Testing approaches to mapping habitat quality and ecosystem condition

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Executive Summary

Information on habitat condition is often missing from natural capital baseline assessments or asset registers, which regularly focus purely on the extent of habitats. Yet this information can prove invaluable and opens up a number of potential applications. Furthermore, although habitats remain the most fundamental component of natural capital, the concept incorporates much more and it is important to capture broader indicators of air, land and water assets and their quality, and indicators of ecosystem processes and functions for a more complete natural capital baseline assessment.

This project therefore attempted to develop a method to assess condition of habitats at a landscape scale, using existing data and inferences, and to bring together a wide range of data from different sources to create maps of natural capital assets and environmental quality. The approach and maps were presented at an online stakeholder workshop, where participants ideas and feedback were used to refine and improve the outputs. Workshop participants also discussed issues around public access and recommendations for taking these ideas forward. The project was focussed on Northamptonshire and Peterborough, but the results are applicable anywhere.

To map condition, we followed a three-step approach:

1) Condition was assigned to all habitats of low or no biodiversity interest.
2) SSSI and Local Nature Reserve / County Wildlife Site condition data were used to assign condition to the best quality wildlife sites.
3) A number of assumptions were developed, based on other data sources, to assign condition to several of the remaining habitats.

The approach to mapping condition developed here enabled 95.4% of the area to be assigned a condition with reasonable confidence. The method was supported by 95% of workshop participants, but with caution advocated over its application and a call for field testing of the results. The majority of opinion at the workshop was that it was better to produce a condition map with gaps but where there was reasonable confidence in the categories assigned, rather than one that was complete but relied on a significant number of assumptions, that outweighed the usefulness of the product.

It was also possible to calculate biodiversity units based on the Biodiversity Metric 2.0 and we can use this to show the average biodiversity units for each habitat type or calculate the total units for any given area. The maps can be used for strategic decision making at the landscape scape, but at a local scale, site surveys and assessment using the Biodiversity Metric 2.0 will still be required. Potential emerging applications include identification of sites and habitats that are not in good condition and can be the focus of restoration and enhancement projects, Nature Recovery Networks, local natural capital plans (natural capital investment plans), broad assessment of baseline biodiversity units and biodiversity net gain for planning and development, and the new Environmental Land Management System (ELMS).

In the next part of this project, 27 different maps of natural capital assets and environmental quality were created, predominantly based on freely available data. Maps included indicators of environmental quality across air, land and water, stocks of natural capital beyond habitats, indicators of risk, degree of protection and information on public access. The single most preferred map was one showing tree cover, although this was the only map that relied on expensive data to be purchased. Some of the other most recommended maps to produce as part of a natural capital assessment included: air quality, agricultural land classification, overall waterbody status, designations, and Public Rights of Way. This would give an indication of environmental quality across a broad set of criteria, covering air, water, agricultural quality, site protection and public access. Additional maps covering carbon storage, further aspects of public access and green infrastructure, flood risk and agri-environment schemes are also recommended.

The workshop participants discussed public access and data sharing and a wide range of opinions were expressed. There was clear concern that the maps of habitat condition and biodiversity units could be used inappropriately. For this reason, it is important that maps are accompanied by notes describing their limitations and how they should and should not be used. Although there was no clear consensus for any one method of sharing maps, the most popular was through a paid system, ideally hosted through an organisation such as the Local Environmental Records Centres, although licencing implications will need to be considered.

Contents

Acknowledgements

This report and the approach outlined has been shaped by and benefited considerably from the expert input of all the participants who attended the workshop. I'd also like to thank the Nene Valley Nature Improvement Area Board who have encouraged and supported this project and all the related work that we are doing in the Nene Valley over many years, and the OxCam LNCP team for their useful input and for funding this project. Finally, thanks to Ed Sibley for invaluable help with initial analysis of the SSSI, LWS and CWS data sets and for producing Figure 4.

1. Introduction

Developing a natural capital asset register is the key first step in understanding natural capital and the benefits that it provides, and underpins efforts to deliver biodiversity net gain, map ecosystem services or account for impacts and dependencies on the natural environment. Approaches to map habitats have advanced in recent years and it is now possible to accurately map which habitats are present, their extent and spatial location over multiple scales. However, it is also important to understand the condition of the habitats, but this has proved to be much more challenging at a landscape scale. At a site scale this can be assessed by site visits, but this is not practical over wider areas. It is also not possible to determine this using remote sensing at present, although efforts are underway in certain situations, such as assessing tree and woodland health. These difficulties have meant that condition is often ignored in natural capital assessments. At the same time, the need for such assessments is increasing. Local natural capital plans, Nature Recovery Networks, the new Environmental Land Management System (ELMS), and the forthcoming mandatory requirement for biodiversity net gain and biodiversity offsetting all present new requirements for a better understanding of natural capital and its condition across landscapes.

Furthermore, although habitats remain the most fundamental component of natural capital, the concept incorporates much more. Natural capital is defined as "*..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions*" (Natural Capital Committee[1]). It is therefore important to capture broader indicators of air, land and water assets and their quality, and indicators of ecosystem processes and functions.

The aims of this project were, therefore, two-fold:

1. To determine if it was possible to assess condition of habitats at a landscape scale, using existing data and inferences.
2. To bring together a wide range of data from different sources to create maps of natural capital assets and environmental quality.

This work was commissioned by the Nene Valley Nature Improvement Area Board and the Northamptonshire Local Nature Partnership and was funded by the OxCam Local Natural Capital Plan (LNCP) Project. It focusses on Northamptonshire and Peterborough, an area that contains the catchment of the River Nene, but can be applied anywhere.

To help determine the usefulness of the outputs and guide recommendations going forward, a stakeholder workshop was planned as a fundamental part of the project. This was initially planned as a face-to-face meeting, but was changed to an online workshop following the Covid-19 outbreak, although feedback suggested that this did not affect the outcomes. Due to the change in structure, a number of polls were run as part of the workshop, as well as extensive discussions, the results of which are integrated into this report. Workshop participants included both local stakeholders familiar with the Nene Valley and technical specialists from further afield who sat on the OxCam LNCP Technical Group.

Part 2 of this report focusses on developing a method to assess habitat condition at a landscape scale and presents the results for Northamptonshire and Peterborough, alongside stakeholder feedback. Part 3 describes and presents a wide range of maps of natural capital assets and ecosystem quality, and stakeholder opinion on these. Part 4 presents further stakeholder feedback on whether the maps should be made publicly accessible, before providing recommendations. Full results of the polls carried out at the stakeholder workshop are included in the Appendix.

[1] Natural Capital Committee (2014) Towards a Framework for Measuring and Defining changes in Natural Capital, Natural Capital Committee Working Paper, Number 1.

2. Mapping Habitat Condition

2.1 Natural Capital assets

The first step was to create a detailed natural capital basemap for the whole study area. To do this we used Ordnance Survey MasterMap polygons as the underlying mapping unit and then utilised a series of different data sets to classify each polygon to a detailed habitat type and to associate a range of additional data with each polygon. The data that was used to classify habitats is shown in Box 1.

Box 1: Data used to classify habitats in the basemap:

- Ordnance Survey MasterMap topography layer
- Open space (green infrastructure) data sets for each local council (9 local councils in total).
- BAP habitat – supplied by Northamptonshire and Cambridgeshire Wildlife Trusts, combined with additional data taken from the National Priority Habitats Inventory (Natural England).
- Local wildlife sites obtained from Northamptonshire Wildlife Trust
- CEH Land Cover Map 2007
- Corine European habitat data
- Built-up Area Boundaries data
- Ancient Woodland Inventory data

The basemapping process follows the same procedure as described in Rouquette (2020)[2], which provides much more detail. Polygons were classified into Phase 1 habitat types and were also classified into broader habitat groups. The basemap was produced for the whole of Northamptonshire (7 local authority areas), the local authority area of Peterborough City Council, and included a small patch from Huntingdonshire District Council to enable complete coverage of the River Nene catchment. The final basemap covered 275,000 ha and contained 1.65M polygons, each of which was classified to an appropriate habitat type.

Table 1 (overleaf) shows the percentage cover of broad habitat types across Northamptonshire and Peterborough and these are mapped in Figure 1. The area is dominated by cultivated land and improved grassland (making up c. 77% of the area), whilst built-up areas, infrastructure (roads, railways, pavements and paths) and gardens make up a significant 10.1% of the land area. Semi-natural and marshy grasslands make up approximately 2.0% of the area, woodland consists of 6.3% and water occupies 1.4% of the area.

[2] Rouquette, J.R. (2020). OxCam LNCP Natural Capital Baseline Assessment: Data Report. Report for OxCam Local Natural Capital Plan Project, Environment Agency. Natural Capital Solutions.

Table 1. Percentage cover of broad habitat types across the study area.

Habitat type	% cover
Cultivated land (arable)	56.5
Uncertain agriculture	0.2
Improved grassland	20.6
Semi-natural grassland	1.3
Marshy grassland	0.7
Fen, marsh and swamp	0.04
Heathland	0.01
Broadleaved woodland	3.5
Coniferous woodland	0.6
Mixed woodland	2.2
Scrub	0.2
Trees / Parkland	1.8
Water	1.4
Rock, exposure and waste	0.1
Built-up areas and infrastructure	6.3
Garden	3.8
Mixed / other / uncertain	0.4
Unclassified	0.3

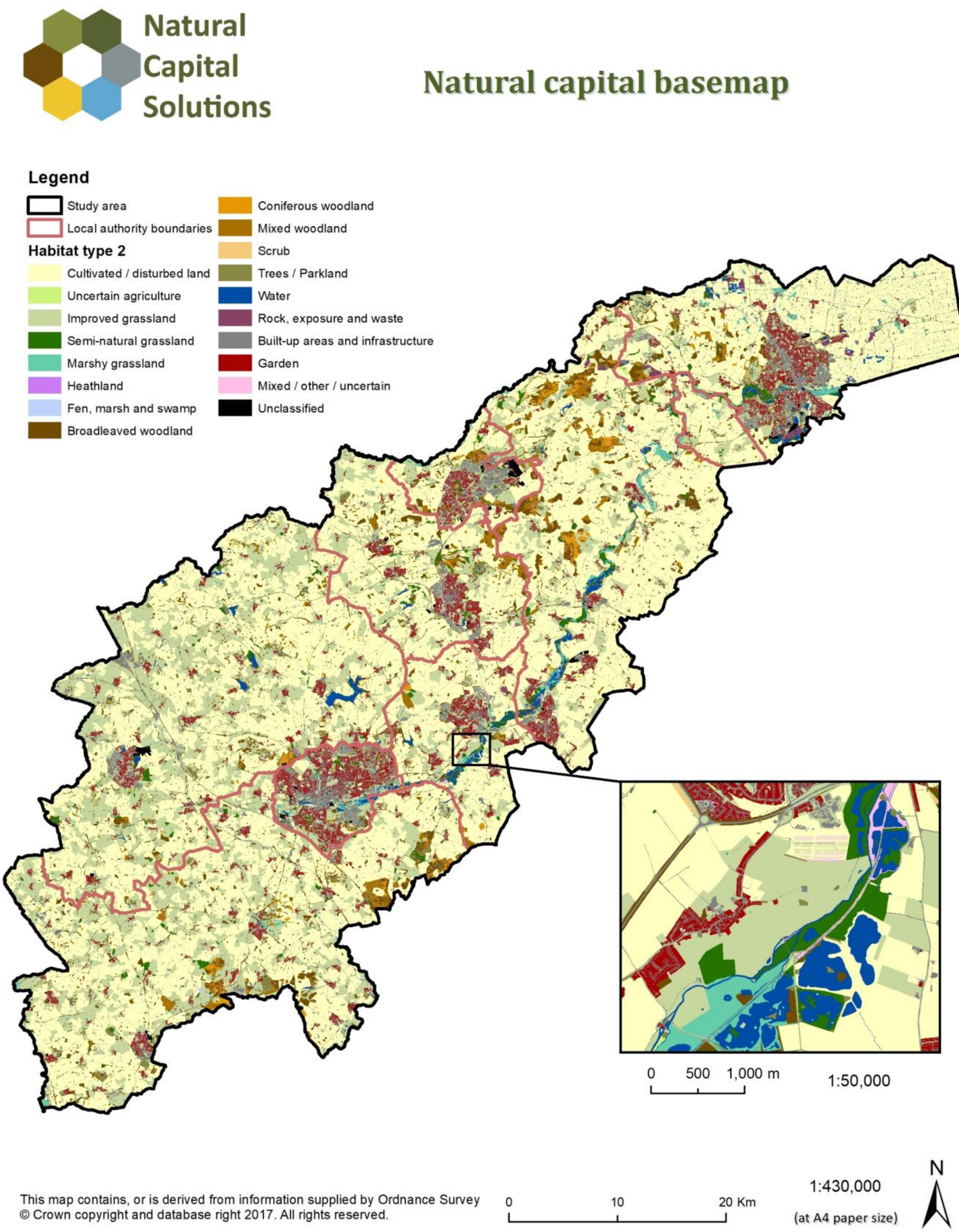


Figure 1: Natural capital basemap for Northamptonshire and Peterborough. Each polygon is mapped to a detailed Phase 1 habitat type (e.g. unimproved neutral grassland), but can also be classified to a broader habitat grouping as shown here. The map is detailed enough to show each individual house, garden, road verge and land parcel across the whole study area.

2.2 Assigning Condition – low quality habitats

Condition was assigned to categories according to the Biodiversity Metric 2.0[3] and shown in Table 2. This assigns categories from Good to Poor and also includes two N/A categories for agriculture and other (non-natural) habitats. When used in the metric, these categories are also given a score from 0-3, as shown in Table 2.

Table 2. Condition categories, from Biodiversity Metric 2.0

Category	Multiplier
Good	3
Fairly Good	2.5
Moderate	2
Fairly Poor	1.5
Poor	1
N/A – Agriculture	1
N/A - Other	0

Based on descriptions in the Biodiversity Metric 2.0, it is possible to assign condition categories to a number of low quality categories without the need for any further information. This includes all built habitats such as buildings and infrastructure (N/A – other), arable (N/A – Agriculture), improved grassland (poor) and gardens (poor). When these categories are assigned across the study area, 1.475M polygons were given a condition category, as shown in Table 3, accounting for 83.4% of the total study area and the map of these habitats is shown in Figure 2.

Table 3: Low quality habitats where condition could be applied automatically. Shows the condition applied, the number of polygons, area and % cover of these habitats in the study area.

Ph1 Code	Habitat type	Condition	No. polygons	Area / ha	% cover
B4	Improved grassland	Poor	79,954	45,241	16.4
B4/J11	Uncertain agriculture	N/A – Agriculture	400	522	0.2
J11	Arable	N/A – Agriculture	20,184	155,344	56.4
J36	Buildings	N/A - Other	643,111	5,159	1.9
J37	Sealed surface	N/A - Other	75,915	4,368	1.6
J51	Roads	N/A - Other	90,745	5,798	2.1
J52	Pavement	N/A - Other	29,603	1,124	0.4
J53	Railway	N/A - Other	776	311	0.1
J54	Path	N/A - Other	24,936	463	0.2
J55	Gardens	Poor	507,576	10,506	3.8
Unclassified	Under development	N/A - Other	2,198	747	0.3
TOTAL			**1,475,398**	**229,582**	**83.4**

[3] Ian Crosher A, Susannah Gold B, Max Heaver D, Matt Heydon A, Lauren Moore D, Stephen Panks A, Sarah Scott C, Dave Stone A & Nick White A. 2019. The Biodiversity Metric 2.0: auditing and accounting for biodiversity value. User guide (Beta Version, July 2019). Natural England.

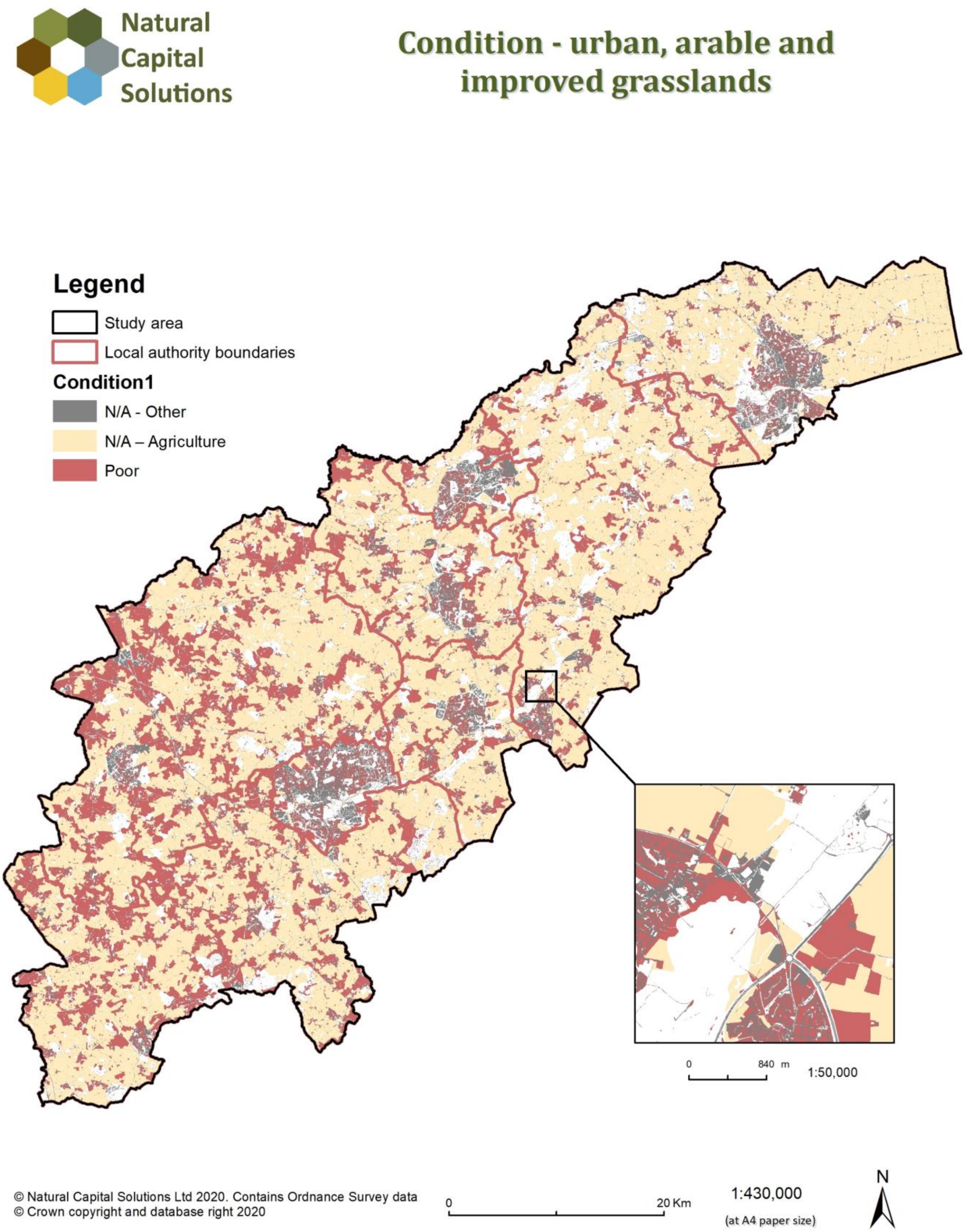


Figure 2. Map showing condition applied to low quality habitats across the study area. Note that these habitats occupy 83.4% of the total area.

2.3 Assigning condition – designated sites

After assigning condition to the habitats of least interest, we then considered if it was possible to assign condition to habitats with greatest wildlife interest, those in statutory and non-statutory designated sites. Here, we obtained data from Natural England on the condition of SSSI units, along with information on the condition of local wildlife sites. The latter are referred to as Local Wildlife Sites in Northamptonshire and data were provided by the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire (WTBCN), and are known as County Wildlife Sites in Peterborough, with data provided by the Cambridgeshire and Peterborough Environmental Records Centre (CPERC).

To assign condition to habitats we need to make one major assumption, which is that semi-natural habitats within a designated site (or unit of a site), can be given the condition of the overall site. Hence if a site is assessed to be in Favourable condition, all the semi-natural habitats within that site are assigned a Good status. Improved habitats and man-made features were excluded. It should be noted that condition of SSSIs is determined in relation to the designated features of the SSSI, hence overall condition may not always be relevant for certain habitats. However, given the lack of detailed condition information for each individual habitats, we felt that our assumption was not unreasonable, and was generally supported in the stakeholder workshop.

Table 4a shows the condition of SSSI Units across the study area and the percentage cover of these sites in relation to the whole area, and the corresponding map is shown in Figure 3. Overall, 36.3% of the SSSI units are assessed to be in favourable condition, a further 61.2% are determined to be unfavourable recovering, with the remaining 2.5% in unfavourable no change or unfavourable declining condition. In total, this data covers 4,466 ha of semi-natural habitats, or 1.62% of the study area.

It is also necessary to translate the SSSI condition categories into condition categories that are compatible across habitats, based on the biodiversity metric (outlined in Table 2). The translation between categories is shown in Table 4b.

Table 4a. Condition of SSSI Units and the area and % cover of these sites in the study area

SSSI condition	Area / ha	% cover
Favourable	1622	0.59
Unfavourable recovering	2733	0.99
Unfavourable no change	85	0.03
Unfavourable declining	25	0.01
Destroyed	0	0.00
Total with condition	**4466**	**1.62**
Not SSSI	270,743	98.38

Table 4b. Translation of SSSI condition categories into habitat condition categories

Category	Condition
Favourable	Good
Unfavourable, recovering	Moderate
Unfavourable, no change	Poor
Unfavourable, declining	
Destroyed	NA-Other

Local Wildlife Sites in Northamptonshire are assessed for condition (Favourable, Part-favourable or Unfavourable), for the trajectory of this (stable, recovering or declining), and for whether the site is considered to be in positive conservation management or not (yes or no). There are 715 LWS in Northamptonshire, with condition assessed at 385 of these (54%) and positive conservation management assessed at 520 (73%) of sites.

For sites where all data is available (355 sites) a balloon plot (Figure 4), shows the frequency of each condition category and whether it is under positive conservation management or not. Unsurprisingly, most (but not all) sites in favourable recovering or favourable stable condition are under positive management, whereas most sites that are declining are not in favourable management.

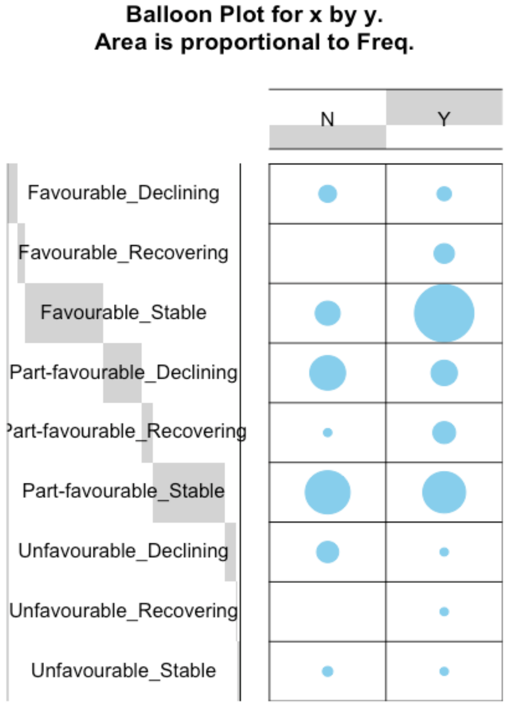


Figure 4: Balloon plot showing LWS condition and whether they are in favourable management.

Table 5a shows the area under each condition category for the Northamptonshire LWS and the percentage cover in relation to the whole area. The total area of semi-natural habitats where condition has been assigned comprise 4,588 ha or 1.67% of the study area, whereas condition has not been assigned for LWS making up 6,701 ha, or 2.44% of the study area. Note that there is some overlap between LWS and SSSIs of about 1190 ha, hence the amount of entirely new condition data covers 1.23% of the total area. Condition categories are shown in Table 5b, and a map showing the Northamptonshire LWS and their condition is shown in Figure 5.

Table 5a. Condition of Local Wildlife Sites in Northamptonshire and the area and % cover of these sites in comparison to the whole study area.

LWS condition	Area / ha	% cover
Favourable stable	1713	0.62
Favourable recovering	218	0.08
Favourable declining	93	0.03
Part-favourable recovering	125	0.05
Part-favourable stable	1943	0.71
Part-favourable declining	400	0.15
Unfavourable recovering	9	0.00
Unfavourable stable	31	0.01
Unfavourable declining	56	0.02
Total with condition	**4588**	**1.67**
No condition info	6701	2.44
Total LWS	11290	4.10
Additional condition info	**3398**	**1.23**

Table 5b. Translation of LWS condition categories into habitat condition categories.

Category	Condition
Favourable Stable	Good
Favourable Recovering	
Favourable Declining	Fairly Good
Part-favourable Recovering	
Part-favourable Stable	Moderate
Unfavourable Recovering	
Part-favourable Declining	Fairly Poor
Unfavourable Stable	Poor
Unfavourable Declining	

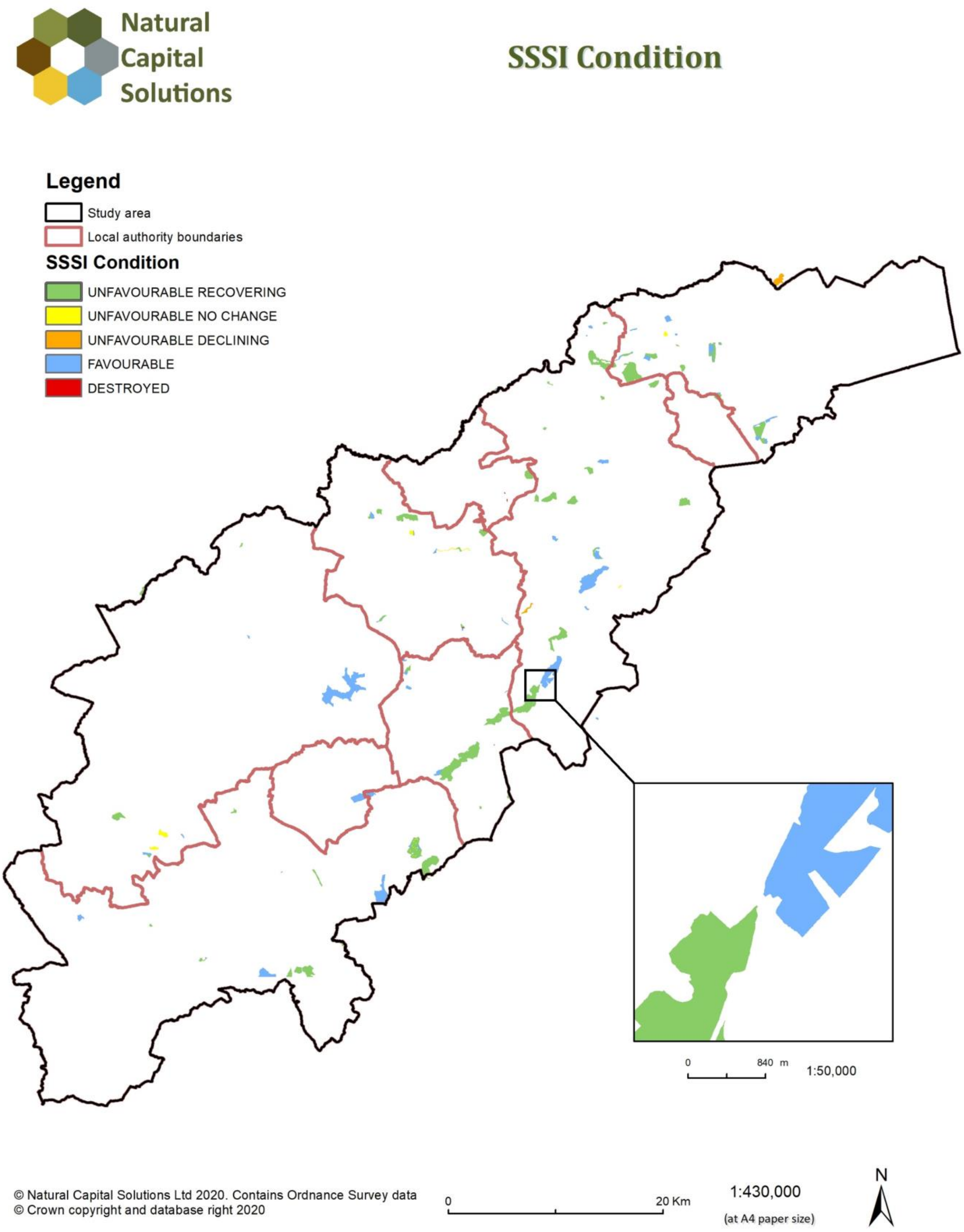


Figure 3: Condition of SSSIs across the study area (data from Natural England).

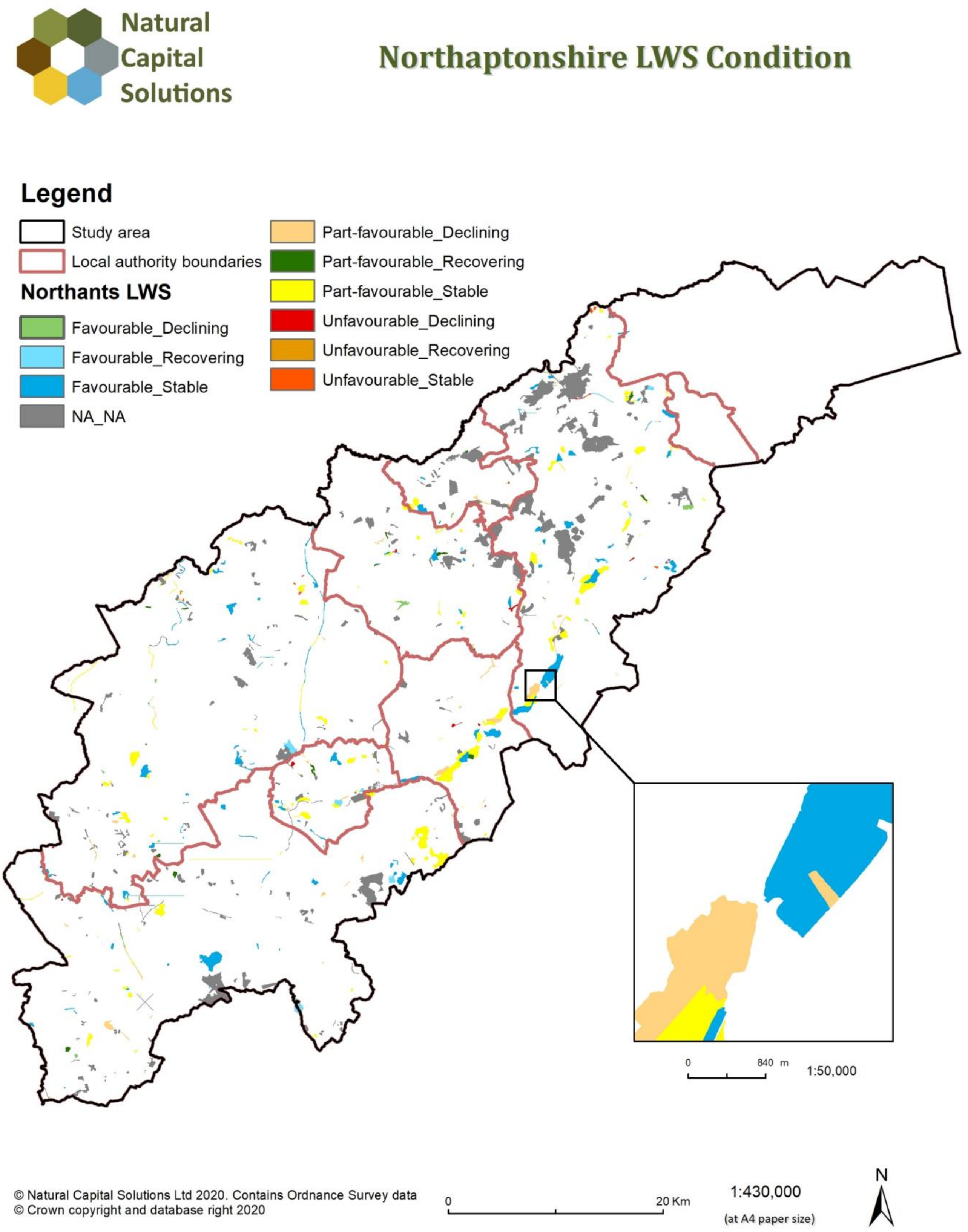


Figure 5: Condition of Local Wildlife Sites in Northamptonshire (data from the Wildlife Trust for Bedfordshire, Cambridgeshire and Northamptonshire).

The equivalent data for County Wildlife Sites in Peterborough is shown in Table 6a and on Figure 6. In Peterborough condition is recorded in three categories (Favourable, Part-favourable, and Unfavourable) and these are directly translated into Good, Moderate and Poor condition categories, as shown in Table 6b. In total, condition data is available for 1,792 ha of semi-natural habitats, or 0.65% of the whole study area, with no condition information for 421 ha (0.15% of the study area).

Table 6. Condition of County Wildlife Sites in Peterborough and the area and % cover of these sites in comparison to the whole study area.

CWS condition	Area / ha	% cover
Favourable	580	0.21
Part-favourable	1126	0.41
Unfavourable	87	0.03
Total with condition	**1792**	**0.65**
No condition info	421	0.15
Total PCWS	2213	0.80
Additional condition info	**1775**	**0.64**

Table 6b. Translation of CWS condition categories into habitat condition categories.

Category	Condition
Favourable	Good
Part-favourable	Moderate
Unfavourable	Poor
NA	NA-Other

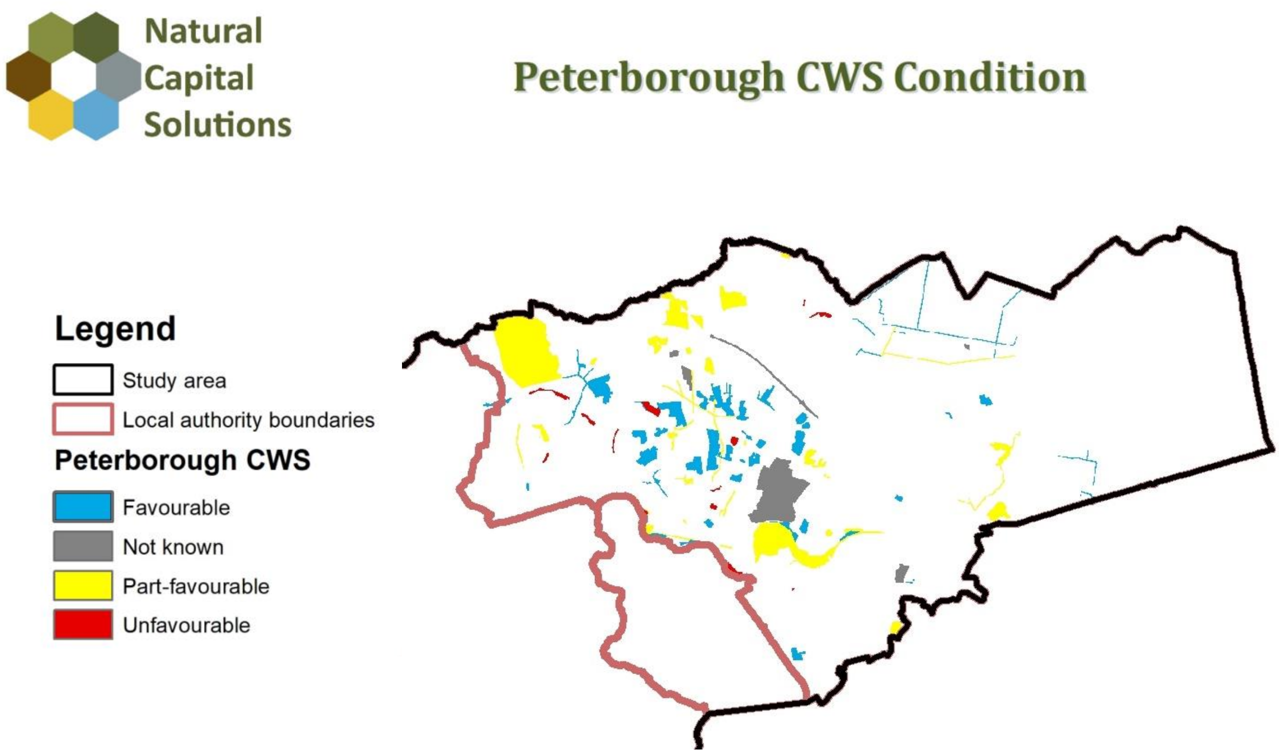


Figure 6: Condition of County Wildlife Sites in Peterborough (data from the Cambridgeshire and Peterborough Environmental Records Centre).

Where sites overlap, it is necessary to decide which data set is used to represent the condition of that site. Here we have used the SSSI data as the primary data source. When asked at the stakeholder workshop, which data set should be given priority, 77% of respondents were unsure, with 18% choosing the SSSI data set and only 4.5% choosing the LWS/CWS data. However, a number of participants recommended that the data chosen should be based on the date of the condition assessment, with the most up-to-date chosen. This seems sensible, but would add considerable time to the process, as each overlapping site would need to be checked and processed individually. Note that SSSI and Northamptonshire LWS condition data were broadly in agreement, but there were some differences.

Table 7 shows the total area where new condition data has now been supplied using these data sources, after removing overlaps. In total, this data provides condition information for 9,639 ha of semi-natural habitats, representing 3.50% of the total area of Northamptonshire and Peterborough.

Table 7. Total area with condition information derived from the three data sources. For the Northamptonshire Local Wildlife Sites (NLWS) and Peterborough County Wildlife Sites (PCWS), overlaps with SSSI data are removed, to show the additional area with condition data.

Area with condition info	Area / ha	% cover
SSSI condition	4466	1.62
NLWS additional condition	3398	1.23
PCWS additional condition	1775	0.64
Grand total condition	**9639**	**3.50**

Once the information from SSSIs, LWS and CWS have been integrated with the habitat basemap, the resulting map of condition for these sites is shown in Figure 7. These were then combined with the condition data assigned to low quality habitats to produce a map showing all habitats that have been ascribed a condition (Figure 8).

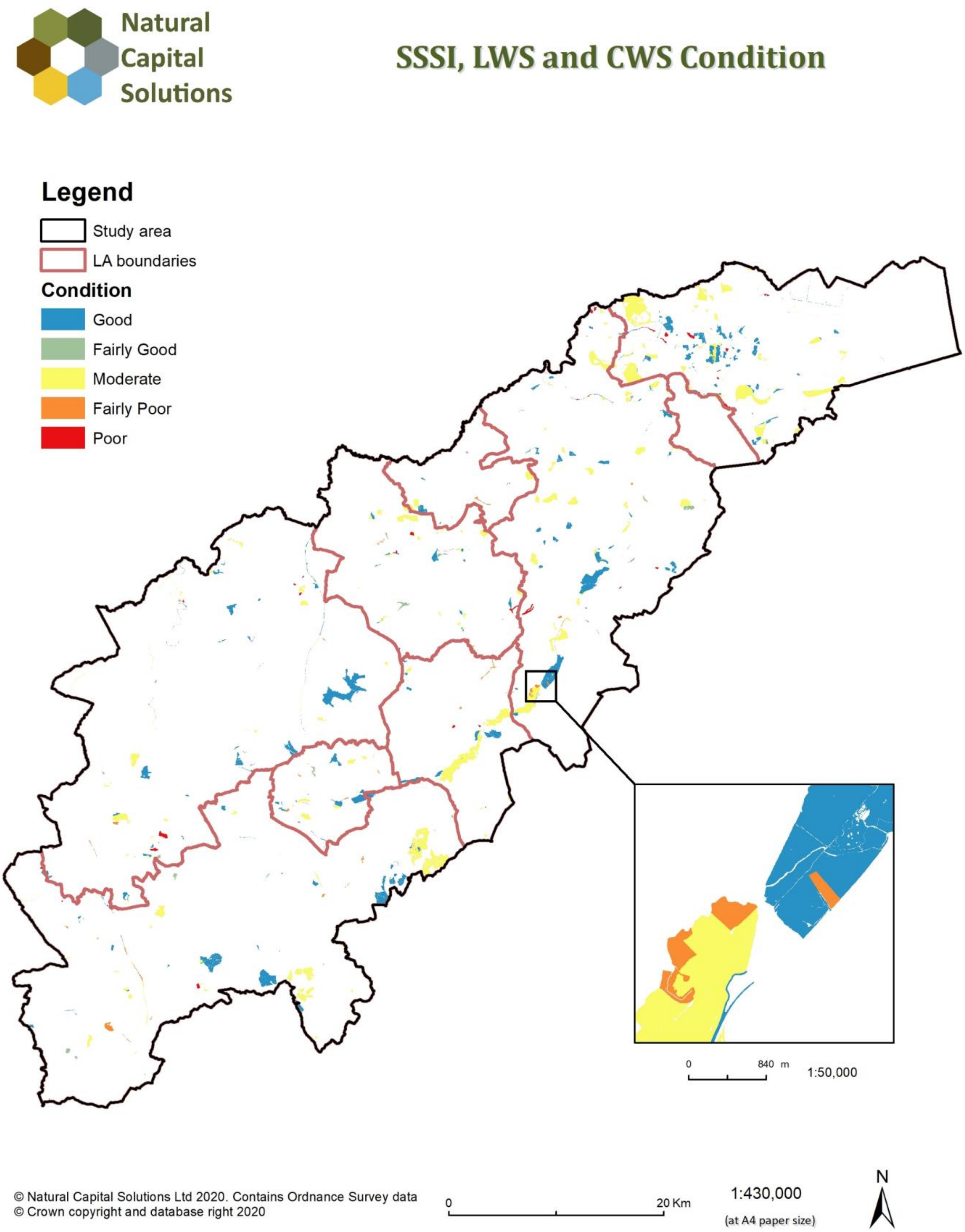


Figure 7: Condition of habitats assigned using SSSI, Northamptonshire LWS and Peterborough CWS data sets.

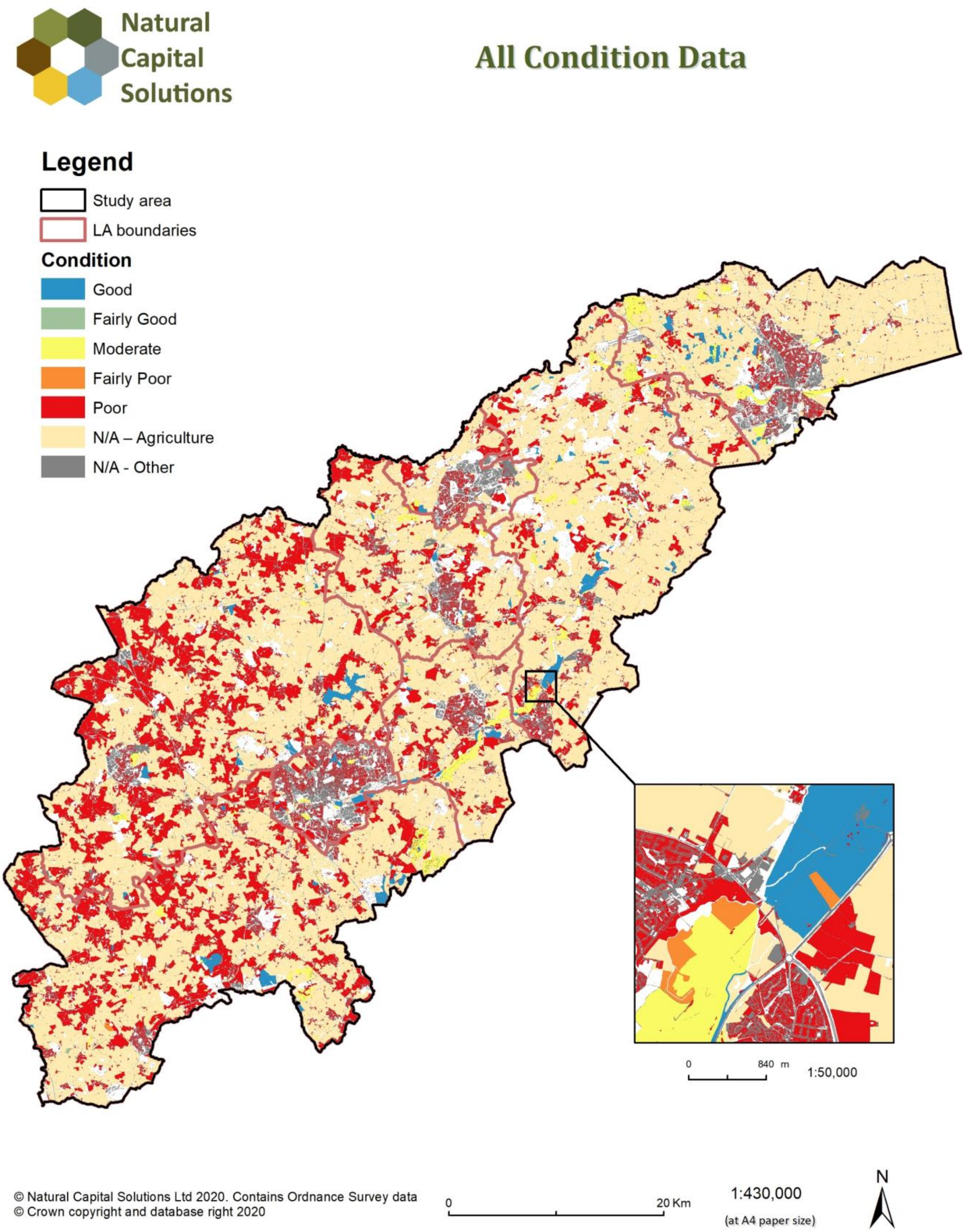


Figure 8: Map combining condition data assigned to low quality habitats with condition data from designated sites.

2.4 Assigning condition – remaining habitats

Once condition had been assigned to low quality habitats and to habitats in designated sites, the remaining habitats without a condition were extracted and are shown in Table 8. The habitat with the largest area without condition assigned was amenity grassland, representing 4.1% of the study area (improved grasslands were assigned a condition of poor, but amenity grasslands had not been assigned a condition). The majority of woodlands and habitats with trees had not been assigned a condition and made up a significant portion of the study area. Approximately two thirds of semi-natural and marshy grasslands were not assigned a condition and together these made up 1.3% of the study area, whilst water areas without a condition assigned made up 0.8% of the study area.

Table 8. Habitat types that had not been assigned a condition, showing the area of each habitat with and without condition assigned, the % of the habitat type without a condition assigned, and the % cover of the study area that this represented.

Habitat type	Area with condition assigned / ha	Area without condition assigned / ha	% of habitat type without condition	% cover of study area
Broadleaved woodland	2930	6585	69.2	2.4
Coniferous woodland	247	1512	86.0	0.5
Mixed woodland	1200	4780	79.9	1.7
Scrub	61	458	88.3	0.2
Trees / Parkland	597	4460	88.2	1.6
Semi-natural grassland	1342	2175	61.8	0.8
Marshy grassland	505	1433	74.0	0.5
Improved and amenity grassland	45574	11198	19.7	4.1
Fen, marsh and swamp	98	14	12.1	0.0
Heathland	15	2	13.4	0.0
Rock, exposure and waste	0	393	100.0	0.1
Water	1649	2205	57.2	0.8
Mixed / other / uncertain	206	944	82.1	0.3

The next consideration was whether it was possible to infer condition for any of the habitats shown in Table 8. Various options were presented to the experts at the workshop and additional ideas were raised by the participants. Following discussions and follow up work, it was decided that the habitats shown in Table 9 could be assigned a condition with reasonable confidence.

Table 9. Habitats where is was felt that a condition could be inferred and the explanation for how the condition was assigned.

Habitat type	Inferred Condition	Explanation
Broadleaved woodland (excluding orchards)	Moderate	According to recently published NFI Condition data[4], 92% of broadleaved woodlands in England are given a condition score of intermediate, 6.4% are favourable and 1.5% are unfavourable. Given that some of the best broadleaved woodlands are likely to be in SSSIs and LWS for which we mostly have condition data, and so is likely to pick up the majority of the sites in favourable condition, it would seem likely that the remaining sites would almost all be in intermediate condition.
Coniferous woodland	Poor	Almost all coniferous woodlands in the study area are plantation woodlands. According to the Biodiversity Metric 2.0 these should be given a condition of poor.
Mixed woodland on ancient woodland sites	Moderate	Ancient Woodland Inventory data was overlain and those mixed woodlands that were on ancient woodland sites were given a condition of moderate, as they are likely to be PAWS (Plantations on Ancient Woodland Sites). In total, 2203 ha or 46% of the previously unclassified mixed woodlands were on ancient woodland sites.
Remaining mixed woodlands	Unclassified	Remaining mixed woodlands were unclassified due to the high variability in these sites.
Amenity grassland	Poor	Amenity and road verge grasslands are usually classified as poor, following Biodiversity Metric 2.0 and 86% of workshop participants either agreed with this inference or were not sure. Note that there will be a small proportion of these grasslands that are being managed for biodiversity and are of higher (moderate) quality, but it was felt that these would be a very small minority.
Quarries / mineral extraction sites	N/A – Other	Currently active quarries, landfill sites and mineral extraction sites should be classified as N/A - Other. Sites being restored or recovering would not be classified.
Water	Variable	It was suggested and agreed at the workshop that Water Framework Directive (WFD) overall waterbody class should be used to assign condition to water habitats (see Figure 19c). WFD categories of high, good, moderate, poor, and bad, were translated directly into good, fairly good, moderate, fairly poor, and poor condition categories, respectively. We used the most detailed WFD River Waterbody catchments (the study area contains 117 different waterbodies) and overlaid this data layer onto the basemap. All water areas within each waterbody were assigned to the condition category of the waterbody.

[4] Forestry Commission (2020). NFI woodland ecological condition in England. National Forest Inventory.

We discussed other habitats at the workshop, but the consensus was that there was too much variation in these habitats to warrant assigning a condition to them. It may be possible to assign the following habitats to the poor condition category if the aim is for completeness, but there are likely to be some sites in better condition:

- Rough grassland, scattered trees (not historic parkland), allotments, linear features (this is a catch-all category that captures many small strips of habitats, so is inherently highly variable)

The following unclassified habitats are of greater wildlife value, but condition could range from good to poor:

- Floodplain grazing marsh, reedbeds, fen, unimproved neutral grassland, scrub

The workshop discussed the idea of assigning all unclassified habitats to a standard "Moderate" category to enable completeness of the mapping. But when asked the question, "should all remaining seminatural habitats be assigned a condition of Moderate?", 50% of participants responded "no" and a further 45% responded "for some of them", with only 5% responding "yes". Overall, the majority of opinion at the workshop was that it was better to produce a condition map with gaps but where there was reasonable confidence in the categories assigned, rather than one that was complete but relied on a significant number of assumptions, that outweighed the usefulness of the product.

The process of inferring condition for these unsurveyed habitats, where assumptions are not too great, results in an additional 23,906 ha of habitats being assigned a condition, or 8.7% of Northamptonshire and Peterborough (see Table 10). These habitats are mapped in Figure 9. This leaves 12,532 ha of habitat unassigned, or 4.6% of the study area, and a map of these locations is shown in Figure 10.

Table 10. Overall number of polygons, area and the % cover of the study area, that have been assigned a condition based on the assumptions outlined in Table 9, and the total remaining unassigned habitats.

Condition assigned	No. polygons	Area / ha	% cover
Inferred condition	131,567	23,906	8.7
Unassigned	30,975	12,532	4.6

The final condition map for Northamptonshire and Peterborough is shown in Figure 11. Overall, it was possible to assign a condition with reasonable confidence to 95.4% of the area.

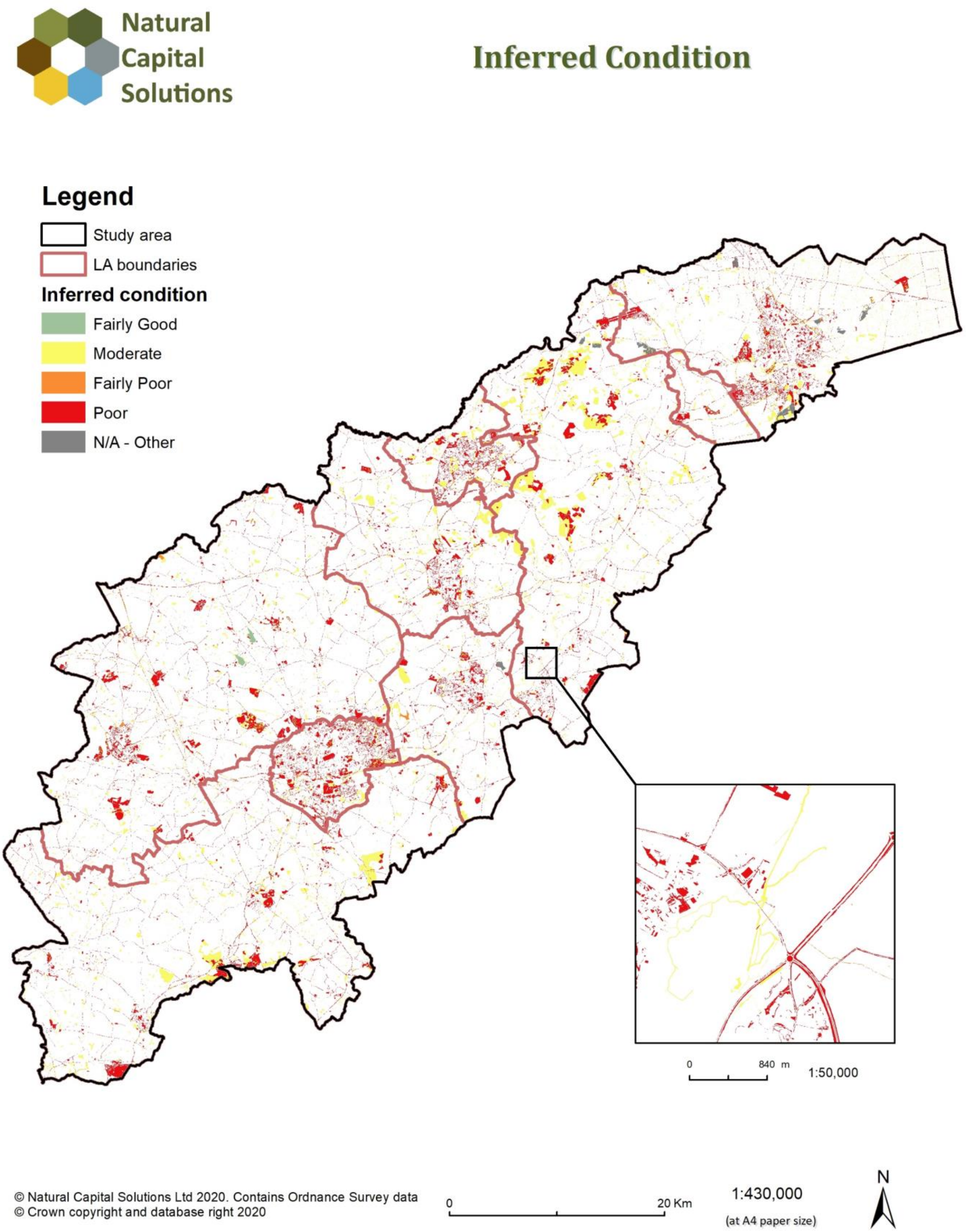


Figure 9: Condition of additional habitats that can be inferred with reasonable confidence.

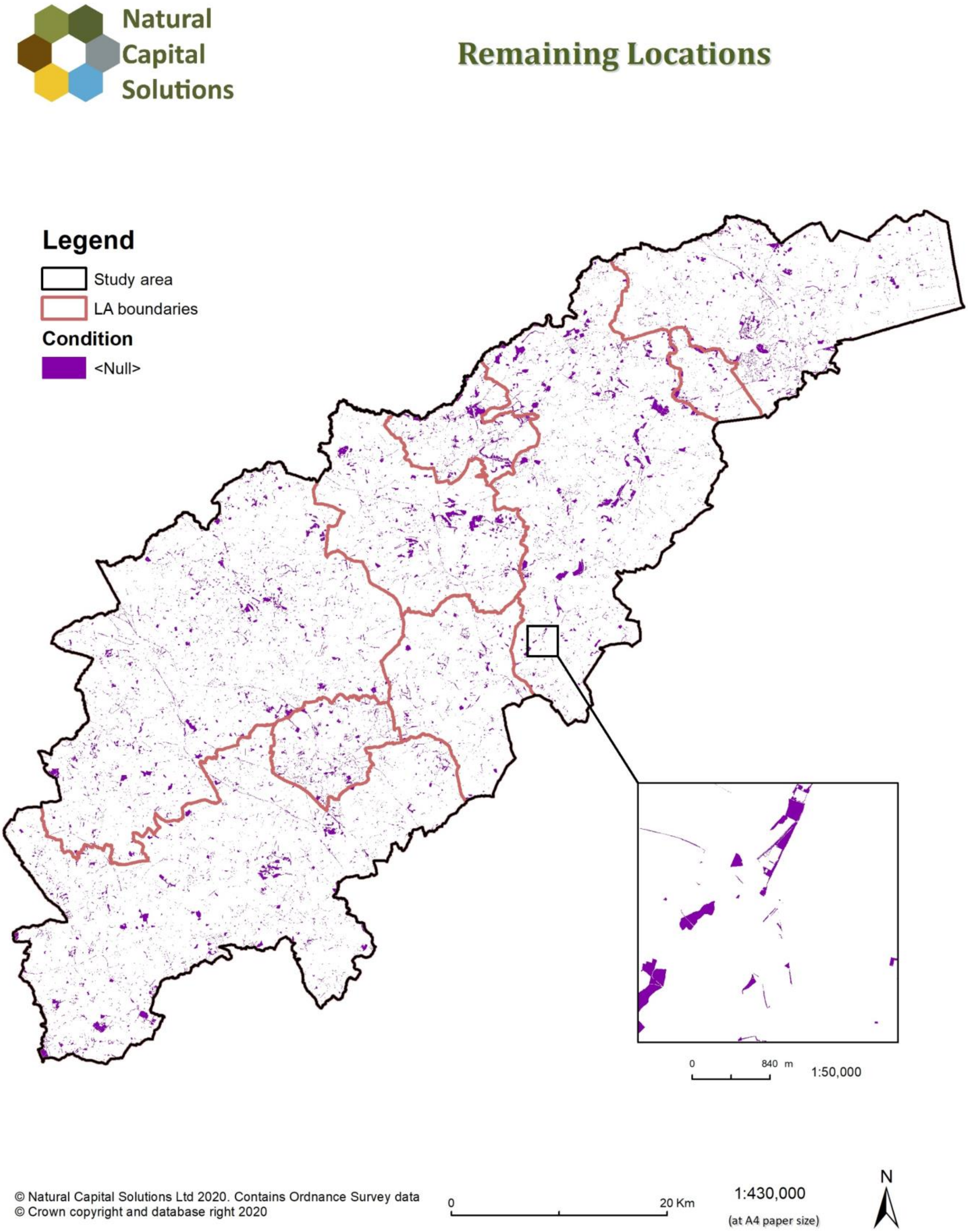


Figure 10: Remaining habitats where condition cannot be inferred without making a large number of assumptions that were considered unacceptable.

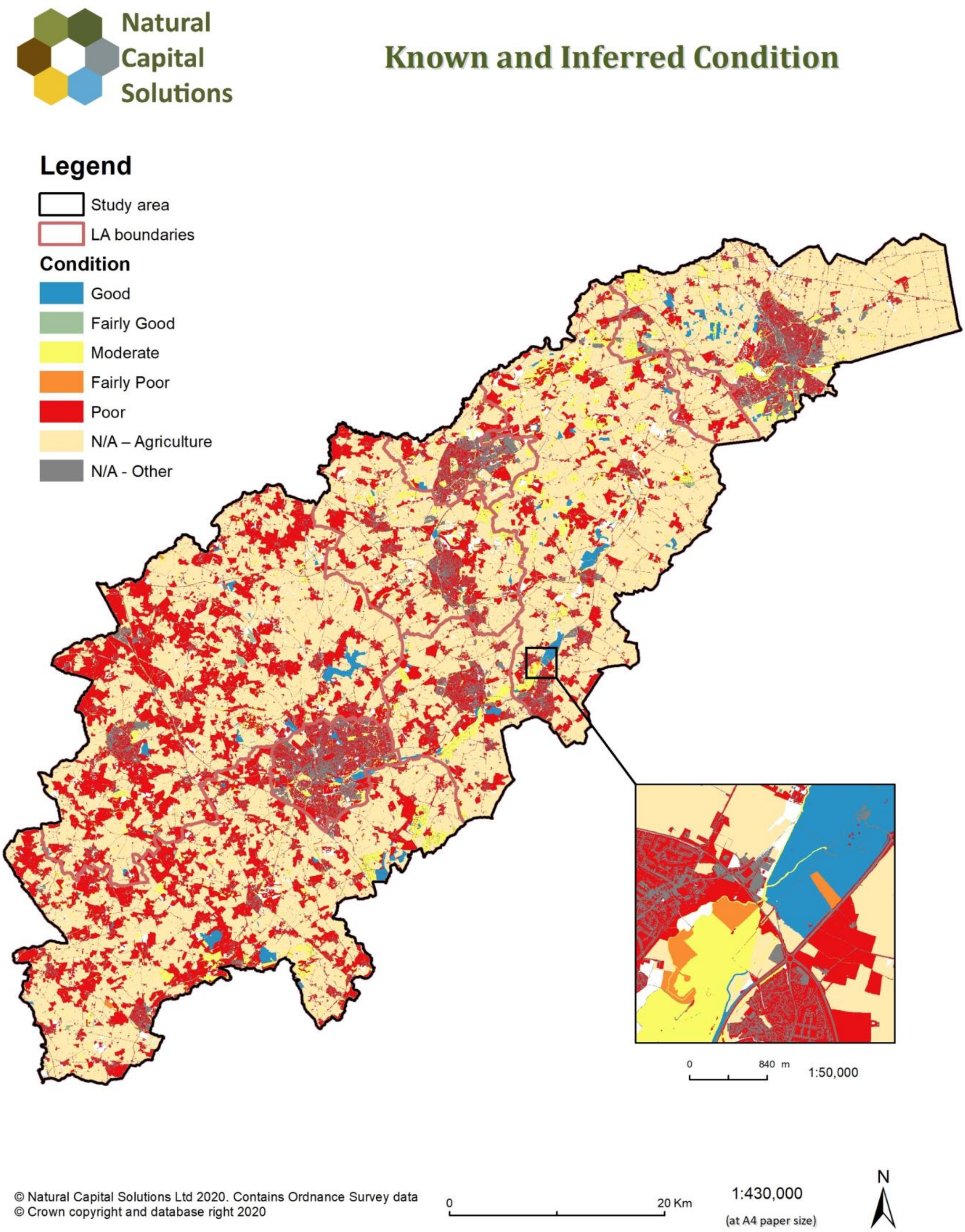


Figure 11: Final map of condition, showing all habitats and sites where condition has been assessed or can be assigned with reasonable confidence. Note that condition has been assigned to 95.4% of the study area, with unassigned areas shown as white space.

2.5 Calculating Biodiversity units

To calculate biodiversity units using the Biodiversity Metric 2.0, as well as information on condition, we also need information on distinctiveness. Habitats are classified into one of 5 categories, ranging from very high to very low, based on the habitat type. Table 11 shows how these categories are defined, and the Biodiversity Metric classifies all habitats into one of these categories.

Table 11. Distinctiveness categories, as defined by the Biodiversity Metric 2.0.

Category	Scores	Multiplier
Very High	8	Priority habitats as defined in Section 41 of the Natural Environment and Rural Communities (NERC) Act that are highly threatened, internationally scarce and require conservation action e.g. blanket bog
High	6	Priority habitats as defined in Section 41 of the NERC Act requiring conservation action e.g. lowland fens
Medium	4	Semi-natural habitats not classed as a Priority Habitat
Low	2	Habitat of low biodiversity value. Temporary grass and clover ley; intensive orchard; rhododendron scrub
Very Low	0	Little or no biodiversity value e.g. hard standing or sealed surface

Each habitat type found in the study area was therefore allocated to a distinctiveness class based on the Biodiversity Metric guidance and Figure 12 shows the resulting map. This shows that the vast majority of Northamptonshire and Peterborough contains habitats of low distinctiveness, representing arable and improved grassland habitats, with the patches of woodland of the Rockingham Forest showing clearly as medium distinctiveness, and the Nene Valley river corridor distinguishable with medium and a few higher distinctiveness habitats.

To calculate biodiversity units, the score for distinctiveness (out of 8) is multiplied by the score for condition (out of 3). This was therefore calculated for each polygon in the basemap and the resulting map is shown in Figure 13. The majority of the area scores two biodiversity units, as this comprises arable and improved grassland, which is of low distinctiveness and poor condition. But higher scoring habitats are clearly distinguishable, especially along the river corridor.

Note that when calculating biodiversity units using the Biodiversity Metric, two further factors are also considered: strategic significance and connectivity. Each of these can uplift the scores by a maximum factor of 1.15. As the main aim of this study was to consider how effectively condition could be assigned, rather than focussing on the Biodiversity Metric, we did not attempt to calculate these factors. It would, however, be relatively straightforward to apply a weighting for strategic significance. Polygons showing areas of high and medium strategic significance across the study area could be defined and overlain onto the basemap, and where these did overlay, a weighting of 1.15 and 1.1 could be applied to the scores respectively. Applying a weighting for connectivity would be much less straightforward as this relies on a tool developed by Natural England and this is designed to work at a site scale. It may be possible to develop a proxy connectivity score for use at a landscape scale, but this would require further work.

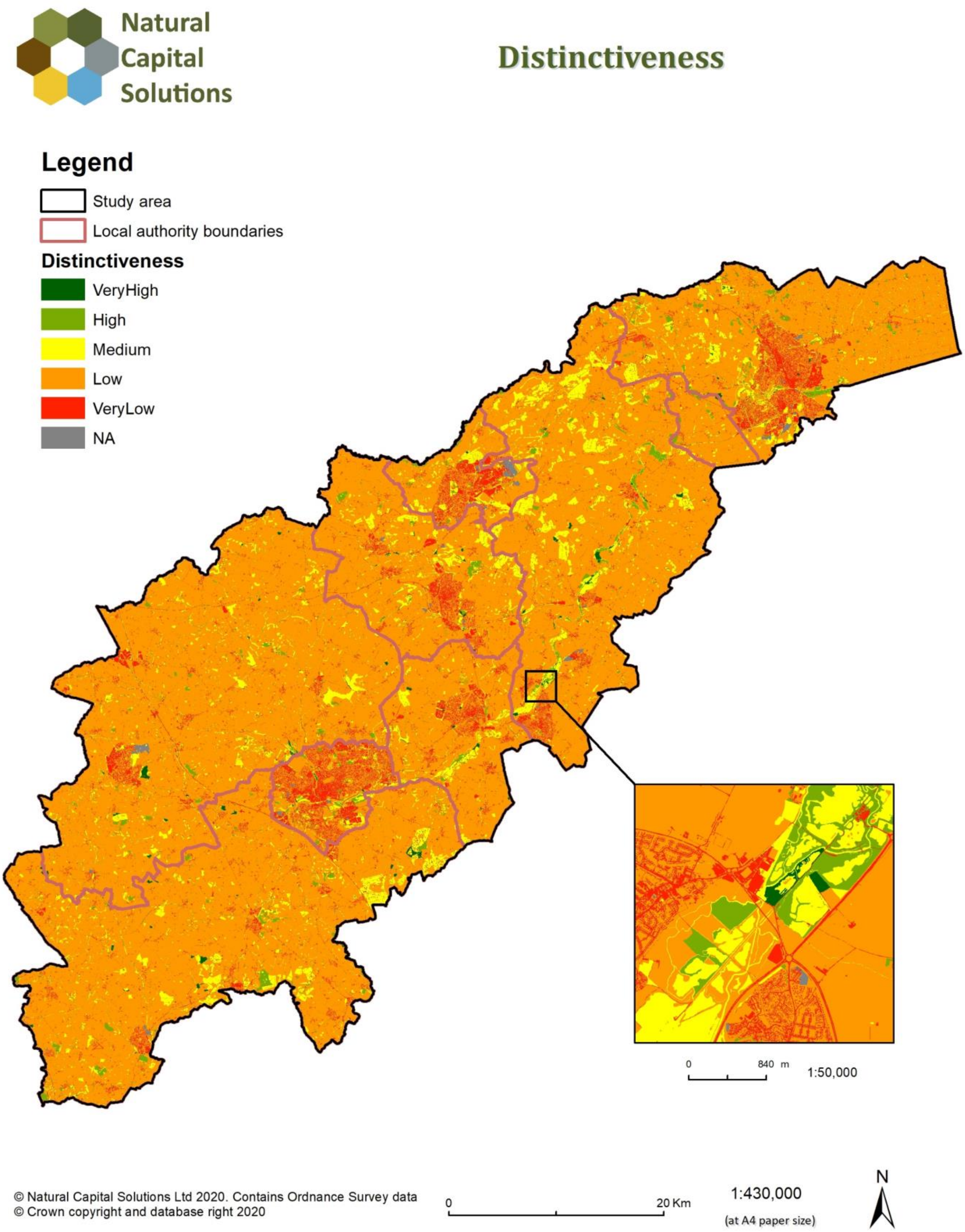


Figure 12: Distinctiveness of habitats in the study area, based on the Biodiversity Metric 2.0.

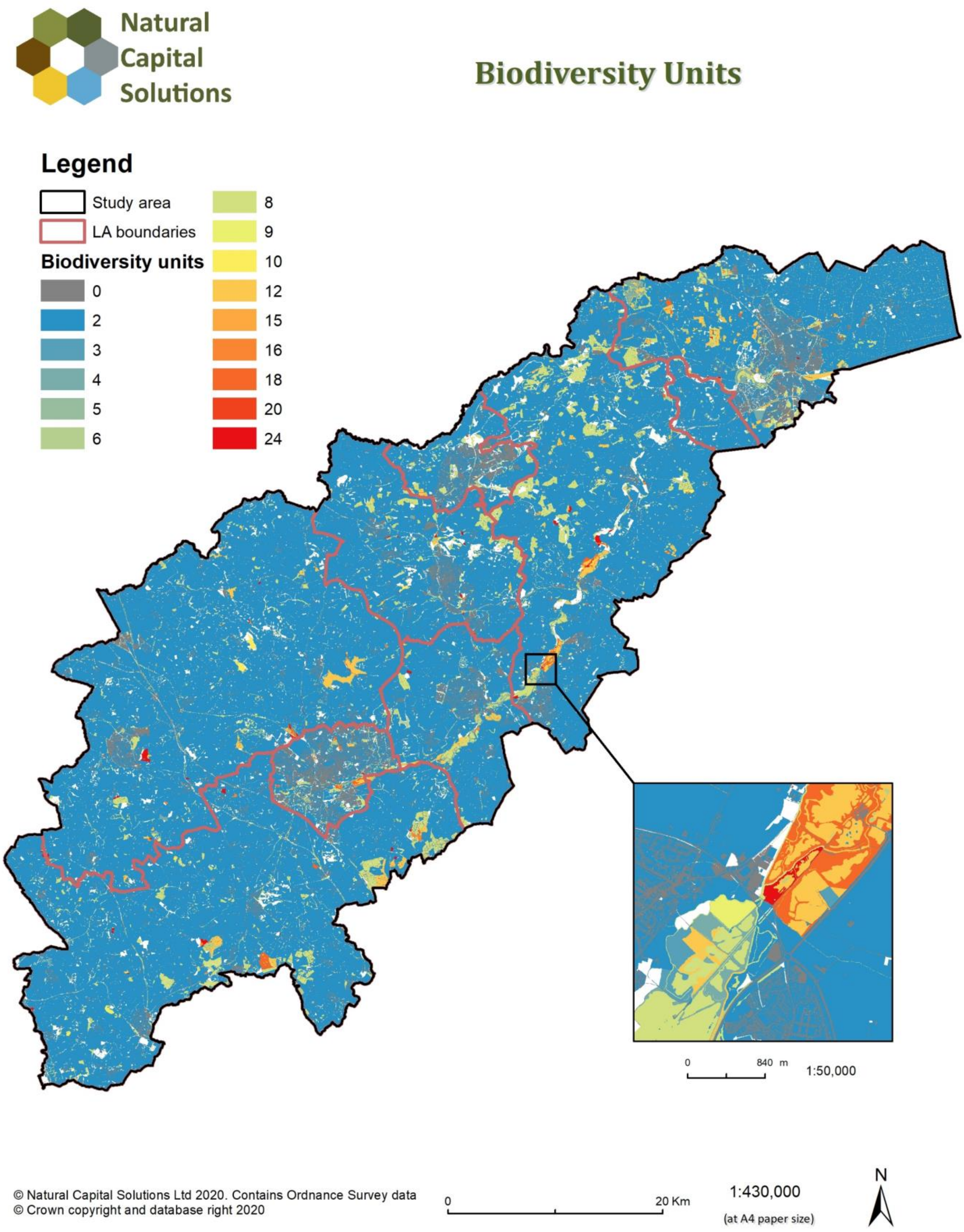


Figure 13: Biodiversity Units of habitats across the study area, calculated as the distinctiveness score multiplied by the condition score. Note that white areas are areas where a score has not been calculated, as condition could not be assigned (as Figure 11).

In total, the study area of Northamptonshire and Peterborough provides 627,231 biodiversity units, excluding the 4.6% of land area that was not classified. Given the high frequency of arable and improved grassland (and built-up areas), the average score was only 2.4. However, as the land that could not be classified contained a number of habitats of some biodiversity interest (although these were all outside of SSSIs), this will be an underestimate. Table 12 shows the total biodiversity units for each broad habitat type, with cultivated land (310,698) and improved grassland (114,260) supplying the most, despite the low score per hectare, due to the dominance of these habitat types. Of the semi-natural habitat types, broadleaved woodland delivers the most total biodiversity units (77,816).

The percentage of each habitat type that has been given a score (Table 12), reflects the habitats where condition could and could not be assigned and shows that scrub and scattered trees / parkland were the habitats that were most difficult to score, with only around 12% of both habitat types being given a biodiversity score. Marshy grassland, semi-natural grassland, mixed / other habitats, and mixed woodland were also difficult to score, with biodiversity units calculated for between 18-57% of the area of these habitats. All other habitats were captured well, with at least 85% of habitat areas given a biodiversity score.

Table 12. Total biodiversity units scored for each broad habitat type, the area of each habitat that has been given a score, the % of the total area of each habitat that was been scored, and the average score per hectare for each habitat.

Habitat Type	Biodiversity units	Area given score (ha)	% of habitat area given score	Biodiversity units per ha
Cultivated land (arable)	310,698	155,347	99.8	2.0
Uncertain agriculture	1,044	522	100.0	2.0
Improved grassland	114,260	56,773	100.0	2.0
Semi-natural grassland	16,266	1,342	38.2	12.1
Marshy grassland	7,268	505	26.0	14.4
Fen, marsh and swamp	1,661	98	87.9	16.9
Heathland	269	15	86.6	18.0
Broadleaved woodland	77,816	9,325	98.0	8.3
Coniferous woodland	4,309	1,758	100.0	2.5
Mixed woodland	29,120	3,403	56.9	8.6
Scrub	552	61	11.7	9.1
Trees / Parkland	8,454	597	11.8	14.2
Water	33,054	3,854	100.0	8.6
Rock, exposure and waste	0	393	99.9	0.0
Built-up areas and infrastructure	0	17,222	100.0	0.0
Garden	21,011	10,506	100.0	2.0
Mixed / other / uncertain	1,450	208	18.1	7.0
Unclassified	0	747	100.0	0.0
All habitats	**627,231**	**262,676**	**95.4**	**2.4**

The average biodiversity units scored by each habitat type is shown in the final column in Table 12 and illustrated in Figure 14. This shows that heathland (18.0), fen marsh and swamp (16.9), and marshy grassland (14.4) were the top three highest scoring habitats per hectare (providing the highest biodiversity value). Scattered trees / parkland and semi-natural grassland also score highly. Broadleaved woodland, mixed woodland, scrub and water all achieved medium scores (8.3-9.1), whilst coniferous woodland, cultivated land, uncertain agriculture, improved grassland, and gardens all scored poorly.

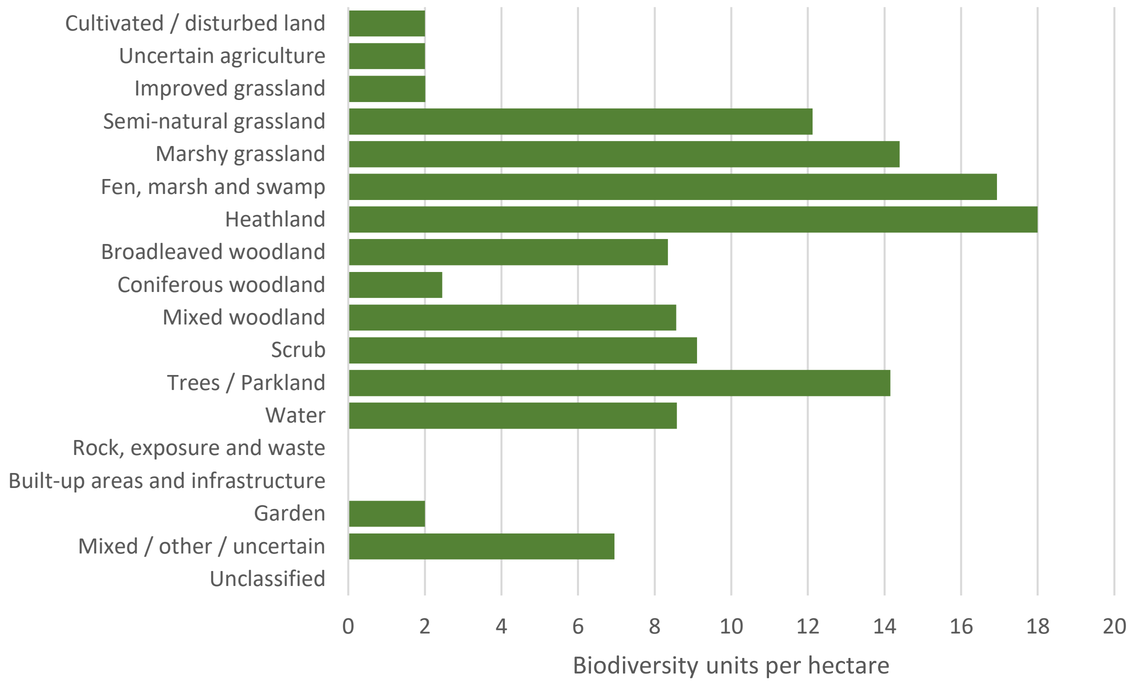


Figure 14: Average biodiversity units per hectare for each habitat type.

3. Building a Natural Capital Asset Register and Mapping Environmental Quality

3.1 Introduction

The core component of a natural capital asset register is a map and accompanying data on the habitats present across a study area, which provides information on the type, extent and location of natural capital assets. The previous section has shown how we can now also successfully gather data on the condition of the majority of these assets, another key component in understanding natural capital assets. However, to build a more complete picture, it is helpful to include information on broader aspects of natural capital beyond habitats. This may include indicators of environmental quality across air, land and water, stocks of natural capital beyond habitats, indicators of risk, degree of protection and information on public access. The focus here is on stocks of assets themselves (i.e. the amount or quality of the asset) rather than flows of benefits that are derived from the assets, or ecosystem services, which are typically captured in later stages of an ecosystem services assessment or natural capital account.

The potential range of data is very large, and it is not clear which would be the most useful in terms of building a complete natural capital asset register. Therefore, the aim of this part of the project was to gather data and prepare maps on a wide range of natural capital and environmental factors, to determine which can be mapped with available data and then to discuss these with stakeholders to determine which are most useful. Section 3.2 therefore describes and presents the maps created and the data sets behind them and Section 3.3 shows the reaction of stakeholders at a workshop held to discuss the maps. The focus was on using or developing maps using freely available data and this is the case for the vast majority of maps shown below. There are a small number that required paid data, and these are clearly indicated.

Please note that the maps developed here are all concerned with natural capital assets and environmental quality. They do not attempt to show ecosystem services i.e. the flow of benefits that arises from the natural capital assets. Mapping ecosystem services is very important and can be mapped effectively at a landscape scale at high resolution, but that is not the focus of this report.

3.2 Maps and data sets

<u>Air Quality</u>

Name: Modelled Background Pollution Data for PM_{10} and NO_x

Source: Defra *Licence:* None

Description: Modelled background pollution data was obtained from Defra at a resolution of 1km^2, and was used to create a map showing PM_{10} (particulate matter at 10 µm, Figure 15a) and another showing NO_x (nitrogen oxides, Figure 15b).

Justification: Air quality is a key indicator of environmental quality and is the greatest environmental health risk in Western Europe and globally, according to the World Health Organisation. Air pollution also contributes to climate change, reduces crop yields, and damages biodiversity. Importantly, the natural environment can play a significant role in absorbing and ameliorating air pollution. Particulate matter (PM) and nitrogen oxides (NO_x) are considered to be two of the most significant pollutants, in terms of impact on health. Note that it is becoming evident that smaller particulate matter causes even greater damage to health, so it may be more appropriate to map $PM_{2.5}$ in the future, for which data is also available from the same source.

Noise

Name: Strategic Noise Mapping 2017. Road Noise Lden and Rail Noise Lden

Source: Defra *Licence:* Open Government Licence

Description: strategic noise mapping of road and rail sources within areas with a population of at least 100,000 people (agglomerations) and along major traffic and rail routes. Records the annual average noise level over 24 hours. We combined the road and rail data sets onto one map (Figure 15c).

Justification: Noise is a significant environmental health risk and can impact health, wellbeing, productivity and the natural environment. Like air pollution, it can also be absorbed and diffused by aspects of the natural environment, although the effects are relatively small.

Tranquillity

Name: National Tranquillity Mapping Data 2007

Source: Campaign to Protect Rural England (CPRE) *Licence:* Required from CPRE

Description: CPRE and Natural England commissioned Northumbria University to undertake an extensive public consultation to discover the components that contributed to an experience of tranquillity. Following this consultation, a composite indicator was developed based on 44 positive and negative factors that contribute towards tranquillity and this was turned into a national map. The map for the study area is shown as Figure 15d.

Justification: Tranquillity is considered to be an important aspect of the natural environment and access to tranquil places has been linked with enhanced health and wellbeing. Furthermore, tranquillity is one of the most stated reasons for visiting the countryside in general.

Naturalness

Name: Perceived naturalness

Source: Derived using data in EcoServ-GIS *Licence:* Free under a General Public Licence

Description: The perceived naturalness for all habitat types has been calculated within EcoServ-GIS, based on two independent studies of public perception of naturalness of different land cover types in England. Each polygon in the basemap described in Section 2 was then allocated a naturalness score based on its habitat and was then converted into a raster (gridded) output, showing perceived naturalness for each 10m by 10m cell across the study area (Figure 16a).

Justification: Research has shown that there is a link between wellbeing and perceptions of biodiversity and naturalness.

Carbon storage

Name: Carbon storage model

Source: Adapted from an EcoServ-GIS model *Licence:* Free under a General Public Licence

Description: An adaptation of the EcoServ GIS carbon storage model was used. This model estimates the amount of carbon stored in the vegetation and the top 30cm of soil. It applies average values for each habitat type taken from a review of a large number of previous studies in the scientific literature. This is then converted into a raster (gridded) output, showing the carbon storage in tonnes per hectare for each 10m by 10m cell across the study area (Figure 16b).

Justification: Carbon storage and sequestration are seen as increasingly important as we move towards a low-carbon future and the importance of managing land as a carbon store has been recognised by the UK government. Carbon storage is a measure of the stock of carbon (a natural capital asset), whereas carbon sequestration measures the annual flow of carbon and is an ecosystem service.

Agricultural Land Classification

Name: Agricultural Land Classification (ALC) Grade

Source: Natural England *Licence:* Open Government Licence

Description: uses a grading system to assess and compare the quality of agricultural land at national, regional and local levels. It assesses the potential for land to support different agricultural uses, based on a combination of climate, site and soil characteristics. The map for the study area is shown in Figure 16c.

Justification: There is a very strong link between ALC and agricultural productivity. ALC can therefore be used as a proxy indicator for agricultural productivity or the quality of the land from an agricultural perspective. It can also be used in conjunction with habitat opportunity mapping to highlight areas of land that should be maintained for agricultural production and other areas where alternative land uses could be beneficial.

Agri-environment Scheme data

Name: Countryside Stewardship Scheme Agreements, Environmental Stewardship Scheme Agreements

Source: Natural England *Licence:* Open Government Licence

Description: Shows land holdings where Countryside Stewardship Scheme and the older Environmental Stewardship Scheme Agreements are in place and provides information on the type of scheme in operation and the end date. Data from the two schemes were shown on the same map (Figure 16d).

Justification: Indicates where agreements are in effect and the type of conservation action that is being undertaken. Can also be used for targeting areas for further engagement, especially in conjunction with habitat opportunity mapping.

Topsoil nitrogen

Name: Soil nitrogen

Source: Centre for Ecology & Hydrology (CEH) *Licence:* Open Government Licence

Description: Mean estimates of total nitrogen concentration in topsoil (0-15cm depth) in percent dry weight of soil. Based on extrapolating data from CEH's Countryside Survey 2007 for Natural England and CEH's 'Mapping Natural Capital' project (2016). Map shown in Figure 17a.

Justification: Soil total nitrogen concentration is a basic measurement of soil fertility. It is a key component of natural capital for supporting ecosystem services, in particular nutrient cycling, soil formation and primary production, and underpins the delivery of food, fibre and energy from agriculture and forestry, water quality and soil quality.

Soil biota

Name: Soil invertebrates

Source: Centre for Ecology & Hydrology (CEH) *Licence:* Open Government Licence

Description: Mean estimates of total abundance of invertebrates in topsoil (0-8cm depth). Based on extrapolating data from CEH's Countryside Survey 2007 for Natural England and CEH's 'Mapping Natural Capital' project (2016). Map shown in Figure 17b.

Justification: The activities of the soil biota are critical for the provision of many important soil functions including biomass production and storing, filtering and transforming nutrients. Soil invertebrate abundance is particularly important for, and an indicator of, soil quality, which is linked to almost all the other regulating services.

Plant indicators

Name: Plant indicators for habitats in good condition

Source: Centre for Ecology & Hydrology (CEH) *Licence:* Open Government Licence

Description: Based on the occurrence of plant species that are positive indicators for different habitats. The indicator species are taken from the Common Standards Monitoring guidance for SSSSIs and represent species that are characteristic of habitats which are in good condition. Based on extrapolating data from CEH's Countryside Survey 2007 for Natural England and CEH's 'Mapping Natural Capital' project (2016). Map shown in Figure 17c.

Justification: Positive habitat indicators are useful in providing information on ecosystem health and the capacity to maintain supporting or regulatory ecosystem services. They are also a cultural service measure, as a number of the species are 'desirable', aesthetic, culturally important species associated with particular habitat types.

Nectar plants

Name: Nectar plant diversity for bees

Source: Centre for Ecology & Hydrology (CEH) *Licence:* Open Government Licence

Description: Mean estimates of bee nectar plant species richness measured as number of nectar plant species for bees per plot. Based on extrapolating data from CEH's Countryside Survey 2007 for Natural England and CEH's 'Mapping Natural Capital' project (2016). Map shown in Figure 17d.

Justification: An indicator of natural capital relating to pollination. Pollination is key both for food production and for wildflowers.

Water quality – chemical status

Name: Chemical status of WFD (Water Framework Directive) River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: The classification status for the surface water body against the environmental standards for chemicals that are priority substances and priority hazardous substances. Chemical status is recorded as good or fail (Figure 18a).

Justification: A key component of water quality.

Water quality – nutrient status

Name: Phosphate status of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: The classification status for the surface water body against the environmental standards for phosphate. There are five classes of phosphate status (high, good, moderate, poor, or bad). This is mapped in Figure 18b.

Justification: One of the physico-chemical quality elements measured under the WFD, phosphate is a key indicator of nutrient status and hence water quality.

Water quality – ecological status,

Name: Ecological status of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Ecological status is based on the following quality elements: biological quality, general chemical and physico-chemical quality, water quality with respect to specific pollutants (synthetic and nonsynthetic), and hydromorphological quality. There are five classes of ecological status (high, good, moderate, poor, or bad). This is mapped in Figure 18c.

Justification: Ecological status is an assessment of the quality of the structure and functioning of surface water ecosystems. It shows the influence of pressures (e.g. pollution and habitat degradation) on the identified quality elements.

Groundwater status

Name: Groundwater status of WFD Groundwater Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Combines an assessment of chemical status and an assessment of quantitative status (impact of abstraction) on natural aquifer function. Groundwater status is classified as good or poor (Figure 18d).

Justification: Groundwater is important for the provision of water and for a number of terrestrial ecosystems.

Hydrological regime

Name: Hydrological regime of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Describes the naturalness of river flows. There are three classes of hydrological regime (high, supports good, does not support good). This is mapped in Figure 19a.

Justification: Hydrological regime is important for water supply, flood protection, and helps to support river and riparian biodiversity.

Hydromorphology

Name: Hydromorphological designation of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Describes the hydrological and geomorphological processes and attributes of surface water bodies. For rivers, hydromorphology describes the form and function of the channel as well as its connectivity (up and downstream and with groundwater) and flow. There are three classes of hydromorphological designation (Artificial, Heavily modified, Not designated artificial or heavily modified). This is mapped in Figure 19b.

Justification: Hydromorphology defines the ability of the waterbody to allow migration of aquatic organisms and maintain natural continuity of sediment transport through the fluvial system. It therefore has important links to habitat quality and riverine ecology and also has an impact of flood risk.

Overall water body class

Name: Overall water body class of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Combines ecological status (which itself incorporates biological quality elements, hydromorphological elements, physico-chemical quality elements, and specific pollutants), with chemical status to from an overall assessment of the quality of the waterbody. There are five classes (high, good, moderate, poor, or bad). This is mapped in Figure 19c.

Justification: Overall summary of the quality, ecosystem structure and function of the waterbody, which impacts on a wide range of ecosystem services.

Number of water related designations

Name: Number of water related designations of WFD River Waterbody Catchments

Source: Environment Agency *Licence:* Open Government Licence

Description: Maps the number of protected area designations in place across each waterbody catchment. Designations for the following EU Directives were included: Drinking Water Directive, Fresh Water Fish Directive, Habitats and Species Directive, Nitrates Directive, and Urban Waste Water Directive. The number of designations is mapped for each waterbody catchment in Figure 19d.

Justification: Highlights areas requiring special protection under EU legislation, hence indicating demand for high habitat and water quality.

Flood risk

Name: Areas at risk of pluvial or fluvial flooding

Source: Environment Agency *Licence:* Open Government Licence

Description: Combines EA's Risk of Flooding from Surface Water (RoFSW) flood map with EA's Flood Zone 2 flood risk from rivers map. Both map areas with > 1:1000 flood risk. Resulting map is shown as Figure 20a.

Justification: Shows areas at risk of flooding, which can be linked to population and deprivation data. Also shows areas where it may be possible to reconnect floodplains, create wet habitats or install certain natural flood risk management features.

Tree cover

Name: Tree cover

Source: Bluesky National Tree Map *Licence:* Required from Bluesky (paid)

Description: Raster created from individual tree polygons, showing the proportion of tree cover in each 100m by 100m grid square. The base data from Bluesky maps all trees over 3m in height. Note that this data set has to be purchased and was available for Peterborough and North Northamptonshire, but not purchased for West Northamptonshire. The map is shown in Figure 20b.

Justification: Especially important in urban areas where it shows street trees and garden trees and for picking up individual trees or treelines in rural areas, all of which are missing from traditional habitat maps based on woodland cover. Enables more accurate assessment of multiple ecosystem services, such as carbon sequestration, air quality enhancement, water flow regulation, local climate regulation, and visual amenity.

Nature Conservation Designations

Name: Designated sites

Source: Natural England *Licence:* Open Government Licence

Description: Maps statutory designated sites by combining maps of Special Areas of Conservation (SAC), Special Protection Areas (SPA), Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR), and Local Nature Reserves (LNR). The resulting map is shown in Figure 20c.

Justification: Indicates key protected sites, usually delivering the best habitats for biodiversity along with a range of cultural services.

Archaeology and Historic

Name: Historic environment assets

Source: Historic England *Licence:* Ordnance Survey Open Data Licence

Description: Combines national datasets showing Scheduled Monuments, Registered Battlefields, and Registered Parks & Gardens. Map is shown in Figure 20d.

Justification: A cultural service in its own right, it also highlights areas where additional considerations need to be taken into account when considering habitat opportunity mapping.

<u>PRoW</u>

Name: Public Rights of Way

Source: Local Authorities *Licence:* Required

Description: Combines PRoW maps supplied by Northamptonshire County Council, Peterborough City Council and Cambridgeshire County Council. The combined map is shown in Figure 21a.

Justification: A key information source for determining access to the countryside and accessible nature.

<u>Green Infrastructure</u>

Name: Open space datasets

Source: Local Authorities *Licence:* Required

Description: Open space datasets (previously known as PPG17) were obtained from each local council, under licence: Corby Borough Council, Daventry District Council, East Northamptonshire District Council, Huntingdonshire District Council, Kettering Borough Council, Northampton Borough Council, Peterborough City Council, South Northamptonshire District Council, and the Borough Council of Wellingborough. Data were combined onto one map and were marked as being fully publicly accessible (e.g. parks, amenity greenspace, cemetery etc.), or not fully accessible (e.g. golf courses, allotments, school, and institutional grounds etc.). Playing fields were individually checked as some were publicly accessible and some were private. Note that it is possible to use OS Open Greenspace or OS Mastermap Greenspace to complete this map, although these are not as accurate. The map is shown in Figure 21b.

Justification: Green infrastructure is an important consideration when assessing public access to nature, particularly in urban areas, and other cultural services such as recreation, health and wellbeing. Can also be used to carry out an Accessible Natural Greenspace Standards (ANGSt) assessment.

<u>Public access</u>

Name: All land with public access

Source: Various *Licence:* Various

Description: Data from multiple sources were combined: Countryside and Rights of Way Land (Natural England), Woods for People (Woodland Trust), Sustrans Routes, Public Rights of Way (as above), Forestry Commission Recreation Routes, National Nature Reserves (Natural England), Local Nature Reserves (Natural England), Country Parks (Natural England), pavements (derived from basemap), and GI with public access (accessible sites from previous map). Note that this identifies all areas with public access and not just natural sites. The map is shown in Figure 21c.

Justification: Indicates public access in the broadest sense, which can be linked to a number of cultural services.

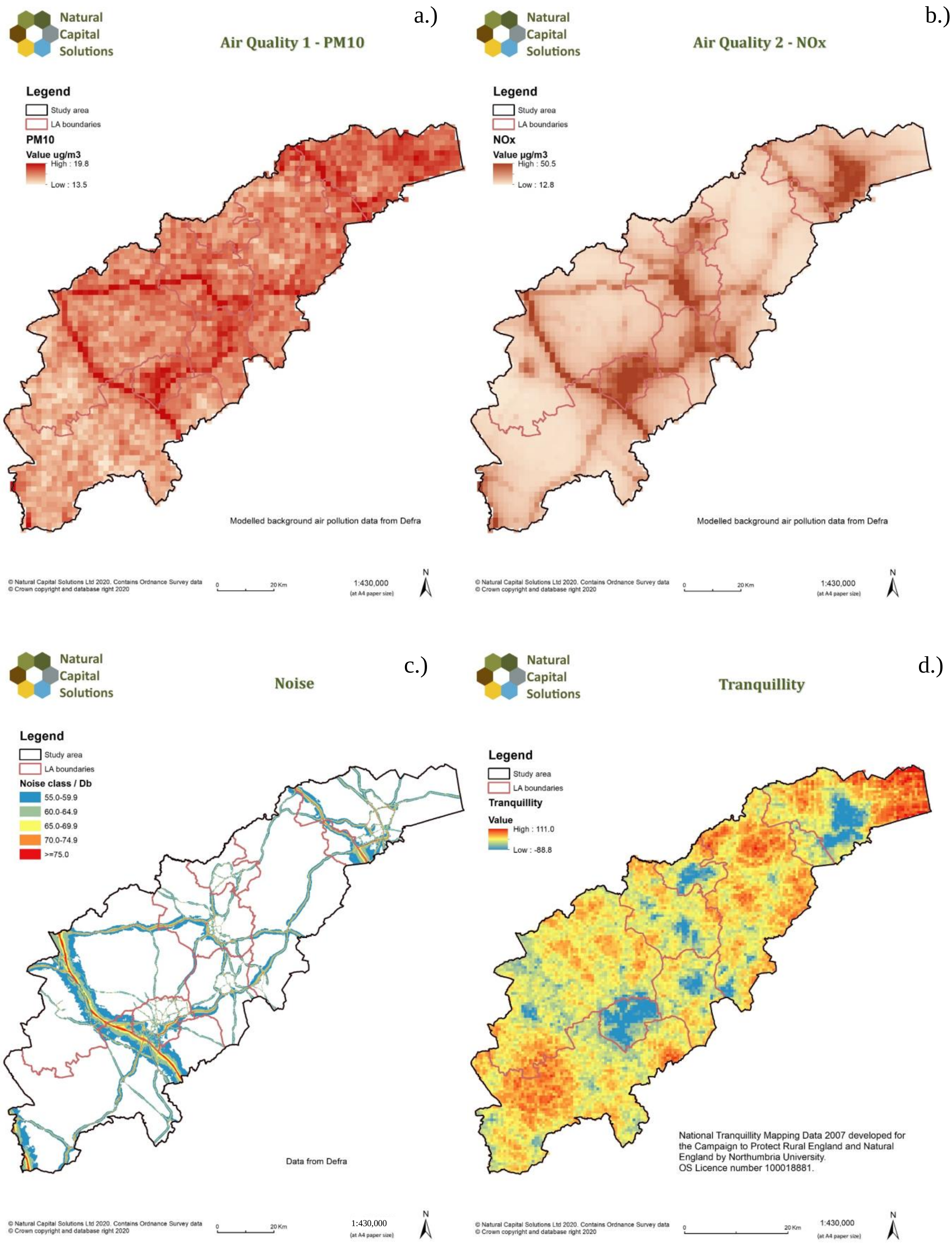


Figure 15: Environmental quality and natural capital asset maps showing a.) air quality with respect to PM_{10}, b.) air quality NO_x, c.) noise and d.) tranquillity, for Northamptonshire and Peterborough.

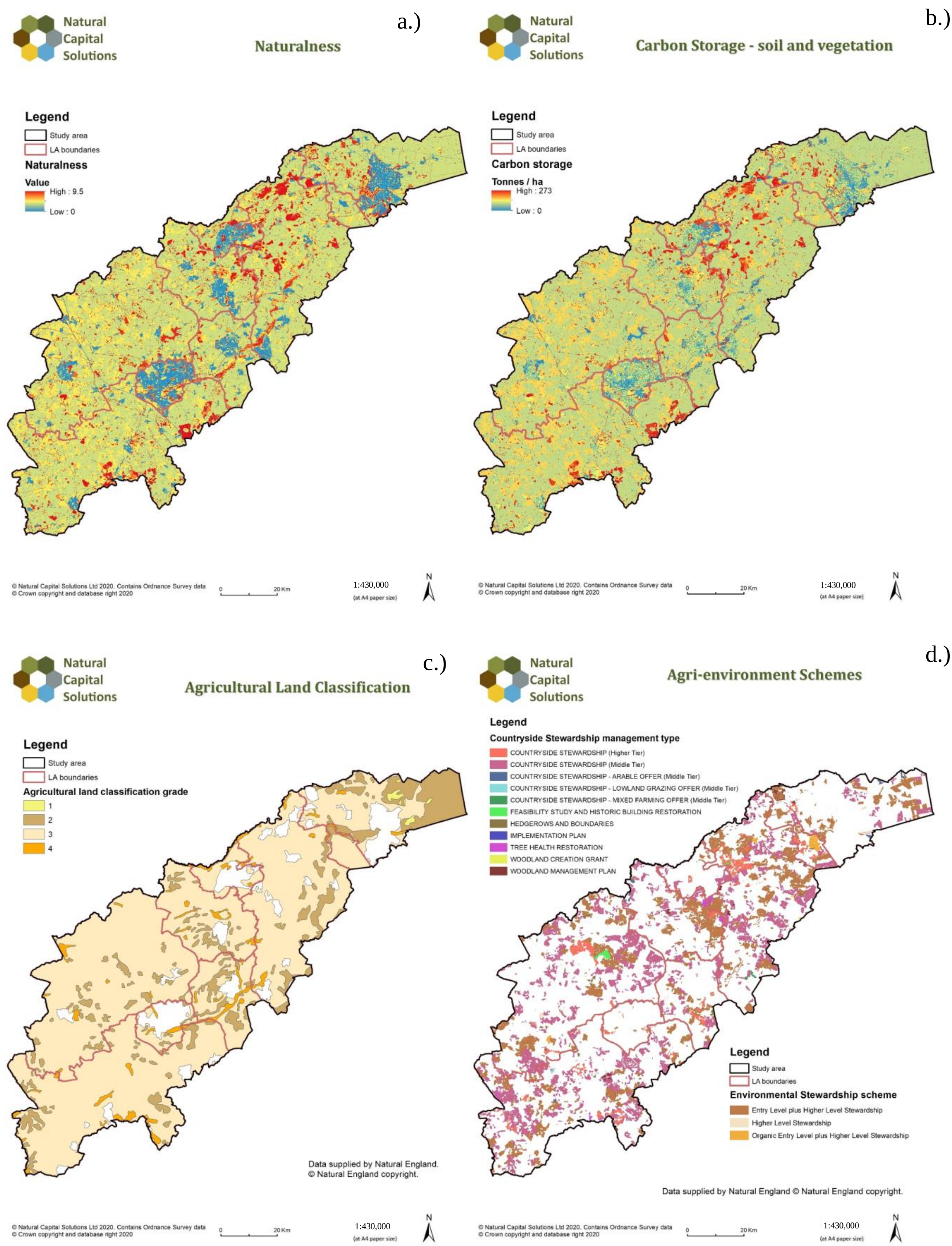


Figure 16: Environmental quality and natural capital asset maps showing a.) naturalness, b.) carbon storage in soils and vegetation, c.) agricultural land classification, and d.) active agri-environment schemes.

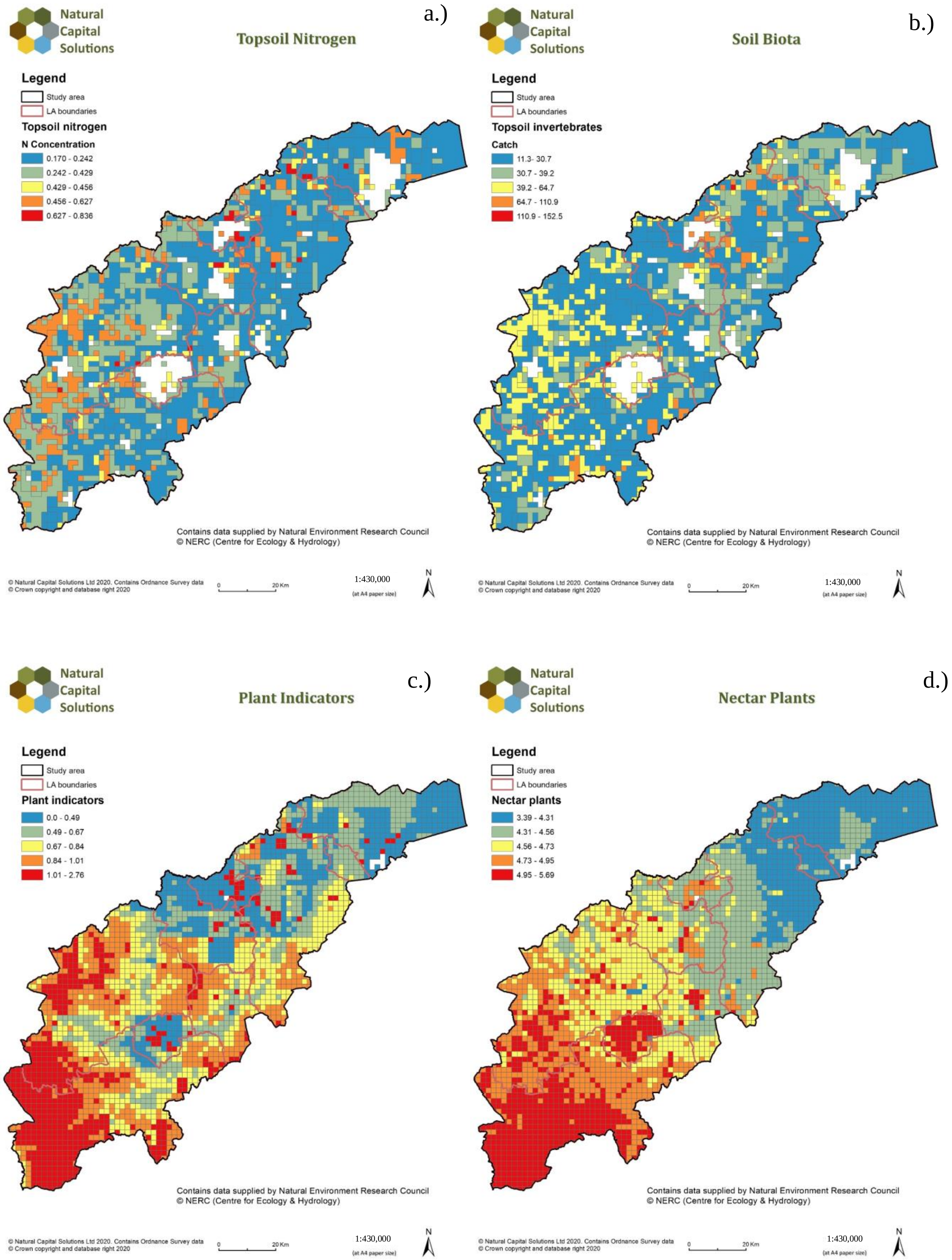


Figure 17: Environmental quality and natural capital asset maps showing a.) topsoil nitrogen, b.) soil biota, c.) plant indicators, and d.) nectar plants.

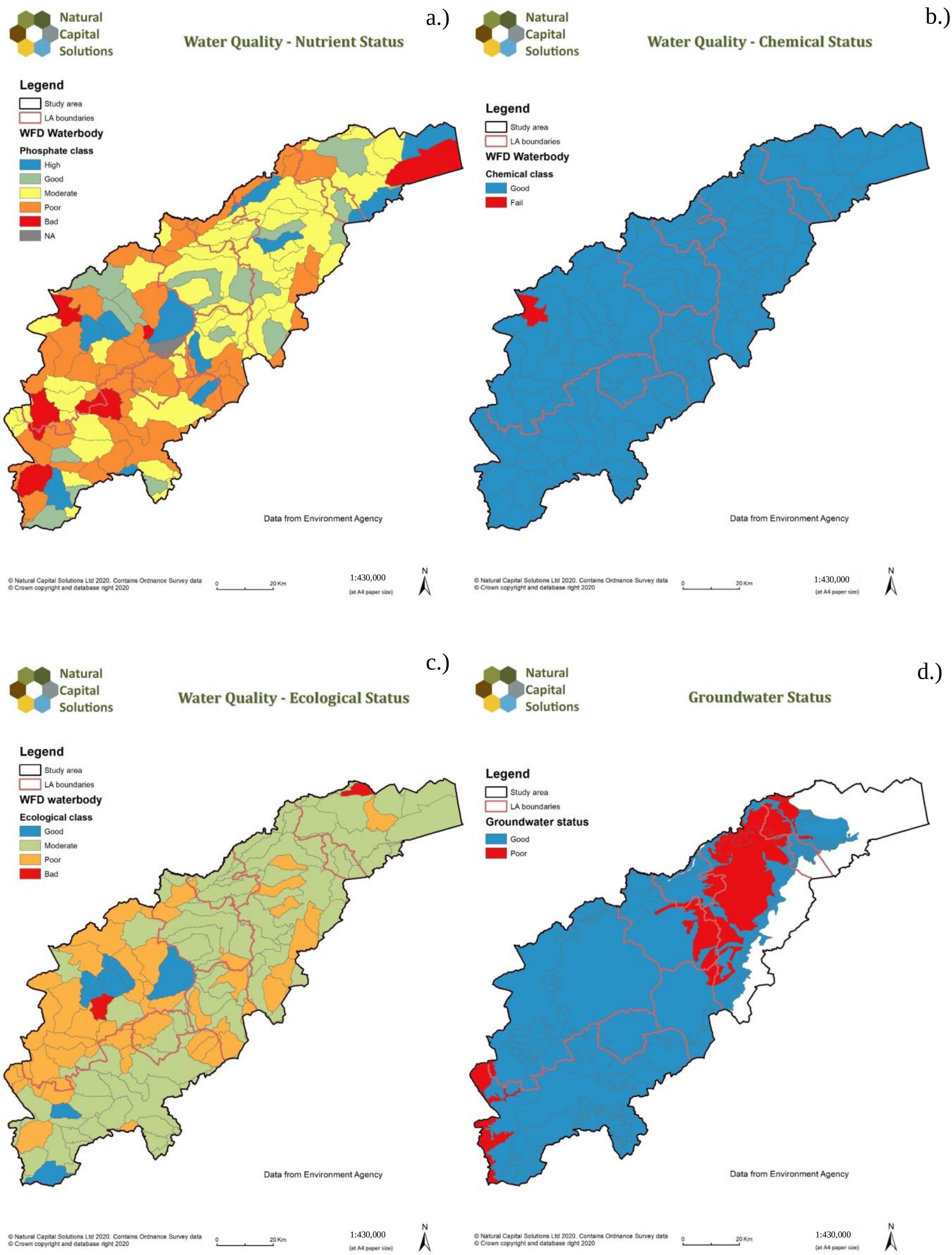


Figure 18: Environmental quality and natural capital asset maps showing a.) nutrient status, b.) chemical status, and c.) ecological status of river waterbodies, and d.) groundwater status.

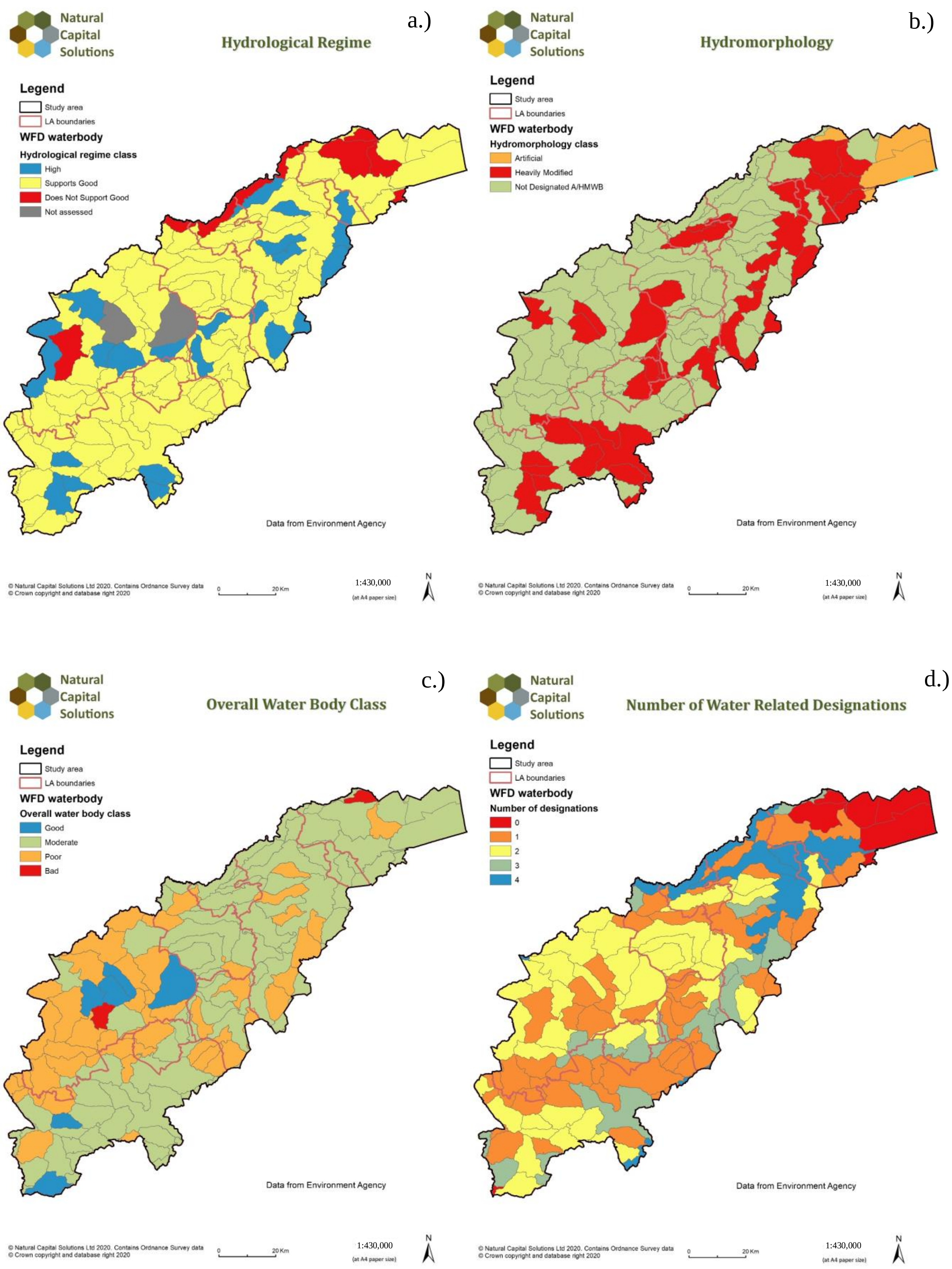


Figure 19: Environmental quality and natural capital asset maps showing a.) hydrological regime, b.) hydromorphology, c.) overall water body class, and d.) number of designations, for each river waterbody.

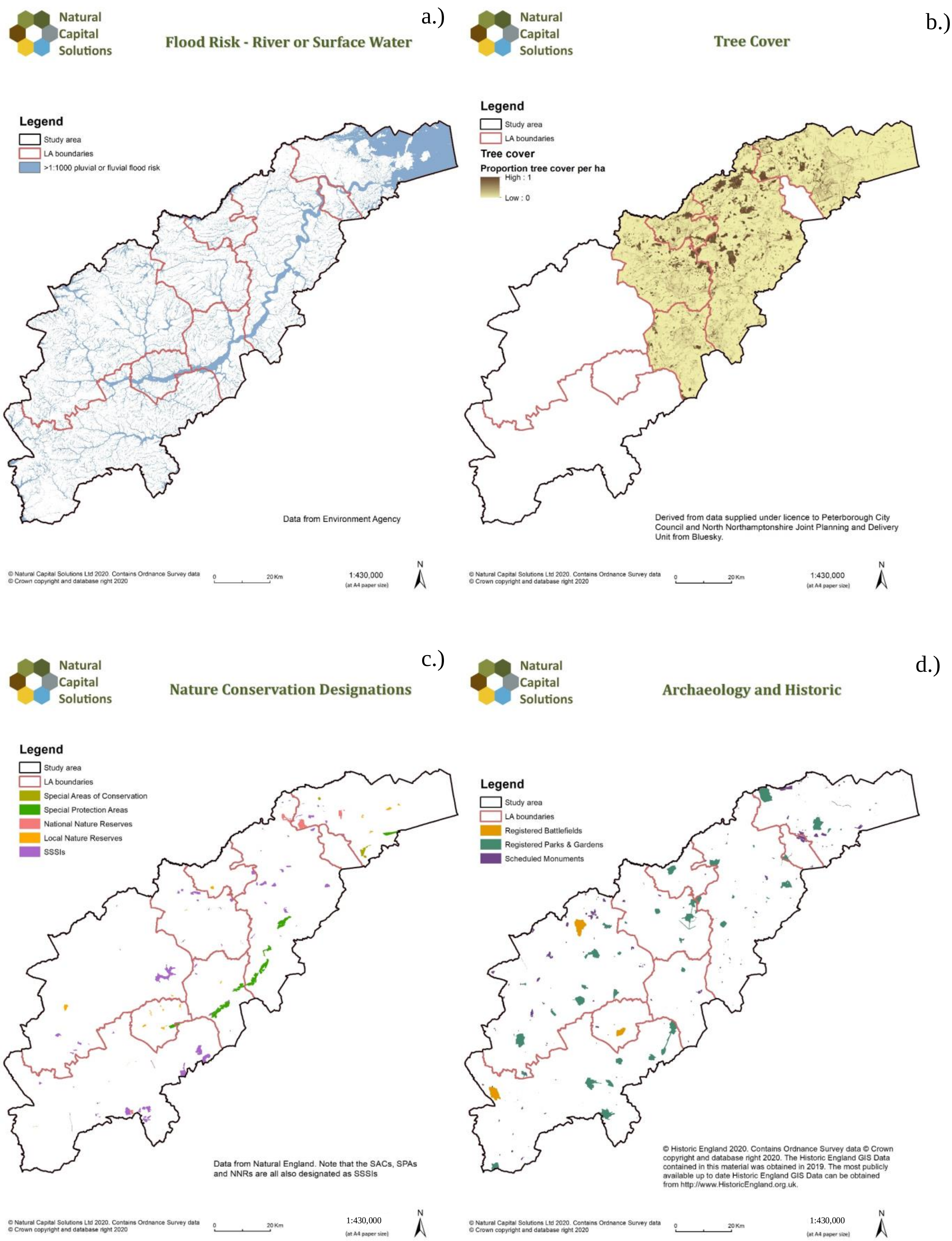
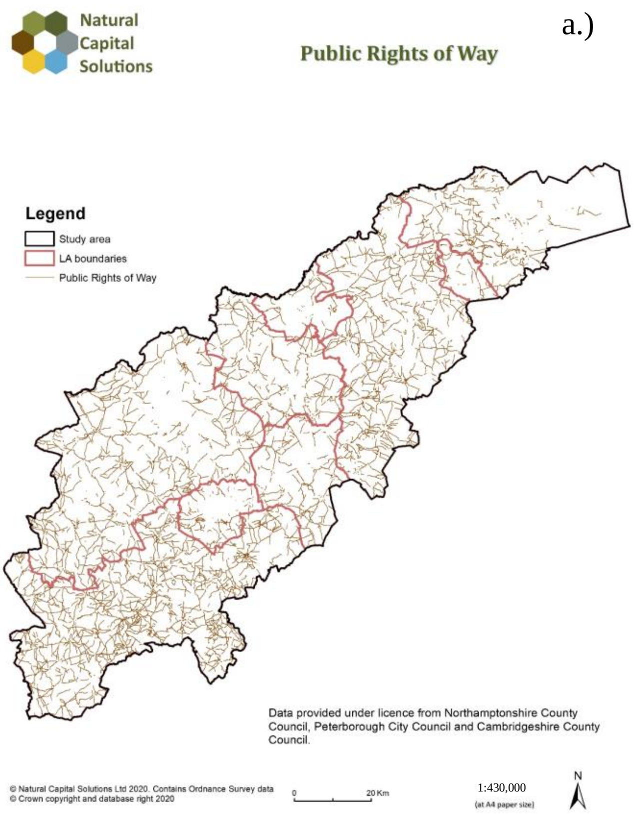
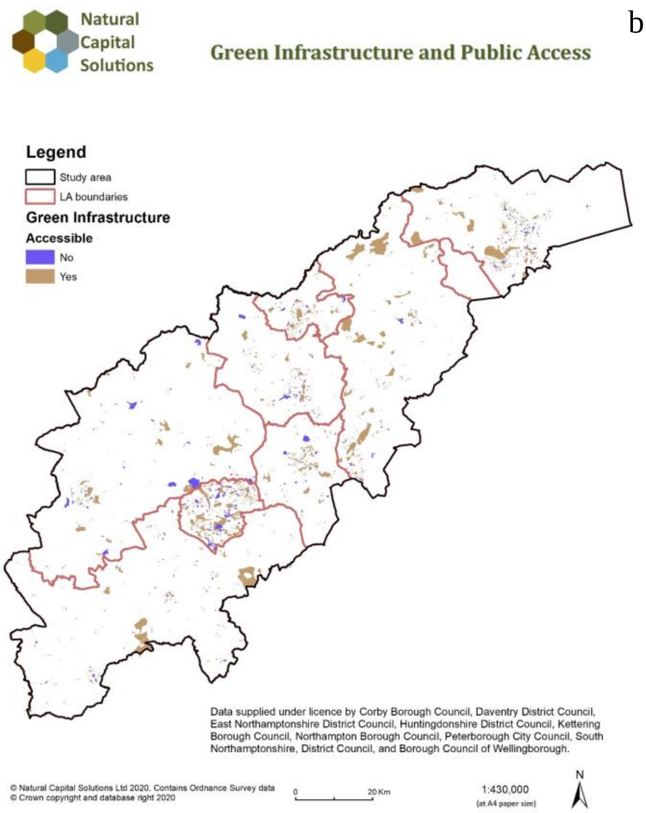


Figure 20: Environmental quality and natural capital asset maps showing a.) river and surface water flood risk, b.) tree cover, c.) nature conservation designations, and d.) historic environment assets.

a.)



b.)



c.)

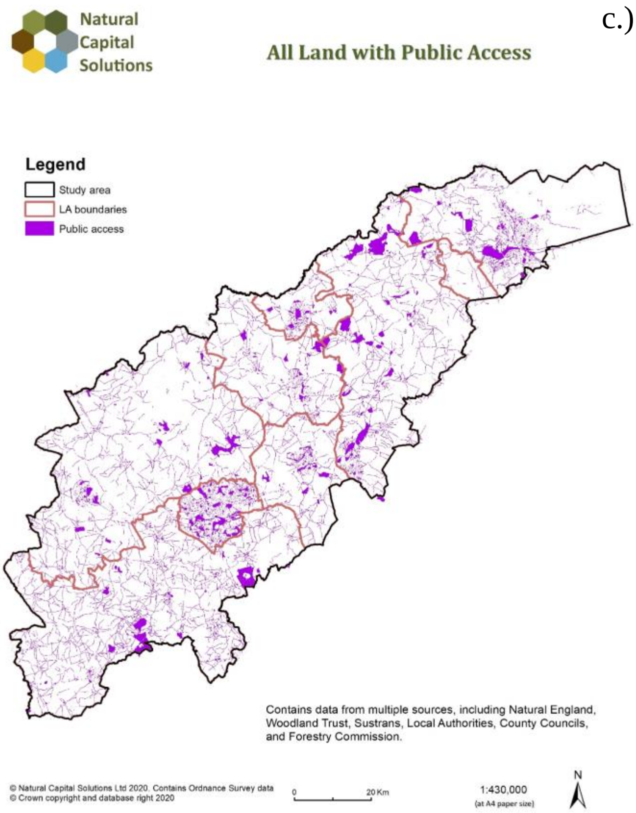


Figure 21: Environmental quality and natural capital assets maps showing a.) Public Rights of Way, b.) Green Infrastructure and public access, and c.) all land with public access.

3.3 Stakeholder opinion

Workshop attendees were asked to rate the usefulness of each of the maps, from 1 (very useful) to 5 (not useful) and results are shown in Figure 22. All of the maps were considered useful to some degree, with all being scored very useful by at least some participants, but some were considered more useful than others. The average scores can be used to divide the maps into three groups, which are shown in Table 13. Tree cover was the single highest scoring map, with 68% of participants giving it a rating of 1 and 84% rating it 1 or 2. Other maps where the majority of participants gave a score of 1 (very useful) and overall score was less than 2, were air quality, agricultural land classification, the water maps showing nutrient status, ecological status, designations and Public Rights of Way.

Maps that have been grouped in the second category on Table 13 had an average score of 2.0 - 2.5 and in all cases the majority of participants rated them as 1 or 2. These included carbon storage, public access, green infrastructure, many of the remaining water themed maps, agri-environment schemes and tranquillity. The majority of participants still rated the historic environment and naturalness maps as 1 or 2, but the remaining maps had a much more mixed response. The CEH maps showing nectar plants, plant indicators, and soil biota, and the map showing the number of Directives were the lowest scoring maps, with a range of opinion expressed and a number of participants expressing no opinion. Discussion at the workshop also indicated that these were the maps that were hardest to understand and some participants suggested that the CEH maps were only of use at indicating broad patterns.

Table 13. Average score given by workshop participants for the maps, where scores ranges from 1 (very useful) to 5 (not useful). The maps are shown in order of score and are divided into 3 groups based on the average score.

Highest scoring maps	Score	Intermediate scoring maps	Score	Lowest scoring maps	Score
Tree cover	1.68	Carbon storage	2.00	Historic environment	2.58
Air quality	1.74	Public access	2.05	Noise	2.68
Agricultural land classification	1.74	Green infrastructure,	2.05	Naturalness	2.68
Water - ecological status	1.78	Flood risk	2.11	Nectar plants	2.71
Overall waterbody status	1.88	Groundwater status	2.18	Plant indicators	2.79
Water - nutrient status	1.89	Hydrological status	2.18	Soil biota	2.87
Designations	1.89	Agri- environment Schemes	2.21	No. of Directives	3.00
Public Rights of Way	1.95	Nutrient status - land	2.24		
		Water – chemical status	2.24		
		Hydromorphology	2.25		
		Tranquillity	2.28		

Workshop participants were also asked if any additional maps should be included. A number of possible maps were suggested, but almost none of these were suggested by more than one person. Suggestions included ANGSt (Accessible Natural Greenspace Standards) maps, biodiversity maps (2 people), land ownership, development sites, river obstructions, vegetation cover, additional paths, population density (2 people) and additional maps indicating demand. Full details are provided in the Appendix.

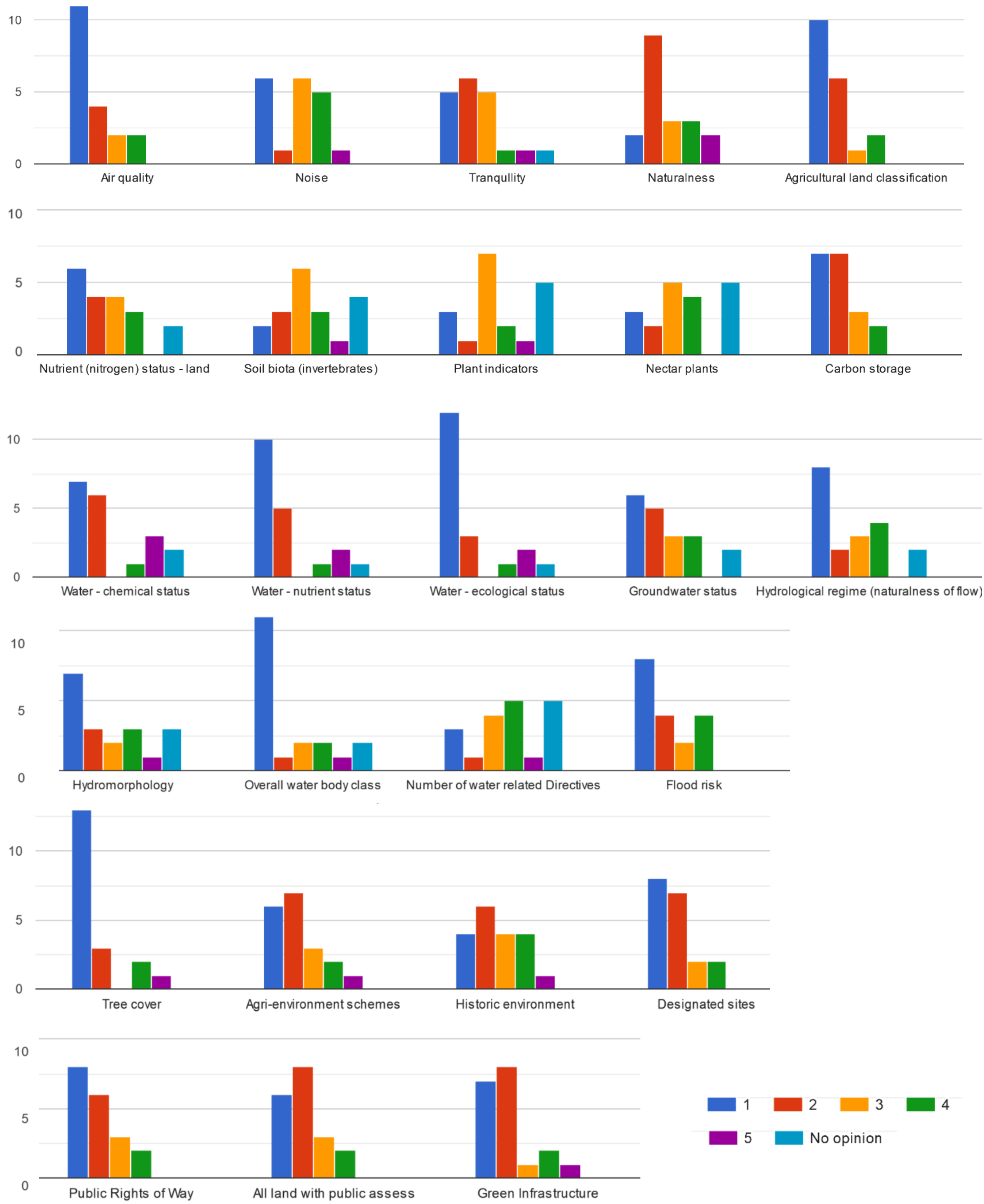


Figure 22. Workshop participant responses to the question: "how useful do you think the following maps are?" Ratings are from 1 (very useful) to 5 (not useful). Maps are those shown in Figures 15-21.

3.3.1 Uses for the maps

The workshop participants were also asked what they saw as the main uses for the maps. A number of possible uses were put forward, with the majority focussed on their use in spatial planning and identifying priority locations. For example, two participants wrote:

> *“In large scale planning for land use change, planning and site protection”*
>
> *“Looking at areas which are good, and therefore need supporting, and areas which are poorer and need specific interventions to improve.”*

There was a general interest in their use to inform decision making and future investments, for example:

> *“Excellent for informing decision making, having everything in one place”*

Finally, some people commented on the usefulness of the maps when seen as a complete set:

> *“I think the power of these maps is when you start to combine / overlay them”*
>
> *“Adding colour to your NC baseline maps. We know the maps are habitat based, but these extra datasets 'fill in' some of the gaps”*

Full responses are included in the Appendix, along with additional comments on the maps that were provided by participants.

4. Conclusions, recommendations and public accessibility

4.1 Workshop discussion

The workshop participants were asked if they would recommend that our approach to mapping habitat condition is used more widely. In total, 95% thought that is should be, although the vast majority of these (84%) agreed with the statement that it should be used with caveats. This result and the discussions throughout the workshop revealed that there was general support for the approach, but also some wariness, hence a desire to process with caution. In particular, there was a call by many for testing of the condition mapping, for example:

> *"Condition mapping needs further work to test the approach and to evaluate more closely some of the data sources, particularly with regards to the different purposes or methods that condition data collection uses."*

Please see the Appendix for full answers from the workshop participants. There was also some concern that it could give a false sense that we know more than we do or be misused if not properly managed. In particular, there was concern that the maps could be used in the wrong way by unscrupulous developers. In total, 33% of participants thought that this was very likely and 39% thought that it was quite possible, with no one thinking that it was very unlikely (see Appendix).

Public access to the maps was also discussed and a number of different options considered. With regard to the habitat condition and biodiversity unit maps, none of the participants felt that these should be fully publicly accessible and only 11% thought that they should be fully accessible to view, but with no downloading. Paid access was supported by 33% of participants, whilst 22% thought that these maps should be for internal use only, although 33% were unsure (see Figure 23).

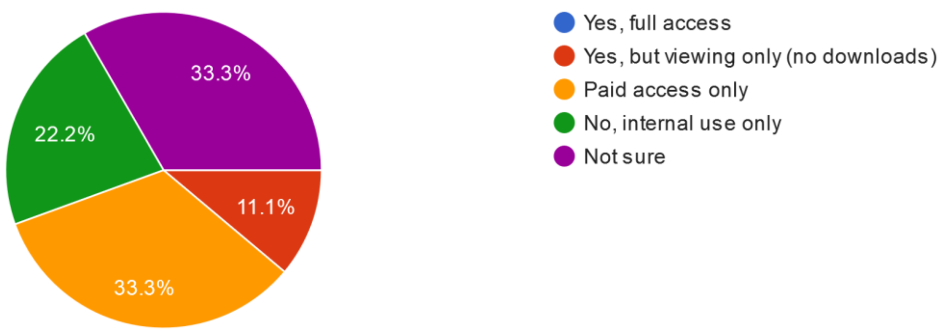


Figure 23. Workshop participant response to the question "*should the condition maps and biodiversity unit maps be made publicly accessible?*".

The advantages of a paid approach were raised by some. For example:

> *"I think paid access managed by the record centre would help manage quality, expert interpretation and also provide a sustainable funding mechanism to continue improving / updating the data"*
>
> *"With a paid license that income could be spent on ground truthing and updating any inferred conditions"*

Access to the environmental quality maps (Part 3 of this report), was also considered. Here there was more support for public access, with 16% supporting full access and 21% supporting access to view but not download data and only 5% did not want any access (internal use only). There was slightly more support for paid access (26%), but the largest number of people stated that they were not sure (32%).

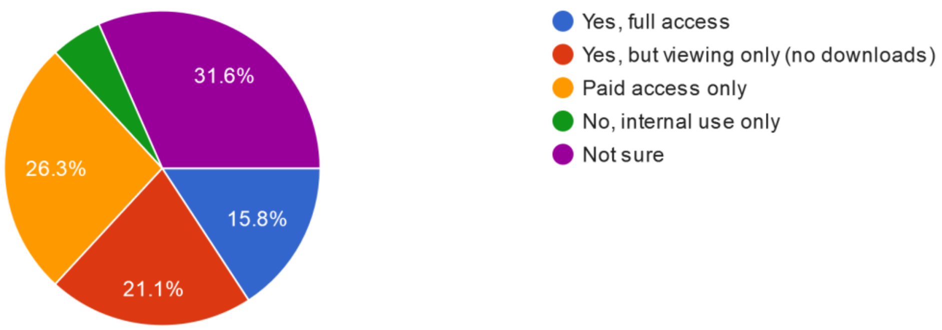


Figure 24. Workshop participant response to the question *"should the quality maps (asset register) be made publicly accessible (subject to licences)?"*.

4.2 Conclusions and recommendations

4.2.1 Mapping condition

- Natural capital asset maps are effective at showing the type, extent and location of habitats, but usually lack information on condition when mapping over landscape (e.g. county) scales. However, adding information on condition is beneficial and should be done whenever possible. This will improve the usefulness of natural capital asset maps and opens up a number of applications. Potential emerging applications include identification of sites and habitats that are not in good condition and can be the focus of restoration and enhancement projects, Nature Recovery Networks, local natural capital plans (natural capital investment plans), broad assessment of baseline biodiversity units and biodiversity net gain for planning and development, and the new Environmental Land Management System (ELMS).
- It is recommended that the approach to mapping condition developed here is taken forward and can be applied in other locations. The three steps used here will also be valid in other places:
    1) Assign condition to all habitats of low or no biodiversity interest.
    2) Use SSSI and LNR/CWS condition data to assign condition to the best quality wildlife sites.
    3) Use the assumptions developed here, based on other data sources, to assign condition to a number of the remaining habitats.
- It would be beneficial if the results of the condition mapping reported here were tested in Northamptonshire and Peterborough. This would require visiting a number of sites and carrying out a condition assessment in situ and comparing the result to the output here. This would be an extremely useful way of validating (or otherwise) the approach developed here and highlighting common inconsistencies, which would then help in rolling out the approach more widely.
- A large number of Local Nature Reserves do not have a recent condition assessment, especially in Northamptonshire. Given the increasing focus on assessing condition for a whole range of different applications, it would seem to be a good idea if these sites could be assessed (and funding released to enable this) as a matter of priority.

- Only 4.6% of the study area could not be assigned a condition. If areas of greater wildlife interest (LNRs, as above) and any remaining habitats of higher biodiversity interest (e.g. semi-natural grassland), were prioritised, it would be possible to identify a relatively small subset of high priority locations that could be the focus of a field assessment programme.
- The method developed here does have limitations and it is important that the results are used with this in mind. It should not be used at a fine scale or in place of site surveys, but should be used at a landscape scale or as an initial screening exercise, or to highlight key areas of interest. It can also be used to highlight key areas to prioritize conservation action or to set up offsetting projects. The map of biodiversity units can be used for strategic decision making at the landscape scape, but at a local scale, site surveys and assessment using the Biodiversity Metric 2.0 will still be required.
- Calculating biodiversity units based on the Biodiversity Metric 2.0 was not the main aim of this work. However, if this was of interest it would be possible to develop scores for strategic significance and connectivity, to enable completion of the metric score. The former would be straightforward to calculate, based on local priorities and zones. For the latter, it would be difficult to use the connectivity calculator that comes as part of the Biodiversity Metric, but it would be possible to develop a parallel scoring approach based on connectivity calculations performed on the basemap. Note that the biodiversity unit scores given in this report will underestimate scores calculated with those two factors included, but will not change the overall pattern of results which are primarily driven by condition and distinctiveness.
- An alternative approach to mapping condition and biodiversity units has recently been developed in Greater Manchester[5]. Exact methodological details are lacking, but condition and strategic importance were determined based solely on ecological designations. It is likely, therefore, that this assumes that all SSSIs are in good condition and all LNRs are in the same (presumably lower) condition and all habitats that are not designated will receive a lower condition again. This method has the appeal of simplicity and therefore time, but these types of assumptions would lead to a number of errors and were not supported by the workshop participants, who explicitly voted against making such sweeping generalisations. The method also conflates strategic significance with condition, whereas it may be more suitable to use designations simply to indicate the former. It is noticeable that the biodiversity units reported in the Greater Manchester assessment are considerably higher than those emerging from our study, with an average of 5.8 biodiversity units per hectare (we recorded 2.4 biodiversity units per hectare), despite the former study being in a highly urbanised area. This difference can be partly explained by the fact that we do not use the strategic connectivity and connectivity multipliers, which would have increased our scores a little, but does not come close to explaining the full difference. This approach therefore overestimates biodiversity units considerably due to the assumptions made. We would recommend that the Greater Manchester approach has its uses at broadly highlighting areas of interest and as a talking point, but should not be used in detailed analysis or to assess biodiversity net gain.

4.2.2 Environmental quality

- Understanding and mapping habitats, including their type, extent, location and condition, remains the single most important component of a natural capital assessment or asset register and is fundamental to understanding the benefits that flow from those assets. But adding additional maps into a natural capital baseline assessment is recommended as it enables a more complete picture to be built up of a broader set of natural capital assets and provides information on environmental quality.

[5] TEP (2020) Greening Greater Manchester. TEP Briefing Note: May 2020

- It is unlikely that a definitive set of maps can be recommended, as this will vary depending on the situation, the aims of the project and sometimes on data availability, but some maps were preferred to others. The maps provide indicators of environmental quality across air, land and water, stocks of natural capital beyond habitats, indicators of risk, degree of protection and information on public access and it is recommended that maps from each type are selected. The maps here can be used as a menu of options from which the most preferred ones for a particular project can be selected.
- The single most preferred map was the one showing tree cover (Figure 20b) and this was considered to be particularly useful. However, this was one of the only maps that was dependent on purchasing data, and in this case the data was very expensive (thousands of pounds). This map is therefore highly recommended if the Local Authority or commissioning body has a licence for the data, but may not be possible in most cases. Note that this data has a number of additional uses if purchased.
- Some of the most recommended maps to produce as part of a natural capital assessment include: air quality, agricultural land classification, overall waterbody status, designations, and Public Rights of Way. This would give an indication of environmental quality across a broad set of criteria, covering air, water, agricultural quality, site protection and public access. Additional maps covering carbon storage, further aspects of public access and green infrastructure, flood risk and agri-environment schemes are also recommended.
- The ecological status and nutrient status of waterbodies were also highly selected by the workshop participants, and should also be chosen if the focus is on water, but these are actually both components of overall waterbody class (and the ecological status map is identical to the overall waterbody class), so can be summarised effectively by the latter. This is also the case for maps of chemical status, hydrology and hydromorphology, which can provide useful additional information on the components of waterbody class if the focus is on these habitats.
- The maps shown in this report are not exhaustive, but they are almost all based on freely available data and are not too time consuming. Some additional possibilities are shown in Natural England's Natural Capital Atlases, which are being launched for each Local Authority. However, note that these atlases have been produced with a resolution of $5km^2$, which is considered to be much less useful than the higher resolution maps shown here. Note also that the maps shown here do not attempt to show ecosystem services (benefits), which can be mapped very effectively, but are not the focus of this report.
- One gap in the maps presented here concerns biodiversity (species) maps, which was raised by a few of the workshop participants. These are a key component of natural capital, so would be good to include if possible. We have previously produced maps showing the species richness of a number of major taxonomic groups across the Nene catchment[6]. These are excellent at highlighting biodiversity patterns and key locations across the study area, but were unfortunately extremely time consuming to produce. It would therefore be difficult to produce these for other areas in a cost-effective manner. It would be useful if a national or local organisation produced similar highly detailed maps that could be integrated into local natural capital assessments.

4.2.3 Access and data sharing

- The workshop participants discussed public access and data sharing of both the condition data (and biodiversity units) and the natural capital and environmental quality maps. A wide range of opinions

[6] Rouquette, J.R. (2016). Mapping Natural Capital and Ecosystem Services in the Nene Valley. Report for the Nene Valley NIA Project. Natural Capital Solutions.

were expressed, and a number of participants were uncertain, hence this is an area that requires further discussion, but some key messages did emerge.

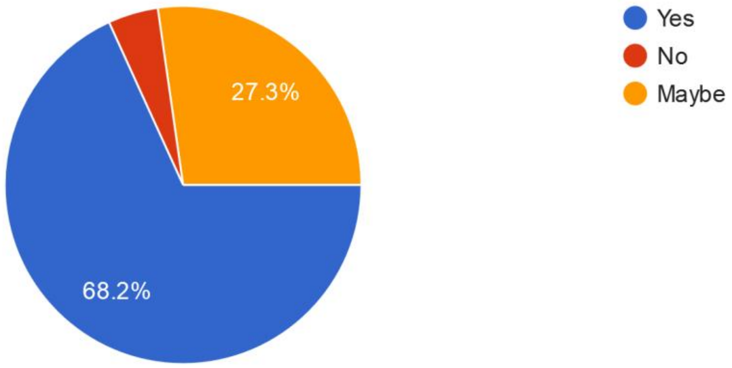
- There was clear concern that the maps of habitat condition and biodiversity units could be used inappropriately, especially by developers who could, for example, try to push to develop areas of land that have high biodiversity interest (e.g. LNRs) but that are in poor condition. For this reason, it is important that any maps that are sent to external organizations are accompanied by notes describing their limitations and how they should and should not be used. It is also one of the reasons why none of the workshop participants felt that these maps should be made freely available for all.
- Although there was no clear consensus for any one method of sharing maps, the most popular was through a paid system, ideally hosted through an organisation such as the Local Environmental Records Centres. This does offer a number of advantages: the money paid can be put towards updating maps, carrying out condition assessments and running the system; they can provide expert interpretation; and developers are already used to purchasing data from them in a similar manner for biodiversity records.
- Licencing implications will need to be considered. The condition and biodiversity units maps use underlying OS Mastermap polygons, so direct sharing would be difficult unless the receiving organisation also had an OS Mastermap licence. This is an area that is under active discussion at present. One possible way to avoid these issues would be to convert the maps into high resolution rasters, which would remove the underlying polygons and hence should avoid any licence restrictions. Licensing for most of the natural capital asset and environmental quality maps should be relatively straightforward, as the vast majority are provided under an Open Government Licence, which allows for sharing of the data and for commercial applications.

Appendix: Full workshop poll responses

Part 1: Mapping Habitat Condition

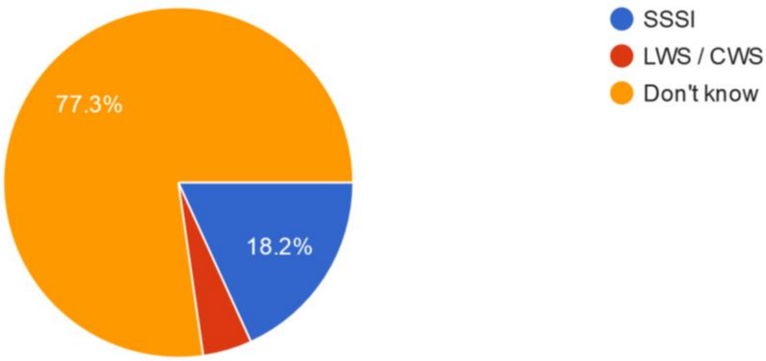
Is it useful to try to map condition across a landscape in this way?

22 responses



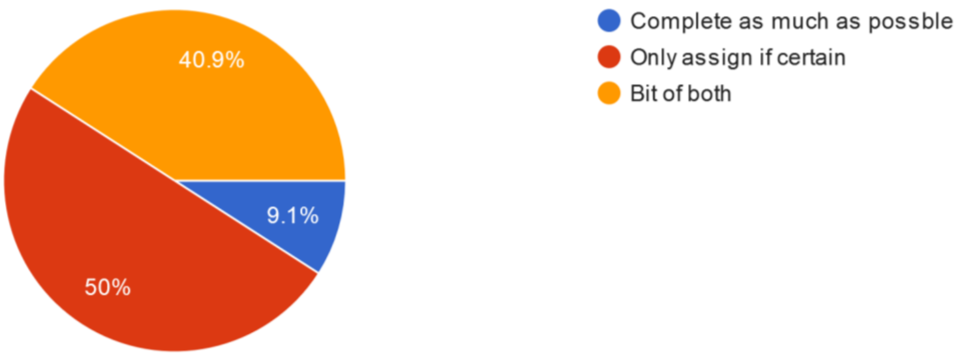
Where condition has been recorded for both SSSI units and LWS / CWS, which should take precedence?

22 responses

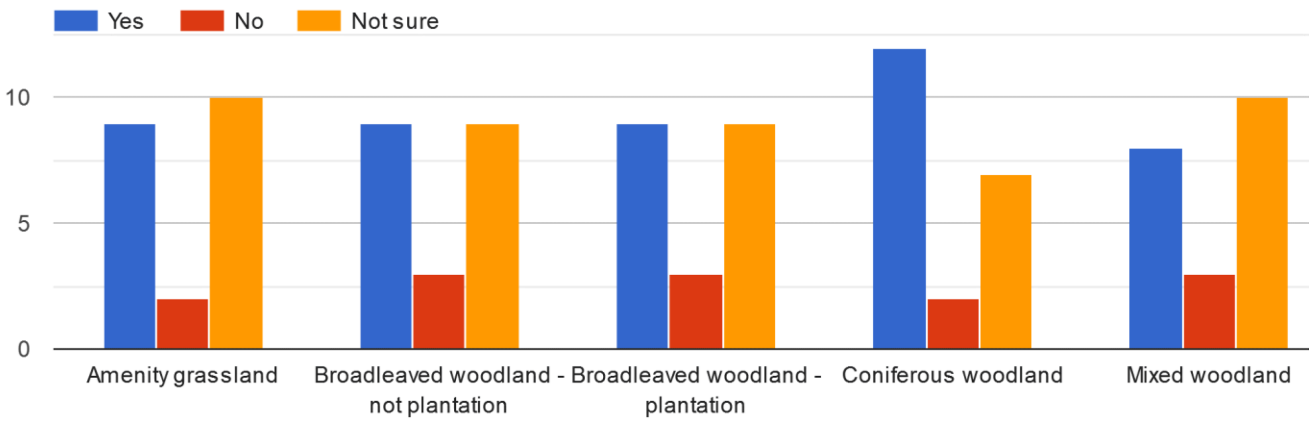


Is it best to try to complete as much as possible by inference or to only assign condition if definitely known

22 responses

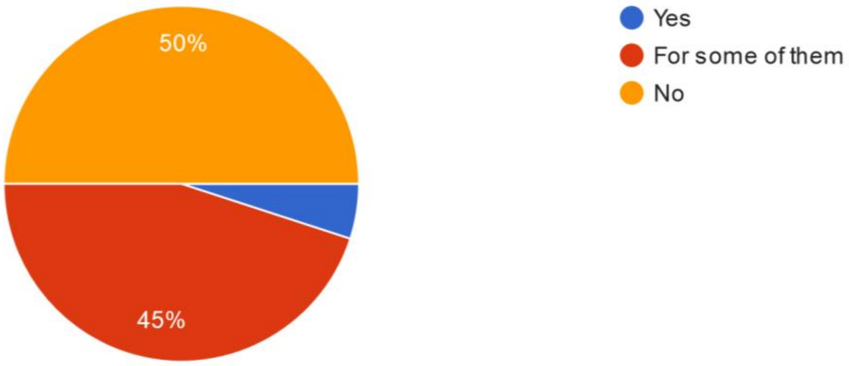


Should we assign condition to the following habitats:



Should all remaining seminatural habitats be assigned a condition of Moderate?

20 responses



<u>Please write down any of the following that you feel should be assigned a standard condition: rough grassland, water, quarries / mineral extraction sites, scattered trees (non-historic parkland), allotments, linear features? Or suggest other habitats or none.</u>

Incredibly dangerous - open to all sorts of abuse (I can upgrade this site because it's scored as "moderate" etc etc)

None

water (WFD status?)

rough grassland and allotments and maybe water. Probably too much variation in the other features.

Quarries/mineral extraction sites, allotments

Allotments

quarries and mineral extraction sites could assigned a condition of poor, allotments could possibly be moderate.

none

maybe allotments. mineral/waste sites if still being used. maybe - not sure I am qualified to say why though...

Allotments. Disused quarries can have high value. Linear features could be anything from rivers and hedges to paths and roads. For water, can we use WFD?

Rough grassland, water,

I think we need to look to see if there are other data sets we could use like WFD. Some mineral sites could be already under a level of restoration where some may not

quarries / mineral extraction sites and allotments

none

<u>Please add any additional comments</u>

16 responses

SSSI or CWS will depend on the date of the data. the quality of the info available will play a large part in able to assign a condition. Don’t want too many assumptions as then can start to lose the quality of the overall data. best to leave blank when we don't know? although saying that woodland might be easier to put a standard condition to? and for these it will be important to retain and also enhance where possible

One habitat we need to pay particular attention to is open mosaic habitat/brownfield. This turns up in Corby in particular where it's under threat. It's not easily identified by this model, and its condition changes rapidly because it's ephemeral by nature.

I think we would need a very clear reason for doing this work if. if it is a first step being used at a very zoomed out scale then the idea is good but there is a big danger of people trying to apply it to decision making

Where lacking condition data, condition assumptions similar to the ones suggested are fairly common practice in BNG assessments, especially for large schemes. These assumptions can be drawn from sources such as EIAs.

I do think there are some other landscape or catchment scale indicators which you could be looking at, eg presence of invasive non-natives, species composition, presence of rare or flagship species, naturalness of water courses, etc.

I think we need to be careful with inference. I can see the strategic reason why we would want to do it considering there is often not the budgets to carry out surveys at scale. But we need to be careful we don’t under / over estimate and it becomes meaningless, or used by in the wrong hands to argue for development in potentially wildlife rich areas. A real challenge

At what point does the number of assumptions that have to be made outweigh the usefulness of the product?

I'm not an ecologist, so have answered as far as I can

Q 1. Yes, but you need to make clear the reasoning for each boundary - what constitutes good? Q. 2 my answer would be the most recent assessment. Q.4 depends on the amount and standard of the data on which you are basing this, could you have a minimum standard criteria? Q. 5 As above, a broad brush can be damaging Overall. This needs to be kept up to date and needs a funding model to support this resource

The latest or most recent data from whatever source should be used to assign condition.

One could infer woodland condition if the site is under a UK Forestry Standard compliant management plan perhaps?

Would it be more palatable if we took a stronger precautionary principle approach and assigned a good status to more important habitats such as native woodland rather than moderate

Important to try to include hedgerows and field boundaries if possible - citizen science? Also large old trees - Woodland Trust ancient trees.

Use data on species that are habitat specialists as a proxy for habitat quality. E.g. ground nesting waders for flood plain grazing marsh?

Really worried about the lack of ground truthing available for any of this data - we are aware that the LWS / SSSI data is incredibly out of date, but are using that to make assumptions about quality without checking.

Part 2: Mapping Environment Quality

Are there any other maps that you think should be included?

10 responses

Does the ANGST standards form part of this. Also the NE MENE data and perhaps strava data

Species biodiversity (heat map?) odd this is omitted - could be by general taxa? i.e. not fine grain

Wider indication of ownership: private, public, estates

none that I can think of - do we need add in any development sites maps - small and medium scale sites with planning permission this can then be given a score. more difficult with the larger sites that may/should have integral GI and other habitats and services throughout the development... what about the HOM maps? and other identified priorities - anything on nature recovery networks?

there are a few in our atlases which might be useful, but the data might be gridded to 5km2 (for county atlases). We have a map on Areas of permanent vegetation cover, river obstructions / river continuity, & areas of deep peat and patch size.

Bird distribution - particularly habitat specialists. Amphibian distribution - good indicator of water quality.

None spring to mind

I think you've covered all the main ones. You can use open street map to get additional paths not included in PROW (especially in urban areas).

population density

More maps that indicate demand could be useful e.g. population density, use of sustrans routes (if available)

What do you see as the main uses for these maps?

17 responses

I think the power of these maps is when you start to combine / overlay them

In large scale planning for land use change, planning and site protection

All of the maps are useful. There needs to be some standard way of working out what it all means. Personally, I think there needs to be some sort of assessment of supply and demand for ES, so you know which are in deficit and which in surplus and therefore be able to prioritise which ES should have the greatest investment. Otherwise this is just looking at nice maps!

Feeding in to the environmental net gain requirements, but also helping spatial planning decision making

Biodiversity net gain info - deciding priority locations for offsets in particular; also for planning purposes (where to locate what / what to protect, expand improve etc); identifying priorities for intervention / protection; monitoring change over time

Inform programmes for future investment e.g. timings and ownership

excellent for informing decision making, having everything in one place

Adding colour to you NC baseline maps. We know them maps are habitat based, but these extra datasets 'fill in' some of the gaps

Looking at areas which are good, and therefore need supporting, and areas which are poorer and need specific interventions to improve.

Wide range of uses from baseline data for SA, EIA and plan preparation to identifying opportunities for enhancement or offsetting.

Give additional information on the potential further value of a habitat in addition to its intrinsic value to wildlife.

Inform landscape and small scale conservation, planning, natural flood management schemes, infrastructure projects...

not sure

Assessing potential supply of ecosystem services and identifying high value natural capital assets

Natural capital mapping but not sure what else, although individual layers obviously have their own uses.

scoping and story telling; identifying tradeoffs between ES

I see real value in these maps for a number of things, including informing planning policy and strategies (e.g. GI strategies)

<u>Do you have any other comments on these maps?</u>

8 responses

q1. my answers reflect trust of the data, and resolution

Scope for combining in some case e.g. access and tranquillity/perceived naturalness

how can we make these available to partners?

The noise dataset isn't that great (from knowing the data). All of the CEH maps are based on the 2007 countryside survey and then modelled, so it is getting quite old, and not very good to use at small scales but OK for patterns across the landscape.

I have only really been able to answer from a planning perspective and how useful they might be in that context

Of interest individually, be interesting to see what can be learnt from combining large numbers of them - is it an increase or dilution of their value.

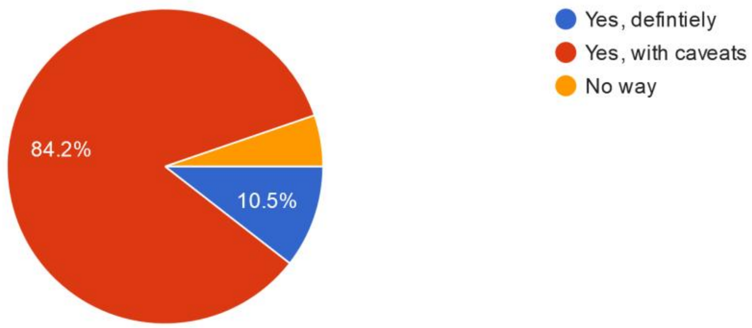
Combine some maps where possible e.g. rights of way and land with public access

Some of the CEH maps are only modelled so have no specific value for local habitat condition - they are based only on habitat type and a few other parameters such as climate and soil type. Flood risk does not indicate natural capital supply or condition though it can be used to help indicate demand for the service - but only if combined with hydrological data on the location of properties and trees etc within a catchment. It is not simple. Bluesky tree map really useful for urban trees.

Part 3: Recommendations and Public access

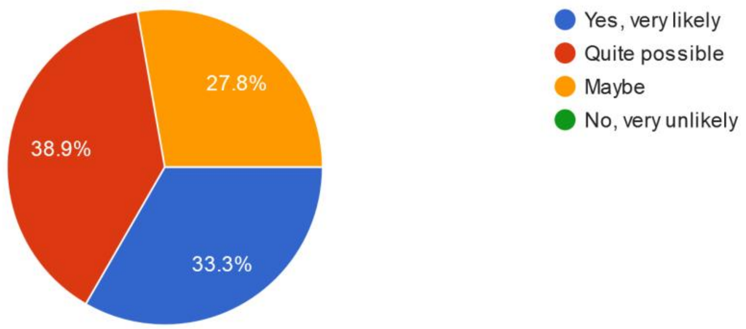
Would you recommend that our approach to mapping habitat condition is used more widely?

19 responses



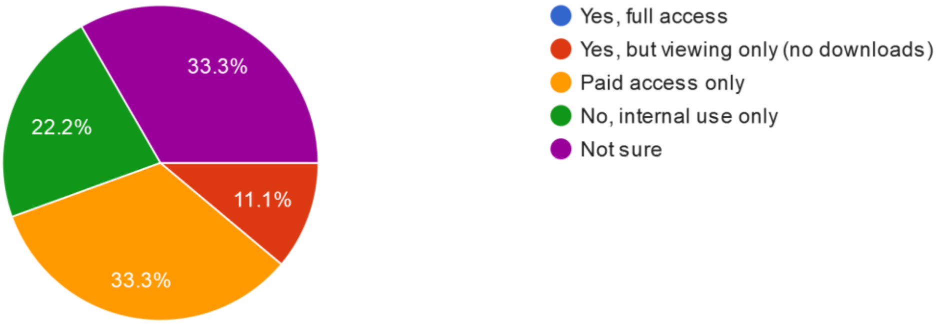
Do you think that the maps could be used in the wrong way by unscrupulous developers?

18 responses



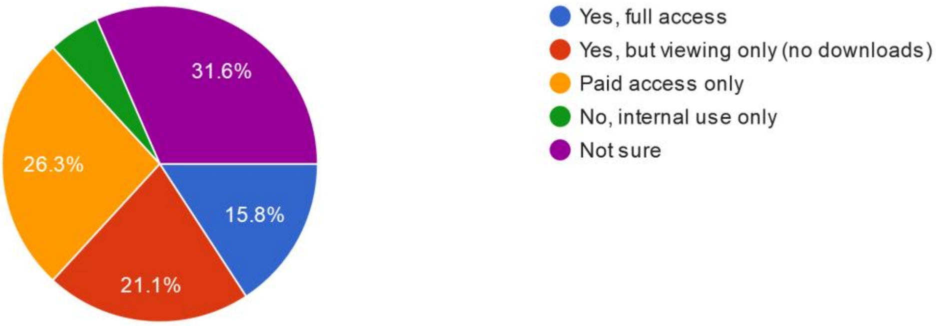
Should the condition maps and biodiversity unit maps be made publicly accessible?

18 responses



Should the quality maps (asset register) be made publicly accessible (subject to licences)?

19 responses



<u>Please add any additional comments</u>

13 responses

I'm still not sure about the condition mapping (eg the rules to assign condition), but there wasn't a not sure option.

probably more individual discussions to have on specifics. be good to see the next stages as well

I think paid access managed by the record centre would help manage quality, expert interpretation and also provide a sustainable funding mechanism to continue improving / updating the data

I think it is difficult to answer some of these questions without seeing the final result.

Still a bit concerned about the limits of the approach, lack of real local data and many assumptions. Could give a false sense that we know more than we do.

I'm very concerned that if we put on a map that a piece of land has x biodiversity units that will give developers a 'target' to argue for if - as will inevitably happen - the site proves on the ground to be worth more. I definitely support identifying sites which may be of high value but wouldn't want to see anything more precise than that being made public.

Who are we aiming this work / data at?

I think we need to consider why people would want the data and tailor it to the user.

My answers are based on the current state - ie without ground truthing any of the quality data. I'd be very concerned about a wider approach that did the same. However, this approach could form the basis of a really useful approach, if there was follow up ground truthing of the quality data to ascertain how real the picture it gives is.

Condition mapping needs further work to test the approach and to evaluate more closely some of the data sources, particularly with regards to the different purposes or methods that condition data collection uses. I think there are some general approaches that might be useful, but there needs to be an agreed standard for doing this. ALERC should be involved with this as they are working on standards for biodiversity net gain and many LERCs hold habitat data. Survey work is important to get the highest quality data, but this is limited by funding. If condition information is useful to publicly funded bodies (e.g. DEFRA group) then perhaps they might like to think about funding additional surveys work.

This information should not come on its own, it needs to have caveats and it needs to be kept up to date - I can see this potentially being misused if not properly managed.

I think that documents summarising quality and condition information could be publicly available not the maps themselves.

With a paid license that income could be spend on ground truthing and updating any inferred conditions