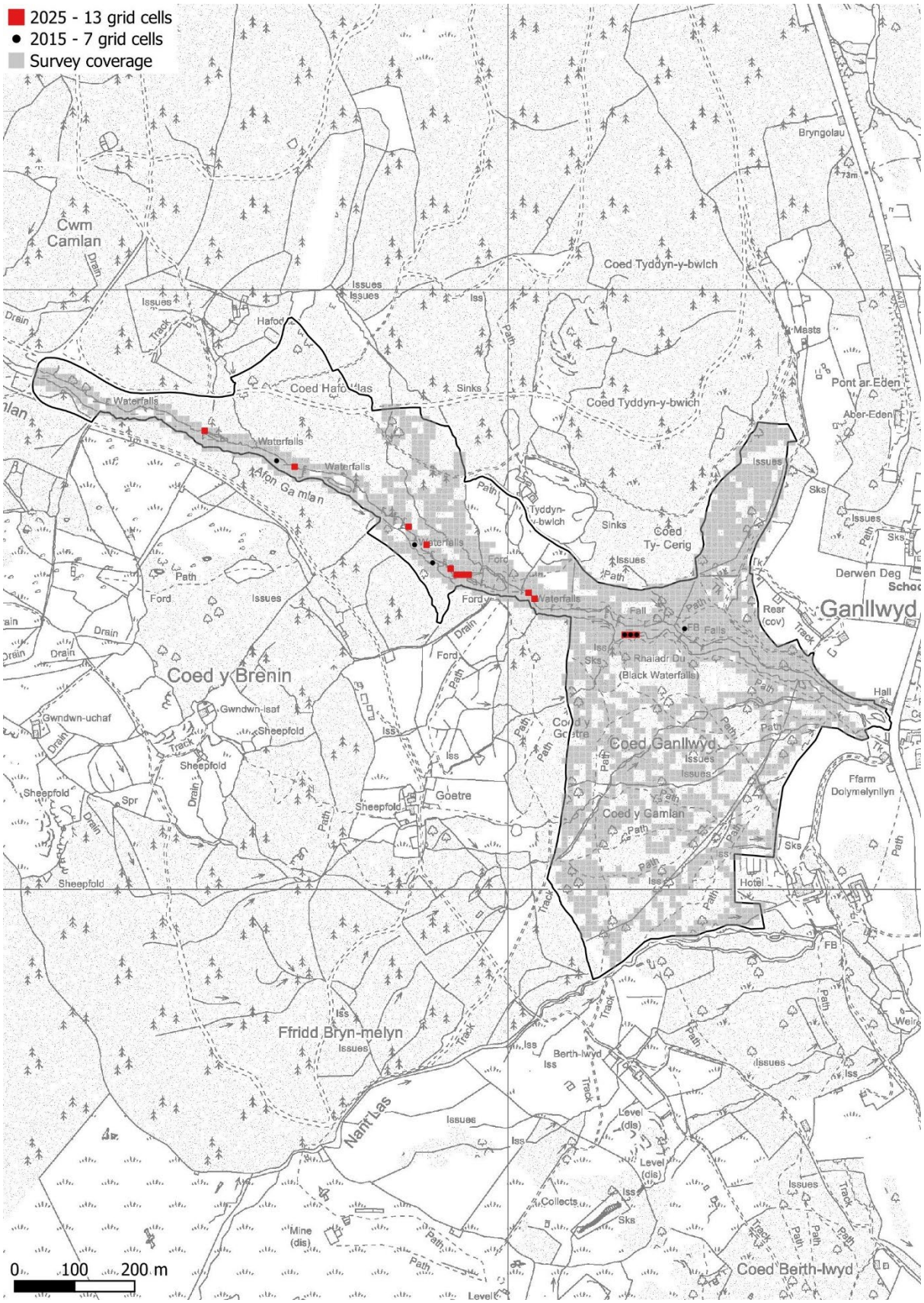
9.2. Appendix 2: Grid-maps of Atlantic woodland bryophyte assemblage

9.2.1. Atlantic woodland bryophyte assemblage

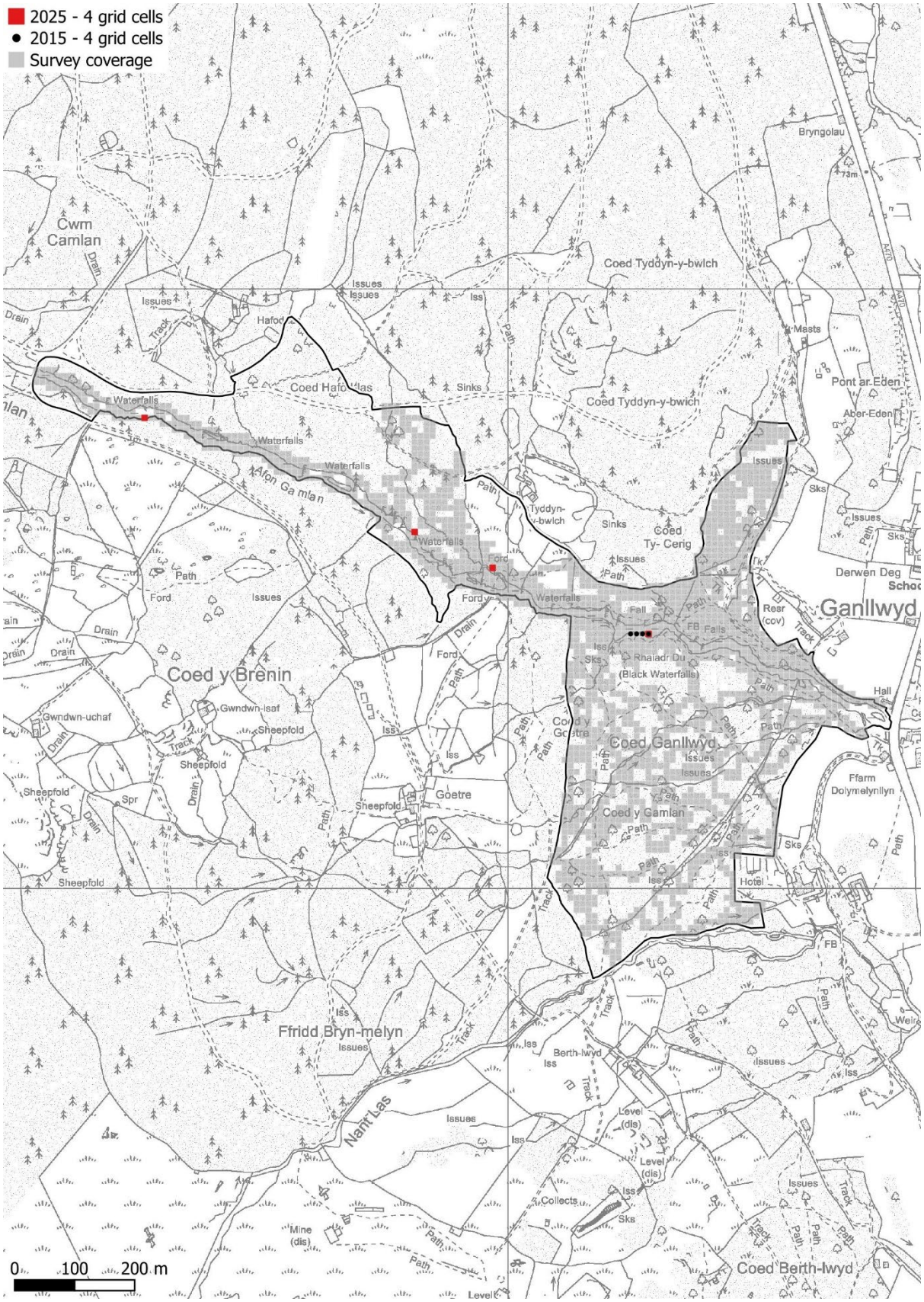
Aggregate map of *Campylopus setifolius, Cololejeunea microscopica, Colura calyptrifolia, Drepanolejeunea hamatifolia, Harpalejeunea molleri, Jubula hutchinsiae, Lepidozia pearsonii, Leptoscyphus cuneifolius, Plagiochila exigua, Pseudomarsupidium decipiens, Radula voluta,* and *Sematophyllum demissum*.



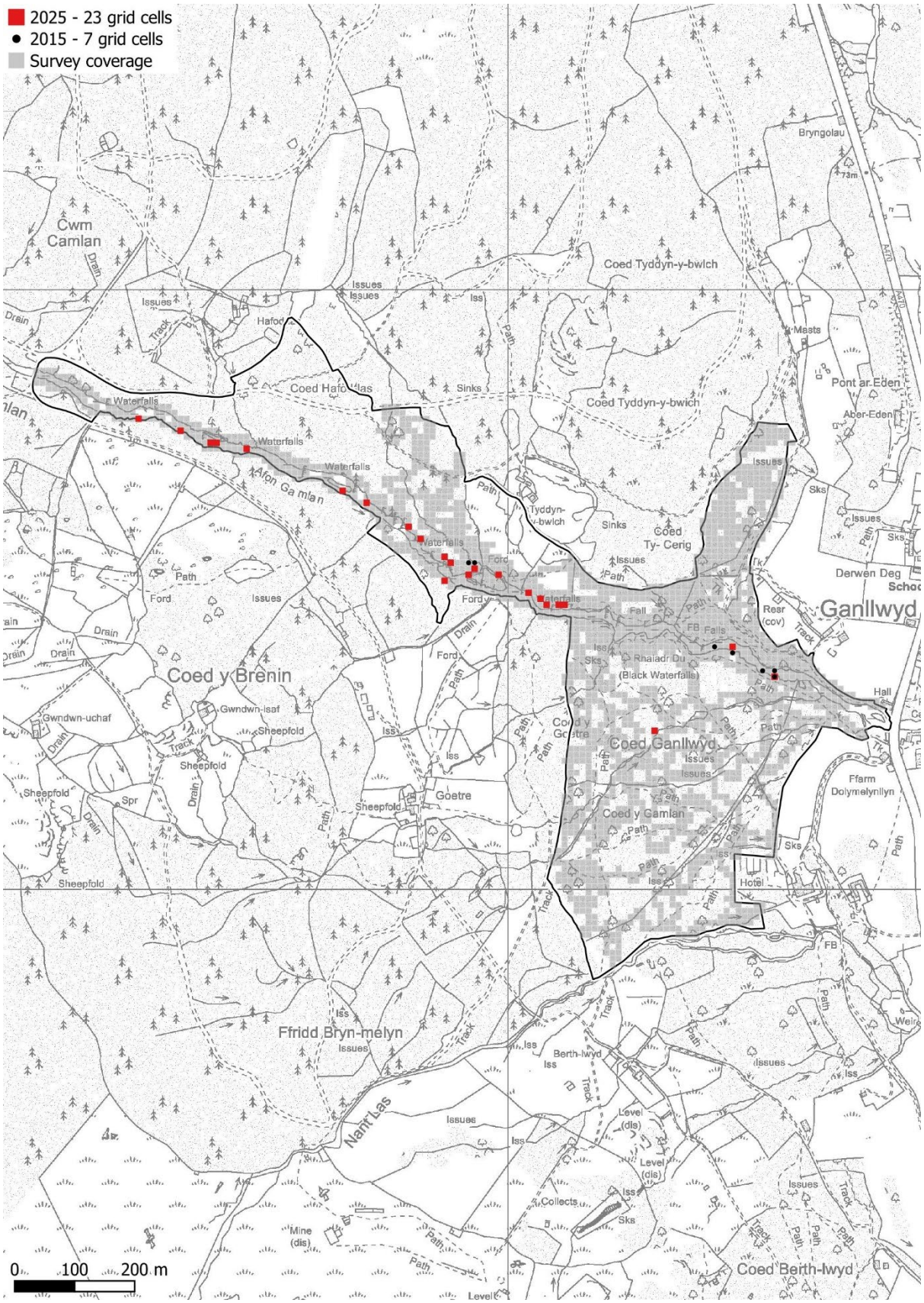
9.2.2. Campylopus setifolius



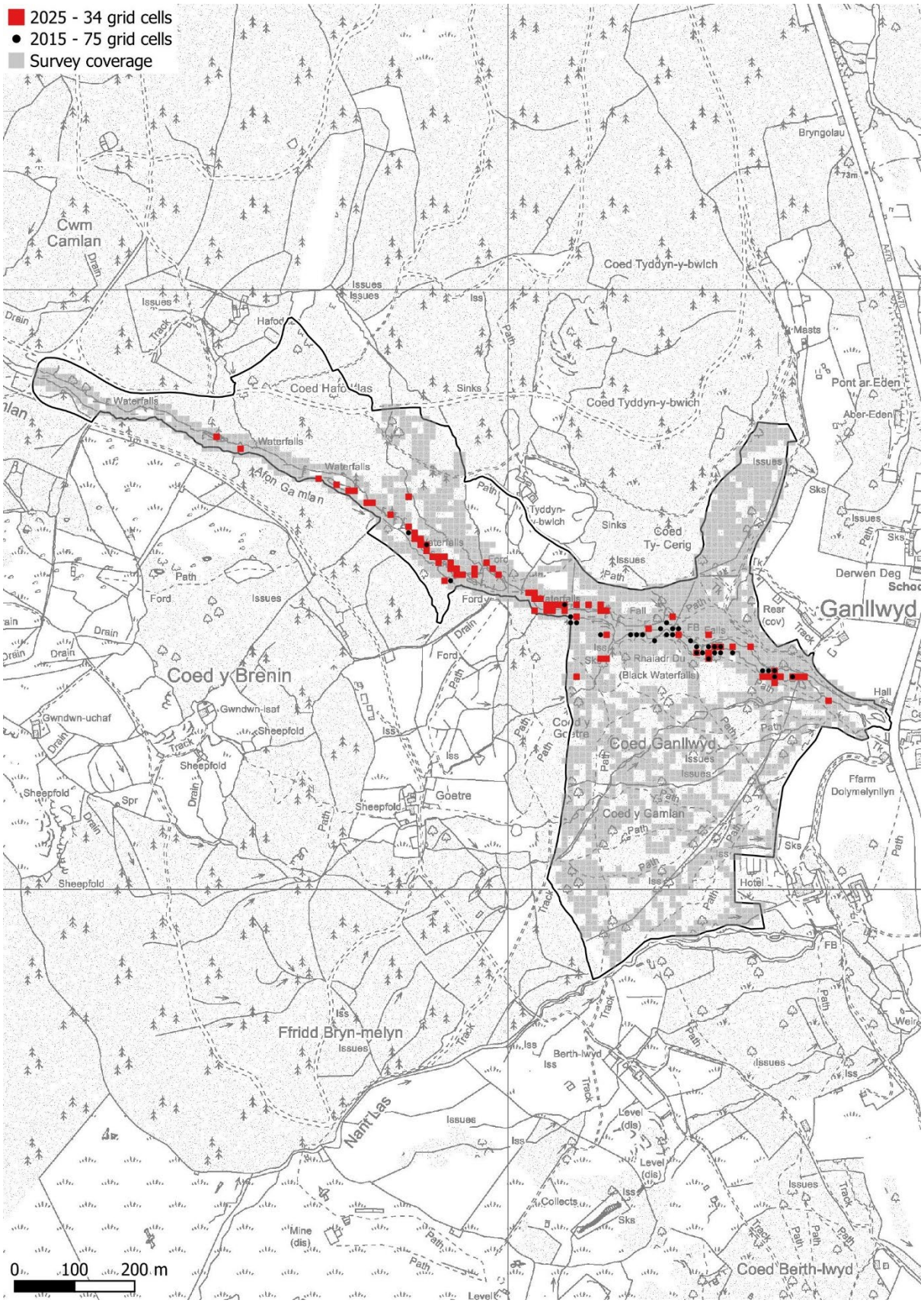
9.2.3. Cololejeunea microscopica



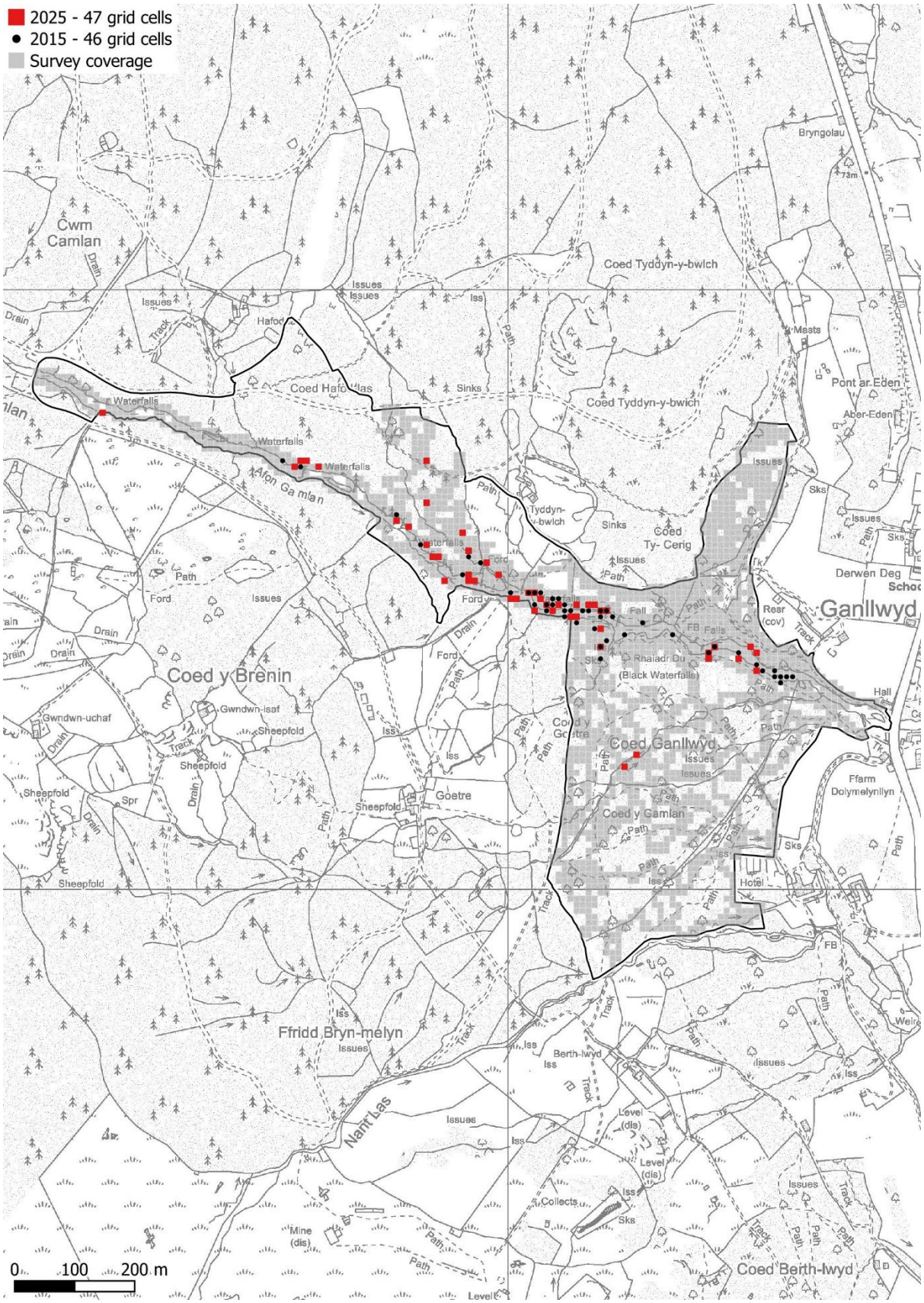
9.2.4. Colura calyptrifolia



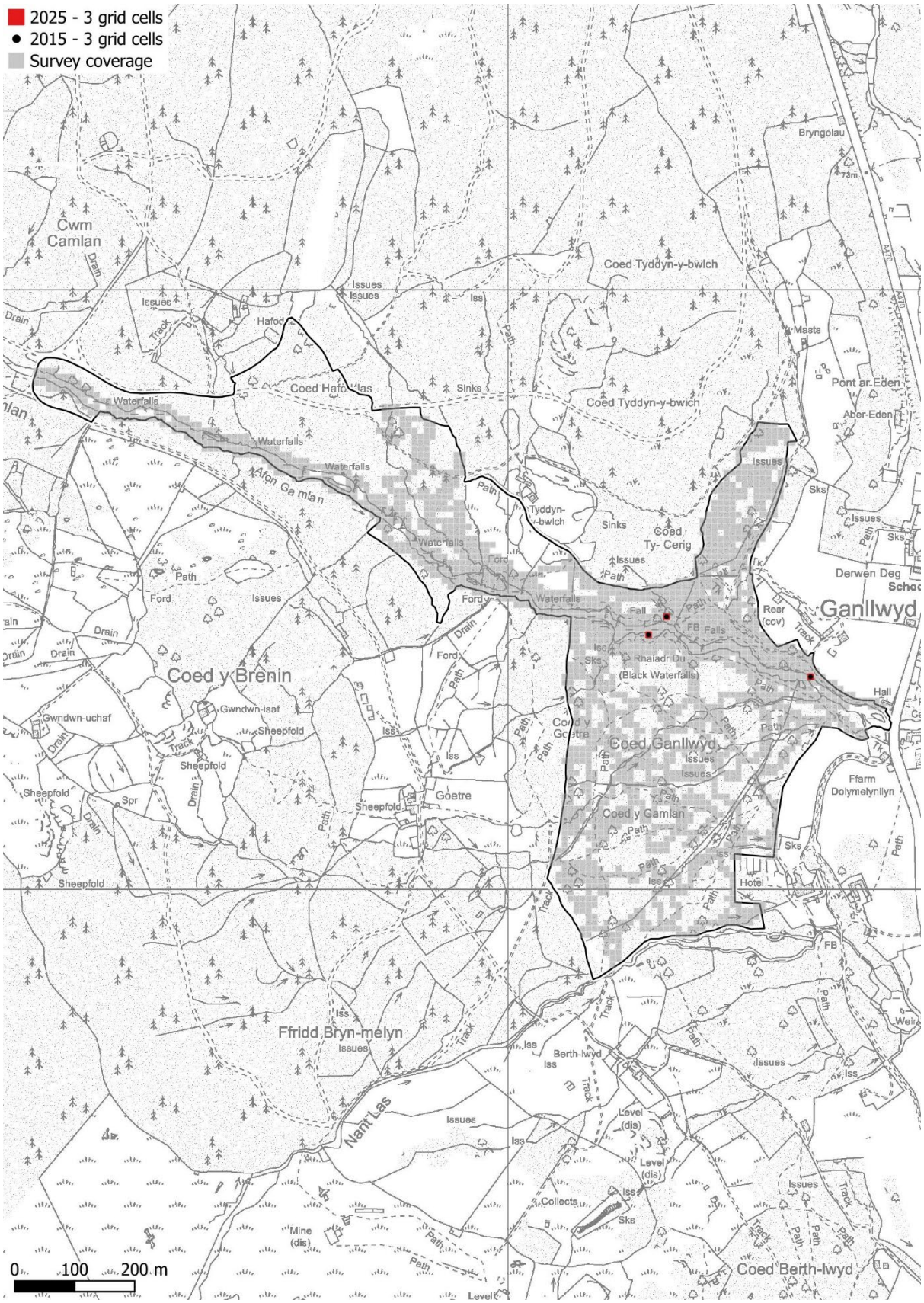
9.2.5. Drepanolejeunea hamatifolia



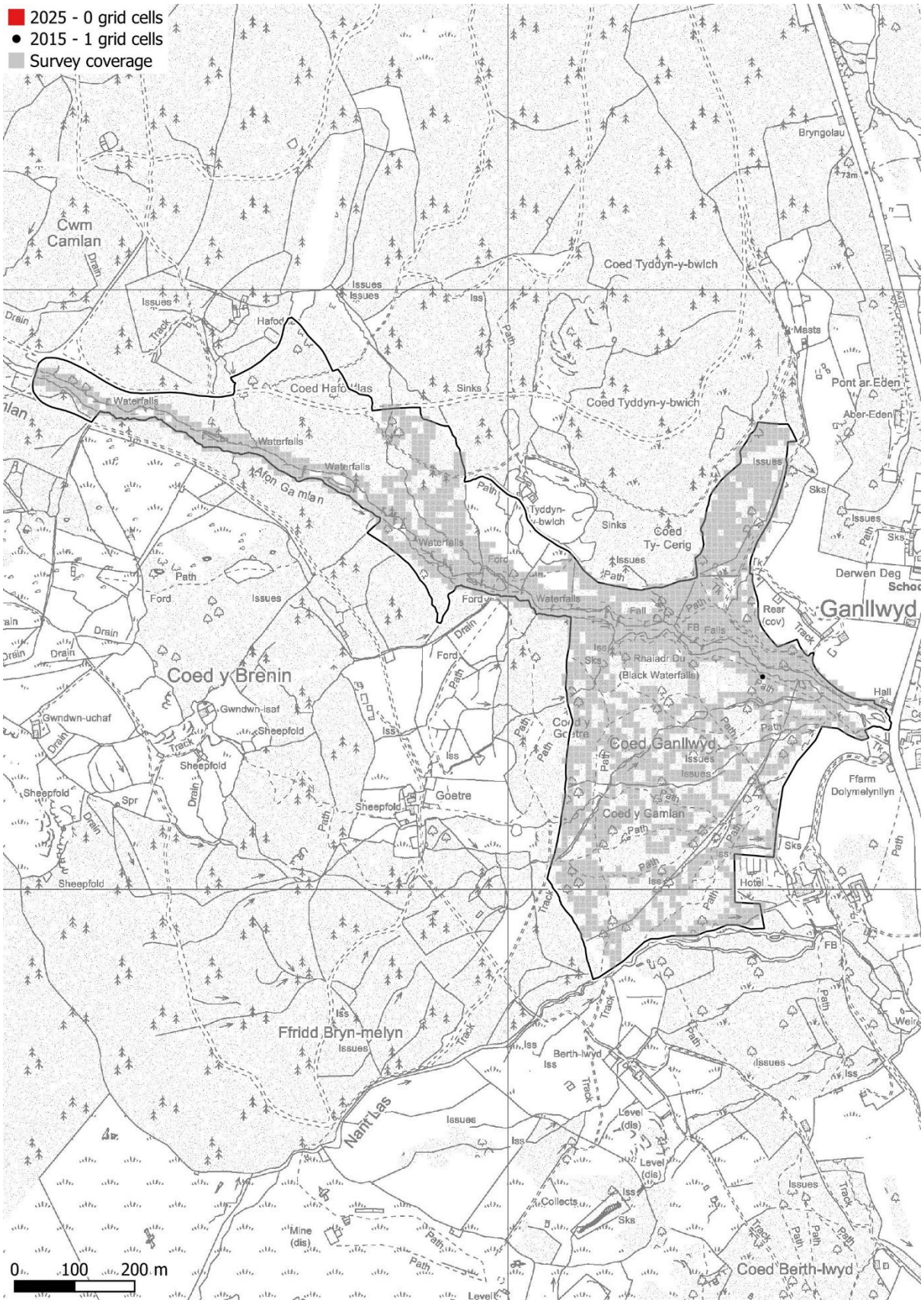
9.2.6. Harpalejeunea molleri



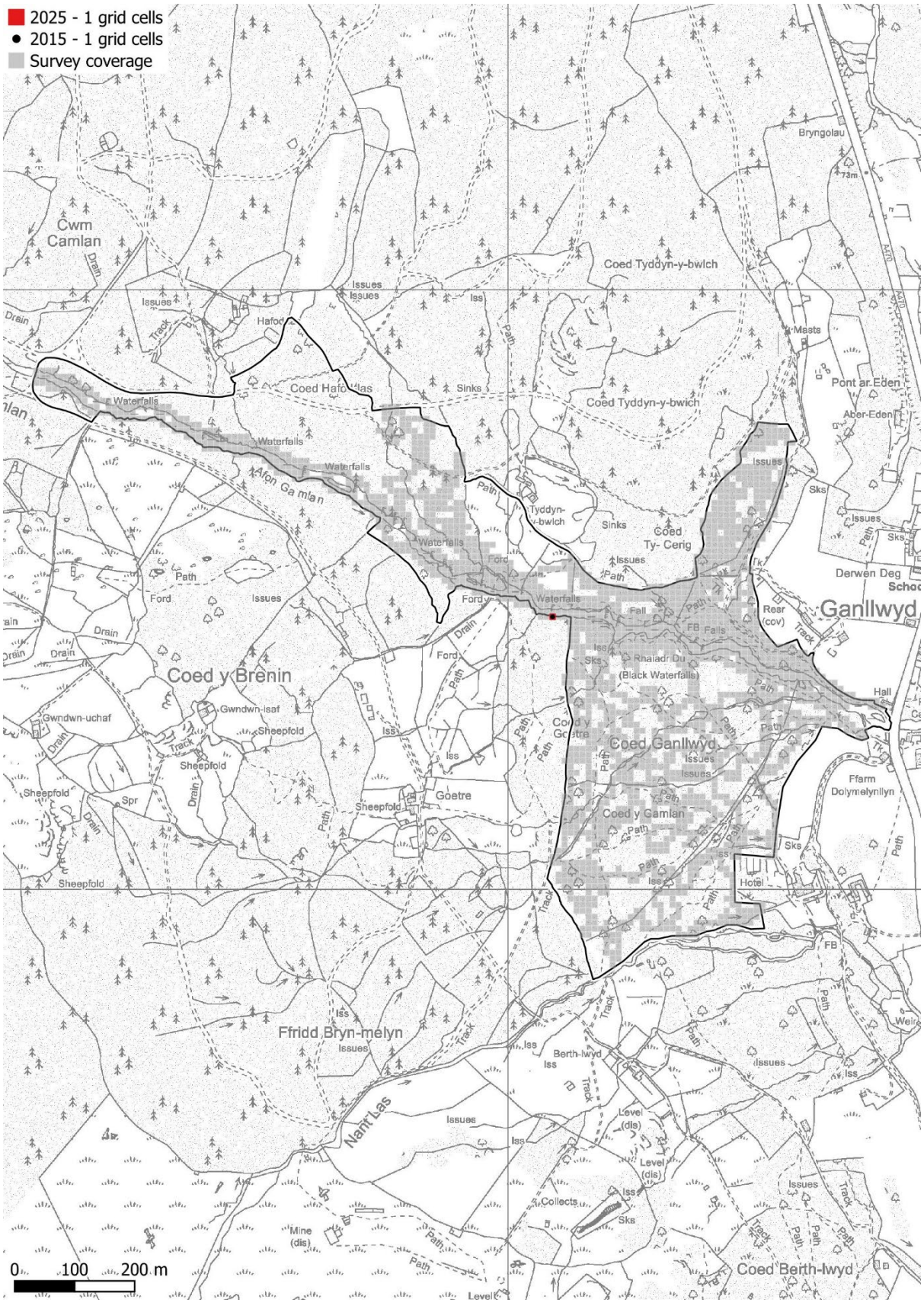
9.2.7. Jubula hutchinsiae



9.2.8. Lepidozia pearsonii



9.2.9. Leptoscyphus cuneifolius

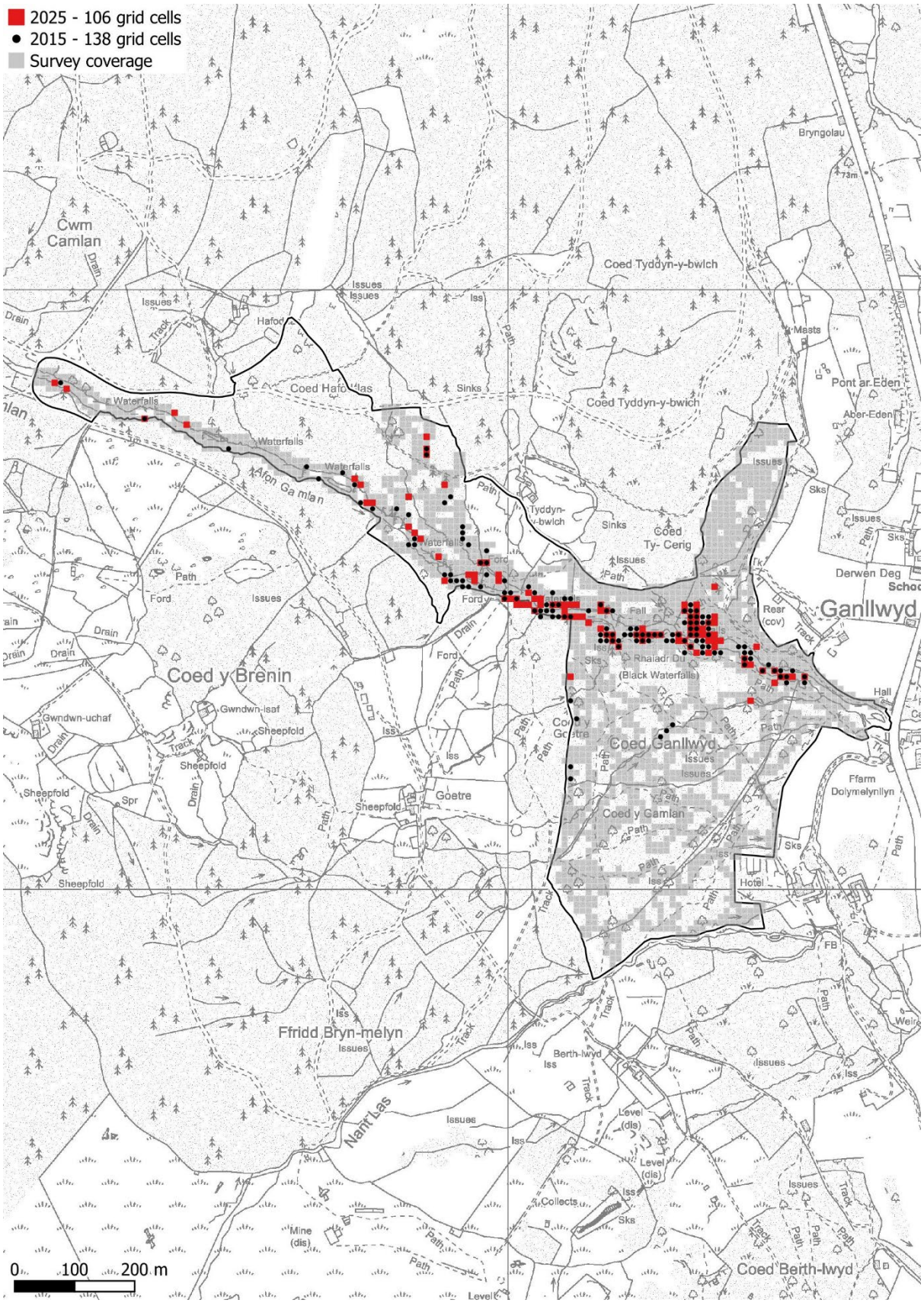


9.2.10. *Plagiochila exigua*

9.2.11. *Pseudomarsupidium decipiens*

9.2.12. *Radula voluta*

9.2.13. *Sematophyllum demissum*



9.3. Appendix 3: Fixed-point photographic monitoring plots

9.3.1. Plots established in 2015

Plot 1

Focal species: *Drepanolejeunea hamatifolia, Colura calyptrifolia, Sematophyllum demissum* (red dots).
Grid reference: SH7244924355
Comparative photographs: Plot 1 of Callaghan (2015)
Assessment: In 2015, *Colura calyptrifolia* and *Drepanolejeunea hamatifolia* were thinly scattered across the rockface. In 2025, *C. calyptrifolia* remains thinly scattered, but *D. hamatifolia* is much more frequent, with one patch about 1 m long. *Sematophyllum demissum* has also newly colonised, with five locations occupied (red dots).

Plot 2

Focal species: *Cololejeunea microscopica* (red), *Drepanolejeunea hamatifolia* (blue)
Grid reference: SH7223124426
Comparative photographs: Plot 3 of Callaghan (2015)
Assessment: In 2015, a single small colony of *Cololejeunea microscopica* occurred. In 2025, a small amount of *C. microscopica* occurred at the same location, and *D. hamatifolia* has newly colonised.

Plot 3

Focal species: *Campylopus setifolius* (red)
Grid reference: SH7219824439
Comparative photographs: Plot 5 of Callaghan (2015)
Assessment: Large colonies of *Campylopus setifolius* on steep bank in mist zone of large waterfall. No change from 2015.

Plot 4

Focal species: *Pseudomarsupidium decipiens*

Grid reference: SH72322444

Comparative photographs: Plot 11 of Callaghan (2015)

Assessment: No significant change in habitat or abundance of focal species since 2015. *Pseudomarsupidium decipiens* remains frequent on boulders throughout.

Plot 5

Focal species: *Leptoscyphus cuneifolius* (red)
Grid reference: SH7207324459
Comparative photographs: Plot 12 of Callaghan (2015)
Assessment: In 2015, *L. cuneifolius* was scattered along a 1 m length of the birch trunk. In 2025, it had declined to occupy about 50 cm. Habitat conditions remained the same, and the change is perhaps related to normal patch dynamics.

9.3.2. Plots established in 2025

Plot 6

Focal species: *Drepanolejeunea hamatifolia*
Grid reference: SH7253824315
Assessment: *Drepanolejeunea hamatifolia* was absent from this location in 2015, but has since colonised and is scattered across the rockface.

Plot 7

Focal species: *Sematophyllum demissum*

Grid reference: SH7231924424

Assessment: This area supports the densest population of *Sematophyllum demissum* in Britain. It occurs frequently on the rocky outcrops throughout, in an area where disturbance from sheep grazing and diffuse pedestrian traffic to the adjacent footbridge keeps the rock faces open and free from competition by larger mosses.

Plot 8

Focal species: *Drepanolejeunea hamatifolia* and *Sematophyllum demissum.*

Grid reference: SH7228924425

Assessment: On the exposed rock outcrops beside the river, there are frequent strong colonies of *Drepanolejeunea hamatifolia* and occasional strong colonies of *Sematophyllum demissum*.

Plot 9

Focal species: *Colura calyptrifolia, Drepanolejeunea hamatifolia.*

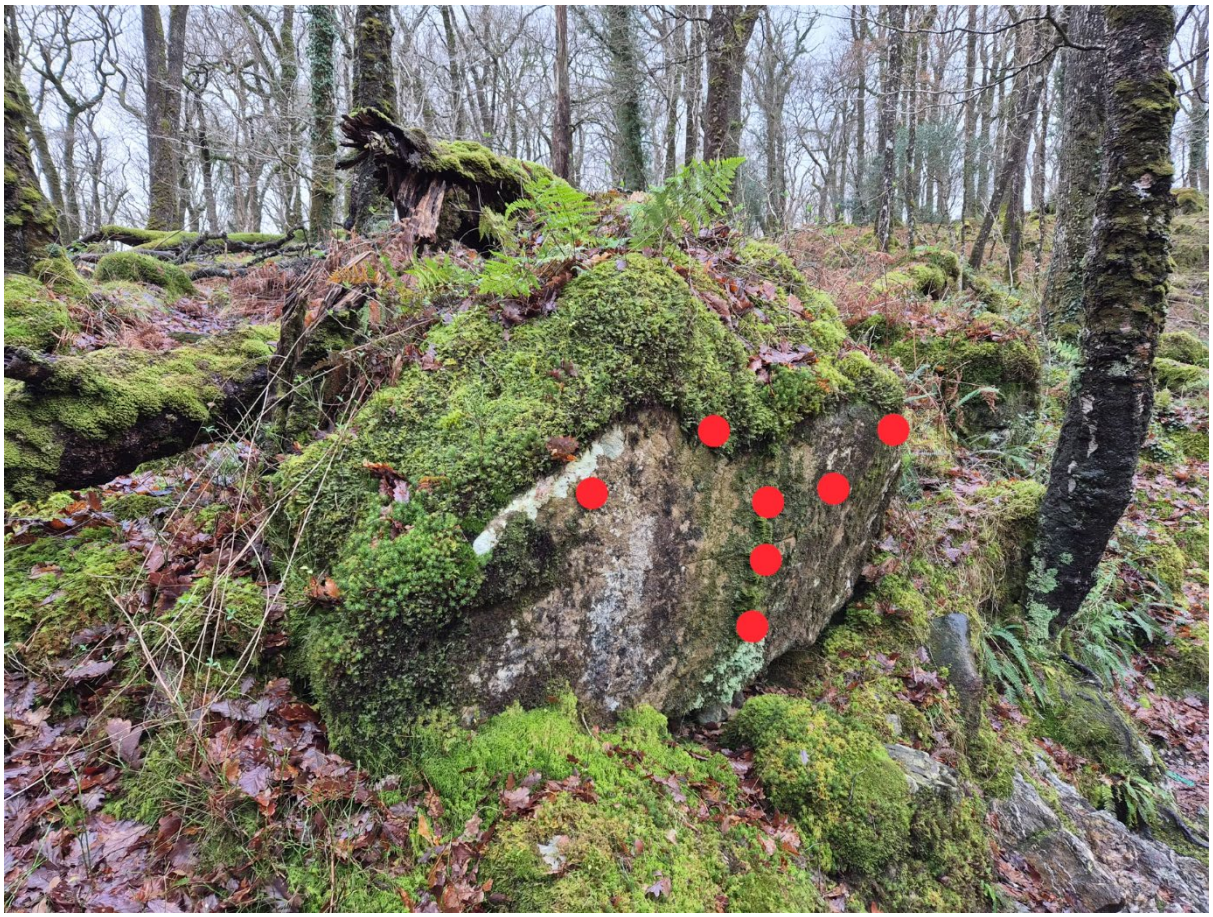
Grid reference: SH7237424400

Assessment: *Colura calyptrifolia* is thinly scattered across the rockface, and *Drepanolejeunea hamatifolia* is occasional.

Plot 10

Focal species: *Drepanolejeunea hamatifolia* (red)*, Harpalejeunea molleri* (blue)*.*
Grid reference: SH7234624402
Assessment: Strong colonies of *Drepanolejeunea hamatifolia* (red) and *Harpalejeunea molleri* (blue). Small colonies of *Ulota hutchinsiae* occur on the boulders behind, including at the yellow dot.

Plot 11



Focal species: *Plagiochila exigua* (red)
Grid reference: SH7223724425
Assessment: Strong colonies of *Plagiochila exigua* (red) on vertical face of large boulder beside footpath.

Plot 12

Focal species: *Sematophyllum demissum*.
Grid reference: SH7222724430
Assessment: Frequent strong colonies of *Sematophyllum demissum* on low, exposed rocks and boulders up incline, benefiting from disturbance caused by diffuse pedestrian traffic accessing waterfall viewing points.

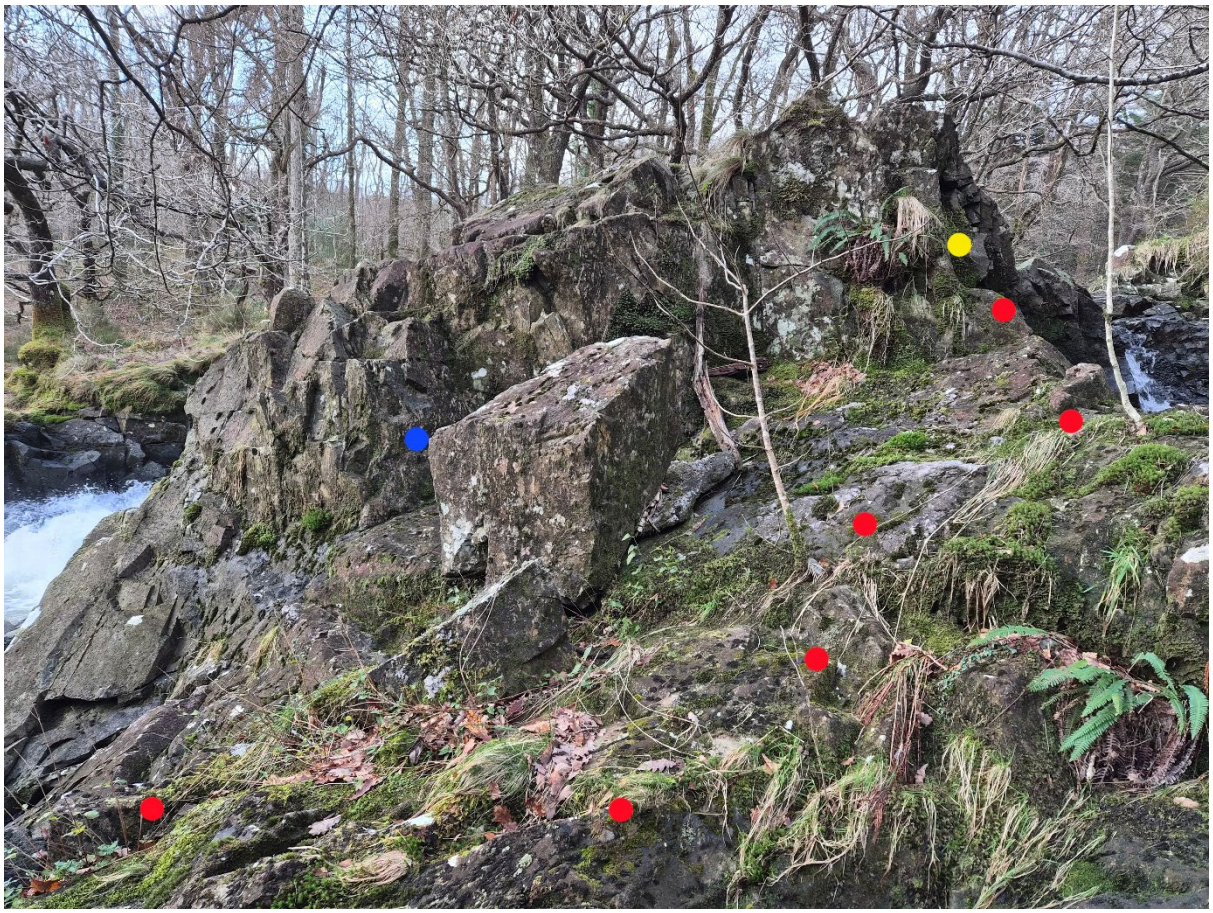
Plot 13

Focal species: *Harpalejeunea molleri* (red), *Plagiochila exigua*
Grid reference: SH7201724480
Assessment: Large amounts of *Harpalejeunea molleri* (red) on oak trunk, together with much smaller amounts of *Plagiochila exigua* scattered through the area occupied by *H. molleri.*

Plot 14

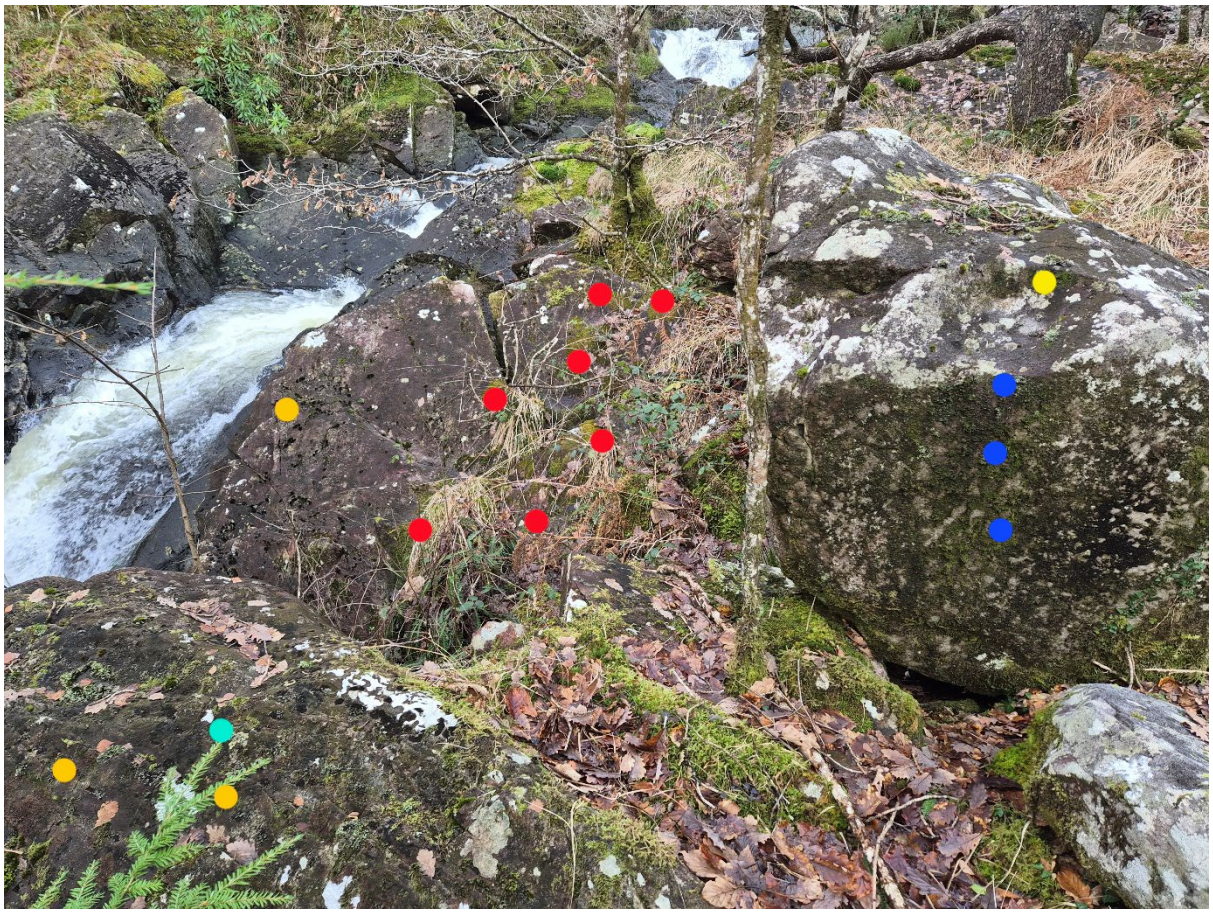
Focal species: *Jubula hutchinsiae* (red)
Grid reference: SH7226124450
Assessment: *Jubula hutchinsiae* is curiously rare within the site. This is one of the few streams where it occurs, in small amounts at the points indicated.

Plot 15



Focal species: *Drepanolejeunea hamatifolia* (yellow), *Harpalejeunea molleri* (blue), *Sematophyllum demissum* (red)
Grid reference: SH7216124464
Assessment: Rock outcrop beside area of rapids, with scattered *Sematophyllum demissum* and smaller amounts of *Drepanolejeunea hamatifolia* and *Harpalejeunea molleri.*

Plot 16



Focal species: *Colura calyptrifolia* (turquoise), *Drepanolejeunea hamatifolia* (orange), *Harpalejeunea molleri* (yellow), *Sematophyllum demissum* (red), *Plagiochila exigua* (blue)
Grid reference: SH7206224475
Assessment: Rock outcrops and boulder beside cascade, with very strong colonies of *Sematophyllum demissum*, a moderate colony of *Plagiochila exigua*, and smaller amounts of *Colura calyptrifolia*, *Drepanolejeunea hamatifolia* and *Harpalejeunea molleri.*

Plot 17

Focal species: *Campylopus setifolius* (red), *Drepanolejeunea hamatifolia* (blue)
Grid reference: SH7192024522
Assessment: Rocky bank beside river, supporting strong colonies of *Campylopus setifolius* and scattered small colonies of *Drepanolejeunea hamatifolia.* *Harpalejeunea molleri* is also present, but on sides of rock facing away from the camera angle.

Plot 18

Focal species: *Radula voluta* (red)
Grid reference: SH7239723947
Assessment: Patches of *Radula voluta*, up to 20 cm diameter, on boulder in small, seasonal stream. This is the lowest occupied location in the stream. Further small colonies occur upstream.

10. Data Archive Appendix

Data outputs associated with this project are archived on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue https://libcat.naturalresources.wales (English Version) and https://catllyfr.cyfoethnaturiol.cymru (Welsh Version) by searching 'Dataset Titles'. The metadata is held as record no NRW_DS161505

Further copies of this report are available from EvidenceReportsAndSubscriptions@cyfoethnaturiolcymru.gov.uk