Cyfoeth Naturiol Cymru
Natural Resources Wales

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

Des Callaghan (Bryophyte Surveys Ltd)

Evidence Report No 920

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Frontispiece: *Plagiochila spinulosa.*

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1. Crynodeb Gweithredol

Mae Coed Crafnant (47.8 ha) yn warchodfa natur sy'n eiddo i Ymddiriedolaeth Natur Gogledd Cymru ac yn cael ei rheoli ganddi, ac mae'n cynnwys rhan o'r coetir hwnnw ynghyd â Choed Dolbebin sydd cydgyffwrdd â hi. Mae holl gynefin coetir cefnforol y warchodfa bron wedi'i gynnwys o fewn SoDdGA Rhinog ac ACA Coedydd Derw Meirionnydd. Cynhaliwyd yr arolwg cynhwysfawr cyntaf o fryoffytau ar y safle yn 2014, pan gasglwyd data monitro llinell sylfaen, trwy fapio gridiau o rywogaethau a thrwy sefydlu lleiniau ffotograffig pwynt sefydlog. Mae'r adroddiad hwn yn rhoi canlyniadau ail-fonitro cymaradwy cyntaf y casgliad o fryoffytau coetiroedd yr Iwerydd. Mae'r canlyniadau'n dangos bod y casgliad at ei gilydd wedi parhau'n sefydlog fwy neu lai rhwng 2014 a 2025, gan ddangos gostyngiad bychan iawn o -4% sy'n debygol o fewn arffiniau cyfeiliornad mesuriad. Fodd bynnag, o fewn y duedd gyffredinol hon, cafwyd tri newid nodedig. Yn gyntaf, cynyddodd amrywiaeth y rhywogaethau, yn dilyn dyfodiad tri math nodedig o lysiau'r afu gor-gefnforol: *Cololejeunea microscopica, Drepanolejeunea hamatifolia* a *Harpalejeunea molleri* . Yn ail, bu cynnydd mewn tair rhywogaeth sefydledig: *Jubula hutchinsiae*, *Pseudomarsupidium decipiens* a *Sematophyllum demissum*, yn enwedig y cyntaf, a gynyddodd fwy na phedair gwaith. Yn drydydd, bu gostyngiad sylweddol o -30% mewn *Lepidozia cupressina*. Mae rhesymau posibl am y newidiadau hyn yn cael eu trafod, a gwneir cymariaethau gyda data monitro tebyg ar fryoffytau Iwerydd a gasglwyd yn ddiweddar o goetir cefnforol cyfagos Coed Graig Uchaf.

2. Executive Summary

Coed Crafnant (47.8 ha) is a nature reserve owned and managed by the North Wales Wildlife Trust, comprising part of that woodland plus the contiguous Coed Dolbebin. Almost all of the oceanic woodland habitat of the reserve is contained within Rhinog SSSI and Meirionnydd Oakwoods SAC. The first comprehensive bryophyte survey of the site was undertaken in 2014, when baseline monitoring data was collected, by the grid-mapping of species and by the establishment of fixed-point photographic plots. This report provides the results of the first comparable re-monitoring of the Atlantic woodland bryophyte assemblage. Results show that between 2014 and 2025 the assemblage generally remained more-or-less stable, exhibiting a very small decline of -4% that is likely within the bounds of measurement error. However, within this general trend, three notable changes occurred. Firstly, the species diversity increased, following the arrival of three notable hyperoceanic liverworts, *Cololejeunea microscopica, Drepanolejeunea hamatifolia* and *Harpalejeunea molleri*. Secondly, there was an increase in three established species, *Jubula hutchinsiae*, *Pseudomarsupidium decipiens* and *Sematophyllum demissum*, especially the former, which increased by more than four-fold. Thirdly, *Lepidozia cupressina* underwent a significant decline, of -30% . Possible reasons for these changes are discussed, and comparisons are made with similar monitoring data on Atlantic bryophytes that has been collected recently from the nearby oceanic woodland of Coed Graig Uchaf.

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 west Scotland, north-west Wales (Eryri), 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 Crafnant (47.8 ha; Figure 1) is a nature reserve owned and managed by The North Wales Wildlife Trust, which actually comprises part of that woodland plus the contiguous Coed Dolbebin. Almost all of the woodland habitat of the reserve is contained within Rhinog SSSI and Meirionnydd Oakwoods SAC. According to the bryophyte selection criteria for SSSIs in Britain (Bosanquet et al. 2018), the 'Atlantic woodland bryophyte assemblage' of the reserve scores 23 points, well above the SSSI selection threshold of 12 points. The assemblage includes 15 species: *Breutelia chrysocoma, Cololejeunea microscopica, Drepanolejeunea hamatifolia, Harpalejeunea molleri, Jubula hutchinsiae, Lejeunea lamacerina, Lejeunea patens, Lepidozia cupressina, Plagiochila bifaria, Plagiochila exigua, Plagiochila punctata, Plagiochila spinulosa, Pseudomarsupidium decipiens, Scapania gracilis* and *Sematophyllum demissum*. All are extant within the site and each was recorded during the present fieldwork. By far the most notable species is *Sematophyllum demissum*, which is known from only eight sites in Britain, all oceanic woodlands in Eryri (Callaghan 2014a).

The first comprehensive bryophyte survey of the reserve was undertaken during 18–21 January 2014, when baseline monitoring data was collected (Callaghan 2014b). A further survey was undertaken in May 2022 (Callaghan 2022), which recorded areas of the reserve not covered in 2014, but did not repeat the species grid-mapping exercise of 2014 due to time constraints. The aim of this study is to repeat the grid-mapping in order to assess what changes have occurred within the Atlantic woodland bryophyte assemblage. Taxonomy follows Blockeel et al. (2021).

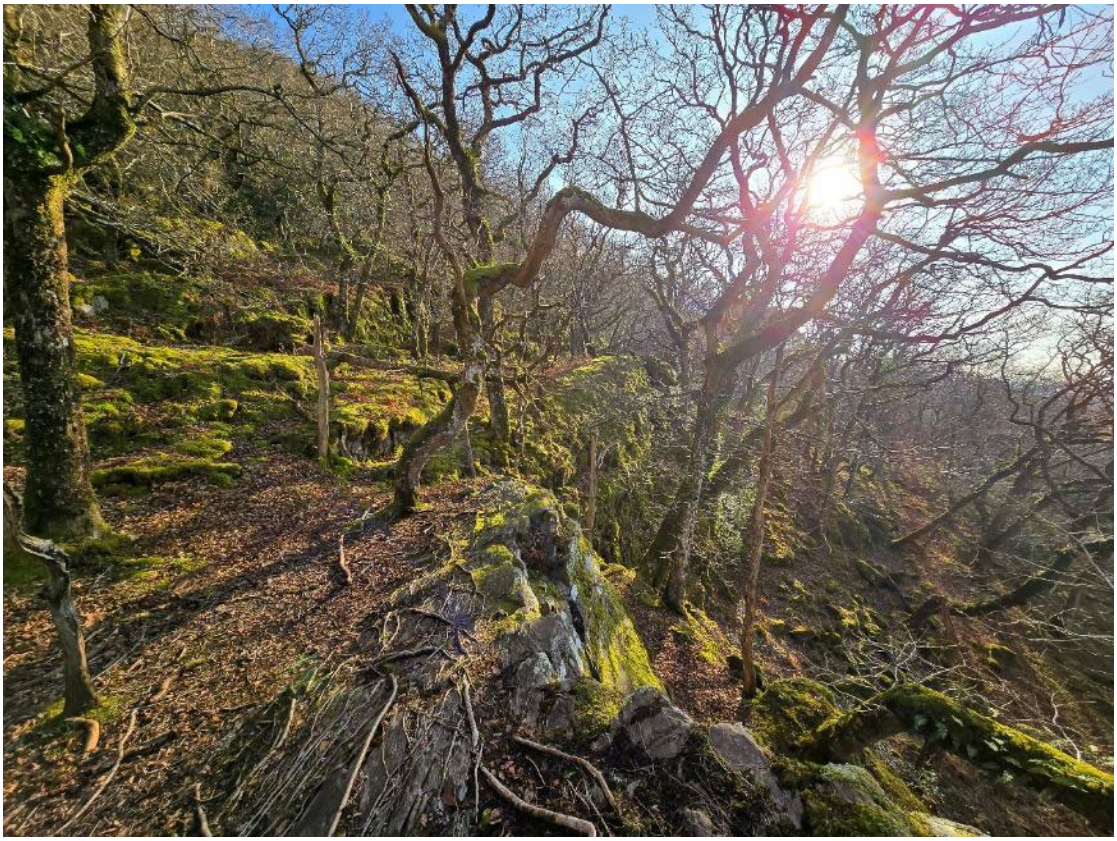

Figure 1 View across steep and rocky oceanic woodland in the northern end of Coed Crafnant.

4. Methods

4.1. Grid-mapping of species

In 2014, a total of 1169 OS 10 m grid cells were surveyed, covering most of the best areas of oceanic woodland within the reserve. GPS waypoints were recorded for all colonies of four notable Atlantic species, *Jubula hutchinsiae, Lepidozia cupressina, Pseudomarsupidium decipiens* and *Sematophyllum demissum*, which were subsequently loaded into GIS to produce maps of grid cells occupied by each species and a count of the number of grid cells occupied.

During the present survey, undertaken during 17–20 February 2025, all of the grid cells surveyed in 2014 were revisited and GPS waypoints were recorded for all colonies of the above four species plus a further seven species of the Atlantic woodland assemblage, including *Cololejeunea microscopica, Drepanolejeunea hamatifolia, Harpalejeunea molleri, Plagiochila bifaria, Plagiochila exigua, Plagiochila punctata* and *Plagiochila spinulosa*. The former three species were absent from the surveyed grid cells in 2014, whilst the other species were present in 2014 but were not grid-mapped due to time constraints. As in 2014, the GPS waypoints were loaded into GIS to produce maps of grid cells occupied by each species and a count of the number of cells occupied.

Other species of the Atlantic bryophyte assemblage were also present within the surveyed grid cells, often widely across the site, but were not grid-mapped due to time constraints, including *Breutelia chrysocoma, Lejeunea lamacerina, L. patens* and *Scapania gracilis*.

4.2. Population change

Percentage change in the number of occupied grid cells between 2014 and 2025 was calculated for: (i) each of the four species that were present and grid-mapped in both 2014 and 2025 (*Jubula hutchinsiae, Lepidozia cupressina, Pseudomarsupidium decipiens* and *Sematophyllum demissum*); and (ii) seven species combined as an aggregate Atlantic assemblage, including these four species plus the three species that have newly colonised the sampled grid cells since 2014 (*Cololejeunea microscopica, Drepanolejeunea hamatifolia* and *Harpalejeunea molleri*).

4.3. Fixed-point photographic plots

Six fixed-point photographic monitoring plots that feature species of the Atlantic woodland bryophyte assemblage were established in 2014, showing habitat conditions and locations of a selection of species. These were all re-visited and re-photographed during the present survey, plus a further five plots were newly established. Locations of all colonies of target species within plots was marked, and for the most notable species the maximum length and maximum width of colonies was measured.

5. Results

5.1. GPS data

GPS data collected during the present survey are provided in Appendix 1.

5.2. Grid-mapping of species

Distribution maps of the eleven species that were grid-mapped from the Atlantic woodland bryophyte assemblage during the present survey are provided in Appendix 2.

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. Whilst the data for the latter suggest the assemblage is more-or-less stable, exhibiting a very small decline of -4% that is likely within

the bounds of measurement error, there are three notable changes within the community. Firstly, the diversity of the community has increased, following the new arrival of three hyperoceanic liverworts, *Cololejeunea microscopica, Drepanolejeunea hamatifolia* and *Harpalejeunea molleri*. Secondly, there have been increases in three previously established species, especially *Jubula hutchinsiae*, but also *Pseudomarsupidium decipiens* and, to a lesser extent, *Sematophyllum demissum*. Thirdly, there has been a significant decline in one species, *Lepidozia cupressina*.

5.4. Fixed-point photographic plots

Images of the fixed-point photographic monitoring plots are provided in Appendix 3. Compared to the plots monitored in 2014, target species do not generally show any major change in abundance, and habitat conditions appear to be very similar. The changes that have occurred appear to be within the bounds of natural patch dynamics, except in Plot 7, where *Jubula hutchinsiae* has increased greatly for reasons unclear, as vegetation structure and stream conditions appear to be unchanged.

Table 1 Counts of OS 10 m grid cells occupied by Atlantic bryophyte species at Coed Crafnant in 2014 and 2025. The Atlantic woodland assemblage is the sum of counts for *Cololejeunea microscopica*, *Drepanolejeunea hamatifolia*, *Harpalejeunea molleri*, *Jubula hutchinsiae*, *Lepidozia cupressina*, *Pseudomarsupidium decipiens* and *Sematophyllum demissum*.

Species	2014 count of occupied 10m grid cells	2025 count of occupied 10m grid cells	% change
Cololejeunea microscopica	0	1	n/a
Drepanolejeunea hamatifolia	0	3	n/a
Harpalejeunea molleri	0	2	n/a
Jubula hutchinsiae	3	16	433%
Lepidozia cupressina	130	91	-30%
Plagiochila bifaria	present	81	n/a
Plagiochila exigua	present	3	n/a
Plagiochila punctata	present	92	n/a
Plagiochila spinulosa	Present	124	n/a
Pseudomarsupidium decipiens	37	49	32%
Sematophyllum demissum	1	3	200%
Atlantic woodland assemblage	171	165	-4%

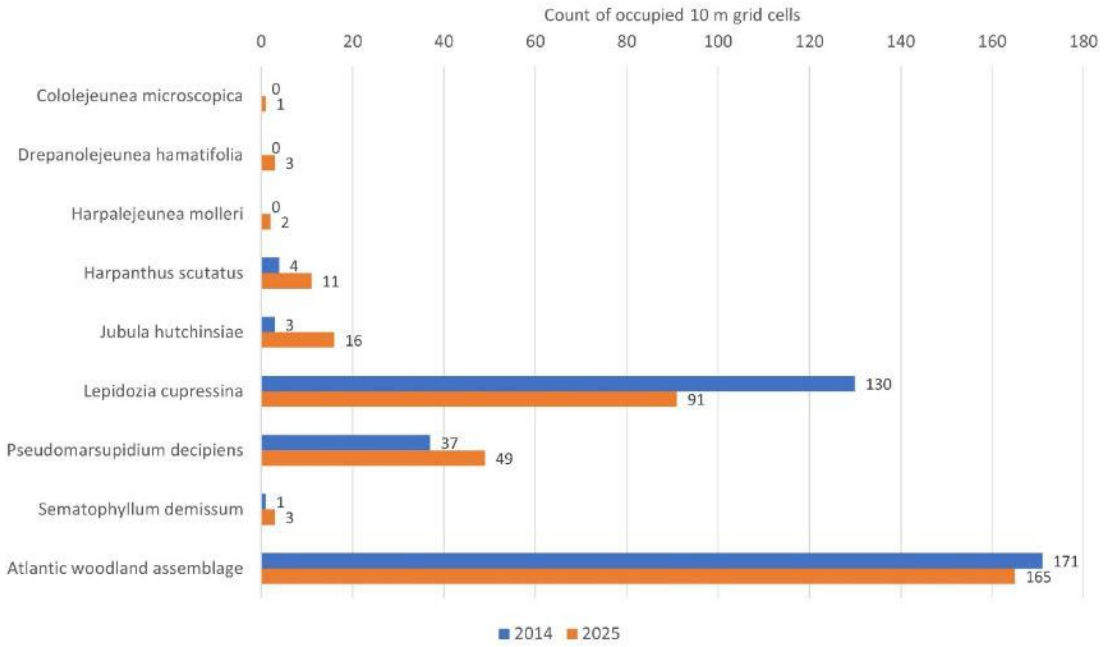

Figure 2 Counts of OS 10 m grid cells occupied by Atlantic bryophyte species at Coed Crafnant in 2014 and 2025. Data for the 'Atlantic woodland assemblage' comprises a sum of the counts for *Cololejeunea microscopica, Drepanolejeunea hamatifolia, Harpalejeunea molleri, Jubula hutchinsiae, Lepidozia cupressina, Pseudomarsupidium decipiens* and *Sematophyllum demissum*.

6. Discussion

The results of this study show that between 2014 and 2025 the Atlantic woodland bryophyte assemblage of Coed Crafnant has broadly remained in favourable condition, with the aggregated abundance of species more-or-less stable. However, some individual species have shown significant change, including three notable species, *Cololejeunea microscopica, Drepanolejeunea hamatifolia* and *Harpalejeunea molleri*, which have colonised the survey area since 2014. These tiny hyperoceanic liverworts occupy a very similar niche to each other and are often co-occur within the best oceanic woodlands of Wales. Comparable monitoring to that conducted here has been completed recently in Coed Graig Uchaf (Callaghan 2024), a high-quality oceanic woodland located just 3 km south-east of Coed Crafnant. *Cololejeunea microscopica* is absent from Coed Graig Uchaf, and the abundance of *Harpalejeunea molleri*, which is present only in tiny quantity in Coed Graig Uchaf, showed no significant change between 2014 and 2024. However, as at Coed Crafnant, *Drepanolejeunea hamatifolia* newly colonised the sampled grid cells at Coed Graig Uchaf sometime after 2014, suggesting it may be spreading generally in the local region. Indeed, there is some limited evidence from casual bryophyte recording in Britain and Ireland that it has been undergoing a recent expansion in its larger range size (Blockeel et al. 2014; Hodgetts 2024), perhaps partly in response to warmer winters.

Interestingly, the large increase in *Jubula hutchinsiae* at Coed Crafnant mirrors a large increase in this species at Coed Graig Uchaf (Callaghan 2024). In both cases, general habitat conditions do not appear to have changed significantly, with occupied streams and woodland structure having the same general appearance between monitoring periods. Whilst populations of rheophytic bryophytes can exhibit surprising stability for periods of time, they can also be subject to major change due intense natural disturbance events caused by extreme spate flows, followed by recovery under more favourable conditions (Bosanquet 2018; Callaghan 2023; Englund 1991). It is therefore possible that the large increases detected at Coed Crafnant and Coed Graig Uchaf are simply due to natural population recovery following a natural decline. However, it is also possible that other factors are the cause, for example warmer winters due to climate change, a matter that deserves further investigation.

Another interesting result from Coed Crafnant is the significant decline in *Lepidozia cupressina*, which has occurred also at Coed Graig Uchaf (Callaghan 2024). At the latter site, there was evidence from fixed-point photographic plots that competitive exclusion by larger bryophytes was at least partly the cause. Results from fixed-point photographic plots at Coed Crafnant are mixed. At Plots 1 and 6, small declines in *L. cupressina* occurred, in Plot 1 for reasons unclear and in Plot 6 due to competitive exclusion by larger bryophytes, while at Plot 5 the abundance of the liverwort remained stable. Generally, grazing pressure appears to remain favourable in the main areas occupied by the species in Coed Crafnant, and clear reasons the overall decline are not immediately apparent, though deserve further investigation.

Following the recent extinction of the only known colony of the nationally rare and Red Listed *Sematophyllum demissum* at Coed Crafnant due to competitive exclusion, as illustrated in Plot 8, it was encouraging to find three new and widely spaced colonies of this rare moss during the present survey work, documented in Plots 3, 10 and 11, indicating a small increase in the population, perhaps within the bounds of natural dynamics. The habitat occupied by the colony illustrated in Plot 11 is particularly interesting, as this moss is almost always associated closely with watercourses in Wales (Callaghan 2014a), but this colony occupies a diffuse seepage on a sloping cliff face, over 100 m from the nearest stream.

As with the results from comparable monitoring at Coed Graig Uchaf (Callaghan 2024), this study clearly 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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9. Appendices

9.1. Appendix 1: GPS data

Species	OS GR
Breutelia chrysocoma	SH6186328815
Breutelia chrysocoma	SH6191228757
Cololejeunea microscopica	SH6171428660
Drepanolejeunea hamatifolia	SH6172028666
Drepanolejeunea hamatifolia	SH6213428920
Drepanolejeunea hamatifolia	SH6216428926
Drepanolejeunea hamatifolia	SH6216628927
Harpalejeunea molleri	SH6171728662
Harpalejeunea molleri	SH6172228669
Harpanthus scutatus	SH6193728556
Harpanthus scutatus	SH6197428752
Harpanthus scutatus	SH6198028743
Harpanthus scutatus	SH6198028824
Harpanthus scutatus	SH6198728770
Harpanthus scutatus	SH6202028704
Harpanthus scutatus	SH6203628729
Harpanthus scutatus	SH6204028734
Harpanthus scutatus	SH6204428739
Harpanthus scutatus	SH6204828776
Harpanthus scutatus	SH6205428781
Harpanthus scutatus	SH6205528758
Harpanthus scutatus	SH6205528758
Jubula hutchinsiae	SH6161628505
Jubula hutchinsiae	SH6164128494
Jubula hutchinsiae	SH6164128495
Jubula hutchinsiae	SH6165528490
Jubula hutchinsiae	SH6165628486
Jubula hutchinsiae	SH6173128449
Jubula hutchinsiae	SH6173228446
Jubula hutchinsiae	SH6174428438
Jubula hutchinsiae	SH6174428439
Jubula hutchinsiae	SH6174428448
Jubula hutchinsiae	SH6174528435
Jubula hutchinsiae	SH6174628444
Jubula hutchinsiae	SH6174828434
Jubula hutchinsiae	SH6175028433
Jubula hutchinsiae	SH6175228430
Jubula hutchinsiae	SH6175328429
Jubula hutchinsiae	SH6175628419
Jubula hutchinsiae	SH6175828409
Jubula hutchinsiae	SH6178428360
Jubula hutchinsiae	SH6178528359
Jubula hutchinsiae	SH6178928346
Jubula hutchinsiae	SH6179828340
Jubula hutchinsiae	SH6180328328

Species	OS GR
Jubula hutchinsiae	SH6180328332
Jubula hutchinsiae	SH6180428327
Jubula hutchinsiae	SH6181128315
Jubula hutchinsiae	SH6181128317
Jubula hutchinsiae	SH6181628310
Jubula hutchinsiae	SH6181728309
Lejeunea patens	SH6187728734
Lejeunea patens	SH6193728773
Lepidozia cupressina	SH6150228171
Lepidozia cupressina	SH6164728245
Lepidozia cupressina	SH6165628243
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Lepidozia cupressina	SH6174328495
Lepidozia cupressina	SH6174428454
Lepidozia cupressina	SH6174428483
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Lepidozia cupressina	SH6176728441

Species	OS GR
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Lepidozia cupressina	SH6177628396
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Lepidozia cupressina	SH6187228777
Lepidozia cupressina	SH6187528833
Lepidozia cupressina	SH6187728756
Lepidozia cupressina	SH6188028730
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Lepidozia cupressina	SH6188528832
Lepidozia cupressina	SH6188628719
Lepidozia cupressina	SH6189328705
Lepidozia cupressina	SH6189428662
Lepidozia cupressina	SH6189428673
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Lepidozia cupressina	SH6195828768
Lepidozia cupressina	SH6196528781
Lepidozia cupressina	SH6197128795
Lepidozia cupressina	SH6197228782
Lepidozia cupressina	SH6197328721
Lepidozia cupressina	SH6197328817

Species	OS GR
Lepidozia cupressina	SH6197528717
Lepidozia cupressina	SH6197528750
Lepidozia cupressina	SH6197928716
Lepidozia cupressina	SH6198028822
Lepidozia cupressina	SH6198028844
Lepidozia cupressina	SH6198128741
Lepidozia cupressina	SH6198128743
Lepidozia cupressina	SH6199228793
Lepidozia cupressina	SH6199228835
Lepidozia cupressina	SH6199428792
Lepidozia cupressina	SH6199428837
Lepidozia cupressina	SH6199428856
Lepidozia cupressina	SH6199628797
Lepidozia cupressina	SH6199828828
Lepidozia cupressina	SH6199928720
Lepidozia cupressina	SH6199928729
Lepidozia cupressina	SH6200028714
Lepidozia cupressina	SH6200028814
Lepidozia cupressina	SH6200028822
Lepidozia cupressina	SH6200128817
Lepidozia cupressina	SH6200228811
Lepidozia cupressina	SH6200428696
Lepidozia cupressina	SH6200528713
Lepidozia cupressina	SH6201428820
Lepidozia cupressina	SH6201428821
Lepidozia cupressina	SH6201428822
Lepidozia cupressina	SH6202028706
Lepidozia cupressina	SH6204428767
Lepidozia cupressina	SH6204728775
Lepidozia cupressina	SH6204828777
Lepidozia cupressina	SH6205028766
Lepidozia cupressina	SH6205028768
Lepidozia cupressina	SH6205228760
Lepidozia cupressina	SH6205228821
Lepidozia cupressina	SH6205828825
Lepidozia cupressina	SH6207928833
Lepidozia cupressina	SH6208128835
Lepidozia cupressina	SH6211428918
Lepidozia cupressina	SH6211628911
Lepidozia cupressina	SH6211828886
Lepidozia cupressina	SH6213228896
Lepidozia cupressina	SH6215728911
Lepidozia cupressina	SH6215728911
Lepidozia cupressina	SH6215828913
Lepidozia cupressina	SH6216028902
Lepidozia cupressina	SH6216128922
Lepidozia cupressina	SH6216628923
Neckera crispa	SH6194328463
Odontoschisma sphagni	SH6173828658
Plagiochila bifaria	SH6113227796

Species	OS GR
Plagiochila bifaria	SH6114727765
Plagiochila bifaria	SH6133028042
Plagiochila bifaria	SH6147028320
Plagiochila bifaria	SH6150228172
Plagiochila bifaria	SH6150728398
Plagiochila bifaria	SH6151228432
Plagiochila bifaria	SH6153228454
Plagiochila bifaria	SH6154428460
Plagiochila bifaria	SH6166728254
Plagiochila bifaria	SH6167328257
Plagiochila bifaria	SH6167828272
Plagiochila bifaria	SH6168828247
Plagiochila bifaria	SH6170028603
Plagiochila bifaria	SH6170128607
Plagiochila bifaria	SH6170228591
Plagiochila bifaria	SH6170328610
Plagiochila bifaria	SH6170728555
Plagiochila bifaria	SH6170828578
Plagiochila bifaria	SH6172528667
Plagiochila bifaria	SH6173328439
Plagiochila bifaria	SH6173328511
Plagiochila bifaria	SH6173328517
Plagiochila bifaria	SH6173928490
Plagiochila bifaria	SH6174528451
Plagiochila bifaria	SH6174528490
Plagiochila bifaria	SH6175028443
Plagiochila bifaria	SH6175028446
Plagiochila bifaria	SH6175728439
Plagiochila bifaria	SH6175828448
Plagiochila bifaria	SH6176028446
Plagiochila bifaria	SH6176728422
Plagiochila bifaria	SH6176728451
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Plagiochila bifaria	SH6176928407
Plagiochila bifaria	SH6178128394
Plagiochila bifaria	SH6178528384
Plagiochila bifaria	SH6178528678
Plagiochila bifaria	SH6180528798
Plagiochila bifaria	SH6180728790
Plagiochila bifaria	SH6185528602
Plagiochila bifaria	SH6185928612
Plagiochila bifaria	SH6187328731
Plagiochila bifaria	SH6187428579
Plagiochila bifaria	SH6187428732
Plagiochila bifaria	SH6187628736
Plagiochila bifaria	SH6187628781
Plagiochila bifaria	SH6188328826
Plagiochila bifaria	SH6188328837
Plagiochila bifaria	SH6188528825
Plagiochila bifaria	SH6188528832

Species	OS GR
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Plagiochila bifaria	SH6189128688
Plagiochila bifaria	SH6189628588
Plagiochila bifaria	SH6190128717
Plagiochila bifaria	SH6190228605
Plagiochila bifaria	SH6190428728
Plagiochila bifaria	SH6190428841
Plagiochila bifaria	SH6190528682
Plagiochila bifaria	SH6190728818
Plagiochila bifaria	SH6190928685
Plagiochila bifaria	SH6192628519
Plagiochila bifaria	SH6193028801
Plagiochila bifaria	SH6193228743
Plagiochila bifaria	SH6193828758
Plagiochila bifaria	SH6194128649
Plagiochila bifaria	SH6194228774
Plagiochila bifaria	SH6194828644
Plagiochila bifaria	SH6195128520
Plagiochila bifaria	SH6196128534
Plagiochila bifaria	SH6196128640
Plagiochila bifaria	SH6197128792
Plagiochila bifaria	SH6197128854
Plagiochila bifaria	SH6197428815
Plagiochila bifaria	SH6197828763
Plagiochila bifaria	SH6197928689
Plagiochila bifaria	SH6198228834
Plagiochila bifaria	SH6198928845
Plagiochila bifaria	SH6199128663
Plagiochila bifaria	SH6199728580
Plagiochila bifaria	SH6199928630
Plagiochila bifaria	SH6200028710
Plagiochila bifaria	SH6200028725
Plagiochila bifaria	SH6200028729
Plagiochila bifaria	SH6200128618
Plagiochila bifaria	SH6200128823
Plagiochila bifaria	SH6201028834
Plagiochila bifaria	SH6201428825
Plagiochila bifaria	SH6202228709
Plagiochila bifaria	SH6205028768
Plagiochila bifaria	SH6205628759
Plagiochila bifaria	SH6206828823
Plagiochila bifaria	SH6207128827
Plagiochila bifaria	SH6210228846
Plagiochila bifaria	SH6211028852
Plagiochila bifaria	SH6213328899
Plagiochila bifaria	SH6214828906
Plagiochila bifaria	SH6215028924
Plagiochila bifaria	SH6217728891
Plagiochila exigua	SH6195728783
Plagiochila exigua	SH6195828836

Species	OS GR
Plagiochila exigua	SH6195928772
Plagiochila punctata	SH6153328453
Plagiochila punctata	SH6167528257
Plagiochila punctata	SH6167528268
Plagiochila punctata	SH6168028234
Plagiochila punctata	SH6168928249
Plagiochila punctata	SH6170928264
Plagiochila punctata	SH6171428637
Plagiochila punctata	SH6171528649
Plagiochila punctata	SH6171728662
Plagiochila punctata	SH6172928645
Plagiochila punctata	SH6173328501
Plagiochila punctata	SH6173928500
Plagiochila punctata	SH6174128485
Plagiochila punctata	SH6174228454
Plagiochila punctata	SH6174528491
Plagiochila punctata	SH6174628453
Plagiochila punctata	SH6174828460
Plagiochila punctata	SH6175028441
Plagiochila punctata	SH6175328439
Plagiochila punctata	SH6175628439
Plagiochila punctata	SH6176728423
Plagiochila punctata	SH6177528418
Plagiochila punctata	SH6177928427
Plagiochila punctata	SH6178328432
Plagiochila punctata	SH6178428375
Plagiochila punctata	SH6178528440
Plagiochila punctata	SH6179128387
Plagiochila punctata	SH6185328596
Plagiochila punctata	SH6185828608
Plagiochila punctata	SH6185928611
Plagiochila punctata	SH6187628800
Plagiochila punctata	SH6187828731
Plagiochila punctata	SH6188428805
Plagiochila punctata	SH6188628816
Plagiochila punctata	SH6188728568
Plagiochila punctata	SH6188728818
Plagiochila punctata	SH6189328670
Plagiochila punctata	SH6189528709
Plagiochila punctata	SH6189628707
Plagiochila punctata	SH6189828650
Plagiochila punctata	SH6190228718
Plagiochila punctata	SH6190328718
Plagiochila punctata	SH6190428815
Plagiochila punctata	SH6190528682
Plagiochila punctata	SH6192228822
Plagiochila punctata	SH6192328823
Plagiochila punctata	SH6193028829
Plagiochila punctata	SH6193628759
Plagiochila punctata	SH6193928775

Species	OS GR
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Plagiochila punctata	SH6194228769
Plagiochila punctata	SH6194528639
Plagiochila punctata	SH6194828669
Plagiochila punctata	SH6194828813
Plagiochila punctata	SH6195028518
Plagiochila punctata	SH6195028811
Plagiochila punctata	SH6195228817
Plagiochila punctata	SH6195328522
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Plagiochila punctata	SH6197328854
Plagiochila punctata	SH6197428716
Plagiochila punctata	SH6197428793
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Plagiochila punctata	SH6197528750
Plagiochila punctata	SH6197528789
Plagiochila punctata	SH6197528791
Plagiochila punctata	SH6197528822
Plagiochila punctata	SH6197528852
Plagiochila punctata	SH6197628786
Plagiochila punctata	SH6197728766
Plagiochila punctata	SH6197828759
Plagiochila punctata	SH6197928819
Plagiochila punctata	SH6197928826
Plagiochila punctata	SH6198028788
Plagiochila punctata	SH6198028821
Plagiochila punctata	SH6198128701
Plagiochila punctata	SH6198328847
Plagiochila punctata	SH6198428835
Plagiochila punctata	SH6199128663
Plagiochila punctata	SH6199328783
Plagiochila punctata	SH6199328822
Plagiochila punctata	SH6199328824

Species	OS GR
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Plagiochila punctata	SH6199928714
Plagiochila punctata	SH6199928729
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Plagiochila punctata	SH6200028710
Plagiochila punctata	SH6200228712
Plagiochila punctata	SH6200228717
Plagiochila punctata	SH6200328832
Plagiochila punctata	SH6200828805
Plagiochila punctata	SH6204628741
Plagiochila punctata	SH6205028777
Plagiochila punctata	SH6205528759
Plagiochila punctata	SH6205728827
Plagiochila punctata	SH6206028792
Plagiochila punctata	SH6211528915
Plagiochila punctata	SH6211728884
Plagiochila punctata	SH6212328872
Plagiochila punctata	SH6213228896
Plagiochila punctata	SH6213528898
Plagiochila punctata	SH6213528921
Plagiochila punctata	SH6213628896
Plagiochila punctata	SH6215328912
Plagiochila punctata	SH6215328917
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Plagiochila punctata	SH6215728911
Plagiochila punctata	SH6215728911
Plagiochila punctata	SH6215828893
Plagiochila punctata	SH6215828921
Plagiochila punctata	SH6216228904
Plagiochila punctata	SH6216328923
Plagiochila punctata	SH6216728923
Plagiochila punctata	SH6217628911
Plagiochila punctata	SH6220928931
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Plagiochila spinulosa	SH6113927739
Plagiochila spinulosa	SH6116927852
Plagiochila spinulosa	SH6119827866
Plagiochila spinulosa	SH6119927797
Plagiochila spinulosa	SH6120627803
Plagiochila spinulosa	SH6122827987
Plagiochila spinulosa	SH6126028061
Plagiochila spinulosa	SH6135128167
Plagiochila spinulosa	SH6137828203
Plagiochila spinulosa	SH6142228266
Plagiochila spinulosa	SH6143128274
Plagiochila spinulosa	SH6143828291
Plagiochila spinulosa	SH6149628390
Plagiochila spinulosa	SH6150228172
Plagiochila spinulosa	SH6150528177

Species	OS GR
Plagiochila spinulosa	SH6151928195
Plagiochila spinulosa	SH6151928445
Plagiochila spinulosa	SH6154428422
Plagiochila spinulosa	SH6160328439
Plagiochila spinulosa	SH6161928227
Plagiochila spinulosa	SH6163428235
Plagiochila spinulosa	SH6165228482
Plagiochila spinulosa	SH6168528245
Plagiochila spinulosa	SH6169728618
Plagiochila spinulosa	SH6169728621
Plagiochila spinulosa	SH6170028603
Plagiochila spinulosa	SH6170228626
Plagiochila spinulosa	SH6170828563
Plagiochila spinulosa	SH6171228272
Plagiochila spinulosa	SH6173228512
Plagiochila spinulosa	SH6173328273
Plagiochila spinulosa	SH6173328446
Plagiochila spinulosa	SH6173528274
Plagiochila spinulosa	SH6173528480
Plagiochila spinulosa	SH6173628441
Plagiochila spinulosa	SH6173828458
Plagiochila spinulosa	SH6174528478
Plagiochila spinulosa	SH6174628441
Plagiochila spinulosa	SH6174628443
Plagiochila spinulosa	SH6174928415
Plagiochila spinulosa	SH6174928434
Plagiochila spinulosa	SH6175028439
Plagiochila spinulosa	SH6175328429
Plagiochila spinulosa	SH6175828425
Plagiochila spinulosa	SH6176228406
Plagiochila spinulosa	SH6176228729
Plagiochila spinulosa	SH6176528404
Plagiochila spinulosa	SH6176528733
Plagiochila spinulosa	SH6176828402
Plagiochila spinulosa	SH6176828405
Plagiochila spinulosa	SH6176828729
Plagiochila spinulosa	SH6177628396
Plagiochila spinulosa	SH6177628733
Plagiochila spinulosa	SH6177828386
Plagiochila spinulosa	SH6177828440
Plagiochila spinulosa	SH6177928346
Plagiochila spinulosa	SH6178228732
Plagiochila spinulosa	SH6178528364
Plagiochila spinulosa	SH6178928387
Plagiochila spinulosa	SH6180128334
Plagiochila spinulosa	SH6180628806
Plagiochila spinulosa	SH6180728790
Plagiochila spinulosa	SH6180828444
Plagiochila spinulosa	SH6181228445
Plagiochila spinulosa	SH6181328811

Species	OS GR
Plagiochila spinulosa	SH6181728784
Plagiochila spinulosa	SH6181828436
Plagiochila spinulosa	SH6181828821
Plagiochila spinulosa	SH6182728462
Plagiochila spinulosa	SH6182928809
Plagiochila spinulosa	SH6183328474
Plagiochila spinulosa	SH6185728603
Plagiochila spinulosa	SH6185928615
Plagiochila spinulosa	SH6186228521
Plagiochila spinulosa	SH6186528830
Plagiochila spinulosa	SH6186728830
Plagiochila spinulosa	SH6187028828
Plagiochila spinulosa	SH6187328730
Plagiochila spinulosa	SH6187428579
Plagiochila spinulosa	SH6187428734
Plagiochila spinulosa	SH6187428777
Plagiochila spinulosa	SH6187628737
Plagiochila spinulosa	SH6187628780
Plagiochila spinulosa	SH6187728781
Plagiochila spinulosa	SH6187828583
Plagiochila spinulosa	SH6188328801
Plagiochila spinulosa	SH6188328804
Plagiochila spinulosa	SH6188528716
Plagiochila spinulosa	SH6188528825
Plagiochila spinulosa	SH6188528832
Plagiochila spinulosa	SH6188728809
Plagiochila spinulosa	SH6188828700
Plagiochila spinulosa	SH6188928817
Plagiochila spinulosa	SH6189528759
Plagiochila spinulosa	SH6190128805
Plagiochila spinulosa	SH6190128811
Plagiochila spinulosa	SH6190228840
Plagiochila spinulosa	SH6190328718
Plagiochila spinulosa	SH6190828728
Plagiochila spinulosa	SH6190928685
Plagiochila spinulosa	SH6190928842
Plagiochila spinulosa	SH6192528829
Plagiochila spinulosa	SH6192728800
Plagiochila spinulosa	SH6193228502
Plagiochila spinulosa	SH6193328491
Plagiochila spinulosa	SH6193328500
Plagiochila spinulosa	SH6193428747
Plagiochila spinulosa	SH6193828749
Plagiochila spinulosa	SH6193928765
Plagiochila spinulosa	SH6194228768
Plagiochila spinulosa	SH6194428663
Plagiochila spinulosa	SH6194528770
Plagiochila spinulosa	SH6194728493
Plagiochila spinulosa	SH6194728775
Plagiochila spinulosa	SH6194828813

Species	OS GR
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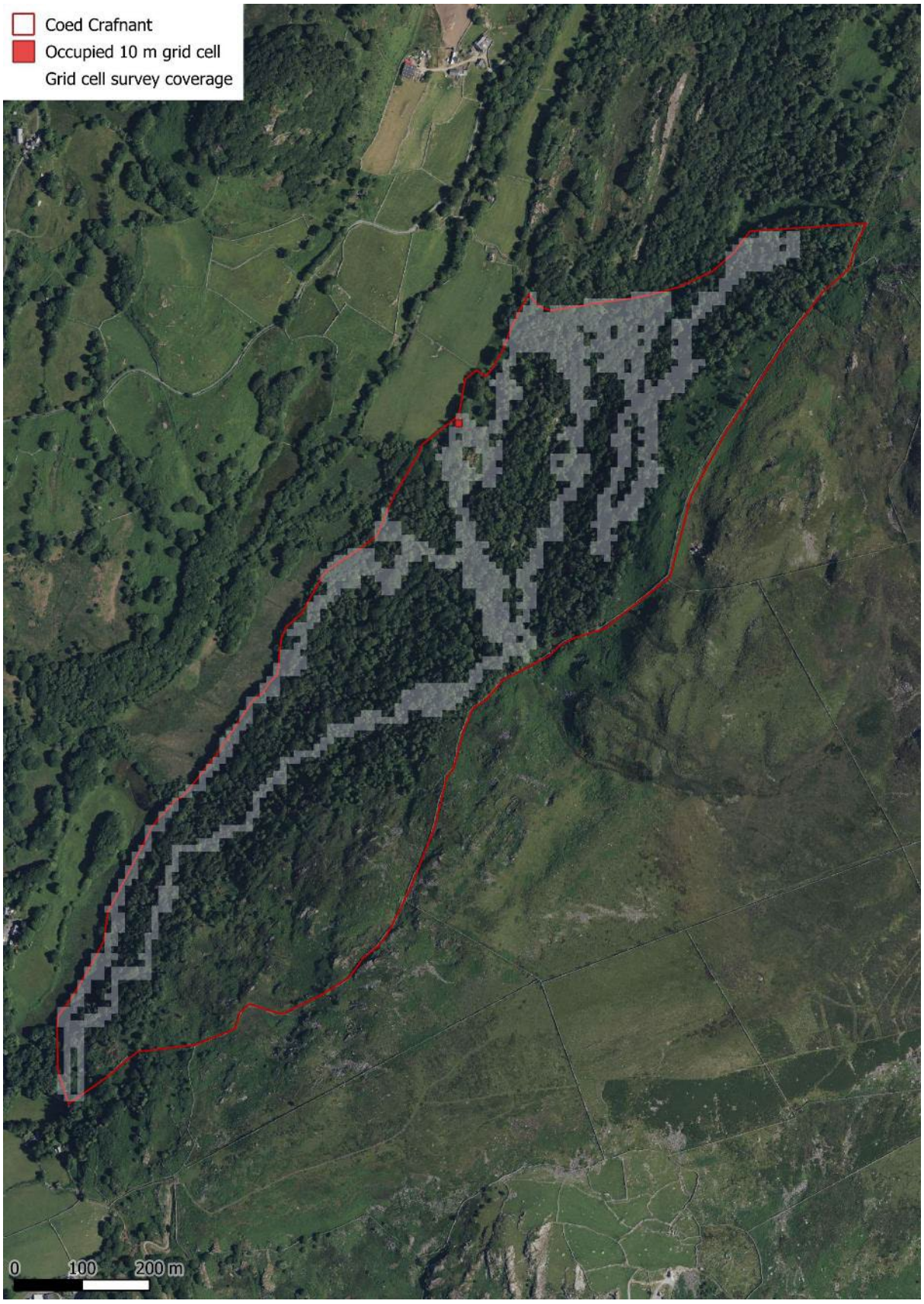
Plagiochila spinulosa	SH6195428848
Plagiochila spinulosa	SH6195528738
Plagiochila spinulosa	SH6195628752
Plagiochila spinulosa	SH6195928783
Plagiochila spinulosa	SH6196028837
Plagiochila spinulosa	SH6196828805
Plagiochila spinulosa	SH6197128794
Plagiochila spinulosa	SH6197228723
Plagiochila spinulosa	SH6197528752
Plagiochila spinulosa	SH6197928841
Plagiochila spinulosa	SH6197928843
Plagiochila spinulosa	SH6198028822
Plagiochila spinulosa	SH6198128743
Plagiochila spinulosa	SH6198128767
Plagiochila spinulosa	SH6199128835
Plagiochila spinulosa	SH6199228824
Plagiochila spinulosa	SH6199328781
Plagiochila spinulosa	SH6199528856
Plagiochila spinulosa	SH6199828799
Plagiochila spinulosa	SH6199928847
Plagiochila spinulosa	SH6200228725
Plagiochila spinulosa	SH6200328847
Plagiochila spinulosa	SH6200428846
Plagiochila spinulosa	SH6201128852
Plagiochila spinulosa	SH6205628780
Plagiochila spinulosa	SH6206128769
Plagiochila spinulosa	SH6206728824
Plagiochila spinulosa	SH6207028825
Plagiochila spinulosa	SH6212128916
Plagiochila spinulosa	SH6212228917
Plagiochila spinulosa	SH6212828875
Plagiochila spinulosa	SH6212928879
Plagiochila spinulosa	SH6214528902
Plagiochila spinulosa	SH6215028926
Plagiochila spinulosa	SH6216128923
Plagiochila spinulosa	SH6216128929
Plagiochila spinulosa	SH6216728923
Plagiochila spinulosa	SH6217228938
Plagiochila spinulosa	SH6217528911
Plagiochila spinulosa	SH6218728898
Pseudomarsupidium decipiens	SH6150528176
Pseudomarsupidium decipiens	SH6169628615
Pseudomarsupidium decipiens	SH6170228609
Pseudomarsupidium decipiens	SH6170328591
Pseudomarsupidium decipiens	SH6170328610
Pseudomarsupidium decipiens	SH6170528629
Pseudomarsupidium decipiens	SH6170528629
Pseudomarsupidium decipiens	SH6172128664
Pseudomarsupidium decipiens	SH6173628479

Species	OS GR
Pseudomarsupidium decipiens	SH6173928489
Pseudomarsupidium decipiens	SH6174228477
Pseudomarsupidium decipiens	SH6174428482
Pseudomarsupidium decipiens	SH6176328732
Pseudomarsupidium decipiens	SH6176528420
Pseudomarsupidium decipiens	SH6176528733
Pseudomarsupidium decipiens	SH6176728422
Pseudomarsupidium decipiens	SH6177828440
Pseudomarsupidium decipiens	SH6186128522
Pseudomarsupidium decipiens	SH6186528764
Pseudomarsupidium decipiens	SH6187428777
Pseudomarsupidium decipiens	SH6187528828
Pseudomarsupidium decipiens	SH6188328802
Pseudomarsupidium decipiens	SH6188528816
Pseudomarsupidium decipiens	SH6188528827
Pseudomarsupidium decipiens	SH6188528832
Pseudomarsupidium decipiens	SH6188628694
Pseudomarsupidium decipiens	SH6188628836
Pseudomarsupidium decipiens	SH6188728817
Pseudomarsupidium decipiens	SH6188728817
Pseudomarsupidium decipiens	SH6188728818
Pseudomarsupidium decipiens	SH6188828703
Pseudomarsupidium decipiens	SH6189528702
Pseudomarsupidium decipiens	SH6190028811
Pseudomarsupidium decipiens	SH6190128811
Pseudomarsupidium decipiens	SH6190428842
Pseudomarsupidium decipiens	SH6191128692
Pseudomarsupidium decipiens	SH6192828515
Pseudomarsupidium decipiens	SH6194228768
Pseudomarsupidium decipiens	SH6195228817
Pseudomarsupidium decipiens	SH6195828768
Pseudomarsupidium decipiens	SH6195828772
Pseudomarsupidium decipiens	SH6196028842
Pseudomarsupidium decipiens	SH6196228779
Pseudomarsupidium decipiens	SH6196428810
Pseudomarsupidium decipiens	SH6196728812
Pseudomarsupidium decipiens	SH6197028797
Pseudomarsupidium decipiens	SH6197228854
Pseudomarsupidium decipiens	SH6197328813
Pseudomarsupidium decipiens	SH6197628787
Pseudomarsupidium decipiens	SH6197928821
Pseudomarsupidium decipiens	SH6198328847
Pseudomarsupidium decipiens	SH6200228846
Pseudomarsupidium decipiens	SH6200328832
Pseudomarsupidium decipiens	SH6215328918
Pseudomarsupidium decipiens	SH6215428919
Pseudomarsupidium decipiens	SH6215528920
Pseudomarsupidium decipiens	SH6215728909
Pseudomarsupidium decipiens	SH6215728911
Pseudomarsupidium decipiens	SH6215728911

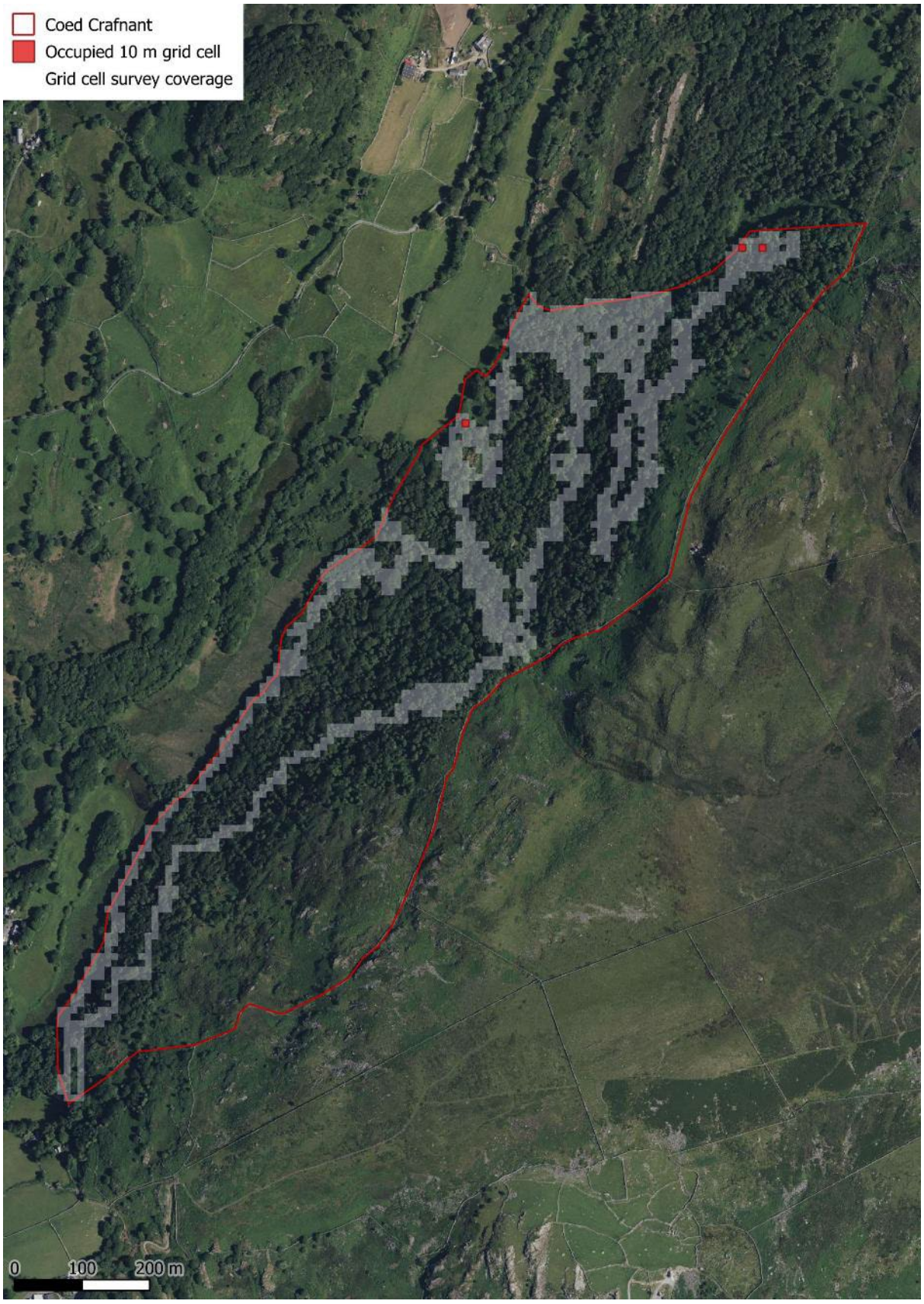
Species	OS GR
Pseudomarsupidium decipiens	SH6215728919
Pseudomarsupidium decipiens	SH6216028914
Pseudomarsupidium decipiens	SH6216028929
Pseudomarsupidium decipiens	SH6216528923
Scapania umbrosa	SH6197528752
Sematophyllum demissum	SH6169728598
Sematophyllum demissum	SH6171228267
Sematophyllum demissum	SH6177828395

9.2. Appendix 2: Grid-maps of Atlantic bryophyte species

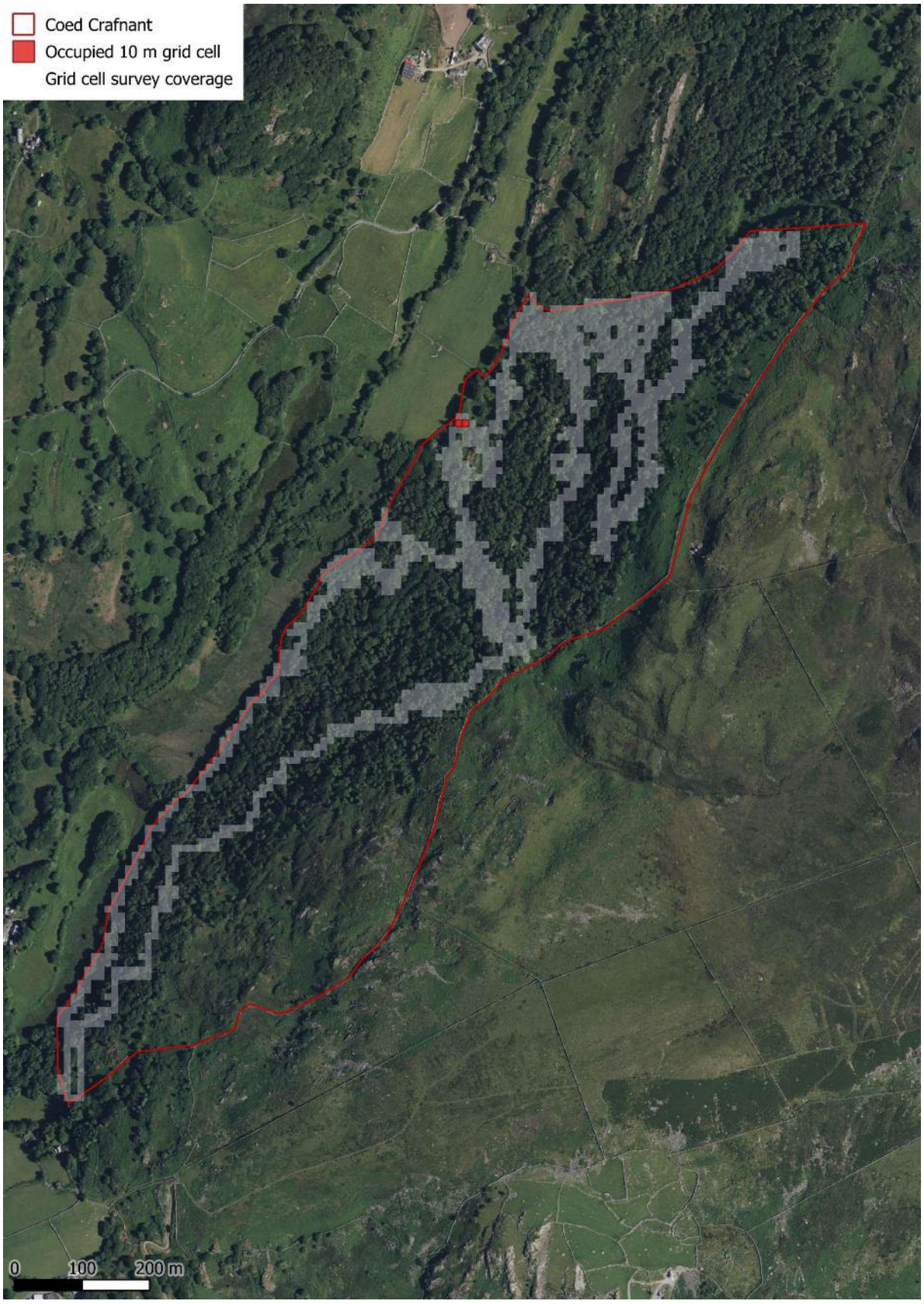
9.2.1. Cololejeunea microscopica



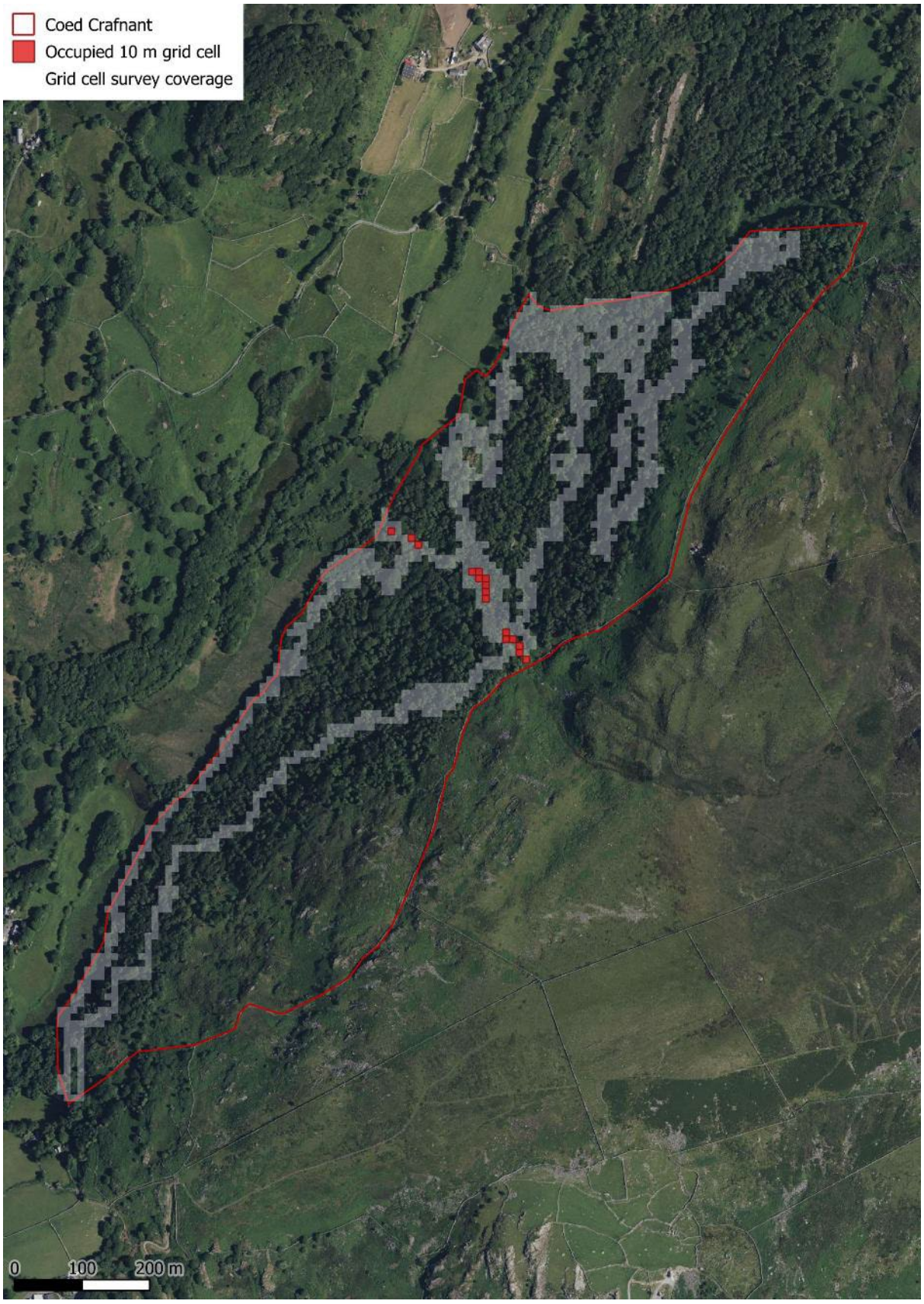
9.2.2. Drepanolejeunea hamatifolia



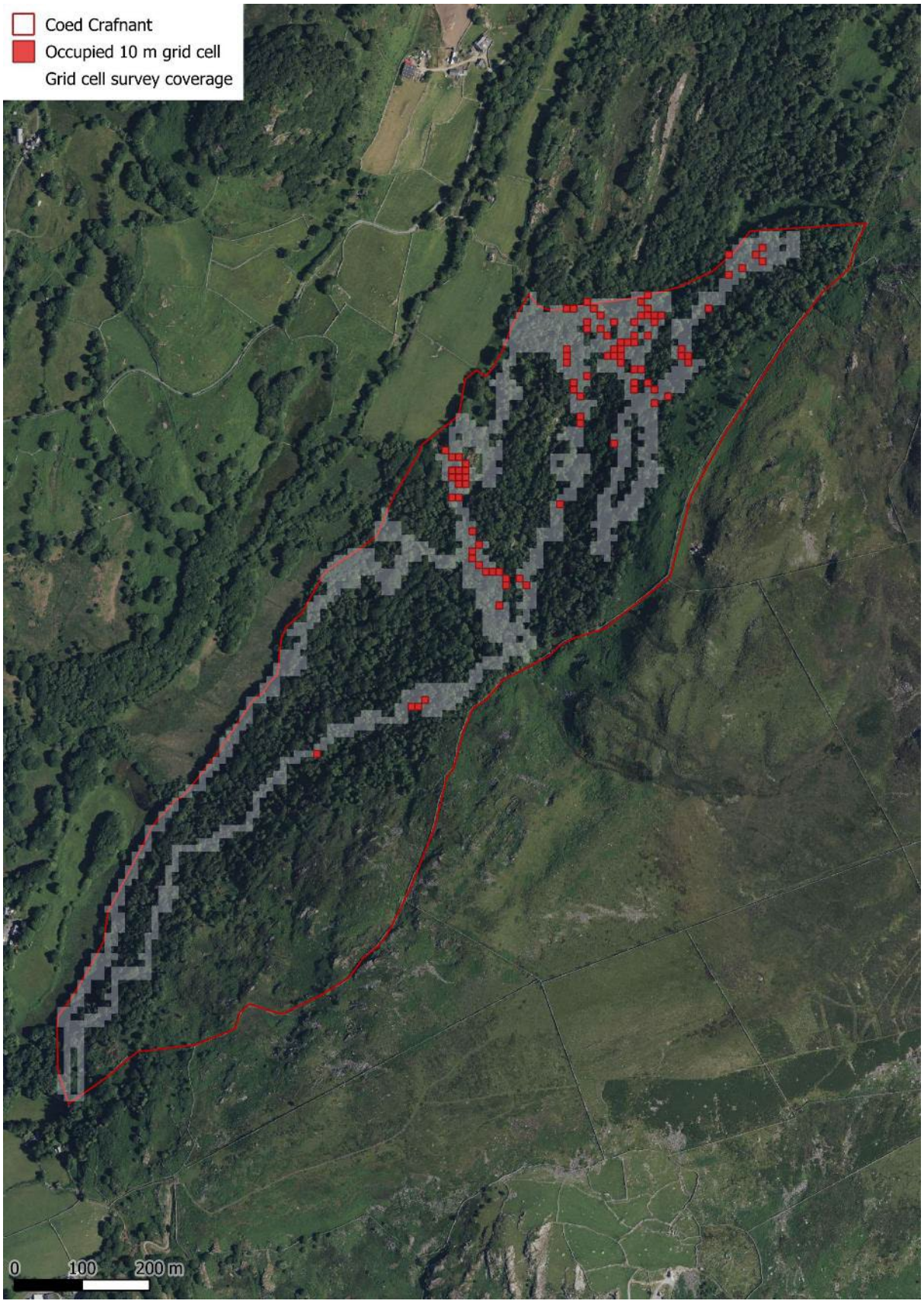
9.2.3. Harpalejeunea molleri



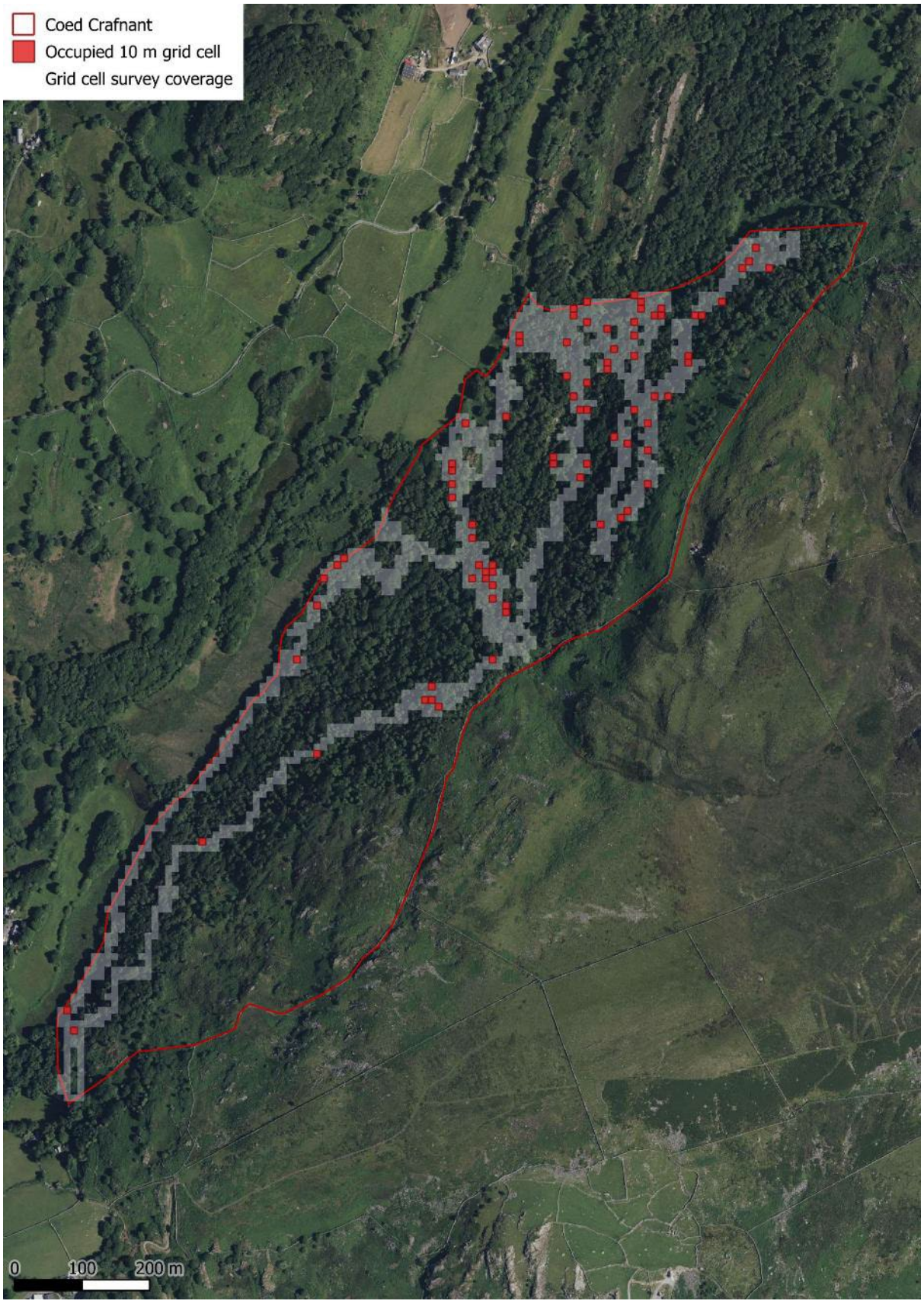
9.2.4. Jubula hutchinsiae



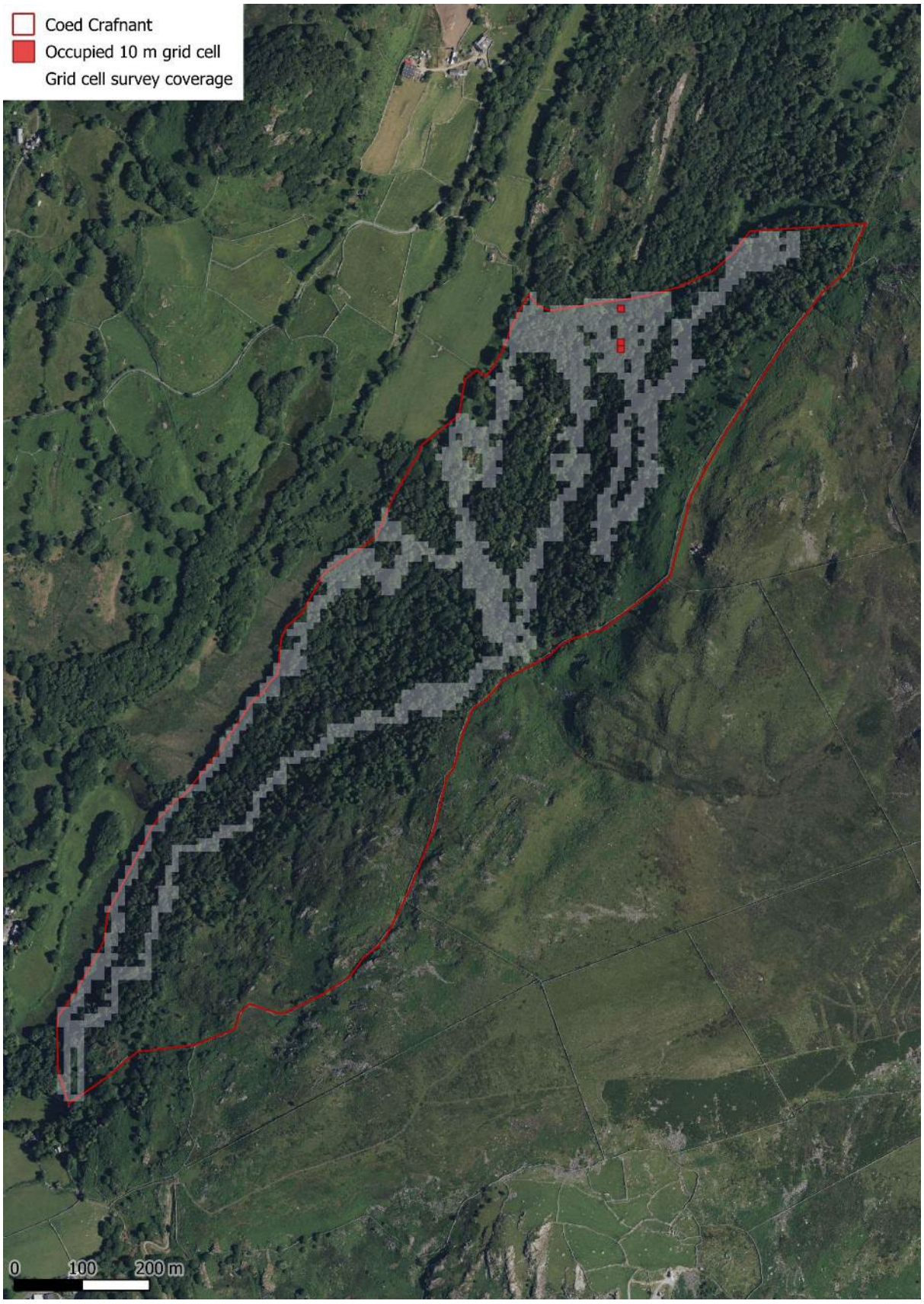
9.2.5. Lepidozia cupressina



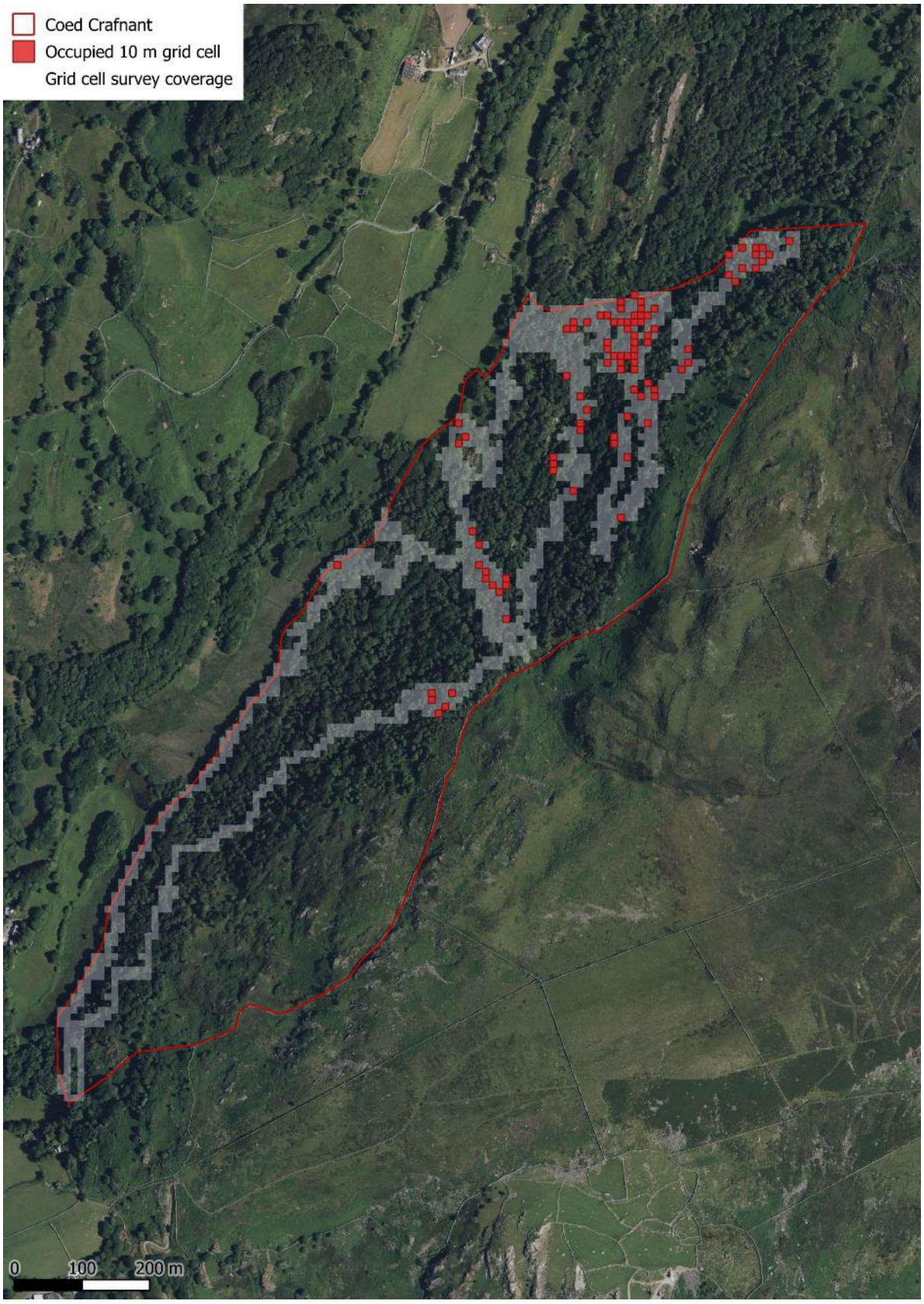
9.2.6. Plagiochila bifaria



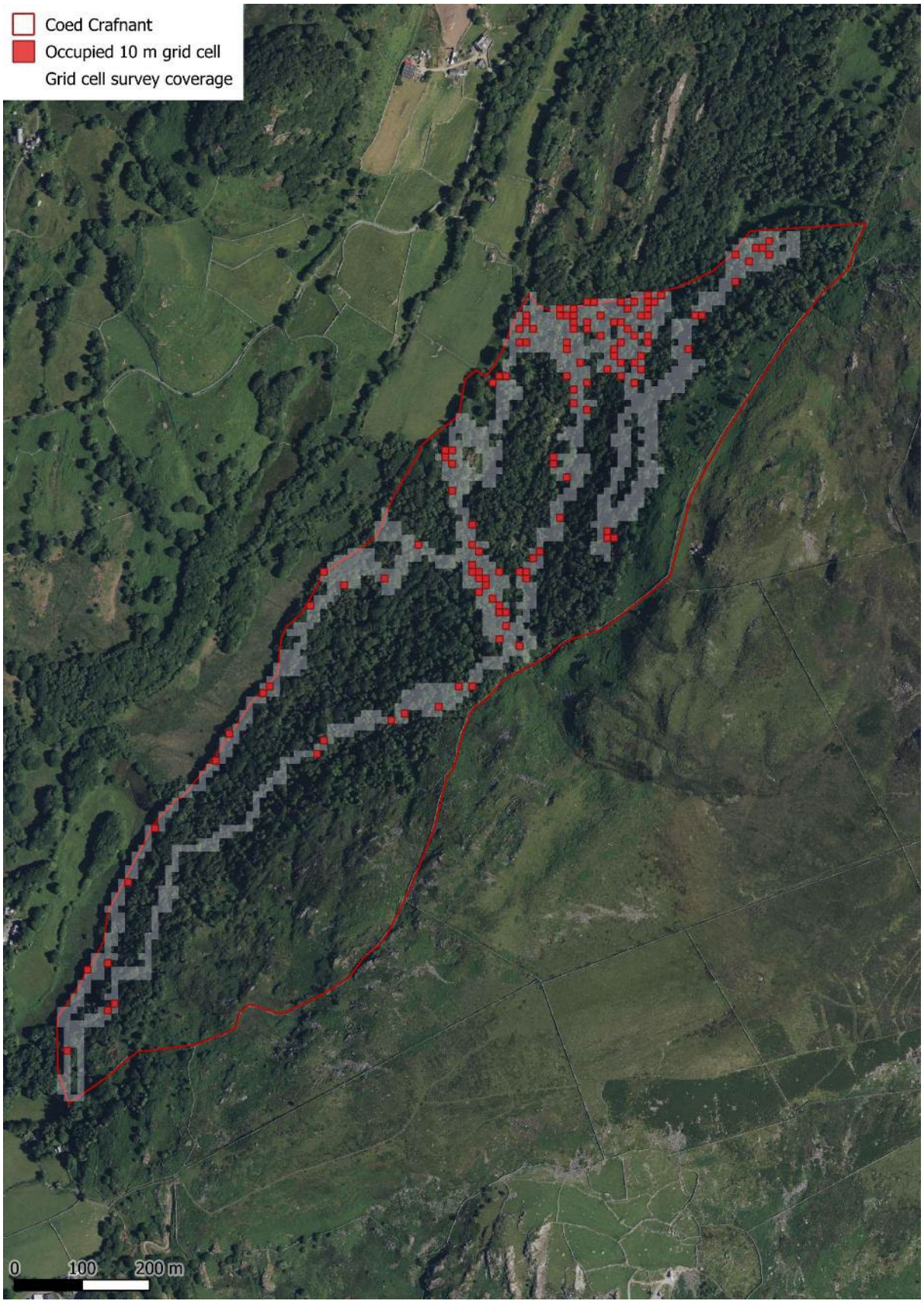
9.2.7. Plagiochila exigua



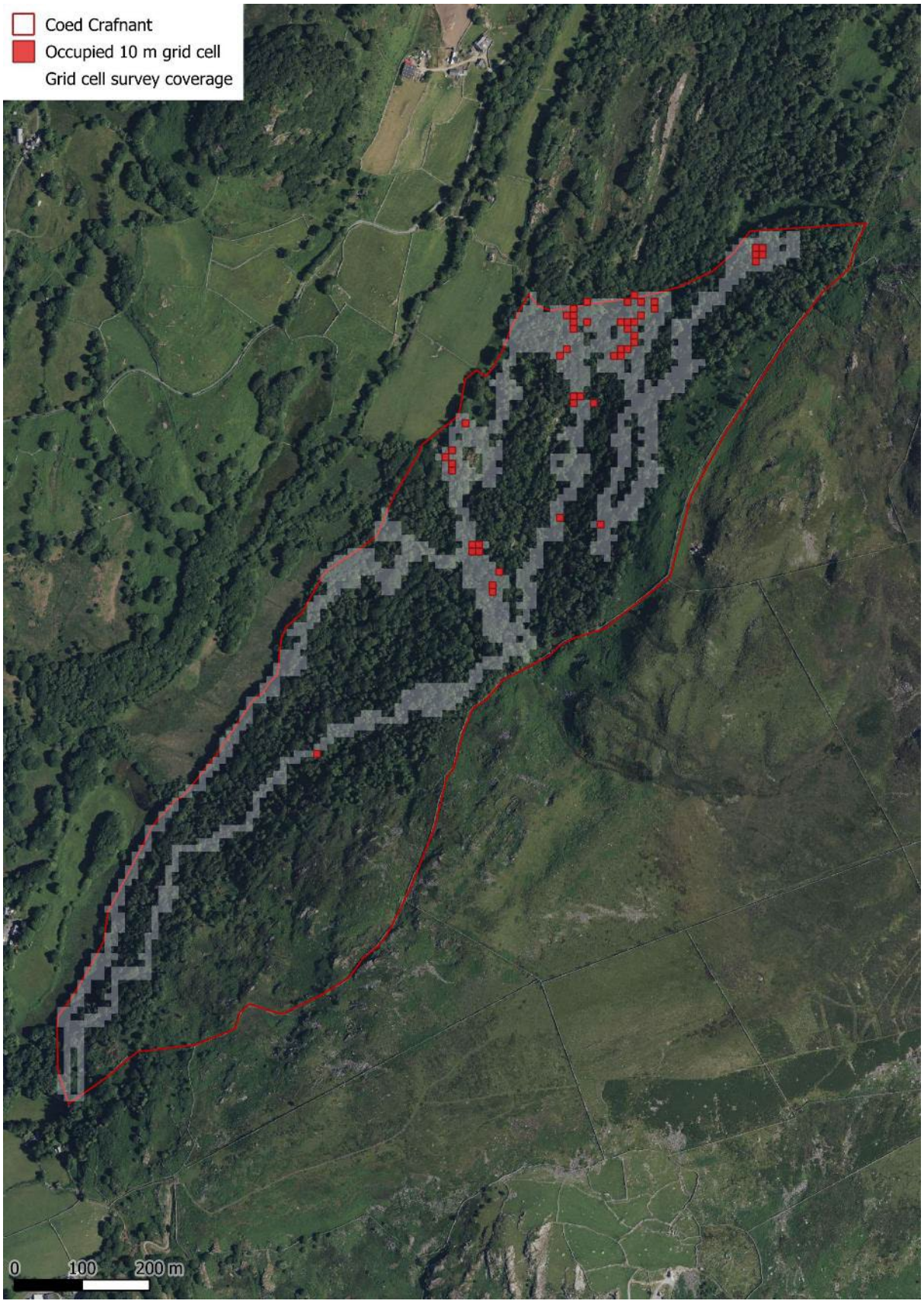
9.2.8. Plagiochila punctata



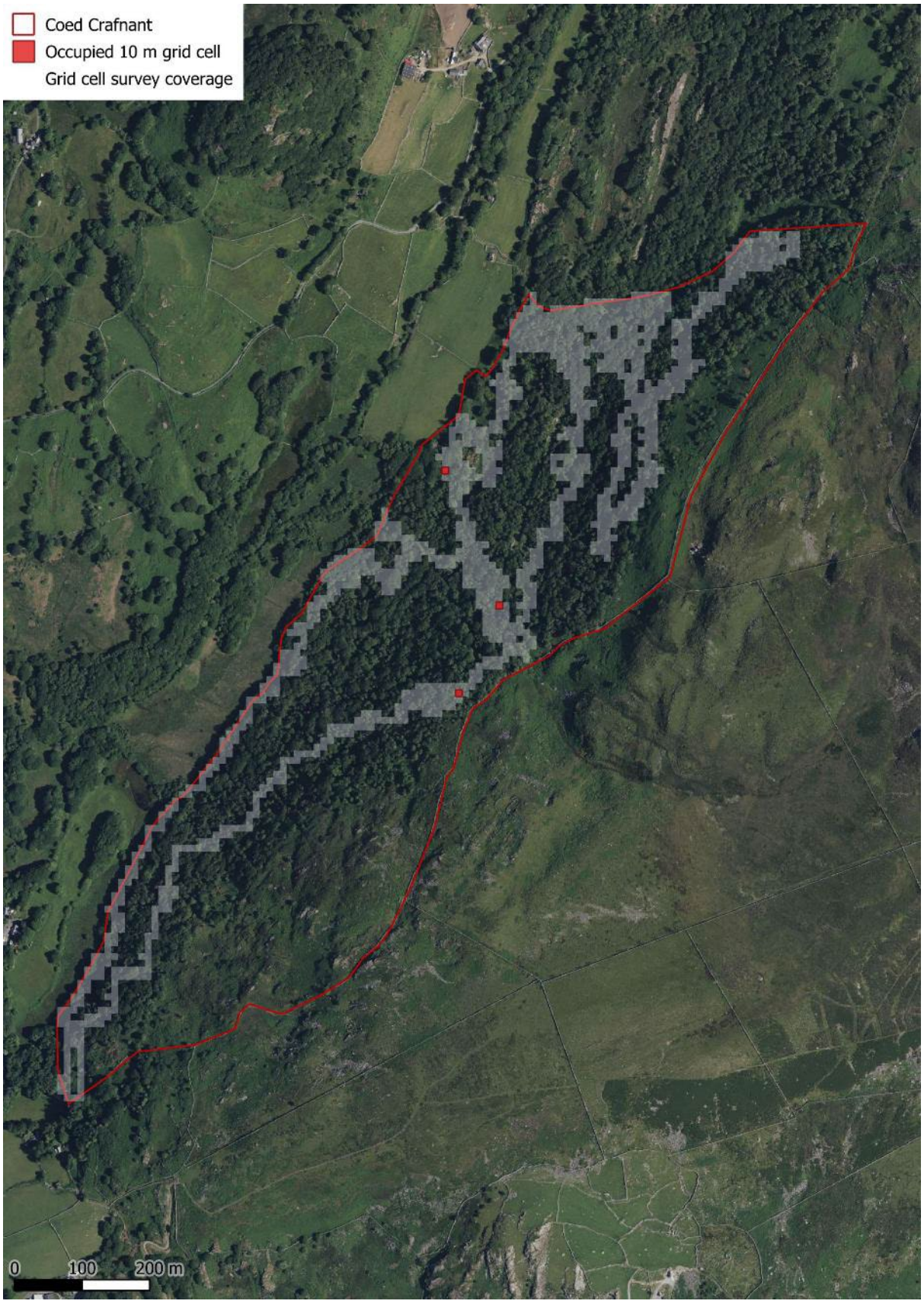
9.2.9. Plagiochila spinulosa



9.2.10. *Pseudomarsupidium decipiens*

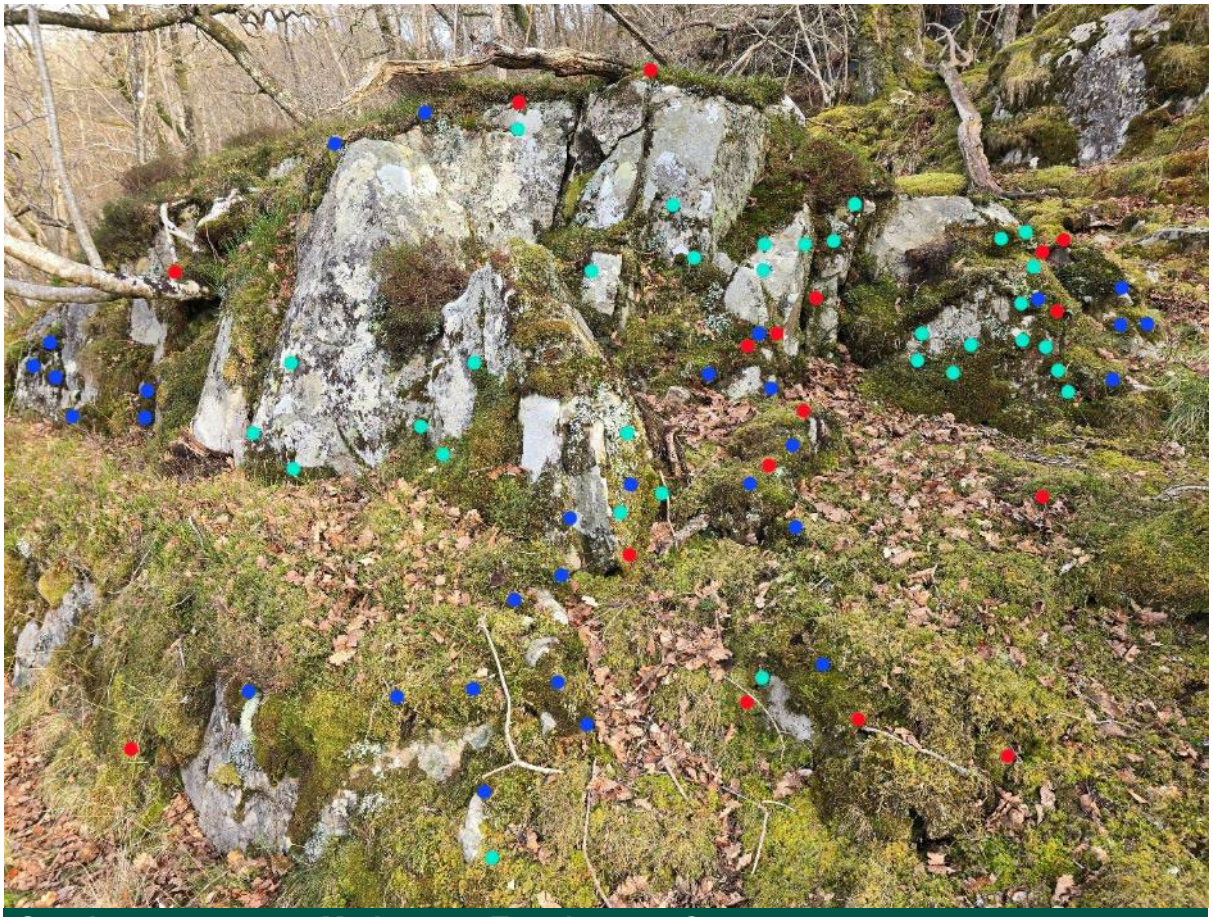


9.2.11. *Sematophyllum demissum*



9.3. Appendix 3: Fixed-point photographic monitoring plots

9.3.1. Plot 1 - SH6215728911



Species	Marker colour	Trend since 2014	Comments
Lepidozia cupressina	Red	Small decline	Vegetation structure remains similar. Trend may be related to natural patch dynamics.
Plagiochila punctata	Turquoise	unknown	Present but not marked-out in plot in 2014, so trend unknown
Pseudomarsupidium decipiens	Blue	Small increase	Vegetation structure remains similar. Trend may be related to natural patch dynamics.

9.3.2. Plot 2 - SH6188528832

Species	Marker colour	Trend since 2014	Comments
Lepidozia cupressina	Turquoise	unknown	Present but not marked-out in plot in 2014, so trend unknown
Plagiochila bifaria	Yellow	unknown	Present but not marked-out in plot in 2014, so trend unknown
Plagiochila spinulosa	Red	unknown	Present but not marked-out in plot in 2014, so trend unknown
Pseudomarsupidium decipiens	Blue	Small increase	Vegetation structure remains very similar. Trend may be related to natural patch dynamics.

9.3.3. Plot 3 - SH6169728598

Species	Marker colour	Trend since 2014	Comments
Plagiochila bifaria	Yellow	n/a	New plot established during present survey
Plagiochila spinulosa	Blue	n/a	
Sematophyllum demissum	Red	n/a	New colony discovered during present survey. Single colony, 12 x 9 cm.

9.3.4. Plot 4 - SH6216728923

Species	Marker colour	Trend since 2014	Comments
Drepanolejeunea hamatifolia	Red	n/a	New plot established during present survey
Lepidozia cupressina	Turquoise	n/a	
Plagiochila punctata	Pink	n/a	
Plagiochila spinulosa	Blue	n/a	
Pseudomarsupidium decipiens	Yellow	n/a	

9.3.5. Plot 5 - SH6172528598

Species	Marker colour	Trend since 2014	Comments
Lepidozia cupressina	Red	Stable	Some fine-scale gains and losses due to patch dynamics, but abundance approximately stable overall.

9.3.6. Plot 6 - SH6173628479

Species	Marker colour	Trend since 2014	Comments
Lepidozia cupressina	Red	Small decline	Decline mainly due to overgrowth by larger mosses, especially *Thuidium delicatulum*
Plagiochila bifaria	Purple	unknown	Not marked-out in 2014, so trend unknown
Plagiochila punctata	Pink	unknown	Not marked-out in 2014, so trend unknown
Plagiochila spinulosa	Turquoise	unknown	Not marked-out in 2014, so trend unknown
Pseudomarsupidium decipiens	Blue	Small decline	Decline mainly due to overgrowth by larger mosses, especially *Thuidium delicatulum*

9.3.7. Plot 7 - SH6463426658

Species	Marker colour	Trend since 2014	Comments
Jubula hutchinsiae	Red	Large increase	Reason for increase uncertain. Vegetation structure and stream conditions appear very similar.
Plagiochila spinulosa	Blue	n/a	Not marked-out in 2014, so trend unknown

9.3.8. Plot 8 - SH6464126664

Species	Marker colour	Trend since 2014	Comments
Plagiochila bifaria	Turquoise	unknown	Not marked-out in 2014, so trend unknown
Plagiochila punctata	Red	unknown	Not marked-out in 2014, so trend unknown
Plagiochila spinulosa	Blue	unknown	Not marked-out in 2014, so trend unknown
Sematophyllum demissum	Black	Extinct	Original colony of 30 x 10 cm in 2014 declined to 1 x 2 cm by 2022 and is now extinct due to competitive exclusion by larger bryophytes, especially *Thuidium tamariscinum*

9.3.9. Plot 9 – SH6171428660

Species	Marker colour	Trend since 2014	Comments
Cololejeunea microscopica	Blue	n/a	New plot established during present survey
Harpalejeunea molleri	Red	n/a	
Plagiochila bifaria	Turquoise	n/a	

9.3.10. Plot 10 – SH6177828395

Species	Marker colour	Trend since 2014	Comments
Plagiochila bifaria	Turquoise	n/a	New plot established during present survey
Plagiochila spinulosa	Blue	n/a	
Sematophyllum demissum	Red	n/a	New colony discovered during present survey. Single colony, 20 x 15 cm.

9.3.11. Plot 11 – SH6171228267

Species	Marker colour	Trend since 2014	Comments
Plagiochila spinulosa	Blue	n/a	New plot established during present survey
Sematophyllum demissum	Red	n/a	Single, large, partially fragmented colony of 50 x 40 cm

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.

The metadata for this project is held as record no NRW_DS161365.

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