Habitat Map of Wales resurvey pilot – analysis

Report No: 696

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Crynodeb Gweithredol

Oherwydd oedran y fersiwn gyfredol o Fap Cynefinoedd Cymru, sy'n seiliedig ar arolygon a gynhaliwyd rhwng 1979 a 1997, mae Cyfoeth Naturiol Cymru (CNC) yn dymuno datblygu methodoleg ar gyfer ailfapio cynefinoedd Cymru yn fanwl gywir, gan fynd ati'n arbennig i archwilio pa mor ddichonadwy fyddai cynnal unrhyw arolwg dilynol – neu ran ohono, o leiaf – trwy ddefnyddio technegau synhwyro o bell.

Mae'r adroddiad hwn yn ymdrin â dadansoddiad a gynhaliwyd ar bedair o setiau data cynefinoedd GIS, er mwyn asesu a chymharu effeithiolrwydd a dibynadwyedd posibl technegau arolygon maes a thechnegau synhwyro o bell fel dulliau o ddiweddaru'r Map Cynefinoedd. Roedd y data'n cynnwys y canlynol:

- Yr arolwg maes gwreiddiol o gynefinoedd Cam 1 a gwblhawyd rhwng 1979-1997 (Mapdata.llyw.cymru 2022).
- Arolwg maes diweddarach o gynefinoedd Cam 1 a oedd yn cwmpasu tetradau 30 x 4 cilometr (km2), a gwblhawyd yn 2022 (Hudson, 2023).
- Map Cynefinoedd Cymru Fyw (2022) a luniwyd trwy ddefnyddio data synhwyro o bell.
- Map cynefinoedd Cam 1 Castell-nedd Port Talbot a luniwyd trwy ddefnyddio data synhwyro o bell (2020) (Environment Systems, 2021).

Canolbwyntiodd yr elfen o'r gwaith hwn ar Fap Cynefinoedd Cymru Fyw 2022, gan ddisodli dadansoddiad cychwynnol lle defnyddiwyd set ddata Cymru Fyw a luniwyd yn 2020.

Er mwyn cynnal y dadansoddiad, sefydlwyd grid o bwyntiau ar bellter o 25m, a droshaenwyd ar bob haen. Amcangyfrifwyd gwahaniaethau yn y cynefin a bennwyd rhwng a) setiau data'r arolygon maes Cam 1 a gynhaliwyd yn 1979-97 a 2022 a b) cywirdeb y ddwy set ddata a synhwyrwyd o bell yn erbyn y cynefinoedd Cam 1 a ail-arolygwyd yn 2022. Defnyddiwyd parthau clustogi o 10m o amgylch polygonau cynefinoedd er mwyn lleihau 'effeithiau ffiniau' a gwallau mapio.

Dadansoddwyd y data er mwyn gweld beth oedd y cynnydd neu'r gostyngiad yng nghanran gyffredinol y nifer o bwyntiau a neilltuwyd i gynefinoedd arbennig fel y'u mapiwyd gan Cymru Fyw a Chastell-nedd Port Talbot. Ochr yn ochr â hyn, cyfrifwyd maint pob math o gynefin fel cyfanswm, gan ei hollti rhwng ucheldiroedd ac iseldiroedd a rhwng Castell-nedd Port Talbot a Sir Gâr.

Ar ôl cael gwared â ffiniau'r Rhestr Goedwigoedd Genedlaethol, cadarnhaodd y gymhariaeth rhwng haen wreiddiol 1979-97 a'r haen a ail-arolygwyd yn 2022 fod y newidiadau mewn haenau wedi digwydd yn bennaf yn sgil newidiadau naturiol (olyniaethol) neu ddisgwyliedig (artiffisial) mewn cynefinoedd yn y blynyddoedd rhwng yr arolygon.

Mae arolwg Castell-nedd Port Talbot yn addawol iawn yn yr ystyr ei fod wedi amffinio cynefinoedd agored â blaenoriaeth yn eu cyfanrwydd, hyd at gywirdeb derbyniol, gan ei gwneud yn bosibl i ddefnyddio'r wybodaeth honno i gadarnhau ardaloedd o gynefinoedd agored. Fodd bynnag, arweiniodd gwaith mapio gormodol ar goetiroedd at gynnydd mawr yn y nifer o bwyntiau anghywir a gofnodwyd ar gyfer cynefinoedd coetir.

Mae set ddata Cymru Fyw 2022 yn cynnwys categorïau cynefin ehangach megis ‘brwyn Juncus’, ‘Glaswelltiroedd lled-naturiol’ a ‘Glaswelltiroedd Molina’, felly roedd yn anodd dwyn cymhariaeth uniongyrchol rhwng rhai cynefinoedd.

Caiff mapiau Castell-nedd Port Talbot a Cymru Fyw eu llunio ar sail data arsylwi ar y Ddaear, ac yn arbennig yn achos dosbarthiadau cynefinoedd manylach, go brin y gellir eu cymharu â gwaith mapio Cam 1 a gynhaliwyd trwy gynnal arolygon ar lawr gwlad. Cafodd mapiau Cymru Fyw a Chastell-nedd Port Talbot anhawster i gofnodi a gwahaniaethu rhwng maint a dosbarthiad glaswelltiroedd sych a glaswelltiroedd corsiog, pan wahaniaethwyd rhyngddynt.

Er bod modd i ddata synhwyro o bell gyflwyno gwybodaeth am faint rhai cynefinoedd, daeth yr astudiaeth i’r casgliad y bydd gwaith mapio a disgrifiadau sy’n deillio o arolygon maes yn cynnig gwell cywirdeb a gwell manylion, yn enwedig ar gyfer cynefinoedd agored. Fodd bynnag, mae ymestyn arolygon maes i’r dirwedd ehangach yn elwa’n fawr ar ddefnyddio data synhwyro o bell, a dylid defnyddio’r ddau ddull ar y cyd wrth fapio cynefinoedd yn y dyfodol.

Yn gyffredinol, bu set ddata Castell-nedd Port Talbot, sy’n statig ei natur, yn gywir iawn o ran dosbarthu cynefinoedd eang (sef clytweithiau o rostiroedd a choetiroedd) a chynigiodd gywirdeb o oddeutu 90% ar gyfer cynefinoedd agored (yn cynnwys glaswelltiroedd lled-naturiol, rhostiroedd, a gwlyptiroedd). Mewn cyferbyniad, bwriedir i fap Cymru Fyw gael ei ddiweddaru’n barhaus, gyda’r gallu i integreiddio gwelliannau i’r algorithmau ar gyfer gwahaniaethu ar sail adborth gan ddefnyddwyr, yn cynnwys o bosibl adborth gan yr astudiaeth hon pan dynnwyd sylw at wallau..

Executive summary

Due to the age of the existing Habitat Map of Wales, which is based on surveys undertaken between 1979 and 1997, Natural Resources Wales (NRW) wishes to develop a methodology to accurately remap the habitats of Wales, and in particular, to explore the feasibility of conducting at least part of any update survey using remote sensing techniques.

This report covers an analysis of four sets of GIS habitat data, to assess and compare the potential effectiveness and reliability of ground-based (field) survey and remote sensing techniques as methods to update the Habitat Map. The data comprised:

- The original Phase 1 habitat field-survey completed between 1979-1997 (Datamap.gov.wales 2022).
- An updated Phase 1 habitat field-survey covering 30 x 4 kilometre (km^2) tetrads, completed in 2022 (Hudson, 2023).
- The Living Wales Habitat Map (2022) obtained from remote sensing data .
- Neath Port Talbot's (NPT) remote sensed Phase 1 habitat map 2020 (Environment Systems, 2021).

The component of this work focused on the Living Wales Habitat Map 2022, superseding an initial analysis using a Living Wales dataset produced in 2020.

To perform the analysis, a grid of points at 25 m intervals was established and overlain onto all layers. Differences in the habitat identified between a) the 1979-97 and 2022 Phase 1 field-survey datasets and b) the accuracy of the two remote sensed datasets against the 2022 resurveyed Phase 1 was estimated. Habitat polygons were buffered by 10m to reduce 'boundary effects' and mapping errors.

The data were analysed to provide an overall percentage increase or decrease in the number of points assigned to a particular habitat as mapped by LW and NPT. Alongside this, the extent of each habitat type was calculated as a total and split between upland or lowland, and between Neath Port Talbot or Carmarthenshire.

The comparison between the original 1979-97 layer and the 2022 re-survey layer confirmed, once the full National Forest Inventory (NFI) extent had been removed, that the changes in layers were largely due to natural (successional) or expected (man-made) habitat changes over the intervening years.

The NPT resurvey does show significant promise in that it delimited open priority habitats as a whole, to an acceptable accuracy, which could then be used to ground truth open habitat areas. However, excessive mapping of woodland caused a significant rise in the number of erroneous points recorded for woodland habitats.

The 2022 Living Wales dataset includes some broader habitat categories such as '*Juncus* rushes', 'Semi-natural grassland' and '*Molinia* grassland', making direct comparisons between some habitats difficult.

The NPT and LW maps are generated from Earth observation data and, particularly in the case of more detailed habitat classes, are unlikely to be comparable to Phase 1 mapping undertaken through ground survey. Both LW and NPT maps had difficulty in differentiating

and capturing the extent and distribution of dry grasslands and marshy grasslands, where these had been differentiated.

The study concluded that whilst remote sensing data can provide information on the extent of some habitats, mapping and descriptions through ground survey will provide a greater level of accuracy and detail, especially for open habitat types. However, extending field surveys to the wider landscape benefits significantly from the use of remote sensing data and the two should be used in combination in future habitat mapping.

The NPT dataset, which is static in nature, provided high overall accuracies in the classification of broad habitat types (namely heathland mosaics and woodland) and approximately 90 % for open habitats (including semi-natural grassland, heathland, and wetland). The LW map is, in contrast, designed to be continually updated, with the ability for refinements to the algorithms for discrimination to be integrated based on user feedback, including potentially from this study where errors have been highlighted.

Report

Introduction

Wales is unique in Europe in having comprehensive field survey-based habitat data at a field parcel level for the whole country (Blackstock et al, 2010). These data were collected during two surveys: the Upland Survey (covering 20% of Wales) from 1979 to 1986, and the Lowland Survey from 1987 to 1997. The results of both surveys are available together in GIS format (https://datamap.gov.wales/), as maps of 115 habitat types, defined in accordance with the Phase 1 habitat classification methodology (Joint Nature Conservation Committee, 2016). Much of the Upland data is derived from an earlier classification (Birks & Ratcliffe 1980), from which Phase 1 classes were interpreted, and also included extensive areas which were classed as habitat mixtures or mosaics.

Since collection, the data have had an extremely broad range of uses and, as an open data source, the maps provide the vast majority of information available on the extent and location of 'priority habitats' (as listed under Section 7 of the Environment (Wales) Act 2016) to many stakeholders in Wales.

However, due to the age of the existing Habitat Map of Wales, Natural Resources Wales (NRW) wishes to explore options for updating and remapping the habitats to an acceptable level of accuracy and the feasibility of conducting at least part of an update survey using remote sensing techniques.

This document reports the findings of an assessment of the potential effectiveness and reliability of remote sensing data for updating the Habitat Map of Wales. To inform this assessment, an updated field-based Phase 1 Survey of a defined area in south Wales was conducted in 2022 (Hudson, 2023), with the data used to evaluate two approaches to mapping habitats using remote sensing data. A comparison of the 1979-1997 and 2022 Phase 1 habitat surveys was also undertaken to provide an insight into habitat changes that have occurred over this period.

This is a second iteration of the analytical work following an updated release of the Living Wales remote sensing layers in 2022.

Methods

Data Sources

The following data sources were provided by NRW or are available on-line as open data and in a GIS format.

Field Survey data:

- The original terrestrial Phase 1 habitat field-survey completed between 1979-1997, covering the entirety of Wales, which informed the existing Habitat Map of Wales (DataMapWales).
- An updated Phase 1 habitat field-survey completed in 2022, covering 30 x 4 kilometre (km^2) tetrads. Areas of urban land (as defined by OS Mastermap), areas of the National

Forest Inventory (NFI) and areas of arable land (Welsh Government data) were excluded from the survey on the basis that these data could be relied upon as reasonably accurate.

Remote sensed habitats maps:

- Neath Port Talbot's (NPT) Phase 1 habitat map (Environment Systems, 2021). This layer covers the whole of Neath Port Talbot unitary authority, but only half (15) of the 30 selected 4 km^2 tetrads surveyed in the 2022 field survey. The maps were generated by manually interpreting very high-resolution imagery from Pleiades and lower resolution imagery from Sentinel 1 and Sentinel 2 satellites, captured in 2020, and a time-series of optical and radar imagery, producing a final dataset at 2m resolution (Environment Systems, 2021).
- The Living Wales Habitat Map was generated for the year 2022. The mapping was undertaken using a combination (across three years) of Sentinel-1 C-band Synthetic Aperture Radar (SAR) and Sentinel-2 optical data (at 10 m spatial resolution) to map broad land covers and dominant vegetation types. Contextual information obtained from a range of sources including the Wales Peat Depth map and the original Phase 1 Survey was then used to allocate pixels to classes that aligned with the Phase 1, noting that LW map was not intended as a fully revised Phase 1 product. The LW map covers the entirety of Wales at 10 metre (m) resolution. These data were supplied as a raster and so were converted into a vector layer using QGIS. The resolution was retained through the vectorisation process.

In addition, NRW provided the following information in GIS format:

- 30 x 4 km^2 tetrads comprising the 2022 survey area.
- The Wales upland boundary, with this digitized to define the upper limit of enclosure so as to distinguish upland and lowland habitats. The original field surveys were carried out from 1979-99 as part of a national habitat survey project required to implement conservation at a local level. The boundary was verified and digitised in 2000.

Figure 1: Visual comparison of the four datasets: the original 1979-97 Phase 1 (top left), the 2022 resurveyed Phase 1 (top right), the LW remotely sensed habitat map (bottom left) and the NPT remotely sensed Phase 1 (bottom right). Crown copyright and database rights 2023 Ordnance Survey 100019741

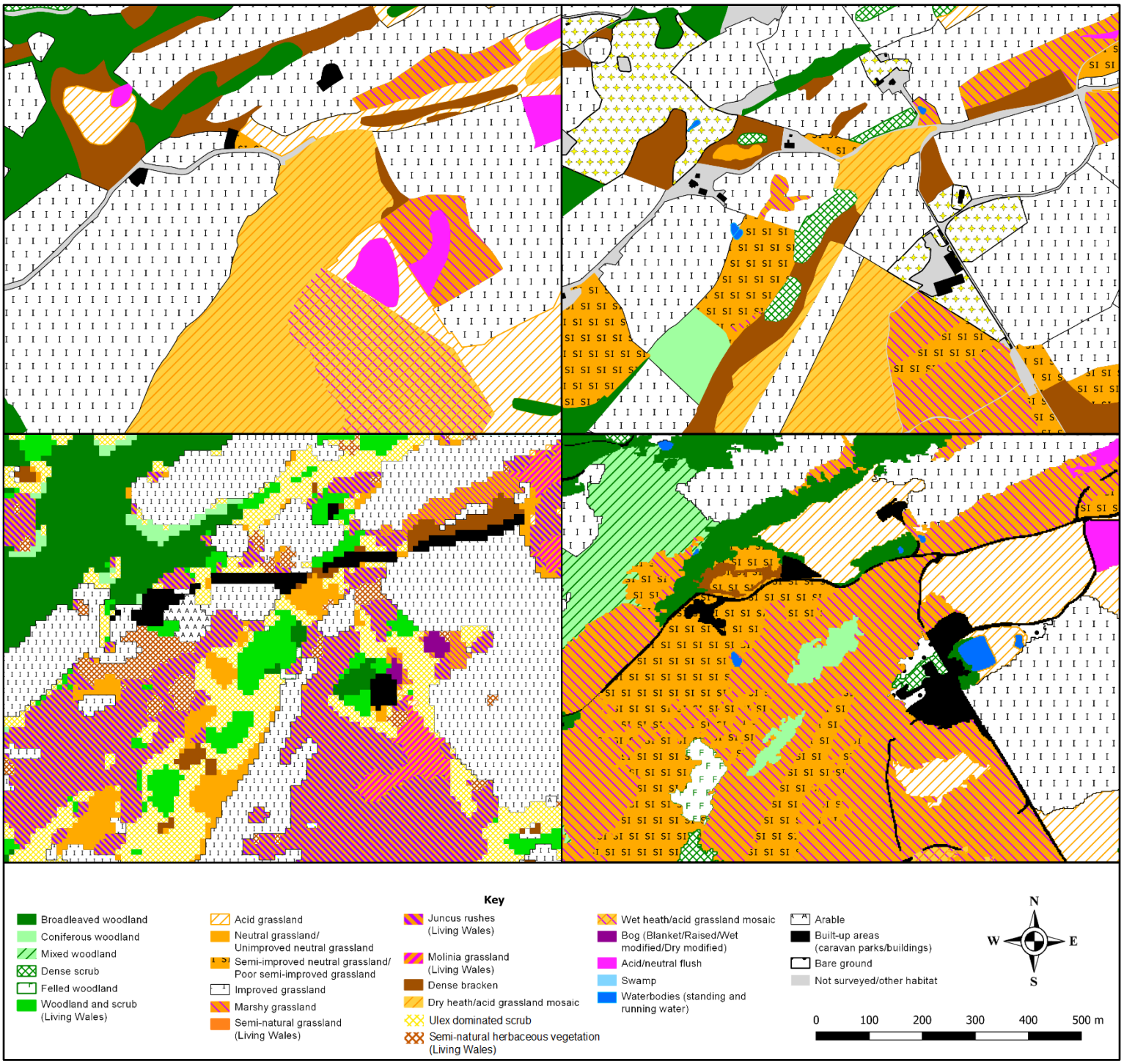
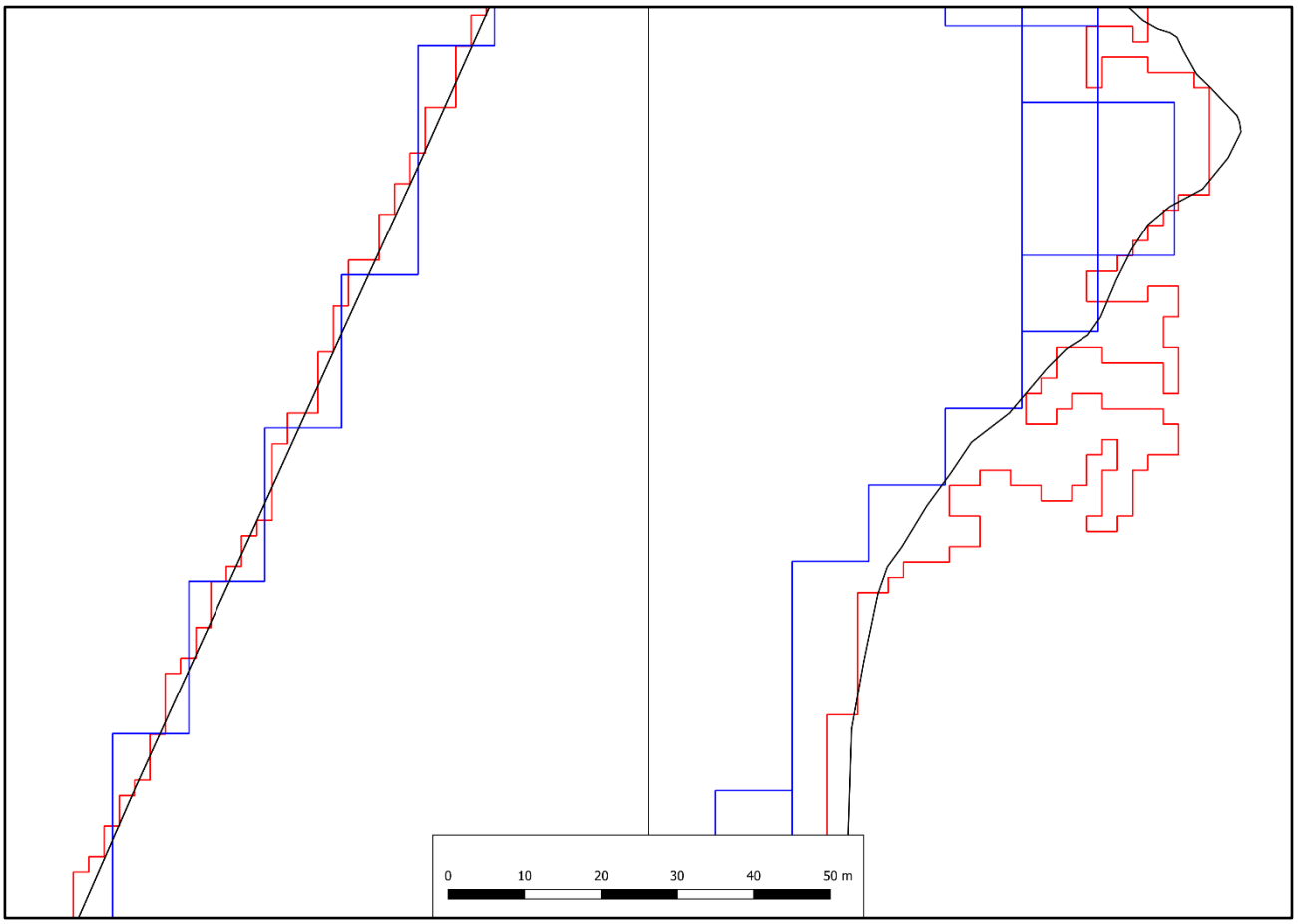


Figure 2: A close look at the boundary mapping of the two remote sensed layers against the 2022 resurveyed layer. This also highlights the difference in resolution between the two remote sensed layers. The 2022 resurveyed Phase 1 in black, Living Wales remote sensed habitat map in blue and the Neath Port Talbot remote sensed Phase 1 in red. The example on the left shows the two remote sensed layers very closely matched to the 2022 dataset. The example on the right shows the much more 'organic' mapping of the remote sensed layers boundaries compared to the 2022 dataset. This example is more representative of the wider remote sensed datasets.

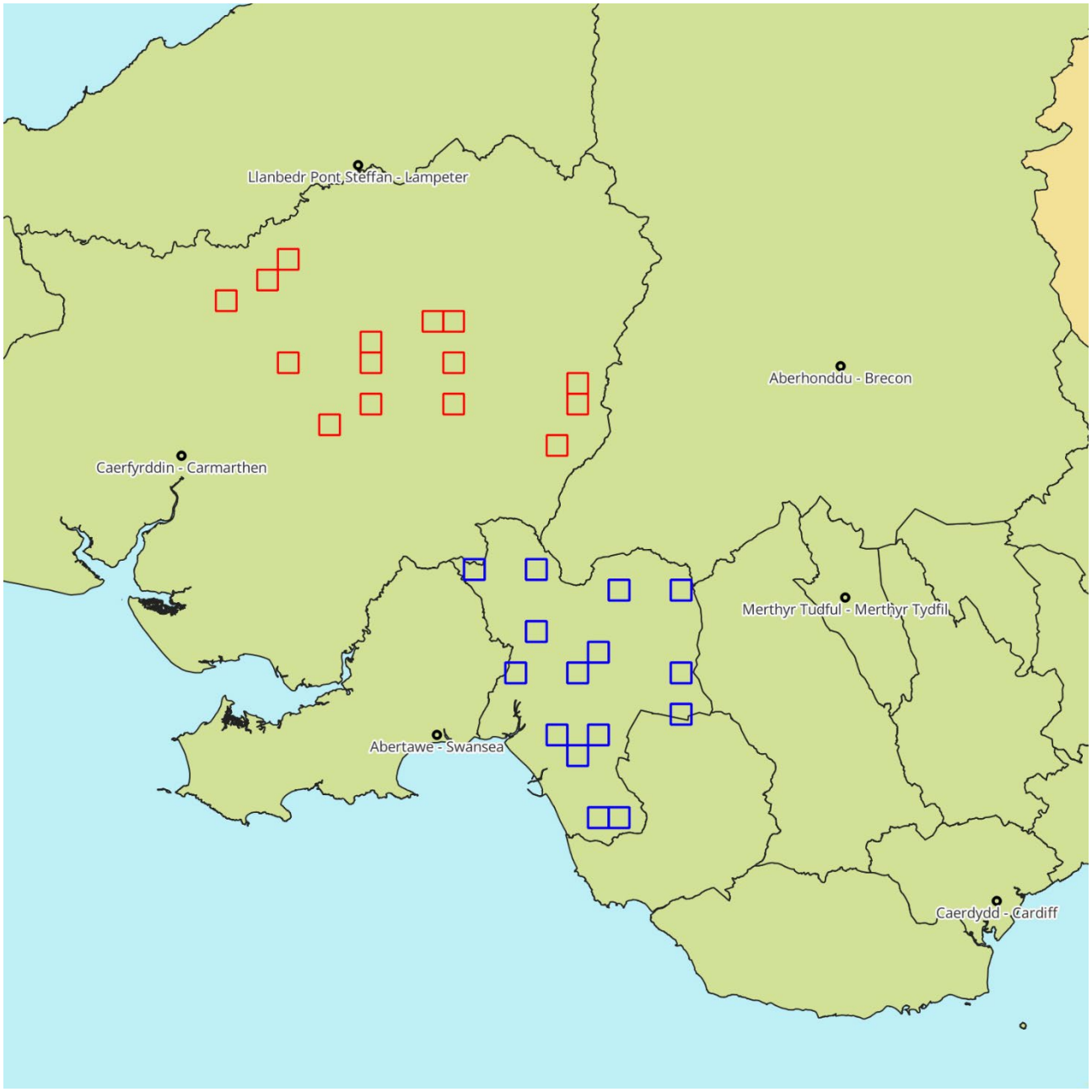


Data Analysis

The analysis of the data provided by NRW was undertaken using QGIS 3.28.2 (QGIS 2022).

The GIS data layers were reduced in extent (clipped) using QGIS, to cover just the 30 x 4 km^2 tetrads defined by NRW, as shown on Figure 3.

Figure 3: Distribution of the 30 survey tetrads in the counties of Neath Port Talbot and Carmarthenshire. The 2022 Phase 1 resurvey, 1979-1997 Phase 1 and Living Wales data covers both the blue and red tetrads. The Neath Port Talbot Phase 1 data covers only the blue tetrads.



Habitat Areas

Areas of each habitat type included in each of the four habitat datasets were calculated by first splitting each of the associated GIS layers by the upland boundary, so that lowland and upland areas could be evaluated separately. This was undertaken because the original upland Phase 1 data includes many mosaic (mixture) polygons to which only the first named habitat could be assigned. These data are therefore generally less accurate than for the lowlands, where each polygon represents a single habitat class. Each habitat area (polygon) mapped within the upland boundary was then assigned an attribute in QGIS to distinguish it

from those occurring in the lowlands. Polygons were also assigned an attribute to define whether they occurred in Neath Port Talbot or Carmarthenshire. The areas of each polygon were then automatically calculated. Each layer was then outputted to Excel and organised into a table so that comparisons of habitat areas could be made across the four datasets. See appendix 1.

Point Sampling Analysis

To compare the differences in habitat types between in the four datasets, a point sampling technique and point sample layer generation were undertaken, as described below.

- A GIS layer comprising a grid of points spaced at 25 m distances was created and overlaid onto the layer comprising the 30 tetrads. A 25m grid was chosen to provide a substantial data sample without being too numerous (e.g. 10x10m grid) as to slow processing or a wider grid (e.g. 50x50m grid) that provides fewer samples and would potentially miss or under record many of the smaller habitat parcels.
- Following this, both the 1979-1997 and 2022 Phase 1 GIS layers were 'negatively buffered'. To negatively buffer is to 'trim' a polygon by a defined amount. In this case the polygons were negatively buffered by 10 m to create a separation of 20 m between any neighbouring polygons within the same dataset. This separation is to avoid minor differences in habitat boundary mapping between the datasets, such as hedge lines or minor mapping errors, which could cause a skew in the data analysis.
- The point grid was overlain onto the negatively buffered 2022 Phase 1 dataset, and the point grid layer was then clipped to the extent of the 2022 dataset (see Figure 4 below) removing any points which fell outside the 2022 dataset. This was to reduce the number of points being analysed that would otherwise have no data due to falling within the buffered regions or which fell in areas previously defined by the NFI or as urban or arable land cover and which had been excluded from the 2022 survey.

Figure 4: Two example tetrads containing the point sample grid clipped to the 2022 Phase 1 resurvey layer (blue polygons), which has been negatively buffered by 10 m.

- In order to remove some discrepancies in the NFI boundary recorded on the 2022 Phase 1 resurvey dataset, the point grid also required clipping to the latest NFI boundary.
- The 15 tetrads within NPT contained 42,745 points. The 15 tetrads within Carmarthenshire contained 60,357 points.
- Each point was assigned a unique identification number so that exact comparisons could be made at the same location across the four datasets.
- All points within the upland boundary were assigned an attribute to distinguish them from the lowland.
- The habitat recorded at each point, for each of the four survey datasets, was attributed to that point.
- The attributed point samples for each dataset were then outputted into Excel.

With reference to the unique identification numbers assigned to each point, the habitats recorded at each point were then compared between:

- 1979-1997 and 2022 Phase 1 survey datasets.
- Living Wales remote sensed dataset and the 2022 field survey dataset; and
- Neath Port Talbot remote sensed dataset and the 2022 field survey dataset.

To provide a measure of the scale of ecological difference between the habitats recorded at each sample point by the different surveys, a habitat divergence rating was assigned based on the following categories that were pre-defined by NRW:

- Match (the same habitat in both surveys)
- Low divergence (a closely related habitat)
- Medium divergence
- High divergence (an unrelated habitat)

- Not applicable (e.g., this could be a result of a lack of access during a survey, the habitat was not defined but mapped as 'other', or the area could not be calculated due to the linear nature of the habitat category)

Thus, for instance, a change from woodland to grassland *or vice-versa* was considered high divergence, but in contrast, a change from acid grassland to heath/grassland mosaic or from acid grassland to neutral grassland was scored as low divergence. The divergence ratings were formalised into a 'matrix of divergence' provided in Appendix 1.

For the comparison between the 2022 Phase 1 resurvey and the 1979-1997 Original Phase 1 sample points, the divergence was scored for each sample point, in accordance with the matrix of divergence (Appendix 1). To assign the divergence efficiently, a series of columns containing IF conditional formulas were created in Excel, with an individual column for each of the potential divergence outputs (i.e., match, low, medium, high, not applicable). An IF conditional formula was used to compare the habitats recorded in 2022 and between 1979-1997 for a single point, with a return of 1 (correct or match) or 0 (incorrect or no match) response. So, the formula in the first column asked if the 2022 habitat matched the 1979-1997 habitat. The second column asked if the 2022 habitat was any of the low divergence habitat options. The third column asked if the 2022 habitat was any of the medium divergence habitats. The fourth column asked if either column contains 'NA', 'No Data' or 'NA-HEDGE-OTHER'. If all previous columns return 0 then the final column returned a 1 for a high divergence habitat. These formulae were applied to all of the individual sample points, tailored to the habitats being compared.

Using a pivot table, these binary comparisons were totalled for each habitat type, and separated by their location in relation to upland and lowland areas. The totals for each habitat type were then displayed as percentages for each divergence rating. The total number of sample points where each habitat was recorded in 2022 was also compared, and the 2022 dataset was given a percentage loss or gain.

The same point sample comparison methodology was undertaken for the comparisons of the results of the two remote sensed datasets against the 2022 field survey dataset, which was considered to be the correct baseline.

Results

Comparisons of the four survey datasets are provided in Appendix 2, with areas subdivided by Country and whether they were upland or lowland. The comparison of the 2022 survey dataset against the original 1979-97 survey is provided in Appendix 3 (and summarised in Table 1). These results are displayed showing the percentage change in the number of points and the percentage breakdown of the divergence categories for each habitat. The appendix includes a second table that divides the results by location within the uplands or lowlands.

Table 1: The percentage change in habitats between the 1979-97 Phase 1 survey and the 2022 Phase 1 resurvey using sample point analysis. Sample points with no data in 2022 and habitats with less than 200 sample points in both surveys are not included.

Phase 1 habitat name (JNCC 2016)	**Number of points 1979-97**	**Number of points 2022**	**% change in habitat cover**
Broadleaved woodland	265	539	103.4
Coniferous Woodland	502	22	-95.6
Dense Scrub	53	789	1388.7
Acid Grassland	10447	14004	34.0
SI Neutral/Poor SI Neutral Grassland	3749	5090	35.8
Improved Grassland	56305	53391	-5.2
Marshy Grassland	10202	7445	-27.0
Bracken	2442	4412	80.7
Dry Dwarf Shrub Heath/Dry Acid Heath	2840	2017	-29.0
Wet Heath	4129	4460	8.0
Dry Heath/Acid Grassland Mosaic	2533	3034	19.8
Wet Heath/Acid Grassland Mosaic	244	672	175.4
Bogs	327	492	50.5
Acid/Neutral Flush	224	250	11.6
Artificial Bare Surface	299	12	-96.0
Arable	888	3379	280.5

The comparison of the LW map against the 2022 Phase 1 update survey is provided in Appendix 4 and show the percentage change in the number of points and the percentage breakdown of the divergence categories for each habitat. A second table divides the results by location within the uplands or lowlands. The breakdown of uplands and lowlands is not discussed further for the Living Wales dataset in this report but is included for potential future interpretation.

The following tables show the breakdown of how the Phase 1 2022 field survey points identified as acid grassland (B1), semi-improved neutral grassland (B.2.2), improved grassland (B.4), marshy grassland (B.5), bracken (C.1.1), dry dwarf shrub heath/dry acid heath (D.1), wet heath (D.2), dry heath/acid grassland mosaic (D.5), wet heath/acid grassland mosaic (D.6) and bogs (E.1) were classified by the **Living Wales** remote sensed survey. Habitats with low numbers of sample points are not tabulated.

Table 2.1: Breakdown of how the 2022 Phase 1 field survey points identified as **acid grassland (B1)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 Acid grassland (B1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Acid Grassland	5206	37	Match
Molinia Grassland	4380	31	High
Improved Grassland	996	7	Medium
Dry Dwarf Shrub Heath/Dry Acid Heath	527	4	Medium

Phase 1 2022 Acid grassland (B1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Marshy Grassland	520	4	Medium
Semi-natural Grassland	510	4	Medium
Juncus rushes	426	3	High
Dense scrub	366	3	High
Bogs	350	2	High
Neutral Grassland	344	2	Low
Dense Bracken	235	2	Medium
Woodland and Scrub	34	0	High
Broadleaved woodland	30	0	High
Arable	24	0	High
Artificial bare surface	20	0	High
Waterbodies (standing and running)	**15**	**0**	**High**
Felled woodland	11	0	High
Coniferous woodland	10	0	High
Total number of sample points (2022):	**14004**	**100**	-

Table 2.2: Breakdown of how the 2022 Phase 1 field survey points identified as **semi-improved neutral grassland (B.2.2)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 semi-improved neutral grassland (B.2.2) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Semi-improved neutral grassland	0	0	Match
Juncus rushes	1809	36	High
Improved Grassland	1535	30	Low
Semi-natural Grassland	392	8	High
Dense scrub	265	5	High
Woodland and Scrub	236	5	High
Neutral Grassland	203	4	Low
Broadleaved Woodland	161	3	High
Marshy Grassland	142	3	High
Acid Grassland	137	3	Medium
Molinia Grassland	86	2	High
Dense Bracken	47	1	Medium
Arable	26	1	High
Bogs	18	0	High
Artificial bare surface	13	0	High
Swamp	9	0	High
Dry Dwarf Shrub Heath/Dry Acid Heath	6	0	High
Coniferous Woodland	5	0	High
Grand Total	**5090**	**100**	-

Table 2.3: Breakdown of how the 2022 Phase 1 field survey points identified as **improved grassland (B.4)** were classified by the Living Wales remote sensed survey

Phase 1 2022 improved grassland (B.4) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Improved Grassland	40683	76	Match
Juncus rushes	3638	7	High
Arable	2859	5	Medium
Semi-natural Grassland	2083	4	High
Neutral Grassland	1467	3	Medium
Dense scrub	986	2	High
Woodland and Scrub	586	1	High
Broadleaved Woodland	414	1	High
Marshy Grassland	200	0	High
Acid Grassland	145	0	Medium
Dense Bracken	128	0	High
Coniferous Woodland	80	0	High
Artificial bare surface	54	0	High
Molinia Grassland	51	0	High
Swamp	7	0	High
Bogs	6	0	High
Dry Dwarf Shrub Heath/Dry Acid Heath	3	0	High
Felled woodland	1	0	High
Grand Total	**53391**	**100**	-

Table 2.4: Breakdown of how the 2022 Phase 1 field survey points identified as marshy grassland (B.5) were classified by the Living Wales remote sensed survey.

Phase 1 2022 marshy grassland (B.5) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Marshy Grassland	1475	20	Match
Molinia Grassland	2165	29	Medium
Acid Grassland	1159	16	Medium
Juncus rushes	978	13	High
Dense Bracken	312	4	High
Improved Grassland	311	4	High
Woodland and Scrub	267	4	High
Broadleaved Woodland	208	3	High
Dense scrub	145	2	High
Bogs	142	2	Medium
Semi-natural Grassland	114	2	High
Neutral Grassland	75	1	Medium
Dry Dwarf Shrub Heath/Dry Acid Heath	40	1	High
Coniferous Woodland	18	0	High

Phase 1 2022 marshy grassland (B.5) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Felled woodland	17	0	High
Swamp	10	0	Medium
Artificial bare surface	5	0	High
Arable	3	0	High
Waterbodies (standing and running)	1	0	High
Grand Total	**7445**	**100**	-

Table 2.5: Breakdown of how the 2022 Phase 1 field survey points identified as **bracken (C.1.1)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 bracken (C.1.1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dense Bracken	1472	33	Match
Broadleaved Woodland	985	22	High
Woodland and Scrub	714	16	High
Dense scrub	457	10	High
Semi-natural Grassland	210	5	High
Improved Grassland	114	3	High
Neutral Grassland	105	2	Medium
Semi-natural Grassland	210	5	High
Acid Grassland	104	2	Medium
Molinia Grassland	66	1	High
Juncus rushes	65	1	High
Felled woodland	60	1	High
Artificial bare surface	32	1	High
Coniferous Woodland	15	0	High
Marshy Grassland	6	0	High
Arable	4	0	High
Dry Dwarf Shrub Heath/Dry Acid Heath	2	0	High
Wet Heath	1	0	High
Grand Total	**4412**	**100**	-

Table 2.6: Breakdown of how the 2022 Phase 1 field survey points identified as **dry dwarf shrub heath/dry acid heath (D.1)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 dry dwarf shrub heath/dry acid heath (D.1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dry Dwarf Shrub Heath/Dry Acid Heath	400	20	Match
Acid Grassland	545	27	Medium
Molinia Grassland	332	16	High
Semi-natural Grassland	246	12	High

Phase 1 2022 dry dwarf shrub heath/dry acid heath (D.1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dense Scrub	201	10	Medium
Dense Bracken	177	9	High
Juncus rushes	55	3	High
Marshy Grassland	43	2	High
Improved Grassland	13	1	High
Woodland and Scrub	3	0	High
Wet Heath	1	0	Low
Artificial bare surface	1	0	High
Grand Total	**2017**	**100**	-

Table 2.7: Breakdown of how the 2022 Phase 1 field survey points identified as **wet heath (D.2)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 wet heath (D.2) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Wet Heath	1975	44	Match
Molinia Grassland	1752	39	High
Dry Dwarf Shrub Heath/Dry Acid Heath	342	8	Low
Acid Grassland	170	4	High
Semi-natural Grassland	110	2	High
Marshy Grassland	52	1	Low
Dense Bracken	18	0	High
Dense Scrub	13	0	High
Bogs	8	0	Low
Improved Grassland	7	0	High
Juncus rushes	6	0	High
Artificial bare surface	4	0	High
Broadleaved Woodland	3	0	High
Grand Total	**4460**	**100**	-

Table 2.8: Breakdown of how the 2022 Phase 1 field survey points identified as **dry heath/acid grassland mosaic (D.5)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 dry heath/acid grassland mosaic (D.5) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dry heath/acid grassland mosaic	0	0	Match
Acid Grassland	1389	46	Low
Molinia Grassland	427	14	High
Dry Dwarf Shrub Heath/Dry Acid Heath	288	9	Low
Semi-natural Grassland	255	8	Medium
Dense Scrub	221	7	High

Phase 1 2022 dry heath/acid grassland mosaic (D.5) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Juncus rushes	189	6	High
Improved Grassland	102	3	High
Neutral Grassland	85	3	High
Wet Heath	48	2	Medium
Dense Bracken	21	1	High
Waterbodies (standing and running)	3	0	High
Coniferous Woodland	2	0	High
Woodland and Scrub	2	0	High
Felled Woodland	1	0	High
Artificial bare surface	1	0	High
Grand Total	**3034**	**100**	-

Table 2.9: Breakdown of how the 2022 Phase 1 field survey points identified as **wet heath/acid grassland mosaic (D.6)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 wet heath/acid grassland mosaic (D.6) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Wet heath/acid grassland mosaic	0	0	Match
Molinia Grassland	417	62	Medium
Acid Grassland	192	29	Low
Semi-natural Grassland	32	5	High
Juncus rushes	13	2	High
Dry Dwarf Shrub Heath/Dry Acid Heath	10	1	Low
Dense Bracken	6	1	High
Dense Scrub	2	0	High
Grand Total	**672**	**100**	-

Table 2.10: Breakdown of how the 2022 Phase 1 field survey points identified as **bogs (E.1)** were classified by the Living Wales remote sensed survey.

Phase 1 2022 bogs (E.1) identified as Living Wales habitat class:	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Bogs	278	57	Match
Molinia Grassland	168	33	Medium
Acid Grassland	33	7	High
Juncus rushes	15	3	High
Dense Scrub	2	0	High
Coniferous Woodland	1	0	High
Grand Total	**492**	**100**	-

The comparisons of the Neath Port Talbot remote-sensed dataset against the 2022 update survey are provided at Appendix 5. These results are displayed showing the percentage change in the number of points and the percentage breakdown of the divergence categories for each habitat. There is then a second table that divides the results by location within the uplands or lowlands. The breakdown of uplands and lowlands is not discussed further for the Neath Port Talbot dataset in this report but is included for potential future interpretation.

The following tables show the breakdown of how the Phase 1 2022 field survey points identified as acid grassland (B1), semi-improved neutral grassland (B.2.2), improved grassland (B.4), marshy grassland (B.5), bracken (C.1.1), dry dwarf shrub heath/dry acid heath (D.1), wet heath (D.2), dry heath/acid grassland mosaic (D.5), wet heath/acid grassland mosaic (D.6) and bogs (E.1) were classified by the **Neath Port Talbot** remote sensed survey. Habitats with low numbers of sample points are not tabulated.

Table 3.1: Breakdown of how the 2022 Phase 1 field survey points identified as **acid grassland (B1)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 acid grassland (B1) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	% **of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Acid Grassland	3153	59	Match
Marshy Grassland	640	12	Medium
Improved Grassland	419	8	Medium
Wet Heath	218	4	High
Felled Woodland	177	3	High
Acid/Neutral Flush	150	3	High
Dry Heath/Acid Grassland Mosaic	131	2	Low
Dense Bracken	96	2	Medium
Dense Scrub	81	2	High
Natural Bare Surfaces	74	1	High
Scattered Woodland and Scrub	58	1	High
Built-up Areas	24	0	High
Bare Ground	22	0	High
Dry Dwarf Shrub Heath/Dry Acid Heath	17	0	Medium
Semi-improved Neutral Grassland	16	0	Medium
Broadleaved Woodland	12	0	High
Scattered Bracken	11	0	Low
Bogs	10	0	High
Coniferous Woodland	9	0	High
Artificial Bare Surfaces	2	0	High
Grand Total	**5320**	**100**	-

Table 3.2: Breakdown of how the 2022 Phase 1 field survey points identified as **semi-improved neutral grassland (B.2.2)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 semi-improved neutral grassland (B.2.2) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Semi-improved Neutral Grassland	964	31	Match
Marshy Grassland	1069	35	High
Improved Grassland	561	18	Low
Acid Grassland	234	8	Medium
Broadleaved Woodland	74	2	High
Dense Bracken	68	2	Medium
Dry Heath/Acid Grassland Mosaic	31	1	High
Acid/Neutral Flush	24	1	High
Mixed Woodland	12	0	High
Dense Scrub	12	0	High
Built-up Areas	12	0	High
NA-HEDGE-OTHER	10	0	N/a
Bare Ground	8	0	High
Coniferous Woodland	7	0	High
Amenity Grassland	6	0	High
Scattered Bracken	1	0	Low
Waterbodies (standing and running)	1	0	High
Grand Total	**3094**	**100**	-

Table 3.3: Breakdown of how the 2022 Phase 1 field survey points identified as **improved grassland (B.4)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 improved grassland (B.4) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Improved Grassland	9061	54	Match
Semi-improved Neutral Grassland	4307	26	Low
Acid Grassland	1243	7	Medium
Marshy Grassland	1075	6	High
Arable	404	2	Medium
Broadleaved Woodland	226	1	High
Amenity Grassland	101	1	Low
NA-HEDGE-OTHER	60	0	N/a
Dense Bracken	55	0	High
Mixed Woodland	38	0	High
Dense Scrub	26	0	High
Built-up Areas	26	0	High
Bare Ground	26	0	High

Phase 1 2022 improved grassland (B.4) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Scattered Woodland and Scrub	6	0	High
Dry Heath/Acid Grassland Mosaic	6	0	High
Coniferous Woodland	5	0	High
Felled Woodland	4	0	High
Scattered Bracken	4	0	Medium
Acid/Neutral Flush	3	0	High
Waterbodies (standing and running)	1	0	High
Grand Total	**16677**	**100**	-

Table 3.4: Breakdown of how the 2022 Phase 1 field survey points identified as **marshy grassland (B.5)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 marshy grassland (B.5) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Marshy Grassland	3298	57	Match
Acid/Neutral Flush	757	13	Low
Acid Grassland	555	10	Medium
Wet Heath	517	9	Low
Dry Heath/Acid Grassland Mosaic	190	3	High
Broadleaved Woodland	100	2	High
Improved Grassland	92	2	High
Dense Bracken	73	1	High
Semi-improved Neutral Grassland	66	1	High
Built-up Areas	48	1	High
Dense Scrub	30	1	High
Scattered Bracken	21	0	High
NA-HEDGE-OTHER	21	0	N/a
Natural Bare Surfaces	16	0	High
Coniferous Woodland	13	0	High
Mixed Woodland	2	0	High
Wet Heath/Acid Grassland Mosaic	2	0	Low
Felled Woodland	1	0	High
Scattered Woodland and Scrub	1	0	High
Waterbodies (standing and running)	1	0	High
Amenity Grassland	1	0	High
Grand Total	**5805**	**100**	-

Table 3.5: Breakdown of how the 2022 Phase 1 field survey points identified as **bracken (C.1.1)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 bracken (C.1.1) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dense Bracken	935	35	Match
Acid Grassland	518	20	Medium
Marshy Grassland	235	9	High
Broadleaved Woodland	211	8	High
Dense Scrub	162	6	High
Felled Woodland	158	6	High
Scattered Bracken	145	5	Low
Semi-improved Neutral Grassland	95	4	High
Scattered Woodland and Scrub	67	3	High
Improved Grassland	25	1	High
Mixed Woodland	19	1	High
Wet Heath	15	1	High
Coniferous Woodland	14	1	High
Dry Dwarf Shrub Heath/Dry Acid Heath	11	0	High
Dry Heath/Acid Grassland Mosaic	9	0	High
Built-up Areas	7	0	High
NA-HEDGE-OTHER	7	0	N/a
Acid/Neutral Flush	3	0	High
Waterbodies (standing and running)	2	0	High
Amenity Grassland	2	0	High
Natural Bare Surfaces	1	0	High
Bare Ground	1	0	High
Grand Total	**2642**	**100**	-

Table 3.6: Breakdown of how the 2022 Phase 1 field survey points identified as **dry dwarf shrub heath/dry acid heath (D.1)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 dry dwarf shrub heath/dry acid heath (D.1) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
dry dwarf shrub heath/dry acid heath	0	0	Match
Dry Heath/Acid Grassland Mosaic	559	56	Low
Acid Grassland	297	30	Medium
Wet Heath	67	7	Low
Marshy Grassland	29	3	High
Semi-improved Neutral Grassland	25	2	High
Dense Bracken	22	2	High
Natural Bare Surfaces	2	0	High

Phase 1 2022 dry dwarf shrub heath/dry acid heath (D.1) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Built-up Areas	2	0	High
Improved Grassland	1	0	High
Grand Total	**1004**	**100**	-

Table 3.7: Breakdown of how the 2022 Phase 1 field survey points identified as **wet heath (D.2)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 wet heath (D.2) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Wet Heath	282	37	Match
Dry Heath/Acid Grassland Mosaic	218	28	Medium
Marshy Grassland	214	28	Low
Wet Heath/Acid Grassland Mosaic	25	3	Low
Broadleaved Woodland	12	2	High
Dense Bracken	8	1	High
Acid Grassland	5	1	High
Improved Grassland	3	0	High
Acid/Neutral Flush	1	0	Medium
NA-HEDGE-OTHER	1	0	N/a
Grand Total	**769**	**100**	-

Table 3.8: Breakdown of how the 2022 Phase 1 field survey points identified as **dry heath/acid grassland mosaic (D.5)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 dry heath/acid grassland mosaic (D.5) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	**% of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Dry Heath/Acid Grassland Mosaic	479	37	Match
Acid Grassland	662	51	Low
Marshy Grassland	76	6	High
Dry Dwarf Shrub Heath/Dry Acid Heath	47	4	Low
Semi-improved Neutral Grassland	10	1	High
Natural Bare Surfaces	8	1	High
Dense Bracken	6	0	High
Dense Scrub	5	0	High
Coniferous Woodland	3	0	High
Waterbodies (standing and running)	1	0	High
Grand Total	**1297**	**100**	-

Table 3.9: Breakdown of how the 2022 Phase 1 field survey points identified as **wet heath/acid grassland mosaic (D.6)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 wet heath/acid grassland mosaic (D.6) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	% **of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
wet heath/acid grassland mosaic	0	0	Match
Dry Heath/Acid Grassland Mosaic	366	85	Medium
Acid Grassland	60	14	Low
Wet Heath	4	1	Low
Acid/Neutral Flush	1	0	Medium
Grand Total	**431**	**100**	-

Table 3.10 : Breakdown of how the 2022 Phase 1 field survey points identified as **bogs (E.1)** were classified by the Neath Port Talbot remote sensed survey.

Phase 1 2022 bogs (E.1) identified by Neath Port Talbot as Phase 1 habitat name: (JNCC 2016)	**Number of sample points where habitat recorded**	% **of total sample points**	**Divergence Rank** (compared to the 2022 dataset)
Bogs	66	18	Match
Acid/Neutral Flush	122	34	Low
Dry Heath/Acid Grassland Mosaic	115	32	High
Acid Grassland	40	11	High
Waterbodies (standing and running)	19	5	High
Grand Total	**362**	**100**	-

It is recommended that to fully interrogate all habitat types, for each of the remote sensed datasets against the 2022 field survey dataset, a full set of comparison tables is created like those above. Such tables identify the habitats that the remote sensing datasets struggle to classify correctly and indicate improvements that can be made to the remote sensing techniques.

Analysis and Discussion

Limitations of the Methodology

A 10m buffer removed most of the boundary errors for the comparison between the 2022 and 1979-97 Phase 1 Habitat Survey dataset and the habitat maps generated for Neath Port Talbot. However, the comparisons were compromised by the LW dataset having a resolution of 10m, which is the same distance as the buffer. As such even a single ‘pixel’ difference in boundaries between the LW and 2022 Phase 1 datasets resulted in the boundary differences not being fully removed by the buffer. A negative buffer applied of 20m or more may have been more appropriate for this dataset; however, this would then significantly reduce the number of sample points used and also potentially lose some of the narrow/small field systems altogether.

During the 1979-1997 survey, a considerable proportion of the upland zone was mapped as mosaics of two or more (and sometimes many) habitats, with proportions of the different habitats not provided, other than the predominant habitat being listed first. Mosaics of this type were not mapped during the 2022 field survey. This will have resulted in some significant differences in the areas of upland habitats that form a significant part of these mosaics, such as acid and marshy grassland, bracken, heathland categories, and bogs and flushes. Therefore, differences between the upland part of the 1979-1997 survey and the other datasets need to be interpreted with caution.

For the purposes of the analysis, an assumption was made that the 2022 field survey is completely correct. While it was undertaken by a fully equipped and experienced surveyor, no vegetation-based survey can be considered 100% perfect. In the 2022 field survey dataset, there seems to have been some greater mapping of bracken due to differing interpretation of complex habitat mixtures, particularly mixtures of bracken and woody habitats. The 2022 field survey dataset also appears to overlook small habitat parcels (i.e., scree, Inland cliff, and very small parcels of built-up areas) within larger field systems or extensive habitat areas, although at least some of these are less than the minimum mapping unit for Phase 1 survey used in Wales of 0.1 ha. These only lead to a couple of percent or less of the number of points mapped as a habitat type but it does suggest that the 2022 layer could be improved as a base comparison layer.

Comparison of Field Survey Datasets

The 2022 and the 1979-1997 GIS habitat layers show strong similarities as might be expected, as they are both derived from field-based Phase 1 habitat surveys. However, for certain habitats, significant differences were highlighted in the data, which are summarised below (see figure 5). Many differences between the surveys are undoubtedly due to changes in the time period between the surveys, although some differences between the surveys are likely to be associated with different survey practices and standards, which would require high QA protocol in any future survey to ensure consistency.

Figure 5. Comparison of the two Phase 1 field survey habitat maps across one tetrad (1979-97 left image, and 2022 right image). In this example, significant habitat change appears to have occurred in the period between the surveys, including changes in the distributions and extents of marshy grassland (purple diagonal stripes over orange background) and semi-improved acid grassland (orange diagonal stripes over grey background). Solid pale and dark green colours are mainly from the National Forest Inventory map (excluded from analysis).

The differences in the approach to mapping of large mixed blocks of upland habitat is the principal reason for disparities between the two surveys, and therefore the discussion of differences between the surveys is split into upland and lowland sections with a specific focus on the lowland portion (which makes up nearly 80% of the total mapped area). However, there also appears to have been greater mapping of dense bracken in the 2022 survey, in areas that were previously mapped as open scrub and woodland during the 1979-1997 Phase 1 survey. This change in habitat type is assessed to be a medium/high habitat divergence. It may represent both expansion of bracken since the original survey and, as mentioned in the limitations, differences in interpretation of complex habitat mixtures.

Interpretation of changes in the extent and distribution of less frequent semi-natural habitats, such as bogs, acid/neutral flushes and fen, has not been attempted as these habitats are represented in the analysis by only a small numbers of sample points, making the comparisons much less reliable.

There are some very stark divergences (both increases and decreases) in the percentage change of sample points where woodland was recorded during each survey. These are, however, largely down to the relatively low number and small size of woodland parcels within the point sample analysis area, the great majority of the woodland within the 30 tetrads being within the NFI layer and thus excluded from the assessment. Some genuine change is also

evident however: some previously recorded grassland fields have since been planted with ‘new’ woodland, some small blocks of woodlands appear to have been felled, and there has been some level of woodland and scrub encroachment in certain less managed areas, where natural succession has been allowed to take place. As mentioned above, bracken also accounts for a notable proportion of the change in sample points.

Upland

Unfortunately, due to the mapping of the majority of the uplands as mosaics of multiple habitats, it makes it very difficult to decern whether changes in habitat have natural or anthropogenic causes or are complicated because of the occurrence of mosaics. It is very likely that some of the trends occurring in the lowlands, discussed below, will also be occurring in the uplands but this remains uncertain.

In the uplands, acid grassland has an increase of 60% in the number of sample points recorded but also early 27% moderate divergence. Improved grassland is closely matched at 84%. Marshy grassland reduced by ~53% of sample points in 2022. However, of those points surveyed as marshy grassland in 2022, 95% of them matched the 1979-97 Phase 1. The significant portion (~42%) of the points were resurveyed as moderate diverging habitats, mainly acid grassland.

Points sampled as bracken increases by nearly 83% in the 2022. Nearly 24% of bracken was remapped, albeit as high divergence habitats, with this mainly attributable to a range of classifications representing heathlands.

In the uplands, dry dwarf shrub heath/dry acid grassland is the only category to reduce in the number of points (-27%). Wet heath, dry heath/acid grassland mosaic and wet heath/acid grassland mosaic are all subject to increases in the number of points, with wet heath/acid grassland mosaic increasing by ~2400% from a very small sample of 27 points. These three heathland types all have high levels (84% or above) of matching or low levels of divergence.

Bogs in the uplands increase by just over 50% in the number of sample points they occur at in the 2022 Phase 1 dataset. Whilst there is a 70% match, there is nearly 30% high divergence. The high divergence exclusively due to remapping as acid grassland.

Lowland

In the Lowlands, acid grassland decreases by ~22% in the number of sample points where it occurs in the 2022 Phase 1 dataset. Acid grassland also has a moderate divergence of ~57%, which is mainly due to remapping of acid grassland as improved or semi-improved grassland, presumably indicating agricultural improvement, or as bracken, presumably indicating the encroachment of bracken.

Semi-improved neutral grassland increases by over 30% of sample points in the 2022 Phase 1 dataset. It has nearly 80% matching or low divergence in habitats, the majority of the low divergence caused by intensification to improved grassland. The 12% high divergence is largely a result of remapping as marshy grassland, potentially where drainage of fields has not been maintained, and arable, where fields have been converted to crop production.

Improved grassland represents over 70% of all points occurring in the lowlands on both surveys. There is a ~5% reduction in the number of sample points and a high match of over

84%. The results suggest some flux between improved and semi-improved grassland between surveys, with 42% of the semi-improved neutral grassland surveyed in 2022 occurring on previously improved grassland and just under 3% of improved grassland mapped in 2022 was in locations where a semi-improved neutral grasslands were previously recorded. An almost three-fold increase in arable sample points in the 2022 survey is mainly where that habitat has replaced improved grassland, which could simply be due to differing interpretation, as short-term leys are included within the Phase 1 arable definition.

Lowland marshy grassland has increased by nearly 29% in the number of sample points it was recorded in 2022. Whilst it has a match of 65%, there is just over 24% of points recorded as high divergence habitats. Improved and semi-improved neutral grassland are the main habitats causing the high divergence, apparently indicating localised intensification of marshy grasslands in some areas. However, despite there being some evidence of marshy grassland loss, the increase in points, 25% of which occur where improved and semi-improved neutral grassland were originally recorded, may at least partly reflect reduced levels of intensification of rough grazing land in some areas.

Sample points with dense bracken increased between the surveys by about 80%. However, there were also local apparent losses of bracken (~26% high divergence), mainly due to mapping in 2022 as improved grassland, dense scrub, or deciduous woodland. This may indicate bracken control and conversion to improved grazing, and natural succession to woodland or scrub. The increase in bracken in the lowlands is highest on areas recorded as improved grassland or where no data was collected in the original phase 1, each representing 19% of points recorded as dense bracken in the 2022 phase 1. Points where acid grassland was originally surveyed represent ~11% of the gain in points of bracken. This suggests that whilst, in some areas bracken is being cleared or succession of woodland and scrub is occurring, there are other areas of grasslands in particular where bracken has encroached upon it, across the tetrads this has amounted to a significant increase in bracken in the lowlands.

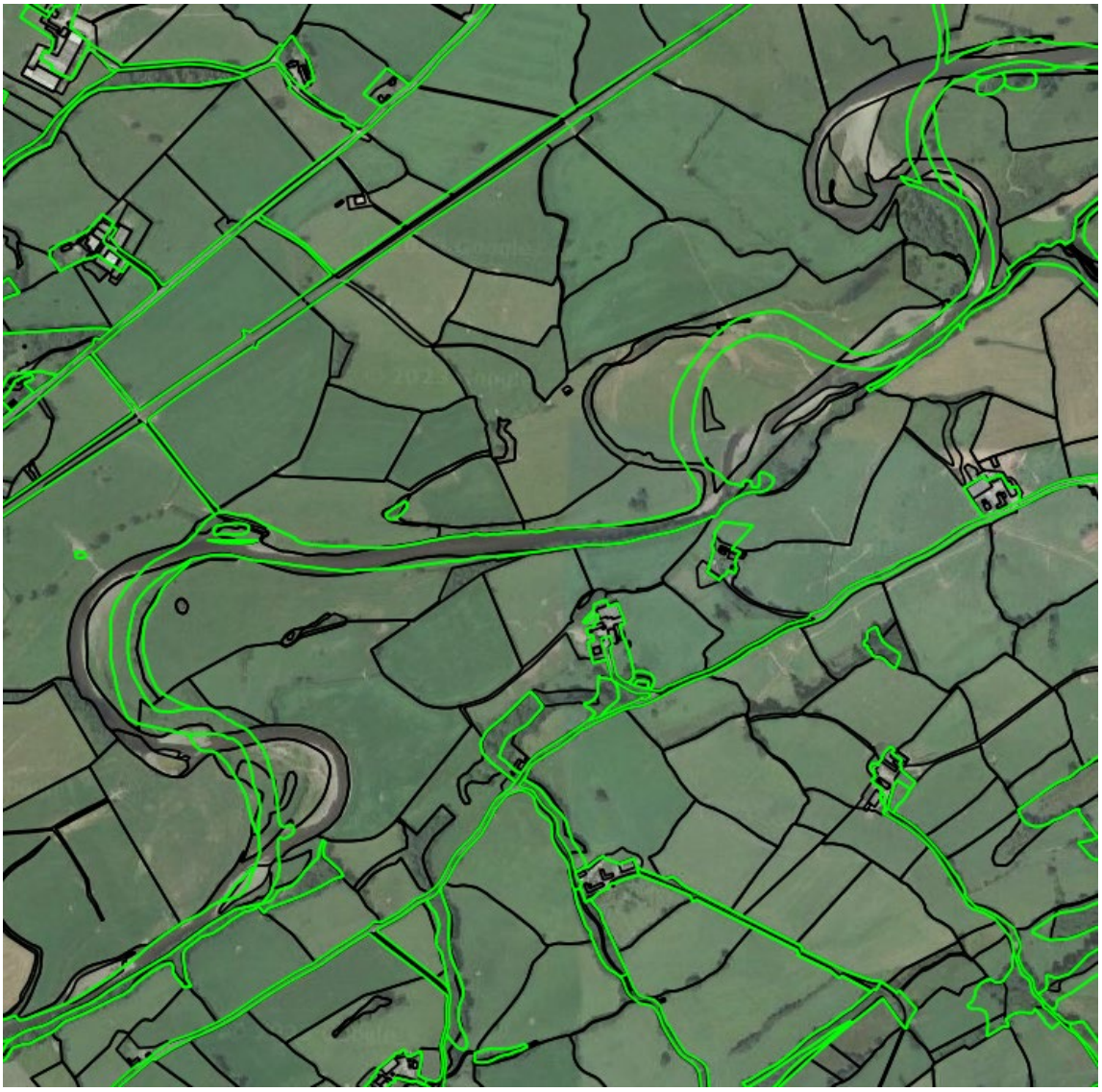
Heathland in the lowlands has relatively small sample sizes and so the large percentage changes are generally insignificant. Dry dwarf shrub heath/dry acid heath has a drop of ~73% of sample points recorded in the 2022 Phase 1. The remapping as acid grassland is the main cause of the 17.5% moderate divergence, which suggests overgrazing of heathland in some areas. Bracken is the major cause of the ~24% high divergence. Wet heath has increased by nearly 145% largely over wet heath/ acid grassland mosaic and is very closely matched with 96% of points matching or low divergence habitats. Dry heath/acid grassland mosaic has increased by 55% in the number of points where it was recorded, 36% of points occurring on previously improved grassland and otherwise largely occurring on other heathland categories. However, there is nearly 67% high divergence habitats recorded in 2022; the main habitats recorded were improved grassland, marshy grassland, and bracken, indicating potential low level clearance of heathland to create improved grazing and the encroachment of bracken. Wet heath/acid grassland mosaic is almost completely lost in 2022, ~98% reduction in the number of points where it was recorded. There are no matching points, however, ~85% of points are low divergence habitats.

Bogs have increased by 50% in the lowlands but is however only a small sample size and most of the gain occurs in areas that were not previously surveyed in 1979-97. This is a very closely matching layer ~94%.

Final thoughts:

Although there are some differences in survey practices and standards between the 2022 and 1979-1997 field survey datasets, for example in the mapping of woodland and bracken, and the upland mosaic mapping in the 1979-1997 dataset means that the upland portion of the data is hard to interpret, many of the differences in the habitat layers between the two field surveys could be reasonably assigned to natural or anthropogenic processes taking place in the landscape in the intervening years, including a few which are readily apparent from aerial imagery (e.g. see figure 6).

Figure 6: Showing one of the starkest habitat changes in the intervening years; the meandering of the Afon Tywi. The original 1979-97 dataset in green and the resurveyed 2022 dataset in black. In the intervening years there has been the formation of a new oxbow lake and the erosion and creation of new grassland adjacent the river. There is even a block of new growth woodland in the northeast of the tetrad which would have been where the river flowed during the original 1979-97 Phase 1 survey.



Comparison of Remote Sensed Datasets with the 2022 field survey dataset

For the purpose of this assessment, NRW considers that an acceptable and reliable remote-sensing technique would be one that results in habitat types that match those recorded in the field or provide at least a combination of matches and low divergence habitats at a rate of at least 90%. It is, however, widely recognised that remote sensing can more readily identify some habitats and features more than others and, for example, a remote sensing technique which can reliably identify improved grassland would provide a valuable filter to help target field assessment.

Of the two remote sensed GIS layers, the Neath Port Talbot Phase 1 dataset, which was based on manual interpretation of high resolution satellite imagery, provided a reasonably close match to the 2022 field survey layer. Estimates of uncertainty (high, medium, or low) were produced with this dataset, but overall, the method produced maps where the accuracy was considered insufficient to fully replace field surveys.

The LW dataset provides a moderately close match to the 2022 field survey layer. The level of accuracy has improved since the 2020 iteration of the LW map, which was used in an initial analysis, although it is still less accurate overall than the NPT dataset and only a couple of habitats were mapped at or close to acceptable levels of divergence. However, the LW map does not include a manual interpretation process as was used to produce the NPT dataset, and it is designed for continual updating as new technologies and supporting/contextual data become available.

The results of the analysis of both the remote sensed datasets indicate that neither, in its current format, is accurate enough to completely replace field-based surveying. Both the Living Wales and NPT surveys accept the need for a level of ground-based verification. Habitat areas recorded by the NPT survey were attributed with a degree of certainty (low, medium, high) in its classification to ‘allow targeting of site visits’ (Environment Systems, 2021), while Living Wales have developed a mobile application (EarthTrack) to provide ground data which can act “to validate maps of land cover” (Living Wales: overview of approach 2020).

Priority habitats

Priority habitats are those listed under Section 7 of the Environment (Wales) Act 2016 as being of ‘principal importance for the purpose of maintaining and enhancing biodiversity in relation to Wales’. An analysis of the classification of open (non-wooded) terrestrial priority habitats by the Living Wales and NPT habitat maps against the 2022 field survey data is presented in Table 4 (below).The NPT dataset misclassified 7% of the sample points of open priority habitats mapped by the 2022 re-survey as non-priority habitats (i.e. not including priority habitats misclassified as different priority habitats). The Living Wales dataset misclassified 12% of priority habitats sample points. The comparison highlighted the need to improve the LW classification particularly of ‘improved grasslands’ and ‘*Juncus* pastures’, noting that the latter is a broad category that could include both semi-natural and highly modified rush communities.

The analysis concluded that the Neath Port Talbot methodology provided classifications of broad open priority habitats across Wales at a reasonable accuracy (i.e., around 90%

matches/combination of matches and low divergence rates). The mapping also identified classes and areas ground-based surveys could be undertaken to confirm and provide more detailed descriptions of the detailed (Phase 1) habitat sub-categories.

Table 4: Percentage of open priority habitat that has been misclassified as a non-priority habitat for each remote sensed layer when compared with the 2022 field survey data. This is then broken down into the individual misclassified non-priority habitat types and their percentage composition.

Living Wales Dataset	Number of sample points	% of total sample points
Total open priority habitat* records (2022)	32,379	100
Total misclassified as woodland or open water	1,598	5
Total misclassified as non-Priority Habitats #	3,962	12
Juncus Rushes	1,693	5
Improved Grassland	1,435	4
Dense Bracken	776	2
Built-up Areas	31	0
Arable	27	0

Neath Port Talbot Dataset	Number of sample points	% of total sample points
Total open priority habitat* records (2022)	15,197	100
Total misclassified as woodland or open water	530	3
Total misclassified as non-Priority Habitats #	1,094	7
Improved Grassland	515	3
Dense Bracken	205	1
Semi-improved Neutral Grassland	118	1
Natural Bare Surfaces	100	1
Built-up Areas	77	1
Scattered Bracken	32	0
Bare Ground	22	0
NA/Hedgerow/Other	22	0
Artificial Bare Surfaces	2	0
Amenity Grassland	1	0

**open priority habitats include: semi-natural grassland, heathland and wetland: Phase 1 habitat codes (JNCC, 2016) B.1, B.2.1, B.5, BX, BY, D.1, D.2, D.5, D.6, E.1, E.2.1. (Woodland and open water are excluded)*

 # Non-priority habitats include: improved grasslands, bracken, bare surfaces and hardstanding and built-up areas. Phase 1 habitat codes (JNCC, 2016) B.2.2, B.4, BZ, C.1.1, C.1.2, I.1, I.2, J.1.1, J.1.2, J.3

Woodland

Woodland initially appears to be well matched to the 2022 survey dataset. This might be expected, as woodlands have very distinctive characteristics when viewed from satellite. However, in both remote sensing habitat layers, there is apparent significant over-recording of woodland habitat extent, some by nearly one thousand of a percentage change in the number of points assigned to a habitat (e.g. Coniferous woodland for Living Wales has increased by 936%). These increases are likely to have been caused by a combination of factors.

The remote sensing techniques map woodland to the canopy spread, and at woodland boundaries the canopy spread generally extends over the habitats beneath, particularly broadleaved woodland. Despite negatively buffering the point grid to avoid minor discrepancies in the mapping of polygon boundaries, the largest canopies can extend beyond this buffer and impact adjacent habitat polygons, resulting in the observed increases in the frequency of woodland habitats. Woodland can also cause significant shadowing on adjacent habitats which may, due its dark colour, be recorded as woodland in the remote

sensed datasets (see figure 7). Another factor is the superimposing of trees / woodland over surrounding habitats when the satellite or aerial image is taken at an oblique angle (see figure 8). This factor can also then exacerbate the issues with canopy spread beyond woodland boundaries.

For Living Wales, the extent of woodlands has been recently amended using the Shuttle Radar Topographic Mission (SRTM) digital terrain model rather than a higher resolution dataset provided by Welsh Government. This resulted in improved geometric location of the radar data and hence an improvement in the mapping of woodland for Wales. The area of woodland mapped includes the NFI mapping but also additional smaller areas of trees (including larger sections of hedgerows). This mapping of smaller blocks of trees will have caused an increase in woodland recorded, as to be expected. The mapping of larger hedgerows along boundaries, which in Phase 1 are recorded as linear habitats, coupled with the 10m resolution of the LW data, which in some cases wouldn't have been removed by the negative 10m buffer (as discussed in the limitations), could have caused a significant increase in woodland recorded if this occurs along sizeable extents of linear boundaries.

These factors have led to some significant high divergences in ground level habitats occurring adjacent to woodland, especially where boundary to volume ratios are high around small woodland parcels, and some high percentage losses of the number of points where these habitats are mapped. These issues are something that could be reduced by further post-processing of the remote-sensed layers to make woodland boundaries consistent with field/land parcel boundaries, where confirmed by other evidence such as ground-based survey.

Figure 7: An example showing the woodland boundary mapping of the two remote sensed layers against the 2022 resurveyed layer. The 2022 resurveyed Phase 1 in black (this line also corresponds with the OS MasterMap boundary), a 10m buffer from the 2022 boundary in dashed yellow, Living Wales remote sensed habitat map in blue and the Neath Port Talbot remote sensed Phase 1 in red. The red line much more closely matches the 2022 dataset than the blue and appears much less afflicted by the shadows of the woodland. The Living Wales dataset is also assigning a lot of single 'pixel' habitat polygons along the boundary; most in this example are assigned broadleaved woodland or scrub.

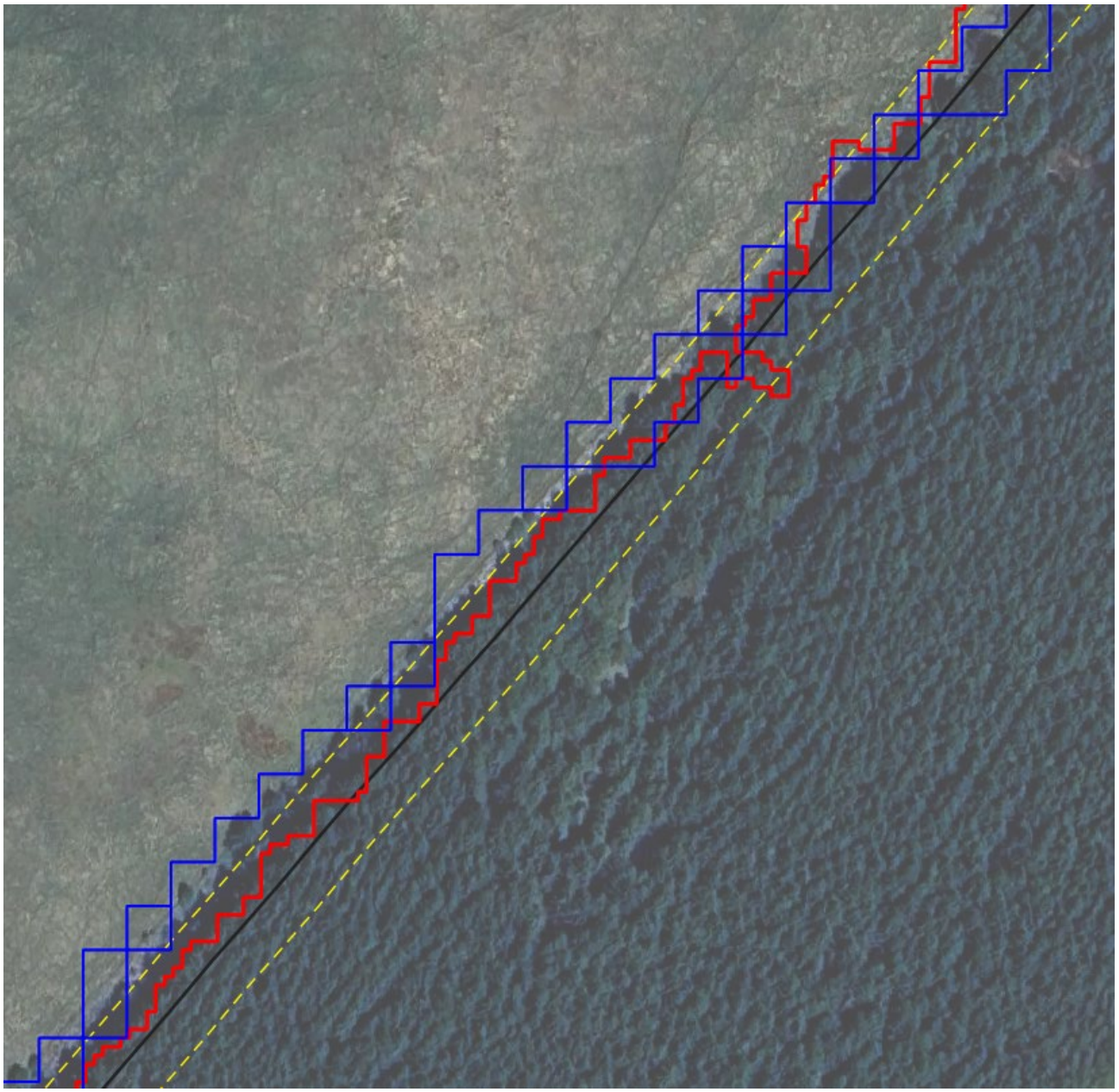


Figure 8: Effect of oblique remote image on tree canopy and ground-level habitats. The image on the left shows a simplified visualisation of satellite imagery of trees being taken from an oblique angle, with the woodland canopy superimposed over ground level habitats beyond the true extent of the woodland. The image on the right is an example of this, extracted from satellite imagery from within one of the surveyed tetrads. **imagery:** @2023 Bluesky, Infoterra Ltd & COWI A/S, CNES / Airbus, Getmapping plc, Maxar Technologies

Mis-recording as woodland categories account for 50.6% and 23.9% of the 2022 field survey dense bracken points in the LW and NPT datasets respectively. This is likely due in part to the greater mapping of bracken in the 2022 field survey, as discussed in the limitations section. It may however point to a limitation of distinguishing dense bracken cover from woodland/scrub canopy cover. It would be of interest to understand how accuracy differs with season and what life stage the bracken is in alongside woodland and scrub within the landscape. With major limitations on choosing when data from satellites are captured this may cause issues with repeated surveys having potentially significant variations in accuracy of these habitats and others that change seasonally.

Grassland

The Neath Port Talbot dataset identified the broad habitat classification of ‘grassland’, covering all grassland habitat types, excluding all improved and amenity grassland, to an accuracy of 70.3%. Whilst a 59.9 % correspondence with 2022 Living Wales dataset was observed.

Living Wales has made changes in the mapping of grasslands, particularly by utilising the time-series of Sentinel-2 data to better capture the extent of water bodies, which has resulted in a reduction in grassland being wrongly mapped as open water, although this was a minor error previously (0.3% error dropping to 0.06%).The error caused by mis mapping as trees has reduced, likely owing to Living Wales changes to woodland recording detailed above. However, the majority of error is attributable to mapping of Improved grassland and the broad ‘semi-natural grassland’ and ‘Juncus rushes’ categories.

The Living Wales dataset recorded ~48,800% more unimproved neutral grassland points ('neutral grassland' in the LW dataset) compared to the 2022 field survey dataset. 60% of the points LW recorded as unimproved neutral grassland were recorded as improved grassland in the 2022 Phase 1 survey. Living Wales do not have a category for semi-improved grassland and of the points recorded in this category in the 2022 field survey dataset, 35.5% were categorised as the 'Juncus rushes' category and ~30% as improved grassland. These results indicate that the LW dataset is unable currently to readily distinguish between the different dry grassland types of improved, semi-improved and unimproved.

The Living Wales dataset recorded marshy grassland at 66.5% fewer sample points than it was recorded at in the 2022 field survey. This is largely due to the Living Wales classification of 'Molinia grassland' and 'Juncus rushes' categories, which are considered to be of moderate (Molinia) and high divergence (Juncus) from marshy grassland due to their broad definition that could cover various Phase 1 grassland categories, including marshy grassland.

The Neath Port Talbot remote sensing methodology mapped a 90% greater number of sample points with semi-improved neutral grassland, compared to the 2022 field survey dataset. This greater number is primarily due to the mapping of some improved grassland as semi-improved neutral grassland. Again, this illustrates the difficulties remote-sensed habitat maps have in the of mapping dry grassland types.

Semi-improved neutral grassland also was mis-classified by the NPT survey as high divergence habitat at 42% of the sample points. This high divergence is almost exclusively caused by misclassification as marshy grassland, which suggests an issue with the ability to distinguish rougher, more tussocky dry grasslands from marshy grasslands. The Neath Port Talbot dataset otherwise mapped marshy grasslands reasonably well, with ~57% match and a further 22% mapped as low divergence habitats.

Heathland

The Neath Port Talbot dataset appears to map heathland and heathland mosaics relatively well, with almost all low and moderate divergences caused by mis-mapping as other heathland categories, or as acid and marshy grassland. There was a 92% decrease in the number of points where dry heath was recorded; however, 62% of the points were recorded as being mapped as habitats with a low divergence from the 2022 dataset. This suggests that the Neath Port Talbot methodology may be relatively accurate at mapping broad heathland mosaics, even if the component habitats (wet/dry and mosaics) are not as reliably distinguished.

Living Wales struggled to accurately map the individual heathland types or broad heathland mosaics. D.5 and D.6 have no equivalent within the Living Wales habitat categories and both D.1 and D.2 are subject to ~13% and ~55% reductions in the number of points they are recorded respectively. Wet heaths were more accurately mapped, with ~44% match, and a further 31% mapped as low divergence habitat. Much of the high divergence across the heathland categories is a result of the 'Molinia grassland' category, and to lesser extents 'semi-natural grassland', dense bracken and dense scrub. It would appear that the Living Wales remote sensing has problems with distinguishing the tussocky grasslands from heathland, although the presence of substantial *Molinia* cover in some neglected heathland may also account for some of this divergence, particularly because the classification of

heathland habitats within Living Wales relies on the discrimination of dominant vegetation types from remote sensing. This suggests a potential use of the LW dataset against the original Phase 1 or on its own to identify where heathlands have become increasingly degraded and Molinia grasslands have become dominant.

Bogs

The Neath Port Talbot sample for bogs was relatively small but significantly less bog habitat was mapped than in the 2022 field survey, due to largely being recorded as acid grassland and wet heath/acid grassland mosaic, indicating an inability of aerial interpretation to reliably distinguish these habitat types. Bogs seem relatively accurately mapped by the Living Wales dataset (perhaps largely due to the use of contextual information such as the unified peat layer), although the ~33% moderate divergence areas are once again caused by mapping as '*Molinia* grassland', which could include some habitat on un-mapped areas of deep peat. Whilst *Molinia* is highly frequent on bogs, the '*Molinia* grassland' category is unspecific and so for this analysis has been specified as moderate divergence from bogs and marshy grassland within the matrix.

Conclusions

Comparison of the 1979-1997 and 2022 field survey habitat maps has revealed significant differences in the extents and distributions of many habitats, presumably largely because of natural and anthropogenic changes in the more than two decades between the two surveys. As a result, the locations of priority habitats and other features on the original Phase 1 maps can no longer be completely relied upon.

Whilst the results of the analysis indicated significant limitations in the use of remote sensing as a sole survey method for mapping habitats according to the Phase 1 taxonomy, the Neath Port Talbot method demonstrates generally high reliability of satellite image interpretation for mapping some broad habitat types e.g., grasslands as a whole and woodland. The Neath Port Talbot protocol appears to show some benefits as an initial method to map the distribution of areas comprising open priority habitat (semi-natural grassland, heathland, and wetland) to an acceptable accuracy (90% accurate), but accurate identification of the individual Phase 1 habitats was less reliable, and therefore this would then need to be followed up by ground-based surveys. These would be essential if the need was to confirm or otherwise the presence of priority habitats or distinguish accurately between habitat sub-categories.

The coarser (10m) resolution, the reduced number of classes compared with standard Phase 1 categories, and the adoption of some nonspecific 'catch all' categories, such as '*Molinia* grassland', suggest that the Living Wales dataset is less applicable for equivalent Phase 1 mapping in its current format. However, the production of the Living Wales map is a far more automated process compared to the Neath Port Talbot map production, which requires a significant manual interpretation stage and thus has a much higher time burden.

It may be possible to see if the NPT technique can be refined further. The LW map, however, is already able to be updated nationally as improvements in the algorithms for retrieving or classifying environmental descriptors are implemented, and the LW 2022 dataset has shown some marked improvements on the LW 2020 dataset which was used in an initial analysis for this report. The LW map can be assisted by studies such as this and the provision of

other timely and relevant ground datasets. Living Wales also provides significant opportunity and capacity to work with field surveyors in optimising the use of satellite sensor data for habitat classification, including through ongoing validation of products and appropriate feedback. It can also be assumed that the increased time requirement with producing the NPT dataset means that the costs for the product (as a one-off) could be significantly higher than the LW map. This has implications for the feasibility of replicating this across the entirety of Wales and also the repeatability of completing a remote sensed habitat map more regularly.

Both methods provide capacity to map many of the larger expanses of habitats, but both options currently necessitate detailed surveys be undertaken to provide additional ground-data to inform algorithm development and the success of classification.

Following advances in remote sensing technologies having already led to significant improvements in satellite imagery resolution (NASA, 2019) and the current best commercial solutions producing resolutions of up to 31 cm (DigitalGlobe, 2022), it is hoped that the proliferation of super high-resolution satellite imagery will see continued improvements in the remote mapping of habitats, although each new protocol or advance would need to be adequately tested against high quality ground survey data.

Recently, licensing of Planet satellite data, with an image resolution of 3 m per pixel and the ability to capture 50 cm resolution images, has been acquired by Welsh Government for use by them and other sponsored bodies. This service also allows for some limited individual 'tasking' of satellites so they can have their orbits altered to capture imagery at specific locations and times. There are still the usual caveats around automated identification and classification of semi-natural landcover types from remotely sensed imagery; however, utilising higher resolution imagery where available will only help development of this and is something that should be investigated and exploited further.

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Appendices

Appendix 1: Matrix of divergence

Appendix 2: Habitat areas

Appendix 3: Comparison of 2022 survey against the 1979-97 survey

Appendix 4: Comparison of Living Wales remote sensed layer against the 2022 survey

Appendix 5: Comparison of Neath Port Talbot remote sensed layer against the 2022 survey

Data Archive Appendix

GIS data outputs associated with this project are archived in **X: Biological > Phase 1 Habitat Mapping > Phase 1 Terrestrial > Resurvey Pilot 2022**.

The data archive contains:

The final report in Microsoft Word and Adobe PDF formats.

A series of GIS layers on which the maps in the report are based

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 to insert this number]

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