South Yorkshire natural capital and biodiversity mapping

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Executive Summary

Several partners in South Yorkshire, including the four Local Authorities and the South Yorkshire Mayoral Combined Authority, identified the need for an assessment of its natural capital, the benefits that it provides and the opportunities to enhance it. The challenges of climate change, biodiversity loss and the need for a green decarbonised economy were a catalyst. This report outlines a natural capital and biodiversity assessment for South Yorkshire, that has mapped natural capital assets, ecosystem services and opportunities for improving and creating habitats for enhancing biodiversity and ecosystem services. This has enabled the creation of a draft nature recovery network and a woodland creation map. It has provided valuation of the benefits that flow from the assets, and how investing in natural capital can help to deliver regional policies and strategies. Crucially, it has created a spatial natural capital evidence base for South Yorkshire that can be used to underpin the formulation of strategies to deliver on multiple policies.

This project has produced a detailed map of the current habitats present across South Yorkshire. It covers an area of 1,552 km^2 and contains 2,314,005 polygons. South Yorkshire has a diversity of habitats within its boundary, but is dominated by arable land in the east and improved grassland in the west (44%). However, there are also extensive areas of woodland and trees scattered across the county (10.6%). There are significant areas of heathland (5%), bog (4%), lowland bogs in the east and upland moorland in the west, and semi-natural grasslands throughout, with marshy grasslands mainly in the east (8.4%). Rivers and reservoirs are an important feature of the South Yorkshire landscape (1.5%). Built up areas, infrastructure and gardens combined cover 20.5% of the area.

The habitats in each polygon of the South Yorkshire basemap were assigned a distinctiveness and condition score so that the Biodiversity Metric 2.0 could be applied. It was possible to estimate the condition for 91% of the region. Much of the area (c.57%) is in poor condition (score 1) due to the predominance of arable and improved grassland habitat, the extent of domestic gardens and amenity grasslands. There were patches of moderate, fairly good and good condition habitats scattered throughout the region, but mainly in the west in the uplands, and the lowland bogs in the east. The overall biodiversity score was 517,734 units.

The ecosystem service maps demonstrate the spatial pattern of provision of eleven different ecosystem services: carbon storage and sequestration, air purification, noise, local climate, water flow and water quality regulation, food production, timber production, recreation and accessible nature. Maps showing the demand for air purification, noise and local climate regulation and accessible nature were also produced. Demand was focussed in the urban centres of Sheffield, Barnsley, Rotherham and Doncaster. However, in the main the capacity to provide these services was highest where woodland occurred, outside of the urban areas, which is scattered across the region, but slightly more concentrated from central Barnsley through the west of Sheffield. The upland heathland and bog habitats in the west and the lowland raised bog in the east are important areas for carbon storage, but also have a high level of provision for access to nature.

The monetary value of the benefits provided by natural capital across South Yorkshire are £550 million per annum, with an asset value (present value) of £18 billion over 50 years. The value of air quality regulation (£237 million annually), recreation (£188 million annually), and physical health (£68 million annually) are particularly large. Despite the dominance of agriculture the value of food production is low (£3 million annually), and this is outweighed by the related GHG emissions that come at a **cost** of

£16 million. Overall the region is a net emitter of carbon at 105,300 tCO_2e per year at a cost of £8 million annually.

The nature network and ecosystem service opportunity mapping is a GIS*-based approach used to identify potential areas for the expansion of key habitats to meet different objectives, whilst taking constraints into account. The biodiversity network mapping highlights numerous opportunities for creating new woodland to connect up existing core woodland habitat, including riparian areas; semi-natural grassland creation would be particularly effective at connecting up core habitat in the west of the region; and wetland habitats could be connected well by creating this habitat along the Rivers Don and Torne in Doncaster. There are also opportunities to create new heathland and bog habitats, although efforts to restore these habitats in the western uplands and in the east would have better outcomes. Opportunities for slowing the flow and improving water quality across South Yorkshire, tend to occur mainly on arable and improved fields. The air pollution, noise and local climate regulation opportunities tend to occur on the outer fringes of the urban centres in the region and adjacent to the road network (in the case of the first two services), where demand for these services is highest. Opportunities to enhance recreation also fall around the major and minor towns in the area. Increasing the condition of habitats in the region is as important for enhancing biodiversity and benefits as creating new habitat. There is a broad area of semi-natural habitats that fall below good condition that can be targeted for restoration through improved management. The biodiversity and ecosystem service opportunity maps have been combined, showing where creating habitat for biodiversity can simultaneously deliver multiple benefits. These maps are the basis for the nature recovery network and woodland creation maps for South Yorkshire.

The policy analysis of the South Yorkshire Mayoral Combined Authority (SYMCA) strategies showed the main goals are to transform the economy whilst decarbonising it, moving away from car-based transport, and creating a fairer society designed around sustainable, healthy and environmentally resilient places. Whilst the strengths are the clear commitment of the SYMCA to these key issues, and building in resilience to climate change, policy must respond to the evolving situation in order to deliver the transformative change needed. For example, more integration is required across policies to support natural capital assets; investment in sustainable connectivity to address car-dependency and to create green corridors is needed, which will provide greener travel, cleaner air, reduced noise pollution and recreational opportunities, increasing health and well-being and a sense of place; and incentivising growth in the environmental and innovation sectors to support a circular and green economy is vital. This analysis also identified natural capital investment opportunities that could be used to fund activity that will ensure this change can happen.

This project has produced a detailed evidence base for South Yorkshire that can be used both at the strategic regional scale, and to meet environmental and socio-economic plans and aspirations at the sub-regional level. It can now be used to plan a suite of prioritised projects that address the needs of key issues in the region, and to meet different funding priorities and investor interests.

Recommendations

A move to sustainable agriculture: in both arable and livestock farming will be key, and it is certainly the aim of the new Environmental Land Management Scheme to promote sustainability and incentivise land management for the provision of public goods. Emissions reduction from farming is

* A Geographic Information System (GIS) is a computer system that captures, stores, checks and displays data related to positions on the Earth's surface. It can show a diversity of data on one map, enabling the data to be visualised and analysed.

important, especially in Doncaster, so a focus on this and simultaneously increasing the sequestration capacity of the farmed landscape will be vital. Interventions that will improve water quality, slow the flow of water, provide increased access to nature will also be important in these areas.

Expanding woodland: as a key asset and there are already plans to expand this habitat at the county scale. Opportunities to create woodland to connect up existing core habitat, to help slow the flow of water, to increase water quality and opportunities for recreation should be taken up. The role of woodland and trees in the urban centres of the region is also vital. Urban trees are key to providing multiple benefits in towns and cities, but the urban tree stock needs to be reviewed to ensure the right species of tree are in the right locations for delivering services where they are needed.

Restore bog habitats: as a significant regional asset, and an important carbon store, restoration of the lowland and upland bogs is important for South Yorkshire. Restoration will significantly reduce GHG emissions from these habitats. It will also be important for slowing the flow of water and increase water quality.

New natural and biodiverse green spaces: should be created in areas where access is currently low. This will be important for increasing recreational opportunities and enhancing the health and well-being of the inhabitants of South Yorkshire (physical inactivity was highlighted as a particular issue in the policy analysis). Health and recreational benefits have a high economic value.

Enhancing biodiversity: can be achieved through increasing the quality of existing habitats, as well as creating new habitats in the opportunity areas mapped. These sites should be prioritised to meet existing habitat and species level strategies, and to formulate future ones. In addition, the nature recovery combined opportunities map should be used to meet biodiversity targets at the same time as providing multiple benefits. Semi-natural habitats are inherently multi-functional, meaning that an investment focussing on one benefit (e.g. natural flood risk management), can deliver multiple additional benefits, hence offering excellent value for money. Biodiversity net gain (BNG) for development can be used to direct off-set opportunities to key sites within the South Yorkshire nature recovery network, that can deliver biodiversity and multiple benefits. The biodiversity unit and nature recovery GIS layers should be used to create a strategically located set of sites for off-sets (a South Yorkshire habitat bank). BNG opportunities can be packaged up in advance to fit in with any scheme that the local planning authorities develop to facilitate biodiversity net gain delivery.

A combined LNRS and natural capital investment strategy: A process is now required by which a strategy for the region can be designed to deliver the nature recovery network (LNRS) and to direct natural capital investment. The evidence base, and particularly the opportunity maps, created in this project should be considered as a tool to guide decision making regarding the best locations to target for habitat creation projects, and those that enhance existing habitats that are not in good condition. A set of workshops are required, with a broad variety of stakeholders, to consider priorities for creating a suite of projects to take forward in South Yorkshire. It is not until there is a strategy in place that the numerous opportunities that have been identified in this project can be prioritised, matched up with appropriate funding and taken forward.

Contents

1. Introduction

Several partners in South Yorkshire including the four Local Authorities and the South Yorkshire Mayoral Combined Authority, have identified the need for an assessment of its natural capital, the benefits that this provides and the opportunities to enhance it, particularly in light of its economic and social development ambitions. Natural capital refers to the stock of assets provided by the natural environment with capacity to produce goods and services that are of value to people (NCC 2014)[1], often classified into provisioning, regulating and cultural ecosystem services (EEA, 2016[2], Hein et al., 2016[3]). Natural capital comprises land and minerals, fresh, tidal and marine waters, air, species and ecological systems, together with supporting natural processes and functions[3]. In many respects, it supports all forms of other capital on which human systems depend, whether man-made, human or social. However, many of the outputs produced by natural capital, such as the regulation of flooding and atmospheric gases by woodlands, are not included in the decisions of individuals or organisations. This is because they often involve non-priced public goods that are not traded in the market place, and are not subject to formal property rights and entitlements (TEEB, 2010[4]). Elements of biodiversity and natural capital are therefore liable to be overused, degraded, depleted and eventually lost, with consequences for long term welfare and the sustainability of economic systems (Dasgupta 2021[5]). There is now much greater awareness of the role of natural capital in the design and achievement of economic and social development strategies, with strong links to business and enterprise[6]. Furthermore, the central role of natural capital in delivering quality of place is being increasingly recognised.

South Yorkshire is a diverse area comprising of the city of Sheffield and the districts of Barnsley, Rotherham and Doncaster. The region supports a population of 1.4 million people, with 47,000 businesses providing 634,000 jobs. The region consists of some significant natural assets, for example, the Peak District National park and South Pennine Moors, the Humberhead Levels, Dearne Valley and significant areas of urban greenspace. The River Don links all four of the region's districts, along with the Dearne, Dove, Loxley, Rivelin, Rother, Sheaf, Porter and Went. Agriculture is dominant in the region providing a significant rural economy. The strategic economic plan demonstrates that the area would like to grow its economy but not at the expense of environment and society, recognising the need to build a zero carbon future.

Natural capital is becoming increasingly embedded across multiple policy domains, including the mandatory requirement for biodiversity net gain for all new developments, as set out in the Environment Bill, with an ambition to move towards environmental and natural capital net gain in the future, backed by changes to the National Planning Policy Framework and the new Planning White Paper. The Environment Bill also sets out the requirement for nature recovery networks and strategies, while the recently enacted Agriculture Act paves the way for a new Environmental Land

[1] NCC 2014. Towards a Framework for Defining and Measuring Changes in Natural Capital. Working Paper 1, Natural Capital Committee.
[2] EEA 2016. Common International Classification of Ecosystem Services (CICES) , European Environment Agency, Copenhagen. https://cices.eu/
[3] Hein, L., Bagstad. K., Edens, B., Obst, C., de Jong, R., Lesschen, J.P. (2016). Defining Ecosystem Assets for Natural Capital Accounting. PLoS ONE,11(11): e0164460. doi:10.1371/journal. pone.0164460
[4] TEEB. 2010. The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Earthscan, London and Washington
[5] Dasgupta, P. (2021) The Economics of Biodiversity: The Dasgupta Review. (London: HM Treasury).
[6] TEEB. 2012. The Economics of Ecosystems and Biodiversity in Business and Enterprise. Earthscan. London; New York.

Management Scheme (ELMs), with a central tenet of farmers and land managers being paid public money for public goods, based on natural capital principles. Further policy alignment is achieved through the requirements for action on climate change and commitments to go carbon neutral, including the planting of large areas of new woodland.

The South Yorkshire Mayoral Combined Authority (SYMCA) and partners, therefore, commissioned this project, in conjunction with the South Yorkshire Local Nature Partnership, to produce a natural capital assessment for South Yorkshire, with the following eight aims:

1. Create a detailed natural capital (habitat) basemap based on the best available existing data.
2. Complete a habitat quality and biodiversity assessment, creating a biodiversity baseline for the region using the Biodiversity Metric 2.0 metric.
3. Model and map the benefits (the ecosystem services) that flow from the natural capital present across the county and the demand for those benefits, where possible.
4. Calculate the monetary value of those benefits wherever possible.
5. Use biodiversity network mapping (habitat opportunity mapping) to highlight opportunities for enhancing biodiversity across the county, with a view to creating a nature recovery network and a woodland creation map.
6. Map opportunities where new habitat can be created for enhancing ecosystem services in the region.
7. Map combined opportunities where new habitat can be created to enhance one or more of the services mapped in point 3 above.
8. Deliver a strategic level policy analysis and guide to the future financing of natural capital in South Yorkshire.

The overall objective was to create a shared spatial natural capital evidence base that the South Yorkshire Local Authorities and partners can use to underpin the formulation of strategies, and to meet the multiple policy domains outlined above.

1.1 The natural capital and ecosystem services framework

The natural environment underpins our wellbeing and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. 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 2014[7]). It is the stock of natural assets (e.g. soils, water, biodiversity) that produces a wide range of ecosystem services that provide benefits to people. These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities (Figure 1).

[7] Natural Capital Committee (2014) The state of natural capital: Restoring our natural assets. Second report to the Economi Affairs Committee. Natural Capital Committee, March 2014.

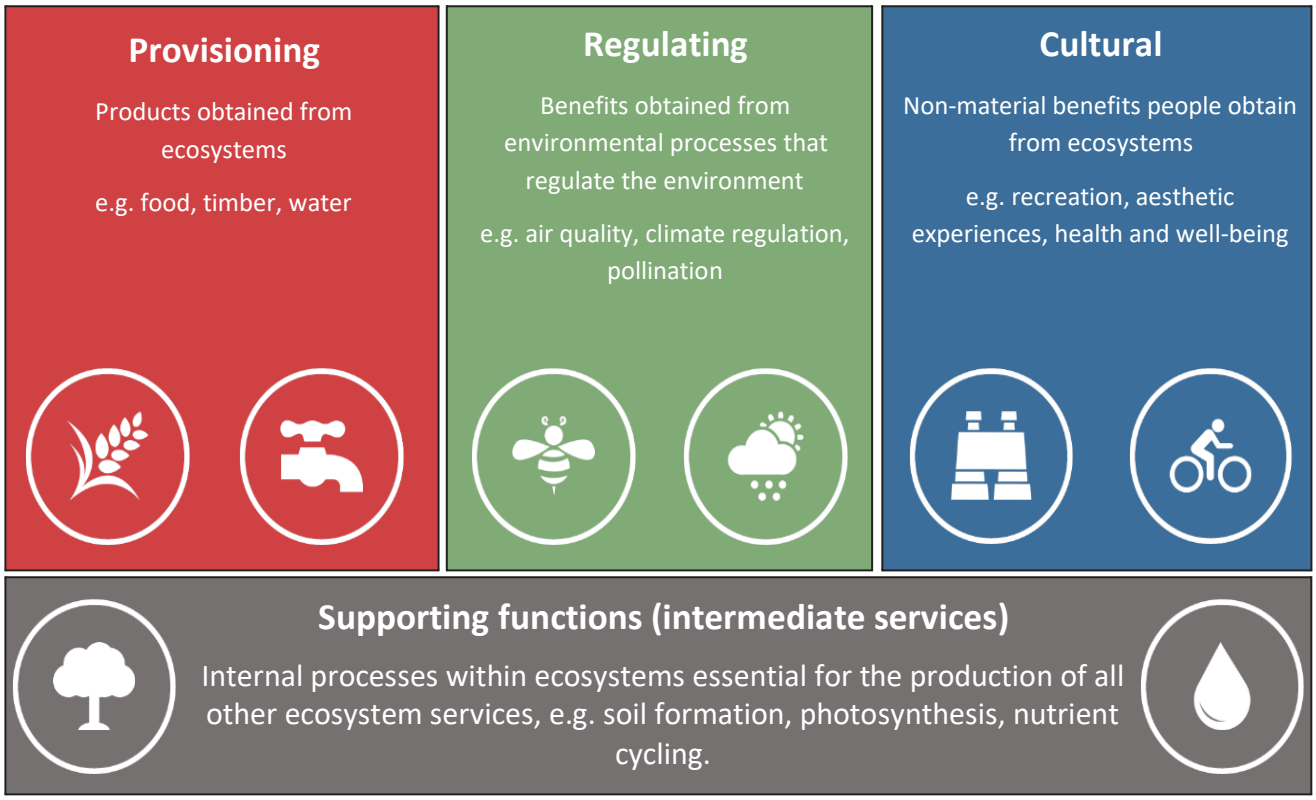


Figure 1 Key types of ecosystem services (based on MA 2005[8]). Note that supporting or intermediate services are now categorised as ecological functions (CICES[9]). They are the underpinning structures and processes that give rise to ecosystem services.

Much work is progressing on how to deliver the natural capital and ecosystem services approach on the ground and how to use it to inform and influence management and decision-making. One of the most important steps is to recognise and quantify ecosystem service delivery (the physical flow of services derived from natural capital). Additional insight can be gained by taking a spatial perspective on the variation in ecosystem service supply and demand across a study area using a Geographic Information System (GIS). Maps are able to highlight hotspots and coldspots of ecosystem service delivery, highlight important spatial patterns that provide much additional detail, and are inherently more user friendly than non-spatial approaches. When information on supply and demand for ecosystem services is known, it is also then possible to objectively determine the best areas to create habitat to increase the supply of each particular ecosystem service in a process known as habitat opportunity mapping. By overlaying opportunity areas for each objective, it is possible to identify areas where changing habitats could deliver multiple benefits.

The flow diagram below (Figure 2) illustrates the steps involved in the natural capital and biodiversity assessment, and the main mapped output produced for South Yorkshire.

[8] Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Synthesis. Island Press, Washington D.C. https://www.millenniumassessment.org/en/index.html

[9] Haines-Young, R. & Potschin, M. (2018) Common International Classification of Ecosystem Services (CICES) V5.1. Guidance on the application of the revised structure. Fabis Consulting.

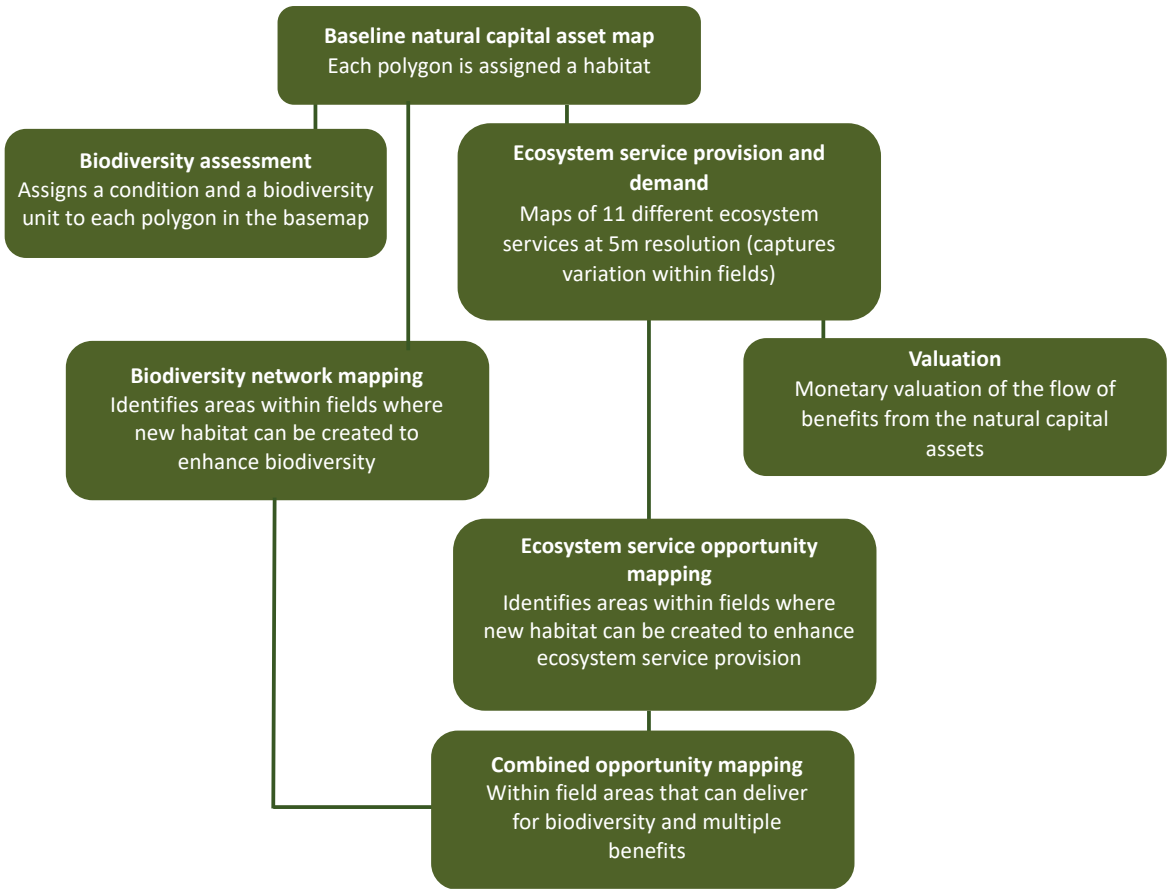


Figure 2 The structure and outputs of the natural capital and biodiversity assessment for South Yorkshire.

1.2 Report structure and scope

A key first step in any natural capital project is to understand the natural capital assets present across the study area. The baseline natural capital assets of South Yorkshire are presented in Section 2. The condition of the assets were then assessed and biodiversity units (Biodiversity Metric 2.0) assigned to each habitat within the basemap, from which an overall biodiversity baseline score has been derived (Section 3).

This was followed by the assessment of eleven different ecosystem services, and where possible, the demand for services was mapped (Section 4). The annual monetary flows of set of ecosystem services were then valued using a natural capital accounting approach (Section 5).

The report then moves on to the assessment of opportunities for enhancing biodiversity and ecosystem services across South Yorkshire. The biodiversity network mapping is presented in Section 6 with maps showing the opportunities for each broad habitat type separately. This is followed by the mapping of opportunities for creating habitat to enhance ecosystem services in the region; for slowing the flow of water, reducing erosion and increasing water quality, for reducing air and noise pollution, for reducing the impact of the heat island effect and for enhancing recreational opportunities in the region (Section 7). These opportunities are combined in Section 8. From these analyses a first stage nature recovery network (Section 9) and a woodland creation map (Section 10) are presented.

A policy analysis focusing on SYMCA strategies (Section 11) outlines potential funds available for investment in natural capital and funding mechanisms (detailed data tables on this are presented in Annex 1 at the end of the report).

The report ends with conclusions and recommendations from the results of the natural capital assessment and policy analysis (Section 12). This is followed by an outline of issues for consideration in the future (Section 13), for example how to maintain the evidence base, ground truthing and data sharing.

The report includes an outline of the outcomes of a project workshop in Annex 2.

The main body of the report is focused on analysing the tends at the scale of South Yorkshire. However, the asset registers and basemaps for each of the four Local Authorities and their individual natural capital accounts are presented within it.

2. South Yorkshire baseline natural capital assets

2.1 Approach to mapping habitats

The first and key step was to produce a detailed map of the current habitats present across South Yorkshire. This is an important component of any assessment of natural capital assets and is required before an assessment of the condition of the assets, the ecosystem services or habitat opportunities can be undertaken. To do this, we used Ordnance Survey MasterMap polygons as the underlying mapping unit and then 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 are shown in Box 1.

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

- OS MasterMap Topography layer
- OS VectorMap District
- OS Open Greenspace data
- Natural England Priority Habitat Inventory
- Phase 1 survey data from project partners (including survey data from Bradfield Moor)
- National Forest Inventory
- Hedgerow data (Doncaster only)
- CORINE Land Cover
- Crop Map of England (CROME)
- Hydrology of Soil Types (HOST)
- Built-up Area Boundaries data
- Digital terrain model (OS Terrain 5)
- Soil organic carbon map - NATMAP Carbon

Further information on how polygons were assigned to habitats is provided in Box 2 (overleaf). Polygons were classified into detailed Phase 1 habitats, and were also classified into broader habitat groups. These were then converted into the UKHab classification. The final basemap covers an area of 155,214 ha or 1,552 km^2. It contains 2,314,005 polygons, each of which has been classified as an appropriate habitat type.

Note that the basemap provides the best approximation of habitat types that can be achieved based on the best available data. It contains the most up to date Phase 1 habitat survey data from each local authority, the Yorkshire Wildlife Trust and the Sheffield and Rotherham Wildlife Trust, that was available in GIS format. It also contains habitat data for Bradfield Moor from field-based surveys carried out in 2020 (donated by the Fitzwilliam Wentworth Estate, and mapped by Natural Capital Solutions in a previous project). It has also been sense-checked by the project Steering Group, the Yorkshire and Sheffield and Rotherham Wildlife Trusts. However, as it is not possible to ground truth the whole of South Yorkshire the basemap will inevitably contain errors. A particular challenge was classifying polygons where more than one habitat was present. Mixed habitats containing woodland and scrub or grassland with woodland were classified in detail, but not all combinations of habitats could be accommodated.

Hedgerow data was provided for Doncaster, but we did not have equivalent data for the other local authority areas. It was not possible to include data on street trees within the four conurbations. These data gaps need to be considered when interpreting the results.

Box 2: Assigning habitats

Our approach to assigning habitats uses OS MasterMap, which is the most detailed and accurate map available across Great Britain and identifies all roads, buildings, fields and other features as individual polygons. However, information on the habitat of these features is limited. We used a series of rules and other layers to classify each polygon. For example, we used rules to assign features as houses, gardens, industrial / commercial buildings and so on.

The habitat information provided by other sources (e.g. PHI data) was then overlain and the degree of overlap calculated using zonal statistics. This does not always match precisely so, for example, if a habitat polygon marked as semi-natural broadleaved woodland (A1.1.1) overlaid houses, gardens and a polygon identified as non-coniferous trees in MasterMap, we could now assign the non-coniferous tree polygon more accurately as semi-natural broadleaved woodland, but the houses and gardens would be left unchanged.

A number of additional rules and layers were used to gradually build up as complete a picture as possible. For example, areas identified as improved grassland, but within urban areas, were classified as amenity grassland. All polygons were assigned to a Phase 1 habitat type initially, although areas currently undergoing development were marked as unclassified. Upon initial completion, the basemap was checked against Google and Bing maps and manual alterations were made in a number of places where miss-classifications had occurred or where habitats could be assigned with greater certainly.

2.2 The natural capital assets of South Yorkshire

Map 1 shows the distribution of broad habitat types across South Yorkshire, and the area and percentage cover are shown in Table 1. The county is dominated by arable land (27%, 42,032 ha), most of which occurs in the north and east of the region (Map 1). Improved grassland has the second highest extent in the region covering 25,715 ha (17%) of South Yorkshire. Alone broadleaved woodland covers the greatest area of all non-agricultural and man-made habitats. In combination with hedges, scrub and parkland coverage totals 18,016 ha (12%). Semi-natural grasslands occur predominantly in the west of South Yorkshire, to the west of Sheffield, with small patches dispersed across the county, and have a combined area of 10,212 ha (6.6%). Marshy grasslands occur mainly in the north-east of the county in Doncaster, on the floodplain region of the River Don (see Map 2), and cover an area of 2,753 ha (1.8%).

Heathland covers 5 % (7,440 ha) of the county, located predominantly on the moorland in the west, but also through the central northern area (east Barnsley). The upland blanket bogs in the west and lowland raised bog in the east total 6,207 ha in area (4%). Fen and swamp habitats cover 238.5 ha (0.2%). Rivers and reservoirs are significant features of the South Yorkshire landscape and cover 2,334 ha (1.5%). Built-up areas and infrastructure (roads, railways, pavements and paths) cover 12.4% of the land area, with gardens comprising a significant 8.1%. Amenity grassland occurs in and around the major conurbations in South Yorkshire covering 3.8% of the area, which includes road verges, golf courses and recreational grounds.

We have presented the river network layer for South Yorkshire separately (Map 2). It is within the natural capital asset map in (Map 1), but it is hard to see clearly. We also present the priority semi-natural habitats separately (the Natural England Priority Habitat Inventory, Map 3) so it is easier to appreciate the location of the higher quality habitats in the region, that are of conservation interest. Please note that there are a suite of habitats that fall under the 'no main habitat' category that have been included as unclassified in Map 3, and there are likely to be inaccuracies in this data set because it is not frequently updated. However, this map is useful to see, as it is used to set the constraints in the biodiversity and ecosystem services opportunity mapping (Sections 6 and 7).

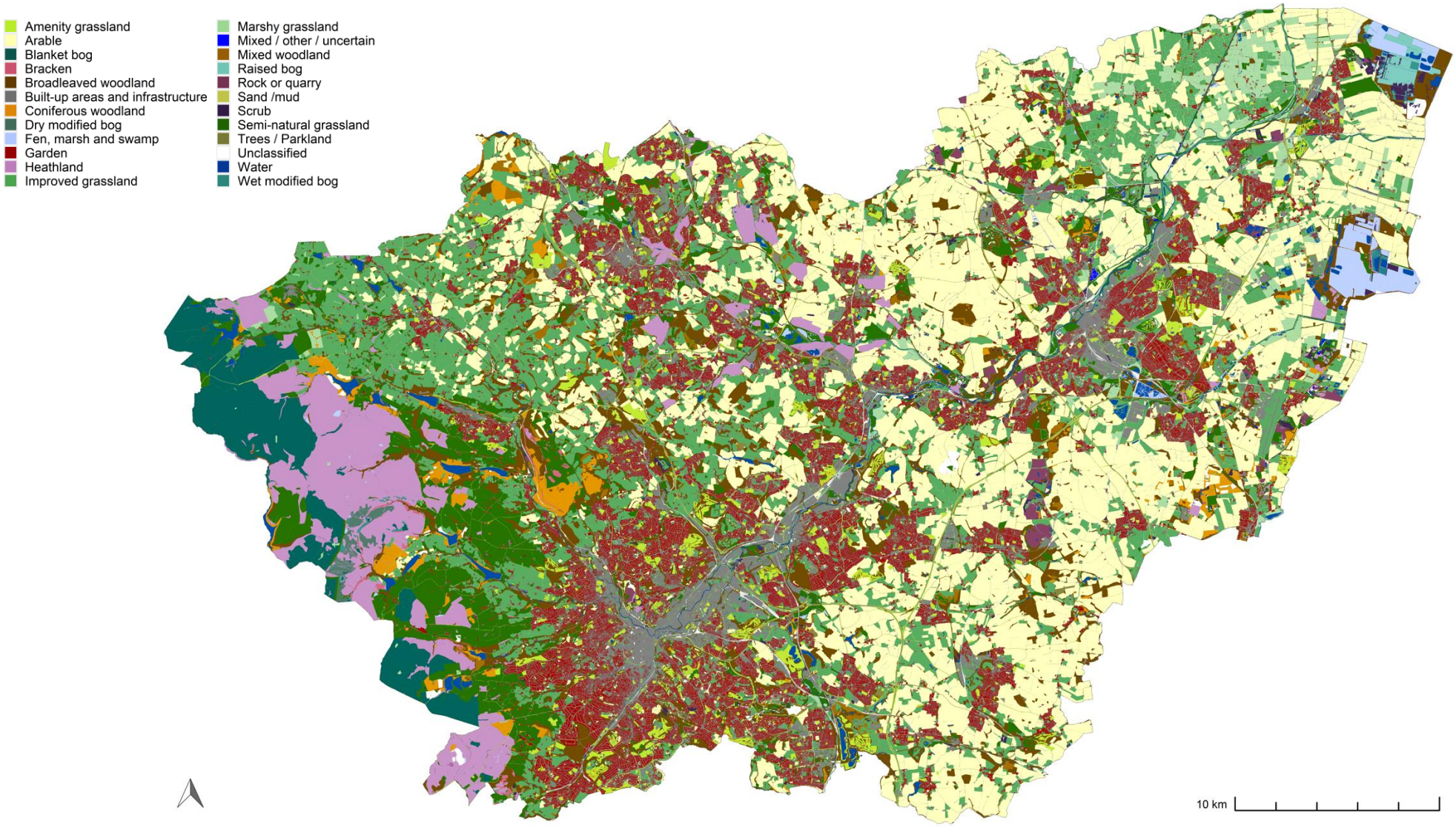
Natural capital asset maps for each of the four Local Authorities, Sheffield, Barnsley, Rotherham and Doncaster, are presented in Annex 1. These highlight the type, extent and distribution of the natural capital assets within the local authority boundaries, so trends can be analysed and used to inform decisions at the sub-regional level. Used alongside the South Yorkshire natural capital map and asset register, it can reveal how the assets within the Local Authorities connect with the wider landscape. These asset registers link to the local authority natural capital accounts that are presented in Section 5. The ecosystem service capacity and demand maps for each local authority are not presented in this report due to the large number of maps, but the maps and GIS layers will be provided to the project Steering Group.

Table 1 Asset register for South Yorkshire and its four metropolitan boroughs containing the area and percentage cover of broad habitat types.

	South Yorkshire		Sheffield		Barnsley		Rotherham		Doncaster	
Broad habitat	**Area (Ha)**	**% cover**	**Area (Ha)**	**% cover**	**Area (Ha)**	**% cover**	**Area (Ha)**	**% cover**	**Area (Ha)**	**% cover**
Arable	42,031.70	27.1	725.1	2.0	6,487.0	19.7	11,015.9	38.4	23,798.3	41.9
Improved grassland	25,715.30	16.6	3,799.4	10.3	9,273.8	28.2	4,574.6	16.0	8,067.4	14.2
Amenity grassland	5,885.40	3.8	1,648.4	4.5	1,220.6	3.7	1,332.5	4.7	1,684.0	3.0
Semi-natural grassland	10,211.60	6.6	5,537.7	15.1	2,049.6	6.2	598.2	2.1	2,025.6	3.6
Marshy grassland	2,753.30	1.8	55.5	0.2	195.2	0.6	25.7	0.1	2,477.0	4.4
Other grassland	557.5	0.4	119.6	0.3	85.9	0.3	160.6	0.6	191.4	0.3
Heathland	7,439.60	4.8	5,469.4	14.9	1,516.6	4.6	186.5	0.7	267.0	0.5
Bog	6,206.60	4.0	2,840.3	7.7	1,948.9	5.9	0	0	1,417.3	2.49
Fen, marsh and swamp	238.5	0.2	41.2	0.1	46.9	0.2	12.8	0.0	137.6	0.24
Scrub	1,023.00	0.7	167.2	0.5	65.0	0.2	106.7	0.4	684.1	1.2
Trees / Parkland	405.9	0.3	68.1	0.2	97.0	0.3	135.0	0.5	105.8	0.2
Broadleaved woodland	12,833.40	8.3	3,686.9	10.0	2,548.9	7.7	2,982.9	10.4	3,613.9	6.4
Coniferous woodland	2,032.30	1.3	873.3	2.4	665.0	2.0	62.6	0.2	431.1	0.8
Mixed woodland	1,127.20	0.7	245.3	0.7	349.9	1.1	202.8	0.7	329.3	0.6
Boundaries and hedgerows	594.4	0.4	7.1	0.0	0.6	0.0	2.7	0.0	581.8	1.0
Water	2,369.2	1.5	576.4	1.6	360.1	1.1	372.6	1.3	1,059.9	1.9
Mud/sand	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.6	0.0
Sand	3.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	2.8	0.0
Shingle	0.2	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Built-up areas	11,002.90	7.1	3,523.2	9.6	1,918.6	5.8	2,332.9	8.1	3,227.9	5.7
Infrastructure	8,168.30	5.3	2,635.3	7.2	1,528.0	4.6	1,672.9	5.8	2,331.9	4.1
Garden	12,562.20	8.1	4,269.1	11.6	2,381.3	7.2	2,646.0	9.2	3,265.7	5.7
Rock, exposure and waste	622.6	0.4	41.2	0.1	10.4	0.0	102.2	0.4	468.4	0.8
Mixed / other / uncertain*	1,341.20	0.9	432.9	1.2	149.8	0.5	108.3	0.4	650.0	1.1
Unclassified*	82.6	0.1	27.2	0.1	8.4	0	18.8	0.1	28.2	0.00
TOTAL	**155,214.70**	**100**	**36,789.9**	**100**	**32,907.6**	**100**	**28,653.5**	**100**	**56,853.0**	**100**

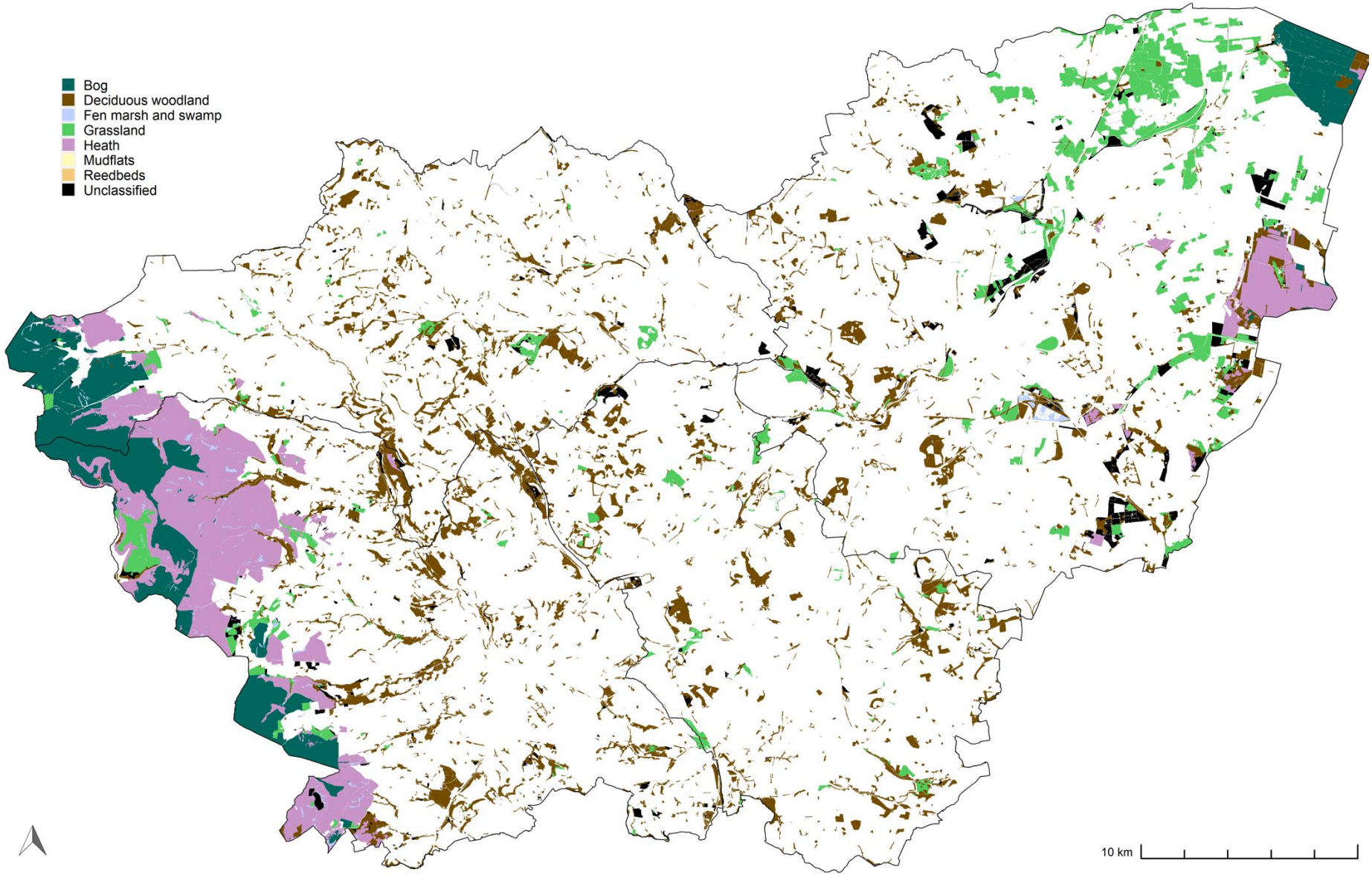
*Mixed habitats as we mention above were hard to capture in this basemapping process. There are also inevitably some polygons that it was not possible to classify despite using a number of comprehensive data sets and phase 1 data.

Map 1 Broad habitats across South Yorkshire.



Map 2 South Yorkshire's river network.

Map 3 Priority Habitats Inventory habitats in South Yorkshire.



3. Biodiversity baseline

An important aim of this project was to set a biodiversity baseline for South Yorkshire. The Biodiversity Metric 2.0, a relatively simple metric developed by Natural England (2019)[10], has been used to calculate 'biodiversity units' for each polygon in the South Yorkshire basemap*. The biodiversity unit score is based on the area of the habitat, its distinctiveness and condition. Habitats that have a high distinctiveness, are in good condition and cover a greater area will achieve a higher biodiversity unit score than smaller areas, with lower distinctiveness and condition scores. This metric is already starting to be used in the development sector to test whether Biodiversity Net Gain (BNG) will be achieved post-development. If the Environment Bill is passed, a BNG of 10% will be compulsory for this sector. Using the metric at a landscape scale is useful (i) to predict how changes in habitats or in habitat management within South Yorkshire will impact biodiversity, (ii) as it provides a baseline score from which to work out the BNG of any developments in the region, and (iii) to identify parcels of land to be managed as biodiversity off-sets purchased by a developer so they can achieve BNG on their development.

The first step was to assign the distinctiveness scores to each natural surface polygon in the South Yorkshire basemap. These are set scores in the Biodiversity Metric 2.0. The second was to assign a habitat condition to each of the habitat polygons according to the Biodiversity Metric 2.0. This assigns categories from 'good' to 'poor' and also includes two N/A categories for agriculture and other (non-natural) habitats (Table 2). When used in the metric, these categories are also given a score from 0-3 (Table 2). Based on descriptions in the Biodiversity Metric 2.0, we were able to assign condition to 91% of South Yorkshire using the following protocol:

i. **Low quality habitats**: this includes all built habitats such as buildings and infrastructure (N/A – other), arable (N/A – Agriculture), improved grassland (poor), gardens (poor), amenity grasslands (poor) and active quarries and mineral extraction sites. An area of 18,655 ha (12%) of South Yorkshire fell into the N/A-other category, and so received a score of 0. The agricultural land covers, amenity grasslands and gardens scored 1 and covered 79,534 ha (51%) of the county.
ii. **Habitats of conservation interest**: we used existing assessments of habitats of conservation interest to guide an estimate of habitat condition. Data from Natural England on SSSI condition was used and translated into the Biodiversity Metric condition categories (see Rouquette 2020 for methodology[11]). Local Wildlife Site (LWS) assessments (whether or not the site was in positive management) were also gathered where they existed from the South Yorkshire Local Authorities. These sites are assessed differently within each region, so we asked a member from each local authority to translate the site assessments into the Biodiversity Metric condition categories as closely as they were able. These data were not available for all existing LWS and not for any sites within Doncaster. We were able to derive condition estimates from the Yorkshire Wildlife Trust (YWT) and the Sheffield and Rotherham Wildlife Trust (SRWT) in relation to their reserves. We

[10] 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.

* Note that the Biodiversity Metric 3.0 was officially launched on the 7th July, at the time of writing this report. There are some differences in the new metric so results may differ slightly, but it is less likely to impact on the calculation of baseline biodiversity units (as we have used it here).

[11] Rouquette, J. (2020) Testing approaches to mapping habitat quality and ecosystem condition. Natural Capital Solutions.

were also able to use condition assessments gathered from field data for Bradfield Moor, from the same process applied in a project for the Fitzwilliam Wentworth Estate. This gave us condition data for 31,527 ha (20%) of South Yorkshire.

iii. **Woodlands outside sites of conservation interest:** it was possible to estimate the condition of woodland habitats using national data sets. Broadleaved woodland was assumed to be in moderate condition, as the recent NFI Condition data[12] suggests that 92% of broadleaved woodland in England receives an intermediate condition score. All coniferous woodland is assumed to be in poor condition according to the Biodiversity Metric 2.0 guidelines. Mixed woodland that falls within ancient woodlands (identified using the Ancient Woodland Inventory data) were assumed to be in moderate condition, and remained unclassified otherwise. This assigned a condition to a further 10,168 ha (7%) of the county.

iv. **Water:** Water Framework Directive (WFD) overall waterbody class was used to assign condition to water habitats. 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 were able to classify 1,474 ha (1%) of the county.

v. **Unclassified habitat:** Where there was no data available to guide the condition assessment, we did not attempt to estimate it. The habitats falling within this category were mainly semi-natural grasslands, but also some heathland, bog, fen, marsh and swamp, marshy grassland, scrub and scattered trees/parkland outside of the sites of conservation interest (ii). Also any habitat that we could not fully classify in the basemapping process was not assigned a score. This left 13,857 ha (9%) of South Yorkshire without a condition score.

Ecologists from the YWT and the SRWT also checked the South Yorkshire condition assessment based on their local knowledge of habitats outside of the SSSIs, Local Wildlife Sites and reserves.

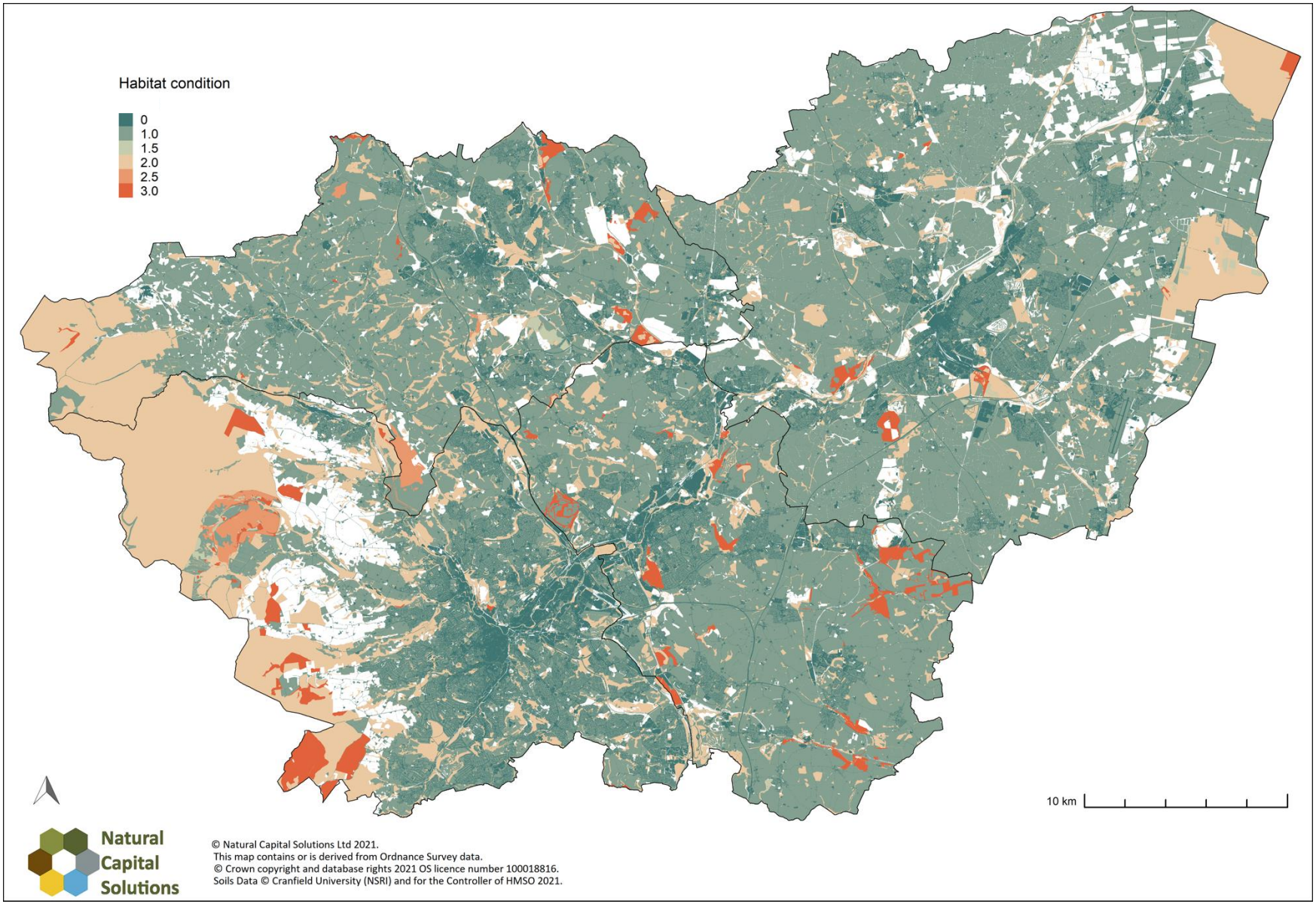
Table 2 Biodiversity Metric 2.0 condition categories and associated scores.

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

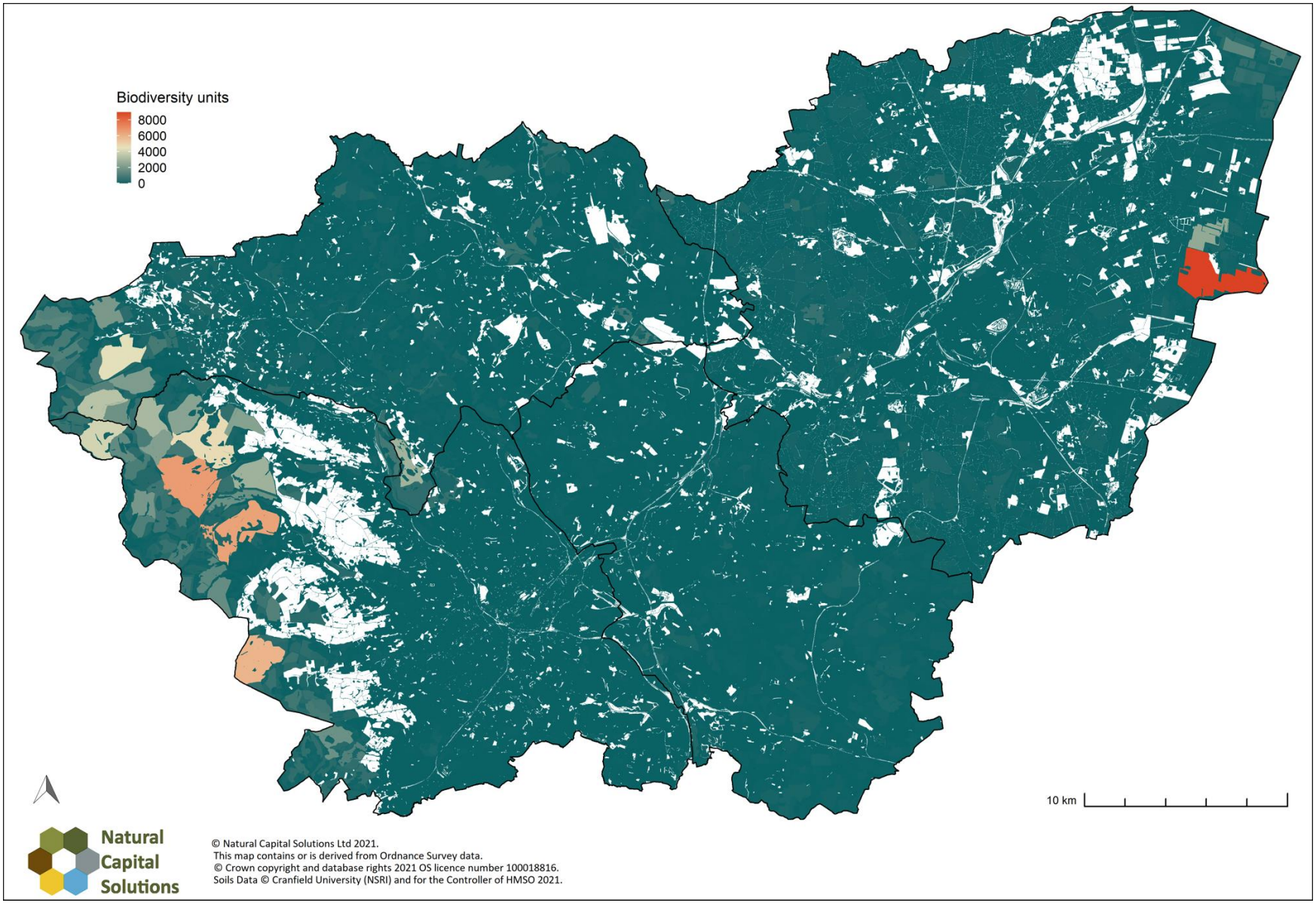
Based on this protocol we were able to mark the level of uncertainty associated with the condition estimate for each polygon using a RAG system, within the GIS layer. Green was given to polygons with estimates that come directly from condition assessments completed in the field, or where there is no doubt associated with the estimate, for example, the poor quality habitats in (i) above. Amber was assigned to polygons with estimates translated from other condition or quality assessments, where expert opinion has been given (where this has not been based on field visits), and where there is good national data to guide the estimate (e.g. broadleaved, coniferous woodland and water in (ii) and (iii) above). Red was associated with estimates that used national data as a guide, but this data was not from a condition

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

Map 4 Habitat condition across South Yorkshire. The white areas are habitats where no data existed on which to base a condition estimate.



Map 5 Biodiversity units across South Yorkshire.



assessment (mixed woodland in ancient woodland in (iii) above).

A large proportion (57%) of the habitats of South Yorkshire (Map 4) are in poor condition (a score of 1, blue areas). In the main this is due to the dominance of agricultural habitats in the region (see Map 1). Some fairly poor areas can also be seen (0.2%), on Bradfield Moor in the western uplands and some of the water bodies in the east of Sheffield. However, there are a number of areas of moderate condition (16% of the region) scattered throughout the county (score 2, light brown). For example, the SSSI area of upland moorland in the west of the region, Thorne and Hatfield moors on the eastern edge of Doncaster, and much of the broadleaved woodland. There are a very small number (0.7%) of fairly good habitats (score 2.5, orange), for example Wharncliffe Woods in north-west Sheffield and patches of heather on Bradfield Moor (also in the north-west of Sheffield). There are a few areas where habitat is estimated to be in good condition (2%, score 3, red) scattered across the region. These sites include Rabbit Ings Country Park in the north of Barnsley, a number of sites in the west, part of the Dark Peak and Eastern Park District Moors SSSIs, a section of Woodhouse Washlands on the border of eastern Sheffield and Rotherham, Roche Abbey Woodland in the east of Rotherham, and Sprotbrough Flash and Gorge, and Cadeby Quarry in Doncaster is considered to be in good condition.

Most of South Yorkshire has a low biodiversity unit score when mapping the biodiversity units by polygon (blue areas Map 5 above). The habitats with the higher scores are all in the western upland habitats, and on Hatfield Moor in the east. These habitats have higher condition and distinctiveness scores, but also the habitat polygons cover a larger area, all of which will increase the unit score. However, the high (red) biodiversity units on Hatfield Moor to the east of Doncaster is driven by being a large area and high distinctiveness score, even though the condition is moderate (this is classified as bare peat but it is categorised as favourable recovering as a unit in the SSSI condition assessment, which is an issue with using such data for these purposes). It is important, when interpreting the map, to note that the habitat units have been assigned to polygons, rather than discrete habitat areas or sites. If a habitat, or site, consists of numerous polygons in the basemap, the biodiversity scores may be low because the area of the polygons is small. To reflect the unit value of the habitat or reserve, the units will have to be summed over the polygons that make up the habitat or site. Overall, the habitats of South Yorkshire has a total of 517,734 biodiversity units[*].

The biodiversity baseline score in and of itself is not particularly informative. The power of this score lies in its comparison with past or future scenarios. If re-calculated after condition assessment updates, for example, following changes in management of certain habitats or after development, it will indicate whether these changes have increased (a net gain) or decreased biodiversity across the county. A way of increasing the biodiversity score is to focus on increasing the condition of the habitats that are in poor or moderate condition (we suggest this is an important part of any Local Nature Recovery Strategy, and have supplied this as a layer to inform the designation of a nature recovery network Section 9). This is particularly relevant where there are sites of conservation interest that fall below good condition, the blanket and raised bog areas (that would deliver much needed reductions in carbon emissions), enhanced management of woodland (see Biodiversity Metric 2.0 guidance[13] for what constitutes a woodland in good condition), maintaining hedgerows and field margins in agricultural areas, or indeed through creating new

[*] Note that the unit score will be higher, but there were habitats we were not classify see v. p21. The total unit value can be recalculated when condition data is available for these areas.

[13] Croshner, I.,Gold, S., Heaver, M., Heydon, M., Moore, L., Panks, S., Scott, S., Stone, D & White, N. (2019) The Biodiversity Metric 2.0: Auditing and accounting for biodiversity value: technical supplement (Beta version, July 2019). Natural England. P39

habitats of high distinctiveness where the ecological opportunities lie, e.g. within the nature recovery network (see Section 9 for further discussion), and as part of ELMs.

There are a number of caveats associated with this approach. The condition scores translated from assessments not set up to specifically assess habitat condition as outlined in the Biodiversity Metric 2.0 guidance, will be prone to error. These other assessments are usually applied to sites that contain a mix of habitats, and applying one condition score across all of these does not pick up variation in condition across habitats at a site. For example, it is possible that woodland within a local wildlife site is of moderate condition but the grassland habitats there are in poor condition. Despite these caveats this approach has delivered reasonable estimates of condition for a large proportion of South Yorkshire. It is certainly a good first attempt at setting a baseline for condition and biodiversity units that can give an indication of what can be improved and where. It can now be ground-truthed and added to as data is collected in the future. We outline an approach to ground-truthing the condition estimates in Section 13.

4. Modelling and mapping ecosystem services (physical flows)

Once a detailed habitat basemap had been created for South Yorkshire, it was then possible to quantify and map the benefits that these habitats (natural capital) provide to people. The following benefits (ecosystem services) have been assessed for this project:

- Carbon storage and sequestration
- Air purification
- Noise regulation
- Local climate regulation
- Water flow regulation
- Water quality regulation
- Agricultural production
- Timber production
- Accessible nature
- Recreation

The list of services assessed was considered to capture all of the most important services provided by the natural capital assets of South Yorkshire. A variety of methods were used, and these are described for each individual ecosystem service in the sections below. In most cases (except carbon storage and recreation), the models were applied at a 5m by 5m resolution to provide fine-scale mapping across the area. The models are based on the detailed habitat information determined in the basemap, together with a variety of other external data sets (e.g. digital terrain model, UK census data 2011, open space data, and many other data sets and models mentioned in the methods for each ecosystem service). Note, however, that many of the models are indicative (showing that certain areas have higher capacity or demand than other areas) and are not process-based mathematical models (e.g. hydrological models). In all cases the capacity and demand for an ecosystem service is mapped relative to the values present within the study area.

For every ecosystem service listed, the capacity of the natural environment to deliver that service – or the current supply – was mapped. For air purification and local climate regulation it was also possible to map the local demand (the beneficiaries) for these services. Mapping demand is not possible for the other services as there is no obvious method to apply, or local demand is not relevant, such as food or timber production.

4.1 Carbon storage

What is it and why is it important?

Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation. Carbon storage and sequestration is seen as increasingly important as we move towards a low-carbon future. The importance of managing land as a carbon store has been recognised by the UK Government, and land use has a major role to play in national carbon accounting. Changing land use from one type to another can lead to major changes in carbon storage, as can restoration of degraded habitats. Note that carbon storage measures the stock of carbon in the natural environment, whereas carbon sequestration (Section 4.2) measures its annual flow.

How is it measured?

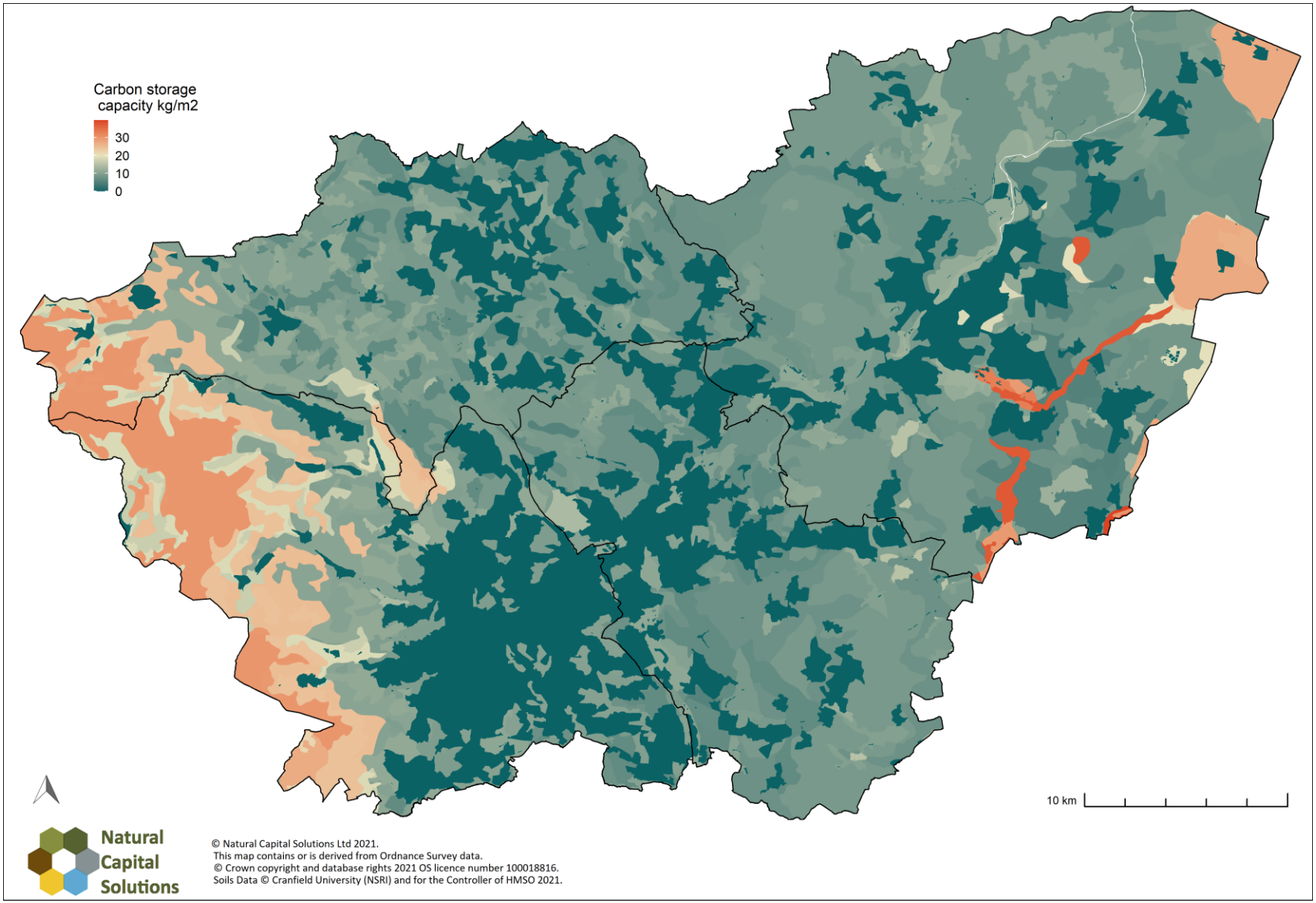
Instead of modelling carbon storage, NATMAP Carbon was used. It summarises the stock of carbon in soils and is derived from the National Soil Map of England and Wales, from the National Soil Resources Institute at Cranfield University. These maps are based on soil series data that have field and laboratory measurements of physical and chemical properties associated with them. The carbon data for each soil type is then linked to CORINE land cover data, so the carbon storage is not modelled from the South Yorkshire natural capital asset basemap produced in Section 2, as is the case with the other services below. The carbon store data is provided in three layer depths, 0-30cm, 30-100cm and 100-150cm. The map produced here uses data from the top 30 cm of soil.

In all the ecosystem services maps that follow, the highest amounts of service provision and demand (hotspots) are shown in red, with a gradient of colour to blue, which shows the lowest amounts (coldspots).

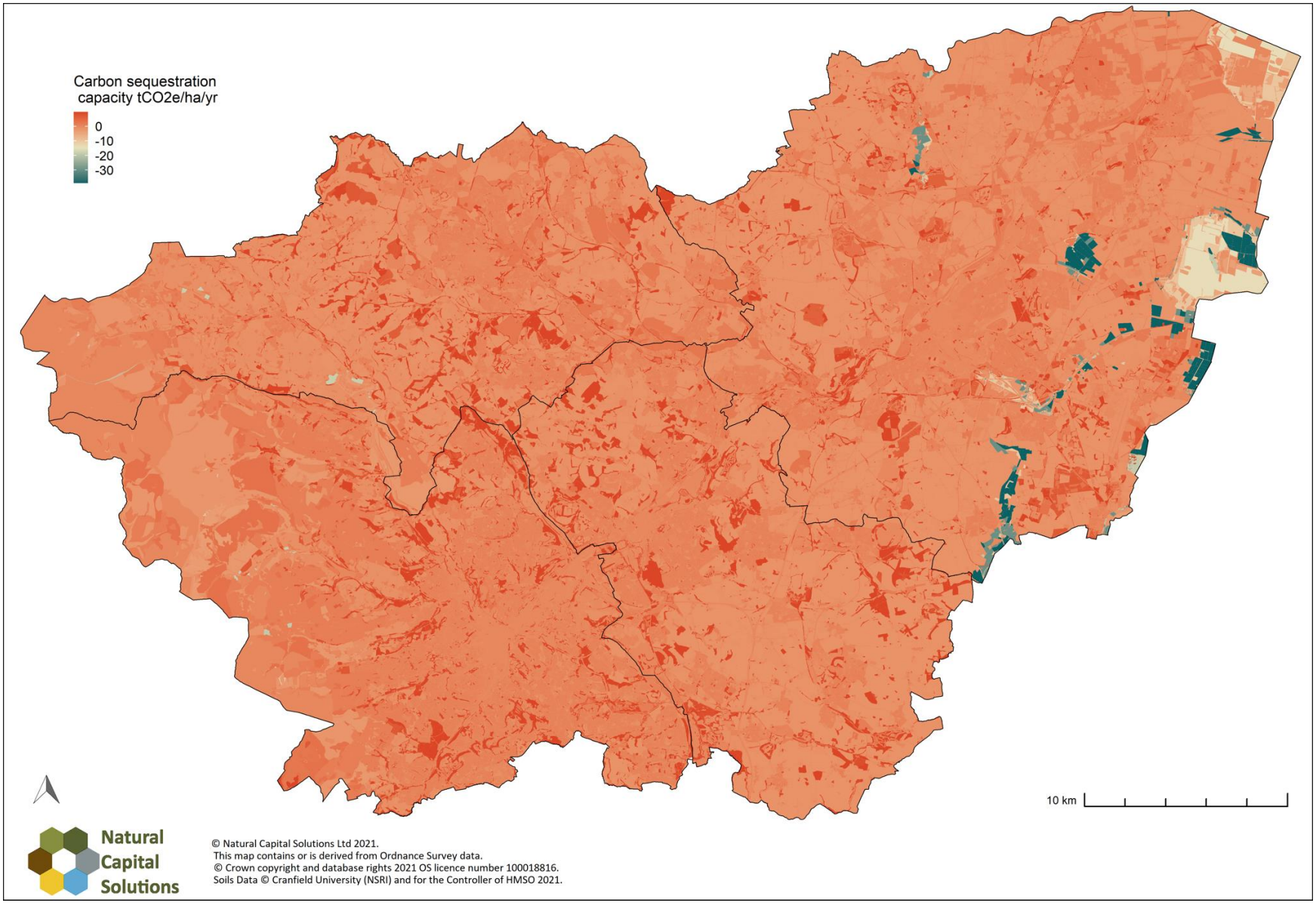
Results for the South Yorkshire

Map 6 shows the baseline average carbon storage across South Yorkshire. The storage is at its lowest in the urban areas (dark blue). Most of the county has values of between 10-20 kg/m^2, these are largely areas dominated by agricultural land practices. There are pockets within this where the carbon storage is around 20 kg/m^2. The east of South Yorkshire on the raised bogs of Thorne and Hatfield Moors show high average carbon storage values (around 30 kg/m^2), and higher still values in a seam of fen peat soil to the south of these moors (up to 40 kg/m^2). High average carbon storage values also occur in the west of South Yorkshire in the upland moorlands with values of up to 35 kg/m^2 in the bog and heather habitats on the tops of the moors.

Map 6 Carbon storage (average kg/m^2 of carbon in the top 30 cm of soil) capacity across South Yorkshire.



Map 7 Carbon sequestration capacity across South Yorkshire in tonnes of carbon equivalent per ha per year.



4.2 Carbon sequestration

What is it and why is it important?

Carbon is sequestered (captured) by growing plants. Plants that are harvested annually (e.g. arable crops, improved grassland) will be approximately carbon neutral over the course of a year as the sequestered carbon is immediately released. However, there are emissions associated with the management of the agricultural land (e.g. machinery and fertiliser application) that are included here. Sequestration rates also depend on the soil type on which the habitat lies. Many habitats on peat soils emit greenhouse gases. There is very little consistent information about sequestration across all habitats (apart from woodlands on mineral soils), but what we do have shows that sequestration rates can be quite low.

How is it measured?

This model estimates the amount of carbon sequestered by each habitat type. It applies average values (tco_2e/ha/year) for each habitat type taken from Natural England (2019)[14] and the RSPB's Accounting for Nature report[15], with more detailed data on GHG flux from land covers on deep and shallow peat soils and from degraded peat bogs from Evans et al. (2017)[16] and Gregg et al. (2021)[17]. We used data on peat from Natural England to locate areas of shallow and deep peat within South Yorkshire, so we were able to estimate carbon sequestration more accurately.

It is worth noting that along with arable, improved grasslands, and woodlands on deep and shallow peat, freshwater lakes and reservoirs are currently thought to emit greenhouse gases. This service was calculated for each habitat polygon and is presented as tonnes of carbon equivalent per hectare per year (tco_2/ha/yr).

Results for South Yorkshire

The baseline carbon sequestration map (Map 7 above) shows that the greatest areas of carbon sequestration (in dark red) to be from the woodland areas across South Yorkshire. Semi-natural habitats across the region will sequester carbon but at a lower level than the woodland (dark orange). However, much of the area is actually emitting carbon (light orange to brown). This is due to the dominance of agricultural land and the GHG emissions associated with the management practices (emissions on intensive improved grassland 1.2 and arable 1.5 tco_2e/ha/year on mineral soils), but also includes bog habitats in the western moorlands that are not in good condition. Some areas with slightly higher emissions (light brown) occur on Thorne and Hatfield Moors in the east, this is due to having areas of degraded bog and bare peat. The highest emissions (dark blue) are in Doncaster in the east of the county, where land managed for agriculture coincides with deep peat soils. As we did not have any data from which we could infer peat condition for much of the blanket bog on the western moorland, it is possible that emissions are actually slightly higher here. A good condition sphagnum blanket or raised bog will emit carbon very slightly at a rate of 0.1 tco_2e/ha/year, with much higher rates for wet modified, dry modified bogs and bare peat (0.81, 3.4, 13.84 tco_2e/ha/year respectively).

[14] Sunderland T, Waters RD, Marsh DVK, Hudson C, Lusardi J. (2019) Accounting for National Nature Reserves: A natural capital account of the National Nature Reserves managed by Natural England. Natural England Research Report, Number 078.
[15] The RSPB. (2017) Accounting for Nature: A Natural Capital Account of the RSPB's area in England. Annex 7.
[16] Evans, C., Artz, R., Moxley, J., Smyth, M-A., Taylor, E., Archer, N., Burden, A., Williamson, J., Donnelly, D., Thomson, A., Buys, G., Malcolm, H., Wilson, D., Renou-Wilson, F. (2017). Implementation of an emission inventory for UK peatlands. Report to the Department for Business, Energy and Industrial Strategy, Centre for Ecology and Hydrology, Bangor.88pp.
[17] Gregg, R. Elias, J.L., Alonso, I., Crosher, I.E., Muto, P. and Morecroft, M.D. (2021) Carbon storage and sequestration by habitat: a review of the evidence (second edition) Natural England Research Report NERR094. Natural England, York.

A report[18] aiming to understand the natural capital potential of Hatfield Moors in Doncaster, and the impact of the recent wildfire there, has been completed at the time of writing this report. The results of this report should be used when aiming to understand the site-specific carbon storage and sequestration values for Hatfield Moor, as they are based on site measurements and a detailed carbon model for estimating GHG flux from managed peatlands. The data used here to demonstrate average carbon storage across the whole of South Yorkshire is based on averages of carbon content of different soil types. The sequestration rates are derived from the annual GHG emissions per ha for UK peatlands. These measures are necessarily more general and should be seen as indicative. They should be replaced by scientifically robust site scale study data if they become available. It is important to note that there is potential to increase carbon storage on agricultural land in the future through more sustainable soil management and reducing agricultural GHG emissions. The peat bogs in the region can also expand their carbon storage by restoring the bog habitat and reducing the potential for emitting greenhouse gases.

[18] Worrall, F. (2021) Understanding the natural capital potential of Hatfield Moors – the impact of the recent wildfire.

4.3 Air purification capacity (air quality regulation)

What is it and why is it important?

According to the World Health Organisation, air pollution is the greatest environmental health risk in Western Europe and globally. In the UK alone, it is estimated to have an effect equivalent to 29,000 deaths each year and is expected to reduce the life expectancy of everyone in the UK by six months on average, at the cost of around £16 billion per year (Defra 2016[19]). Air pollution also contributes to climate change, reduces crop yields, and damages biodiversity.

Air purification capacity estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Vegetation can be effective at mitigating the effects of air pollution, primarily by intercepting airborne particulates (especially PM_{10} and $PM_{2.5}$) but also by absorbing ozone, SO_2 and NO_X. Trees provide more effective mitigation than grass or low-lying vegetation, although this varies depending on the species of plant. Coniferous trees are generally more effective than broadleaved trees due to the higher surface area of needles and because the needles are not shed during the winter.

How is it measured?

Air purification capacity was mapped using a modified version of an EcoServR model. The model assigns a score to each habitat type, representing the relative capacity of each habitat to ameliorate air pollution. The cumulative score in a 20m and 100m radius around every 10m by 10m pixel was then calculated and combined. The benefits of pollution reduction by trees and greenspace may continue for a distance beyond the greenspace boundary itself, with evidence that green area density within 100m can have a significant effect on air quality. Therefore, the model extends the effects of greenspace over the adjacent area, with the maximum distance of benefits set at 100m. Note that the model does not take into account seasonal differences or differences in effect due to the prevailing wind direction.

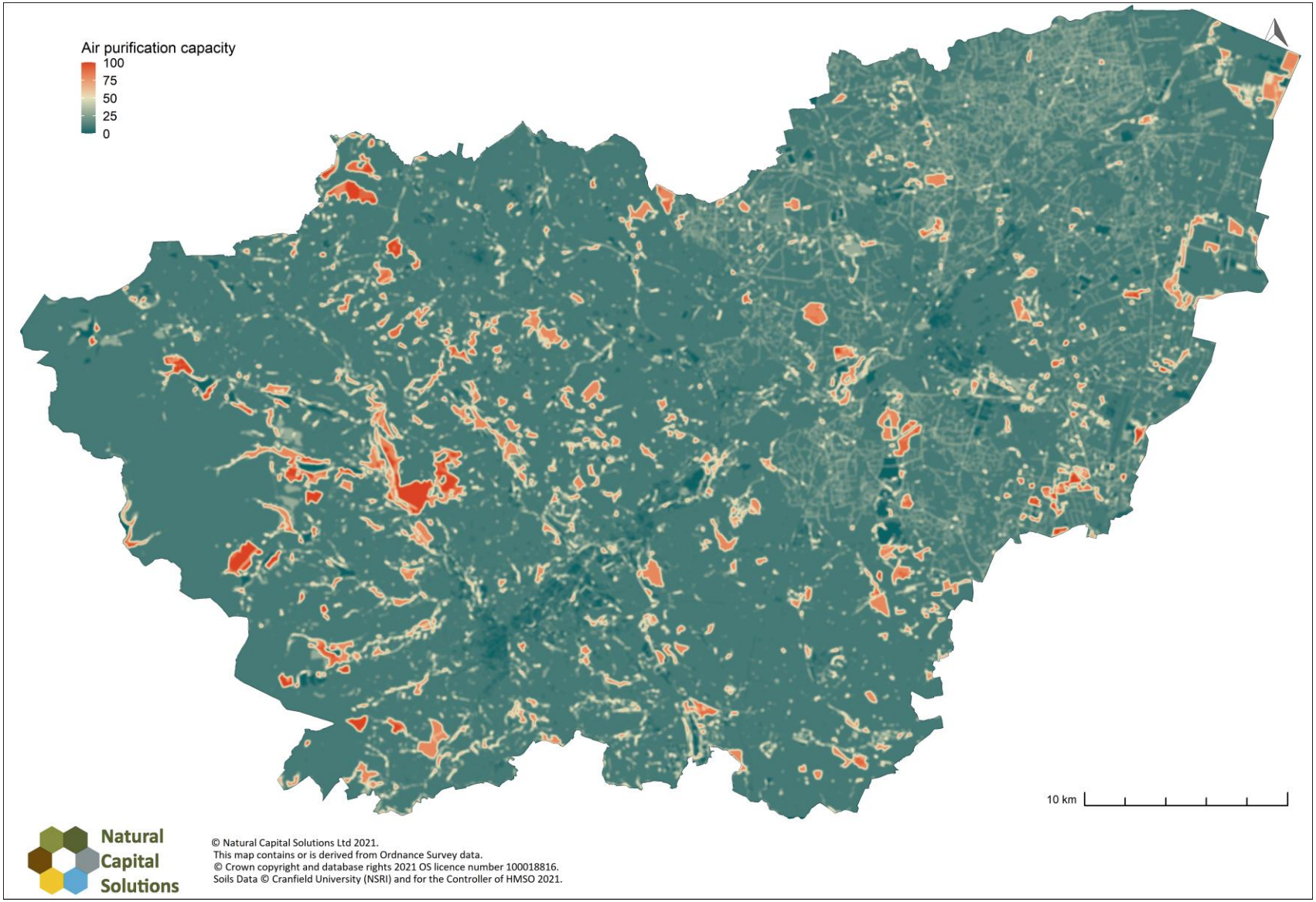
The final capacity score was calculated for every 10m by 10m cell across the study area and was scaled on a 0 to 100 scale relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to trap airborne pollutants and ameliorate air pollution.

Results for South Yorkshire

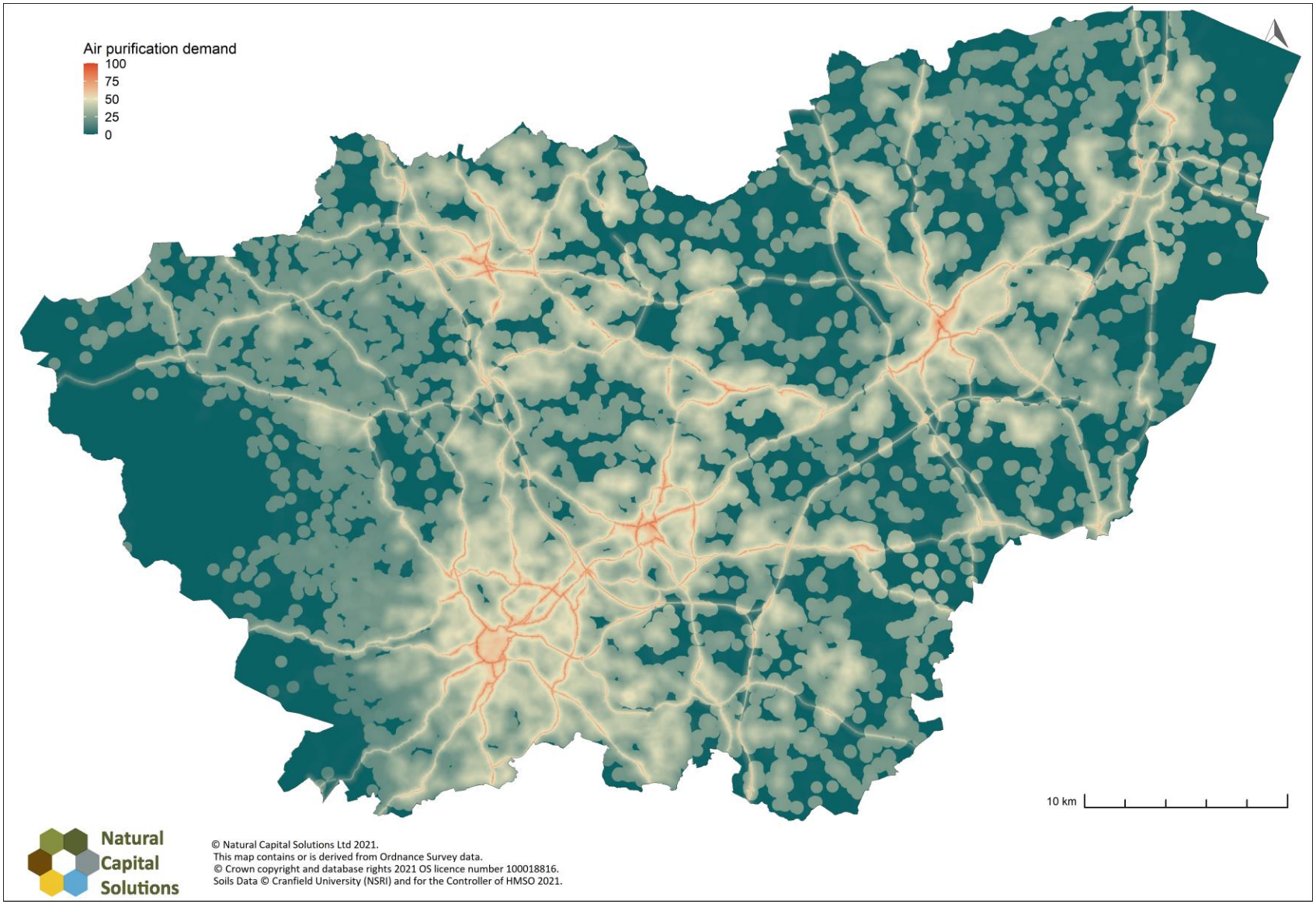
Woodland is by far the best habitat at intercepting and absorbing air pollution, with the very highest scores from the woodland within South Yorkshire (Map 8 below in red), with pockets of the highest air purification capacity in the coniferous woodland in west and north-west and south-west of the region. Broadleaved and mixed woodland provide a high level of this service in blocks throughout the county. Hedges also play an important role, and can be seen in the east of the region in Doncaster providing a medium level of provision (in light brown). Grassland and heathland habitats are also playing a role, but this is to a much lesser degree than the woodland and hedges (blue areas). The lowest scores (dark blue) are from the man-made sealed surfaces, water features that effectively have zero capacity to ameliorate air pollution.

[19] Defra (2016) Air pollution in the UK 2015. Crown Copyright.

Map 8 Air purification capacity across South Yorkshire.



Map 9 Air purification demand across South Yorkshire.



4.4 Air purification demand

What is it and why is it important?

Air purification demand estimates the societal and environmental need for ecosystems that can absorb and ameliorate air pollution. Demand is assumed to be highest in areas where there are likely to be high air pollution levels and where there are lots of people who could benefit from the air purification service.

How is it measured?

Air purification demand was mapped using a model from EcoServR. The model combines two indicators of air pollution sources (log distance to roads and % cover of sealed surfaces) and two indicators of the societal need for air purification (population density and Index of Multiple Deprivation health score).

The scores for each indicator were normalised and combined with equal weighting. The final score was then projected on a 0 to 100 scale relative to values present within the study area. High values (red) denote areas with the greatest demand for air purification as a service.

Results for South Yorkshire

Air purification demand is highest in the urban centres as these have both higher air pollution levels and higher populations that would benefit from better air quality. The main road networks are a major pollution source and where these main roads pass through built-up areas, there is increased demand for air purification. It is possible to see high demand for this service (Map 9 above) on A-roads leading into the main urban centres of Sheffield, Barnsley, Rotherham and Doncaster, the roads that link these centres and the motorways that run through the region, e.g. the M1, M18 and the A1(M) (red and brown areas). There is a noticeable cluster of high demand in the south of the region where Sheffield and Rotherham lie in close proximity and the road network is more dense.

The demand model used here, as outlined above, is based on air pollution sources from roads and sealed surfaces. For this reason, Doncaster Sheffield airport in the south-east of Doncaster, is not appearing as an area of high demand. Aviation emissions (gases e.g. NO_2 and fine particulate matter) are found in and around airport locations, so airports will in reality be an area of high demand for the air purification service.

Balancing supply and demand for air purification services

Air pollution will be a problem in most of the urban centres in South Yorkshire. Given the size and density of the city of Sheffield, it is likely to be of particular significance. Comparing the capacity and demand maps (Maps 8 & 9) it is clear that there is a spatial disparity in the provision of this service and the demand for it. Woodland and hedgerow habitats, the most efficient at trapping pollutants, are largely concentrated outside of the urban centres. There will be street trees in the urban centres, and we were not able to incorporate data on these into the basemap, and consequently the model. These will be important providers of this service where they are located in areas with high pollution levels, for example, by busy roads. However, we do not know to what extent this is the case in the conurbations of South Yorkshire. Comparing the supply and demand of this service is a useful reminder that trees do play an important role providing this service, and that it is very much required in the urban areas within South Yorkshire. Local authorities need to consider whether their urban tree stock, as well as their hedgerows, are positioned to provide this service effectively, and consider expanding these habitats close to main roads where people live. Air pollution can be very localised; hence, it is important to consider the specific location of trees to gain the maximum benefit of this service.

Trees are very effective at mitigating the effects of air pollution. However, there are major differences in the ability of different species to intercept pollution. The location of trees relative to pollution sources also determines how effective they are at removing pollutants, with trees close to sources being the most effective.

4.5 Noise regulation capacity

What is it and why is it important?

Noise regulation capacity is the capacity of the land to diffuse and absorb noise pollution. Noise can impact health, wellbeing, productivity and the natural environment. Consequently, the World Health Organisation (WHO) has identified environmental noise as the second-largest environmental health risk in Western Europe (after air pollution). It is estimated that the annual social cost of urban road noise in England is £7 to £10 billion (Defra 2013[20]). Major roads, railways, airports and industrial areas can be sources of considerable noise, but the use of vegetation can screen and reduce the effects on surrounding neighbourhoods. Complex vegetation cover, such as woodland, trees and scrub, is considered to be most effective. However, any vegetation cover is more effective than artificial sealed surfaces, and the effectiveness of vegetation increases with width.

How is it measured?

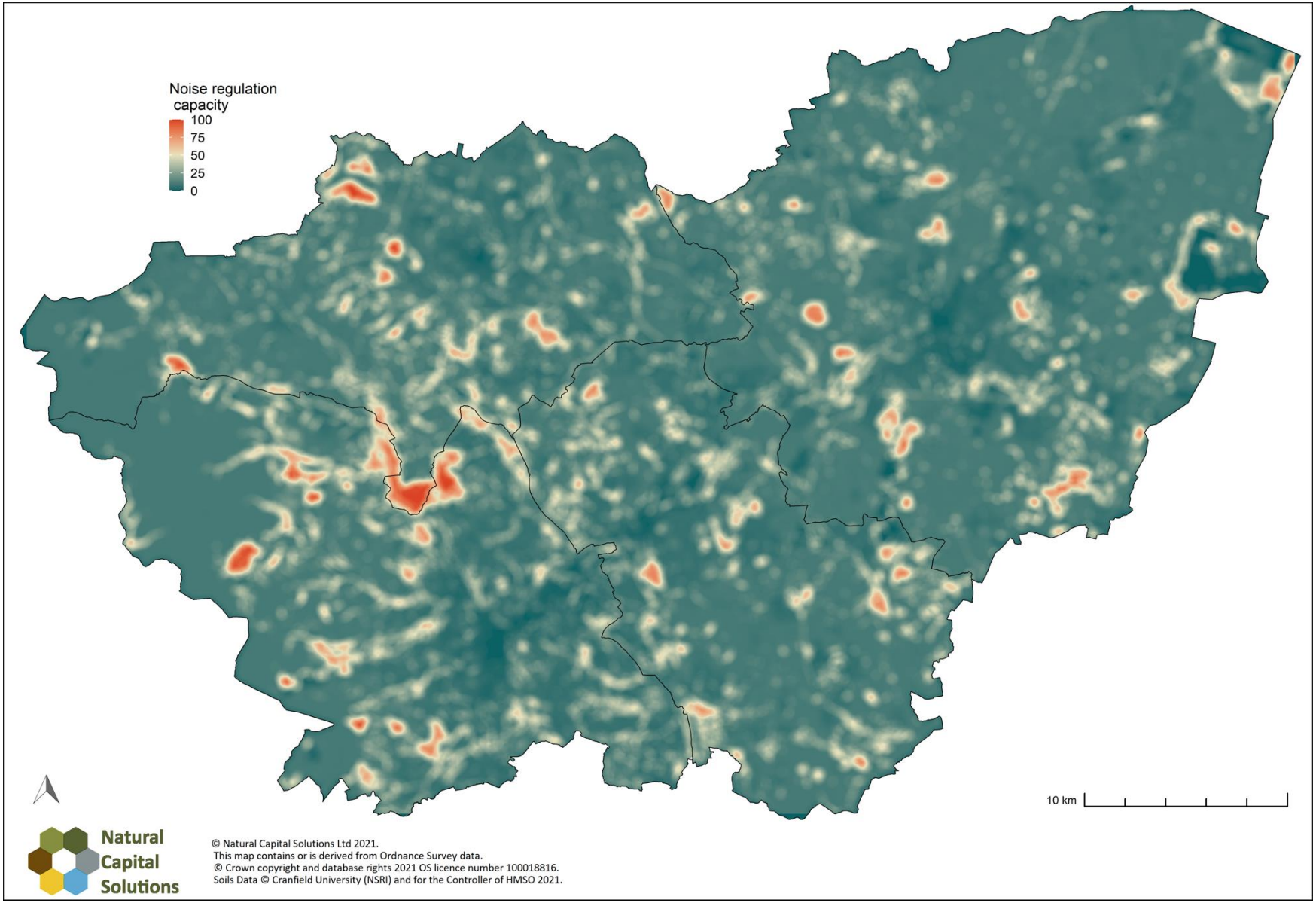
The EcoServR noise regulation model was used, with some modifications. First, the capacity of the natural environment was mapped by assigning a noise regulation score to vegetation types based on height, density, permeability and year-round cover. Next, the noise absorption score in 30m and 100m radii around each point was modelled and the scores combined, which results in wider belts of vegetation receiving a higher score. The score was calculated for every 10 m by 10m cell across the study area and is scaled on a 0 to 100 scale, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to absorb noise pollution.

Results for South Yorkshire

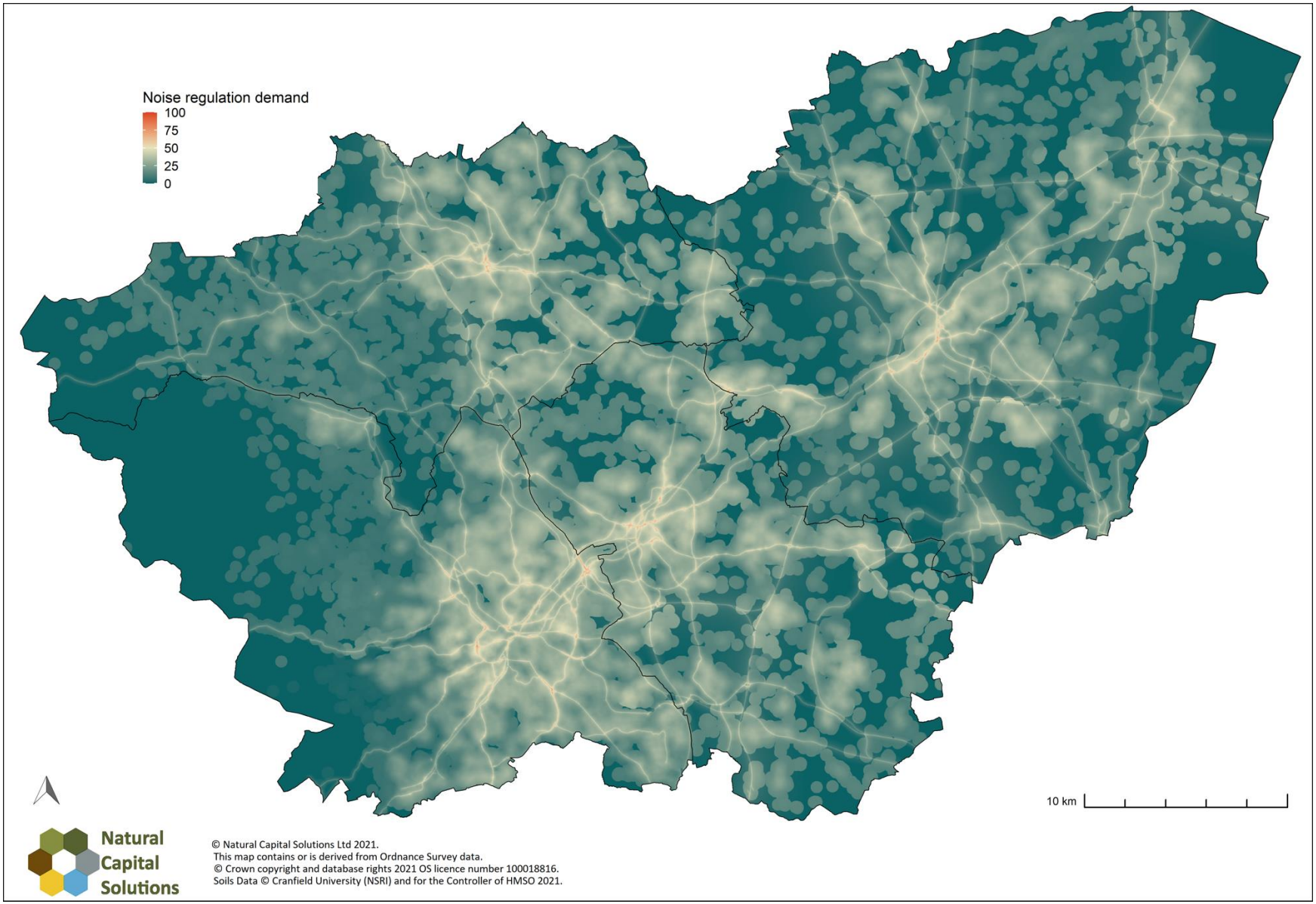
The woodland in South Yorkshire is by far the most effective habitat at absorbing noise (Map 10 below). The larger wider blocks of woodland have the highest provision of this service, for example the larger blocks of conifer plantation and broadleaved woodland to the west and south-west of Sheffield and north of Barnsley, and the blocks of broadleaved and mixed woodland in the south-east of Doncaster. However, the effects can be modest, with reductions of 2-4 dB typically recorded across dense tree belts.

[20] Defra (2013) Noise pollution: economic analysis. Crown Copyright.

Map 10 Noise regulation capacity across South Yorkshire.



Map 11 Noise regulation demand across South Yorkshire.



4.6 Noise regulation demand

What is it and why is it important?

Noise regulation demand estimates societal and environmental need for ecosystems that can absorb and reflect anthropogenic noise.

How is it measured?

Noise regulation demand was mapped using a modified version on an EcoServR model. The model combines one indicator that maps noise sources (inverse log distance to different road classes and railways, custom built for the study area based on Defra noise modelling) and two indicators of societal demand for noise abatement (population density, and Index of Multiple Deprivation health scores).

Scores are on a 1 to 100 scale, relative to values present within the study area. High values (red) indicate areas that have the highest demand for noise regulation as a service.

Results for South Yorkshire

Demand for noise regulation (Map 11 above) is greatest in urban areas close to major roads, as these contain large populations, with potentially poor health, that would benefit from noise abatement from the main roads. There are no areas of very high demand, most of the demand is modest and lies within the urban centres of South Yorkshire.

Balancing supply and demand for noise regulation services

The maps show some spatial disparity between capacity and demand for this service (Maps 10 and 11). Some capacity is located on the edges of the urban centres where there is demand for noise regulation, although this supply is patchy. High capacity in rural South Yorkshire is less useful. Demand is clustered around the denser urban areas, as well as roads and railways, so woodland and trees within the urban centres would be most effective. Planting trees close to main roads and other noise sources would provide the best mitigation. As mentioned in Section 4.4, there will be street trees in the urban centres that we were not able to incorporate into the natural capital asset basemap, and consequently the model, that will play this role. These may be important providers of this service in the most densely urban areas, however, positioning of trees in urban areas is key.

Studies in many countries have shown that densely planted tree belts can reduce noise levels, but the effects are modest, with reductions of 2-4 dB typically recorded. Note however, that there is some evidence to suggest that the presence of vegetation blocking views of a noise source such as a road can enhance the perception of noise reduction. Densely planted and complex vegetation cover such as trees mixed with scrub is considered to be most effective, although any vegetation cover is more effective than artificial sealed surfaces.

4.7 Local climate regulation capacity

What is it and why is it important?

Land use can have a significant effect on local temperatures. Urban areas tend to be warmer than surrounding rural land due to a process known as the "urban heat island effect". This is caused by urban hard surfaces absorbing more heat, which is then released back into the environment, coupled with the energy released by human activity such as lighting, heating, vehicles and industry. Climate change impacts are predicted to make the overheating of urban areas and urban buildings a major environmental, health and economic issue over the coming years. Natural vegetation, especially trees/woodland and rivers, can have a moderating effect on the local climate, making nearby areas cooler in summer and warmer in winter. Local climate regulation capacity estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima.

How is it measured?

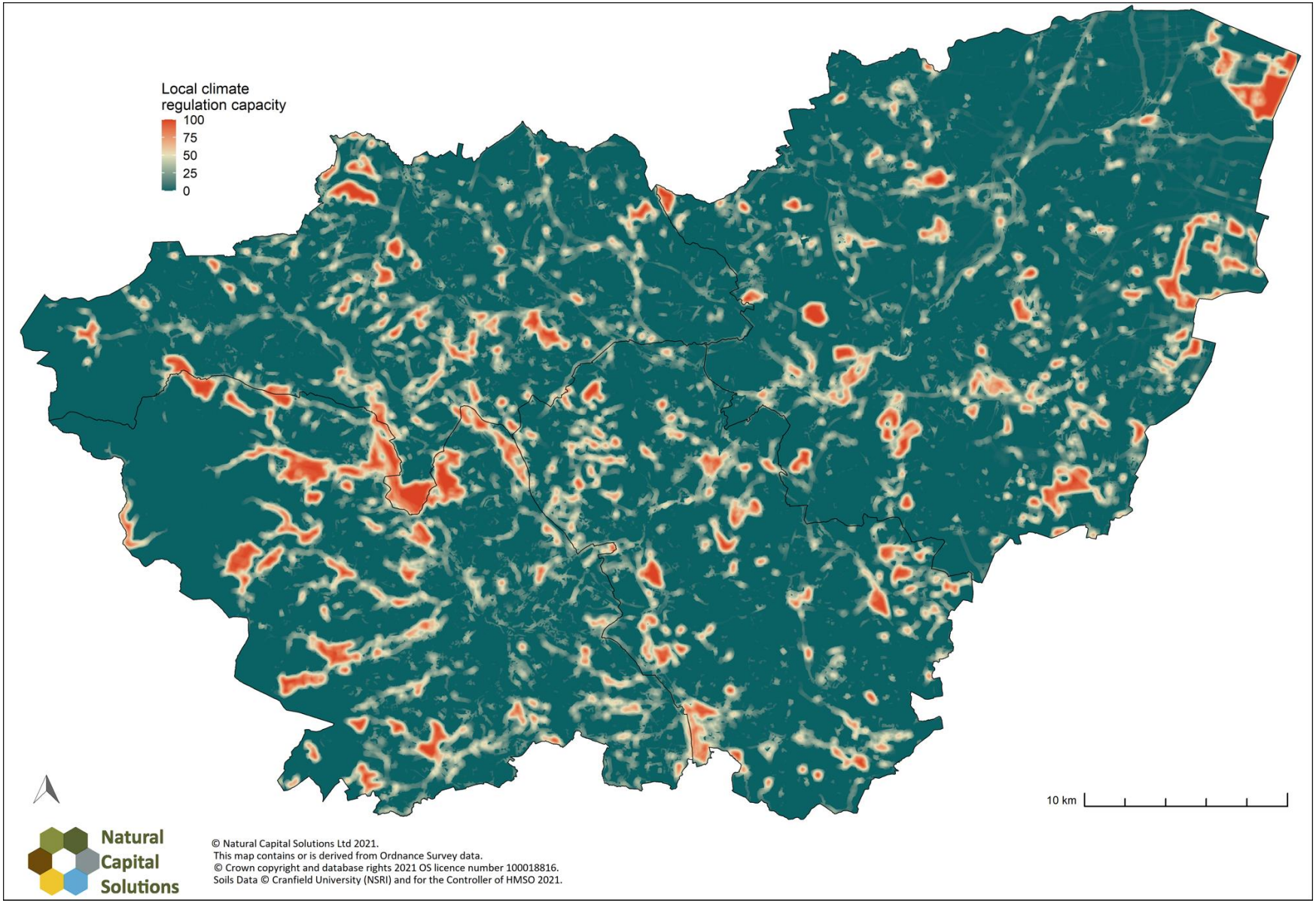
Local climate regulation capacity was mapped using an EcoServR model. The model calculates the proportion of the landscape that is covered by woodland/scrub and water features within a 200m radius around every 10m by 10m cell across the study area. However, temperature-regulating effects of woodland and water will also occur in adjacent areas, with the distance of the effect dependent on the patch size of the natural area. To incorporate this effect, a buffer was applied around each woodland/water patch, with wider buffers modelled around larger natural sites. Note that this model only includes woodland/scrub and water features which provide the most significant effects. All green space is beneficial compared to artificial sealed surfaces, so a future iteration of the model could include all natural surfaces.

The final capacity score was calculated for every 10m by 10m cell across the study area and was scaled from 0 to 100, relative to values present within the mapped area. High values (red) indicate areas that have the highest capacity to regulate temperatures, keeping them cool in the summer and warmer in the winter.

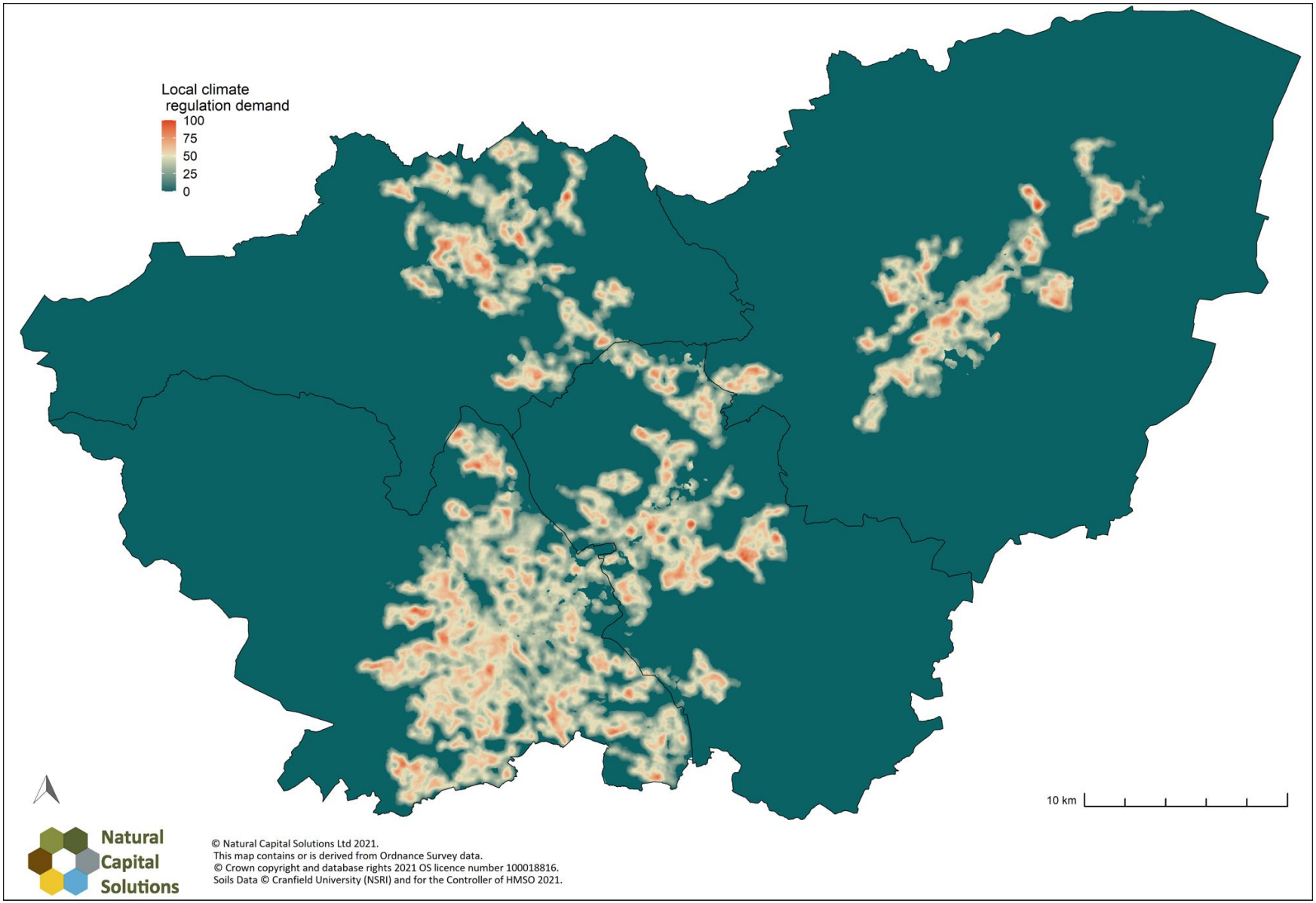
Results for South Yorkshire

The woodland and water bodies deliver the highest provision of the local climate regulation service (red areas in Map 12 below). There are large patches of high provision across South Yorkshire, to the west of Sheffield, and southern, eastern and north-eastern Barnsley where there are numerous patches of woodland and reservoirs. Rotherham and Doncaster also have patches of high provision throughout, which is mainly woodland but also some water bodies. It is possible to see the cooling effect of rivers which show a medium capacity to deliver this service (light brown areas).

Map 12 Local climate regulation capacity across South Yorkshire.



Map 13 Local climate regulation demand across South Yorkshire.



4.8 Local climate regulation demand

What is it and why is it important?

Local climate regulation demand estimates the societal and environmental need for ecosystems that can regulate local temperatures and reduce the effects of the urban heat island.

How is it measured?

Local climate regulation demand was mapped using an adapted version of an EcoServR model. The model combines one indicator showing the location of areas suffering from the urban heat island effect (the proportion of sealed surfaces), with two indicators showing the societal need for local climate abatement (population density and proportion of the population in the highest risk age categories – defined as under ten and over 65).

Scores are on a 0 to 100 scale relative to values present within the study area. High values (red) indicate areas that have the highest demand for local climate regulation as a service.

Results for South Yorkshire

Demand for this service is high in all of the urban centres within South Yorkshire (red areas in Map 13 above). The most extensive area of demand is urban Sheffield and Rotherham in the south of the county, where demand ranges from medium to high. Demand is highest due to the heat island effect in urban areas.

Balancing supply and demand for local climate regulation services

The capacity and demand maps (Maps 12 and 13) for this service show a spatial disparity between the supply and demand for a cooling effect. There is some overlap where there are woodland areas on the urban fringes. But for the most part the water and woodland habitats are outside of the areas of highest demand. As mentioned in Section 4.4 and 4.6, there will be street trees in the urban centres that we were not able to incorporate into the natural capital asset basemap, and consequently the model, that may play a role in local climate regulation. Planting urban trees, incorporating more green spaces and providing urban ponds or water features within the urban centres would help to decrease urban temperatures. The opportunity mapping in Sections 7 and 8 can guide woodland creation to reduce local climate regulation.

Although regulating local climate and moderating the impacts of the urban heat island effect may not be considered to be the highest priority at present, its importance will increase over time due to climate change and an increasing (and ageing) population.

4.9 Water flow regulation

What is it and why is it important?

Water flow capacity is the capacity of the land to slow water runoff and thereby potentially reduce flood risk downstream. Following a number of recent flooding events in the UK and the expectation that these will become more frequent over the coming years due to climate change, there is growing interest in working with natural processes to reduce downstream flood risk. These projects aim to "slow the flow" and retain water in the upper catchments for as long as possible. Maps of water flow capacity can be used to assess relative risk and help identify areas where land use can be changed.

How is it measured?

A bespoke model was developed, building on an existing EcoServR model and incorporating many of the features used in the Environment Agency's catchment runoff models used to identify areas suitable for natural flood management. Runoff was assessed based on the following two factors:

Roughness score – Manning's Roughness Coefficient provides a score for each land use type based on how much the land use will slow overland flow.

Slope score – based on a detailed digital terrain model, slope was re-classified into several classes based on the British Land Capability Classification and others.

Standard % runoff – was obtained from soil data and modified to reflect soil hydrological properties and their sensitivity to structural degradation from agricultural use. This was integrated with a layer showing impermeable areas where no soil was present (sealed surfaces, water and bare ground).

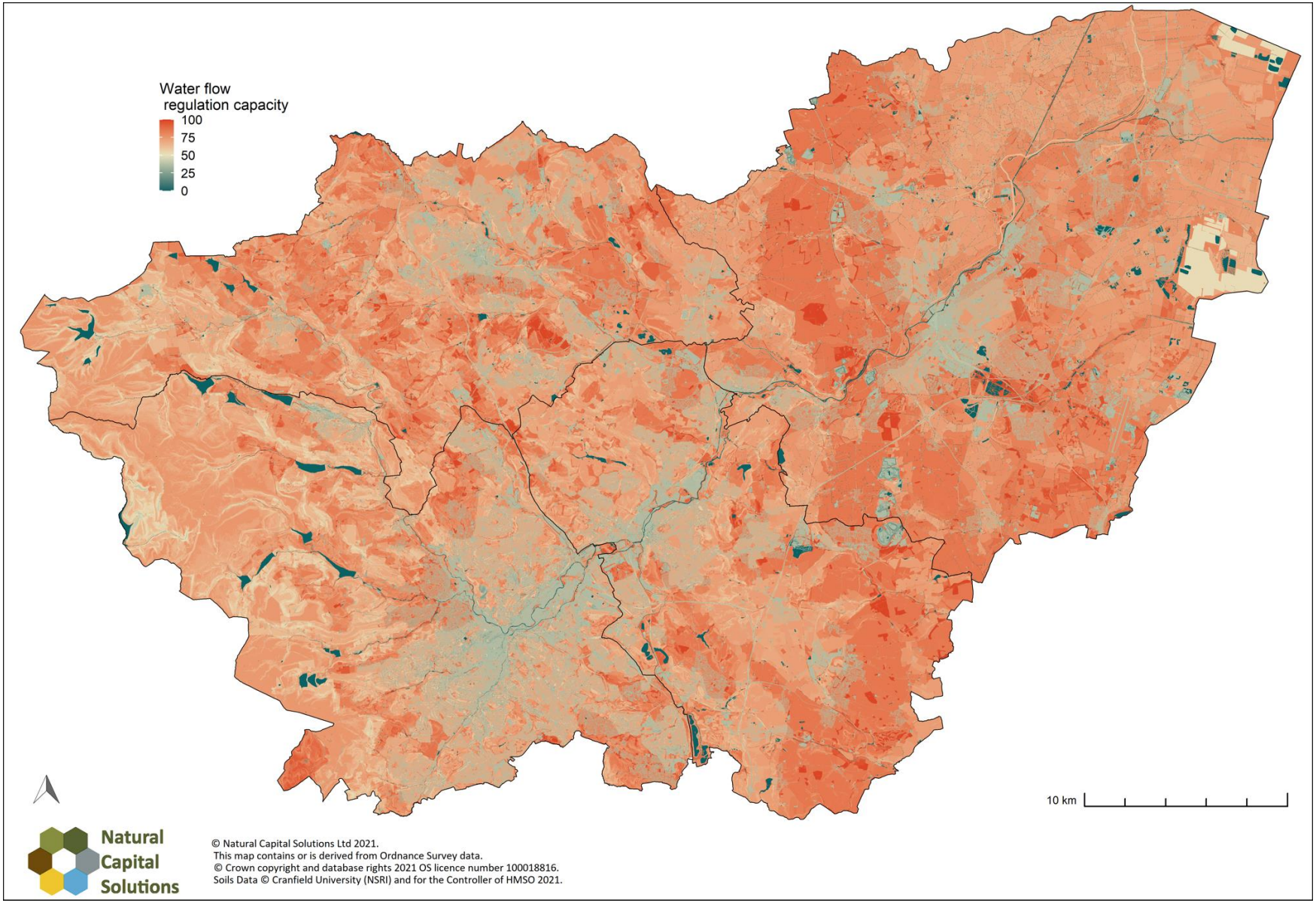
Each indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale, as for the other ecosystem services. Note that this is an indicative map, showing areas that generally have high or low capacity and is not a hydrological model. High values (dark orange and red) indicate areas with the highest capacity to slow water runoff.

Results for South Yorkshire

The best locations for slowing water runoff are areas which have woodland vegetation (providing the highest roughness of any habitat) and be flat. The worst areas are sealed surfaces and slopes. Water flow regulation capacity is highest in the west of Doncaster and the south-east of Rotherham (dark orange and red areas in Map 14 below). Although this area is dominated by arable fields, there are pockets of woodland (which show up in red) and semi-natural grasslands, and it is an area of particularly free draining soil, on relatively flat land. There are areas of high capacity in the west of Sheffield on higher ground, and in east and central Barnsley. This is where pockets of woodland, semi-natural grasslands and heathland lie on permeable soils on gentle slopes. The higher ground in the west of the county has mid to high provision of this service, on steeper slopes with peaty soils which are able to hold water rather than allow it to freely drain. The lowland raised bogs in eastern Doncaster have a medium provision of this service, Hatfield Moor in the south has a lower capacity that Thorne to its north due to the predominance of bare peat at the site. The sealed surfaces in the urban centres have a very low level of this service and water does not provide this service.

It is important to note that while this model does account for different land covers and soil types, it does not incorporate the quality of the land cover, unless the habitat classification reflects this (for example bare peat). Some of the blanket bog in the western upland will be degraded or dry, and there may be some artificial drainage channels present that the OS MasterMap layer does not pick up. Thus, the capacity to provide this service is likely to be lower in these locations than it appears on the map.

Map 14 Water flow regulation across South Yorkshire.



4.10 Water quality capacity

What is it and why is it important?

Water quality capacity maps the risk of surface runoff becoming contaminated with high pollutant and sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. The focus here is on sedimentation risk from diffuse agricultural pollution.

How is it measured?

A modified version of an EcoServR model was developed, which combines a coarse and fine-scale assessment of pollutant risk.

At a coarse scale, catchment land use characteristics were used to determine the overall level of risk. The percentage cover of sealed surfaces and arable farmland in each sub-catchment (EA Waterbody catchment) was calculated, and the values were re-classified into several risk classes. There is a strong link between the percentage cover of these land uses and pollution levels, with water quality being susceptible to the percentage of sealed surfaces in the catchment.

At a fine scale, a modification of the Universal Soil Loss Equation (USLE) was used to determine the rate of soil loss for each cell. This is based on the following three factors:

- **Distance to a watercourse** – using a least-cost distance analysis, taking topography into account.
- **Slope length** – using a flow accumulation grid and equations from the scientific literature. Longer slopes lead to greater amounts of runoff.
- **Land use erosion risk** – certain land uses have a higher susceptibility to erosion, and standard risk factors were applied from the literature. Bare soil is particularly prone to erosion.

Each of the three fine-scale indicators and the catchment-scale indicator was normalised from 0-1, then added together and projected on a 0 to 100 scale. As previously, this is an indicative map, showing areas that generally have high or low capacity and is not a process-based model. High values (red) indicate areas that have the greatest capacity to deliver high water quality (least sedimentation risk).

Results for South Yorkshire

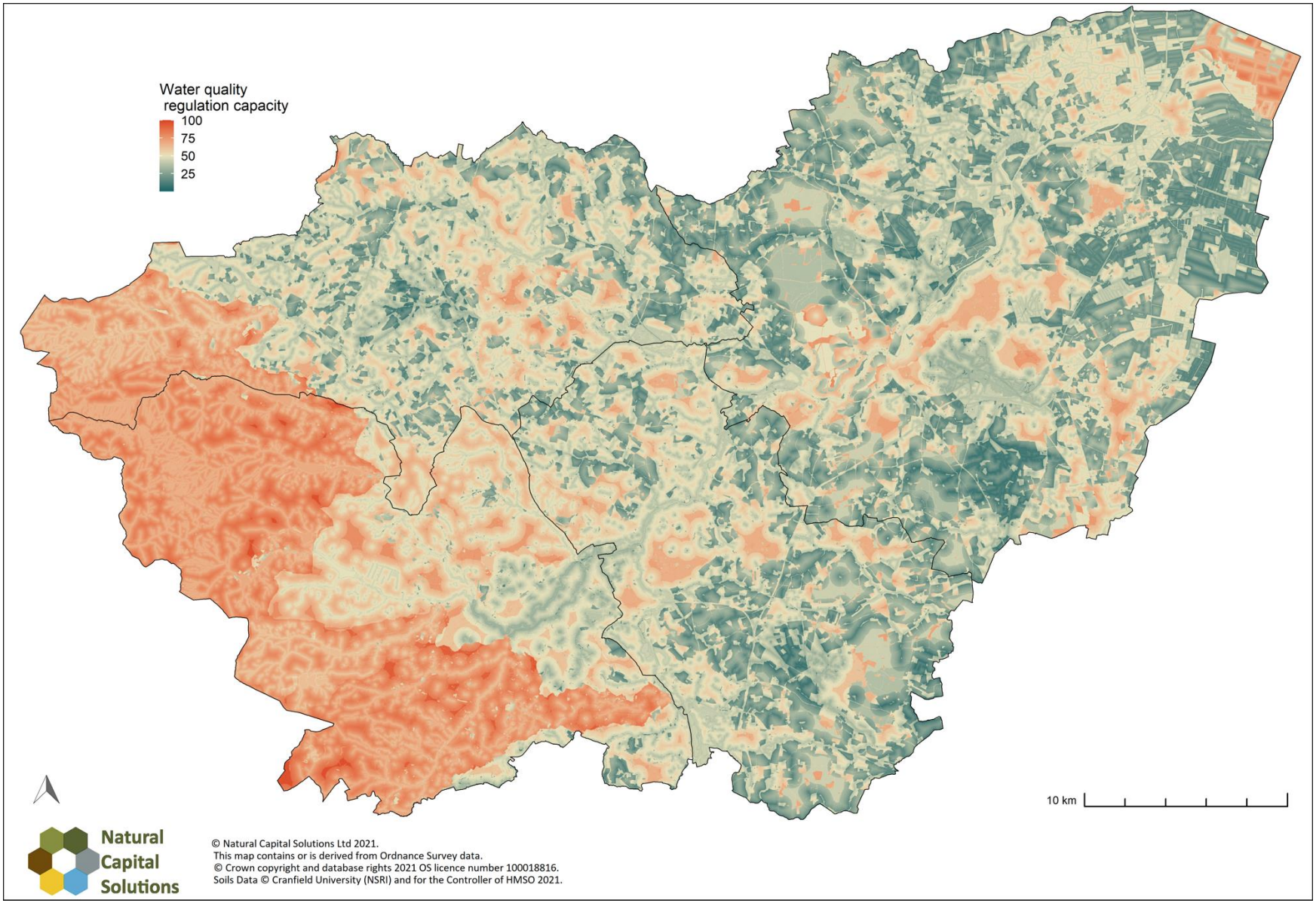
Much of South Yorkshire has a medium to low capacity to deliver the water quality regulation service (light brown and blue areas in Map 15 below). This is due to the dominance of agriculture, particularly arable farming which causes increased erosion. Arable fields are a particular feature across Doncaster where there is also a high density of water courses (see Map 2), so there is a high risk of sedimentation, and thus a lowering of water quality. There are patches of high provision of this service across South Yorkshire, , the highest being woodland or grassland away from water courses (red areas) and built up areas show a medium provision (orange to light brown). Clearly, the largest extent of high provision of this service is along the western edge of the county in the uplands, extending through the south of Sheffield. Here arable farming is largely absent, and there is a mix of semi-natural habitats away from watercourses.

As with the water flow model (Section 4.9), the water quality model does not account for the condition of the land covers/habitats. Particularly in relation to the upland moorlands in the west of the county, the capacity to provide this service may in reality be lower. This is due to the degraded and dry areas of blanket bog where erosion is providing sedimentation, but may also be a consequence of grazing pressure, artificial

drainage and prescribed burning, all of which are thought to increase the rates of erosion[21]. As we clearly outline above this is a model that captures diffuse agricultural pollution rather better than erosion from other forms of land management.

[21] Parry, L.E., Holden, J., Chapman, P.J. (2014) Restoration of blanket peatlands. Journal of Environmental Management, 133: 193-205.

Map 15 Water quality regulation across South Yorkshire.



4.11 Food production capacity

What is it and why is it important?

Food production models the capacity of the land to produce food under current farming practices. Farming is the dominant land-use across South Yorkshire, with arable covering a greater area than grassland for livestock. These land covers provide the largest proportion of food, however, food is produced from a range of other habitats, albeit to a lesser extent. The ability of habitats to provide food, accounting for Agricultural Land Classification, was mapped.

How is it measured?

The methodology followed that outlined in Smith (2020)[22] and was developed for the Eco-metric tool. Broad habitats in Bedfordshire were assigned a score based on their relative ability to provide food:

- Arable, improved grassland – 10
- Orchards, allotments – 7
- Semi-natural and rough grasslands – 6
- Marshy grassland – 4
- Wood pasture and parkland – 3
- Bog/heath, domestic gardens, broadleaved and mixed woodlands - 1

This was mapped in GIS and then the arable, horticulture and improved grassland were weighted by the Agricultural Land Class in which it occurred. The weighting was based on typical dry yield and an additional multiplier for versatility, following Smith (2020):

Grade 1 – 3.03

Grade 2 – 2.40

Grade 3 – 1.33

Grade 4 – 0.67

Grade 5 – 0.50

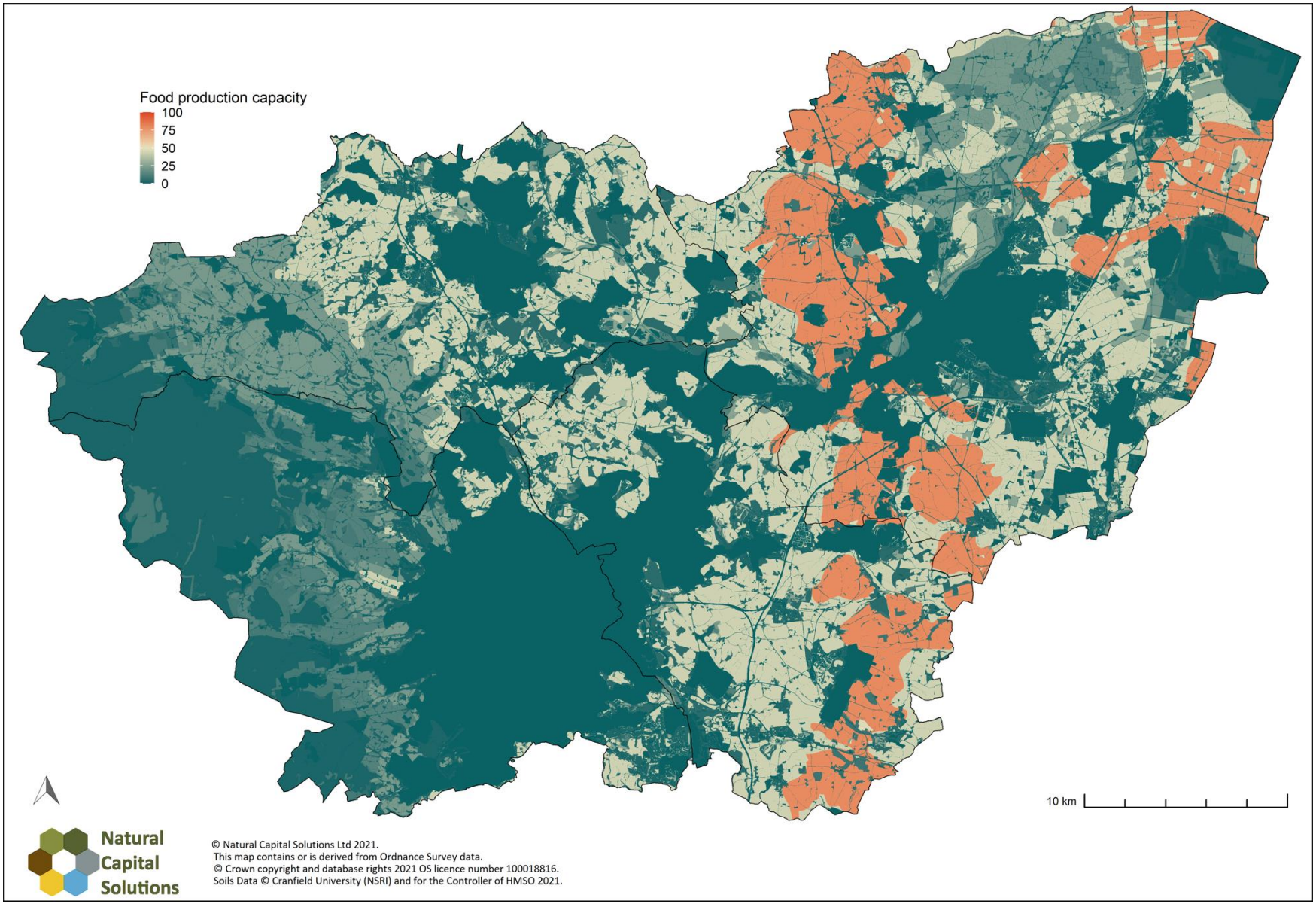
To maintain compatibility with the other ecosystem service maps, the weighted scores were scaled on a 0 to 100 scale relative to values present within the mapped area.

Results for South Yorkshire

Food production capacity is quite variable across South Yorkshire, generally increasing from west to east (Map 16 below). Much of Sheffield and the west of Barnsley has low or no provision of this service (blue). This is due to the agricultural land class being low at 4 or 5. The east of Barnsley has medium production (light brown), with grade 3 land. Rotherham has medium production with higher production in the south-east (red), where the agricultural land class increases to grade 2. Doncaster has a larger area of high production of this service, due to having more grade 2 land.

[22] Smith, A. (2020) Natural Capital in Oxfordshire: Short report. Environmental Change Institute, University of Oxford.

Map 16 Food production capacity across South Yorkshire.



4.12 Timber / woodfuel capacity

What is it and why is it important?

Forestry remains an important component of the rural economy, and many areas of woodland are still valued primarily on their timber value. Timber is an important product of woodlands and is the raw resource of the timber industry. Sustainably managed woodland produces timber that is important in contributing to processing mills and factories that produce wood-based products and also produces wood fuel for the generation of renewable heat and electricity.

How is it measured?

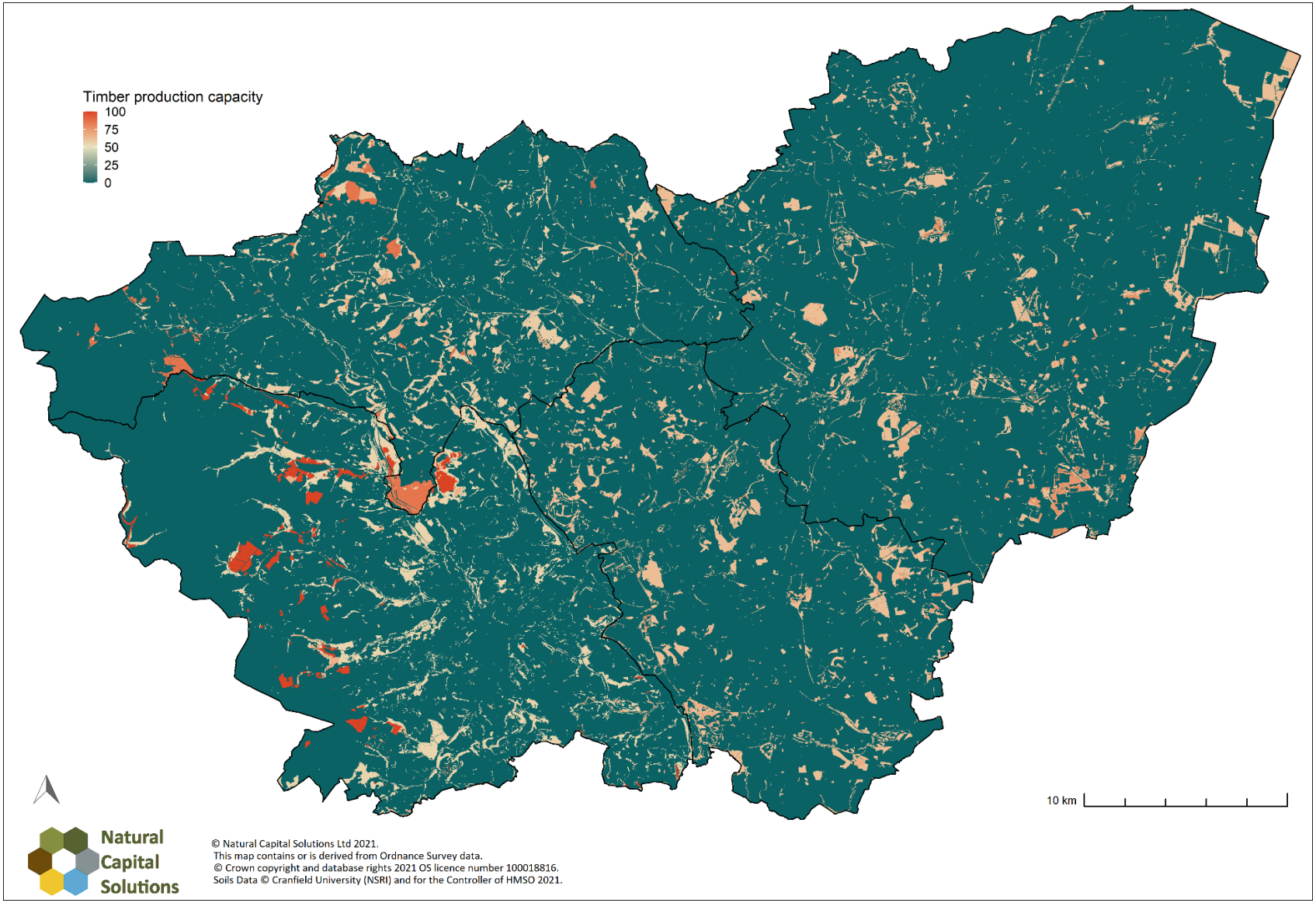
Information on the species mix and yield class was obtained from the Forestry Commission (2002)[23] inventory of woodland and trees. This was used to determine the average yield of timber (m^3) per hectare per year. This was then mapped in GIS and, to maintain compatibility with the other ecosystem service maps, the scores were scaled on a 0 to 100 scale relative to values present within the mapped area.

Results for South Yorkshire

The level of provision of the timber/woodfuel service differs slightly across the woodland areas in South Yorkshire (Map 17 below). The woodlands in Doncaster and Rotherham are mainly just above medium level of provision of the timber service. The highest provision of this service is in the western area of the region, with areas of high provision in some of the coniferous woodlands to the west of Sheffield, for example the conifer plantation adjacent to Bradfield Moor, woodlands around Broomhead Reservoir and parts of Greno Woods. In the south of Barnsley Wharncliffe woods have a high provision of this service.

[23] Forestry Commission (2002) National inventory of woodland and trees. Regional report for Yorkshire and the Humber. Forestry Commission Edinburgh.

Map 17 Timber / woodfuel capacity across South Yorkshire.



4.13 Accessible nature capacity

What is it and why is it important?

The importance of access to greenspace is increasingly recognised due to the multiple benefits that it can provide to people. In particular, there is strong evidence linking access to greenspace to a variety of health and wellbeing measures. Research has also shown that there is a link between wellbeing and perceptions of biodiversity and naturalness. Natural England and others have published guidelines that promote the enhancement of access, naturalness and connectivity of greenspaces.

The two key components of accessible nature capacity are, therefore, public access and perceived naturalness. Both of these components are captured in the model, which maps the availability of natural areas and scores them by their perceived level of "naturalness".

How is it measured?

Accessible nature capacity was mapped using an EcoServR model. In the first step, accessible areas are mapped. These are defined as:

- Areas 10m either side of linear routes such as Public Rights of Way, pavements and Sustrans routes.
- Publicly accessible areas such as country parks, CRoW access land, local nature reserves and accessible woodlands.
- Areas of green infrastructure marked as accessible, including parks, playgrounds, and other amenity greenspaces.

These areas were then scored for their perceived level of naturalness, with scores taken from the scientific literature. Naturalness was scored in a 300m radius around each point, representing the visitors' experience within a short walk of each point.

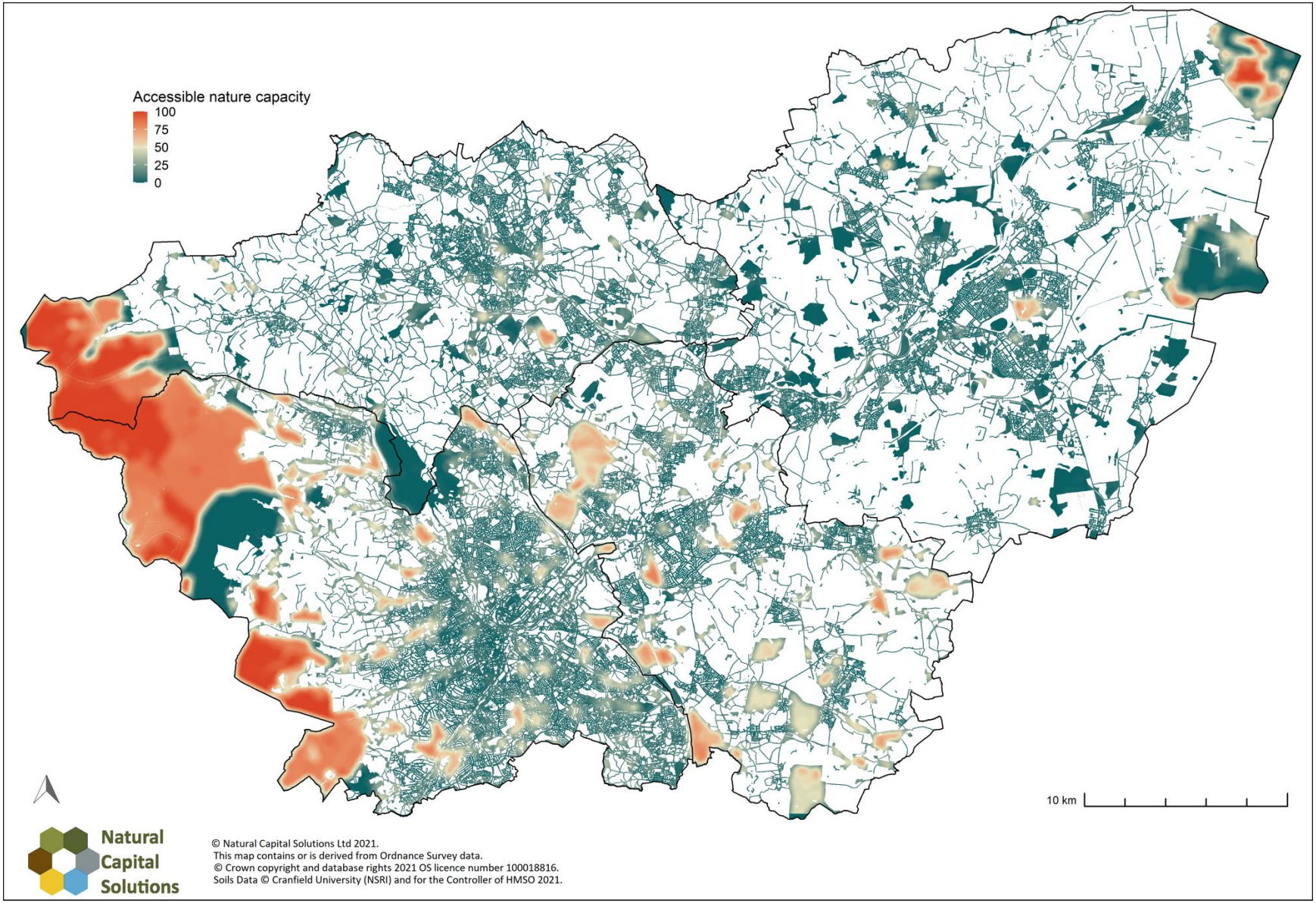
The resulting map shows accessible areas, with high values representing areas where habitats have a higher perceived naturalness score. Scores are on a 1 to 100 scale relative to values present within the study area. White space shows built areas or areas with no public access.

Larger continuous blocks of more natural habitat types will have higher scores than smaller isolated sites of the same habitat type. One consequence is that linear routes, such as footpaths, that pass through the land with no other access will not score highly.

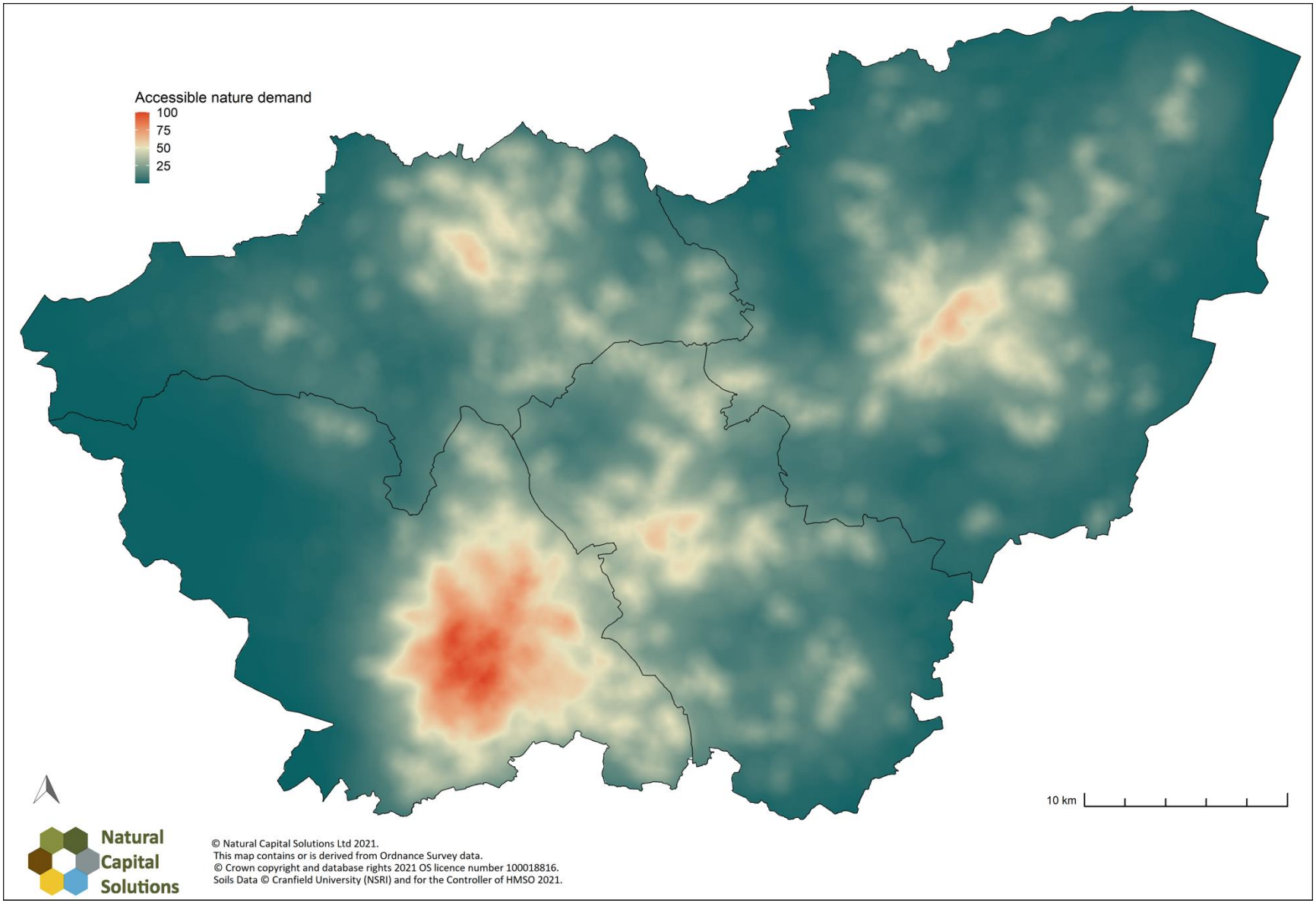
Results for South Yorkshire

The red areas in Map 18 below indicate the highest provision of the accessible nature service. A large area of high provision is the upland moorland of the Peak District National Park, all along the west of the county. There is high provision of the service on Thorne Moors in the east of the region. There are also numerous smaller sites that have a medium to high provision of this service in and around urban Sheffield, and throughout Rotherham, in the south of Barnsley and central and east Doncaster.

Map 18 Accessible nature capacity across South Yorkshire. Areas with zero demand have been excluded to improve map legibility.



Map 19 Accessible nature demand across South Yorkshire.



4.14 Accessible nature demand

What is it and why is it important?

This indicates where there is greatest demand for accessible nature, which is strongly related to where people live. Research, including large surveys such as the Monitor of Engagement with the Natural Environment (MENE), have shown that there is greatest demand for accessible greenspace close to people's homes, especially for sites within walking distance.

How is it measured?

This model maps sources of demand, taking no account of habitat, based on three indicators: population density (based on 2011 census data), health scores (from the Index of Multiple Deprivation), and distance to footpaths and access points. The three indicators are calculated at three different scales as demand is strongly related to distance. The Monitor of Engagement with the Natural Environment (MENE) survey and other literature on visit distance was used to determine appropriate distances. The distances chosen (and rationale) were: 600m (10 minutes walking distance), 3.2 Km (67% of all visits and 90% of visits by foot occur within this distance), and 16 Km (90% of all visits travelled less than this distance).

The three indicators were normalised from 0-1, then combined with equal weighting at each scale and then the three different scales of analysis were combined and projected on a 0 to 100 scale. High values (red) indicate areas (sources) that generate the greatest demand for accessible nature.

Results for South Yorkshire

Demand for accessible nature (Map 19 above) is focussed around where people live, hence the greatest demand is from the four urban centres in the county. Sheffield shows the greatest area of demand.

Balancing supply and demand for accessible nature

Whilst there are certainly greenspaces that are considered accessible and natural within the urban areas of the region, there are few, and there are many more sites that are providing a high level of this service outside of the urban centres of South Yorkshire. This is important because numerous researchers have shown that people travel most frequently to greenspaces very close to their homes and Natural England recommend that everyone should have access to at least some greenspace within 300m (5 minutes' walk) and larger sites within 2 km. Furthermore, surveys have shown that most people will typically travel less than 3.2 km to visit greenspace. Any new accessible greenspace being created should therefore be close to housing areas, and especially close to more deprived and densely populated neighbourhoods. New housing areas will also create increased demand for accessible greenspace, so it is important that this demand is met on-site.

There is now a vast amount of evidence showing the benefits of greenspace, particularly in built-up areas. Furthermore, research has shown that people gain greater well-being from visiting sites that they perceive to be more natural and richer in biodiversity. This shows that as well as providing access to greenspace, it is important that the greenspace is of a high quality and as natural as possible.

4.15 Recreation

What is it and why is it important?

The importance of access to greenspace in urban environments is increasingly recognised. Visits to natural areas have been shown to enhance physical and mental health and well-being, increase social cohesion and contribute greatly to the local economy. This service is related to that of accessible nature, as both are based around accessible greenspaces, but recreation is concerned with estimating the annual number of visits, whereas accessible nature is concerned with the naturalness of the sites.

How is it measured?

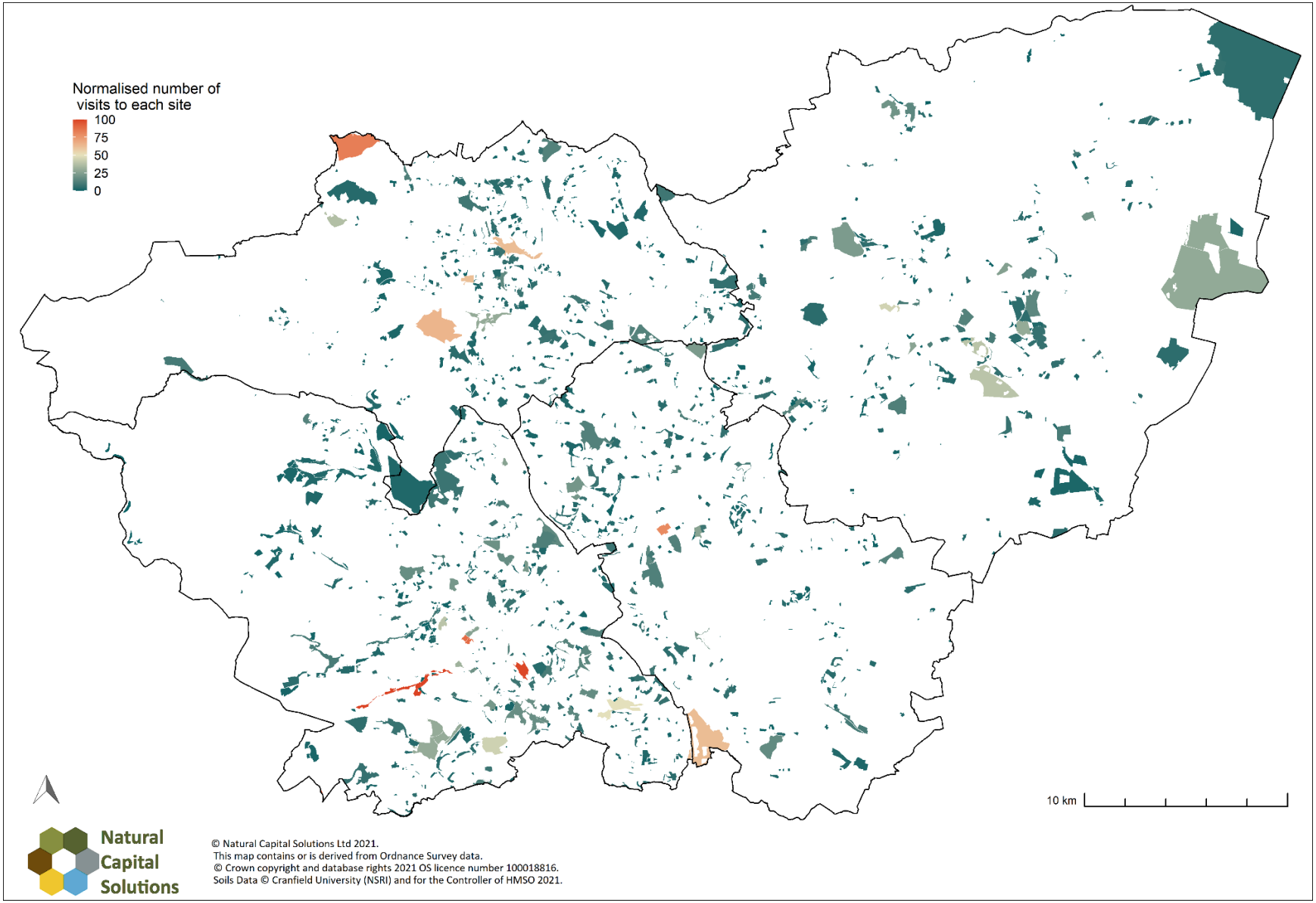
To estimate the physical flow of the recreation service we used the University of Exeter's Outdoor Recreation Valuation Tool (ORVal) version 1. This tool uses a Recreational Demand Model to predict the number of visits that are made to currently accessible greenspaces by adult residents of England (Day & Smith 2017). The number of visits are modelled using data from the Monitor of Engagement with the Natural Environment (MENE) survey, and adjusted based on factors such as socioeconomic characteristics of people, the day of the week, attributes of the greenspace, as well as the availability and quality of any alternative greenspaces.

We took estimates of annual visits for each accessible greenspace site in South Yorkshire that was identified in the ORVal tool. A map of these sites was then created using GIS, some of the sites that ORVal identified were already present in the South Yorkshire project data sets. Those that were not present were drawn as new polygons. Note that any golf courses are not included on this map as ORVal could not estimate visit numbers for these areas.

Results for South Yorkshire

There are currently 1,532 accessible public open spaces identified in South Yorkshire (Map 20 below). They are a mix of parks and country parks, commons, recreational grounds, community woods, woodland, cemeteries, moorlands and nature reserves. In total across all of the sites there are an estimated 60,635,736 visits per year. The site with the highest number of visits (in red) is in Sheffield, and is the green corridor along the Porter Valley, from Endcliffe Park through Whitely Woods (south-west of the city). This is closely followed by Norfolk Heritage Park (south-east of the city), Western park and Crookes Valley Park (north of the city). There are sites that show a high provision of this service in Barnsley also, Bretton Country Park in the north, Stainborough Park in the centre of the borough, Dearne Valley Park and Locke Park towards the east. There are two sites in Rotherham, Clifton Park and Rother Valley Park, that are also have a medium to high provision of this service. The sites in Doncaster are not as well visited as in the other local authority areas, but sites of lower provision are still important for recreation. Sites here with higher provision are Cusworth Hall Museum Park and Potteric Carr Nature Reserve. Many of the sites that show high provision of the recreation service are sites within the urban centres. Whether or not these sites have a high overall provision of this service, it is important for urban dwellers to have access to green spaces.

Map 20 Recreation across South Yorkshire.



5. South Yorkshire ecosystem service valuation

A suite of ecosystem services that are provided by the natural capital assets of South Yorkshire were quantified (physical flow) in order for them to be valued (monetary flow) (see Table 3).

Table 3 Ecosystem services and indicators for physical and monetary measurement.

Ecosystem service	Physical flow	Valuation
Air quality regulation	Tonnes of $PM_{2.5}$	£/tonne of $PM_{2.5}$
Carbon balance	Quantity of CO_2e sequestered and emitted	£/tonne of CO_2e
Recreation	No. of angling trips	£/trip/year
Physical health	Active visits	£/QALY/year
Recreational angling	Number of visits	£/visit/year
Agricultural production	ha	£/ha/year
Timber/woodfuel production	m^3/ha	£/m^3/year
Flood reduction by woodland	m^3/ha	£/m^3/year
Amenity value	No. of houses within proximity of greenspaces	£ and % increase in house prices
Mineral extraction	Million tonnes extracted	£/year

Annual monetary flows of ecosystem services have been calculated based on the latest valuation techniques available in the scientific literature and approaches adopted by the Office for National Statistics (ONS 2017[24]), and recent Defra guidance to standardise approaches to the valuation of ecosystem services[25]. The physical and monetary flows of the ecosystem services are presented below (Table 4) for South Yorkshire. We also present the valuation for each local authority separately (Tables 5-8). We describe the results for the entire area in the text below, and comment on the variation in values across the Local Authorities afterwards. The methods used to calculate the physical and monetary flows are described in more detail at the end of the report (Appendix).

Vegetation can be effective at contributing to **air quality regulation**, with surface area being the most important determinant of capacity. Trees are much more effective than grass at this, and capacity increases significantly as trees grow and their surface area increases. The woodland and grass vegetation across the area is estimated to absorb 915 tonnes of $PM_{2.5}$ (particulate matter with a diameter of 2.5 micrometres or less) annually, at an annual value of £236.85 million and a present value (over 50 years) of £8.58 billion (Table 4).

[24] ONS (2017) Principles of Natural Capital Accounting. Office for National Statistics
[25] Defra (2020). Enabling a Natural Capital Approach (ENCA).

Carbon sequestration is the uptake of carbon by plants as they grow, with woodland being much the best habitat at delivering this service within South Yorkshire, with 89,513 tCO_2e/year being sequestered. However, **GHG emissions** from agriculture, particularly livestock farming, and agriculture on peat soils, begin to outweigh any carbon sequestered across the region (-216,199 tCO_2e /year). The areas of South Yorkshire that contain blanket or raised bog will also contribute GHG emissions unless they are in pristine condition. Bog habitats that are rewetted or are near-natural still emit (0.01 tCO_2e/ha/year), but this is at a low level compared to habitats that are dry or bare. Consequently, the carbon balance for the county is -105,304 tonnes of carbon equivalent per year (tCO_2e) at an annual value of -£7.98 million and a present value (over 50 years) of -£450.74 million. Thus, the natural capital assets of South Yorkshire are currently a source of GHG emissions. Note that soil and vegetation also act as a **stock of carbon**, but this was not valued here because it is not a flow.

Table 4 Annual physical flows, annual monetary flows £(2021) and present values over 50 years of ecosystem services in South Yorkshire.

Ecosystem service	Annual physical flow	Annual monetary flow £M(2021)	Present value over 50 years (£M)
Air quality regulation (*$tPM_{2.5}$*)	915	236.85	8,582.33
Carbon balance (*tCO_2e*) *Break down: Woodland* *Agriculture* *Other habitats*	-105,304 *89,513* *-216,199* *21,382*	-7.98 *6.78* *-16.38* *1.62*	-450.74 *383.15* *-925.41* *91.52*
Recreation (*Visits*)	60,635,736	187.94	4,640.76
Physical health (*QALY*)	4,541	68.11	2,467.95
Recreational angling (*no. trips*)	383,546	28.17	695.55
Agricultural production (*Hectares*)	75,371*	3.30	81.37
Timber/woodfuel production (*m^3*)	130,580	2.37	58.59
Flood reduction by woodland (*m^3*)	4,381,781	2.01	49.68
Amenity value (*no. houses*)	444,955	-	1,330.78
Mineral extraction (Mt)	6.69	29.50	728.51
Total values:	-	**550.28**	**18,184.77**

NB. Figures shown to 2 decimal places. Any discrepancies due to rounding.

*Note that this value is slightly higher than the sum of broad improved grassland and arable habitat categories in the asset register (Table 1). This is because some habitats used for grazing livestock fall in the other grassland categories.

The South Yorkshire region has high recreational value. Using the ORVal tool, we were able to estimate the number of **recreational visits** made to the area (Table 4). There are an estimated 60,635,736 recreational visits per year. The same tool estimates the welfare value derived from these visits, and these are valued at £187.94 annually, with a present value (over 50 years) of £4.64 billion.

A subset of these visitors will also receive **physical health benefits** through making regular active visits that meet national physical activity guidelines (20 minutes of moderate intensity exercise every day). It is estimated that there are likely to be c.133,108 active visitors every year to these accessible sites, which is equivalent to 4,541 Quality Adjusted Life Years (QALY). This delivers an annual value of £68.11 million, and a present value of £2.47 billion (Table 4).

An additional form of recreation captured was **recreational angling**. The majority if this activity is course fishing, although there is some trout fishing. There are an estimated 383,546 fishing trips made in the region in a year, at an annual value of £28.17 million, with a present value (over 50 years) of £695.49 million.

The total area of land in **agricultural production** across the area is 75,371 ha (Table 4). The area under arable production is slightly higher than that under improved and rough grasslands for grazing livestock (see Table 1). When all costs and subsidies (including the Basic Payment Scheme (BPS) which across South Yorkshire is an estimated £12.93 million per year) are excluded, the annual value of agricultural production across the area is £3.30 million with a present value (over 50 years) of £81.38 million.

We have also looked at the woodland asset from a **timber and woodfuel** production perspective. This does not mean that the woodland is necessarily being harvested for these purposes, rather it is another way of exploring the value of woodland in the region. If the woodlands in the area were all to be managed for timber and woodfuel production, they would be able to produce approximately 130,580m^3 per year under their current management and averaged over a full woodland production cycle (Table 4). This has an annual value of £2.37 million and a present value of £58.59 million (Table 4).

Using the new Environment Agency natural capital accounting tool we were able to value the role of **woodland habitats in reducing flooding** in the region. The 15,992 ha of woodland habitat in the South Yorkshire region can hold an estimated 4.38 million m^3 of water. The value is expressed as a replacement cost by applying annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service. This natural water storage has an annual value of £2.01 million, and a present value over 50 years of £49.68 million.

We use the principle of hedonic pricing and evidence of increases in property values as a means of capturing **amenity value**. If homes are in close proximity to greenspace in the South Yorkshire area, it will have a positive impact on the average house values of those homes. Across the region there are 444,955 residential buildings within 500 metres of a greenspace more than 2.5 hectares in size (Table 4). This uplift in the value of these homes delivers £1.33 billion in additional value to (Table 4).

There is **minerals extraction** activity in South Yorkshire, mainly in Rotherham and Doncaster. The annual quota for extraction is of 2.54 million tonnes of crushed rock in Rotherham (Table 7), with 3.34 million tonnes in Doncaster. Doncaster also has an annual quota of 0.81 million tonnes of sand and gravel (Table 8). We did not have a breakdown of the value of this extraction for the Local Authorities separately, but the GVA value for the South Yorkshire £29.50 million annually, with a present value over 50 years of £728.51 million (Table 4).

In total, the value of the benefits delivered by the natural capital assets of South Yorkshire is **£550.28 million** annually, with a present value of **£18.19 billion** over 50 years. This is driven by the high value air pollution regulation, recreation and physical health benefits, as well as the value added to properties by living in close proximity to greenspace. Interestingly, agricultural production, although being dominant in the area, is not one of the most valuable benefits provided by the natural capital assets of the region, even when accounting for the BPS. However, the overall value of the benefits is being decreased by the cost of GHG emissions associated with the agricultural production.

The valuation for South Yorkshire has been broken down by each Local Authority area below (a breakdown of the carbon balance is in Appendix A). The GHG emissions and the sequestration of carbon by the natural capital assets of Sheffield and Rotherham, balance in favour of sequestration. In Sheffield this is because there is little agriculture in comparison to the other areas of Sheffield, and the woodland and other semi-natural habitats are able to off-set the agricultural emissions. However, Barnsley and Doncaster are net emitters of GHG emissions. In Doncaster particularly this is high due to the dominance of arable farming (a small area of which occurs on peat soils), with some contribution from areas of degraded lowland raised bog. Sheffield has the highest provision of the flood reduction by woodland service, supporting a higher overall woodland area than the other Local Authorities. The amenity value service is also the highest, due to being more built up than the other urban areas, but also due to having a large number of accessible green spaces in and around the city. This also influences the provision of the recreation service. As a consequence Sheffield also has the highest total natural capital value.

Table 5 Annual physical flows, annual monetary flows £(2021) and present values over 50 years of ecosystem services in Sheffield.

Ecosystem service	Annual physical flow	Annual monetary flow £M(2021)	Present value over 50 years (£M)
Air quality regulation (*$tPM_{2.5}$*)	229	59.24	2,146.64
Carbon balance (*tCO_2e*)	12,980	0.98	55.56
Recreation (*Visits*)	24,069,864	74.92	1,849.92
Physical health (*QALY*)	1,802	27.04	979.67
Recreational angling (*no. trips*)	111,348	8.18	201.91
Agricultural production (*Hectares*)	8,686	0.10	2.41
Timber/woodfuel production (*m^3*)	39,392	0.75	18.45
Flood reduction by woodland (*m^3*)	1,316,707	0.61	14.93
Amenity value (*no. houses*)	170,970	-	578.38
Mineral extraction (Mt)	0	-	-
Total values:	**-**	**171.82**	**5,847.87**

NB. Figures shown to 2 decimal places. Any discrepancies due to rounding.

Table 6 Annual physical flows, annual monetary flows £(2021) and present values over 50 years of ecosystem services in Barnsley.

Ecosystem service	Annual physical flow	Annual monetary flow £M(2021)	Present value over 50 years (£M)
Air quality regulation (*tPM$_{2.5}$*)	202	52.25	1,893.32
Carbon balance (*tCO$_2$e*)	-12,717	-0.96	-54.43
Recreation (*Visits*)	13,473,705	41.82	1,032.65
Physical health (*QALY*)	1,009	15.13	548.40
Recreational angling (*no. trips*)	97,079	7.13	176.04
Agricultural production (*Hectares*)	16,292	0.78	19.29
Timber/woodfuel production (*m^3*)	29,042	0.55	13.51
Flood reduction by woodland (*m^3*)	976,481	0.45	11.07
Amenity value (*no. houses*)	83,588	-	229.55
Mineral extraction (Mt)	0	-	-
Total values:	-	**117.15**	**3,869.40**

NB. Figures shown to 2 decimal places. Any discrepancies due to rounding.

Table 7 Annual physical flows, annual monetary flows £(2021) and present values over 50 years of ecosystem services in Rotherham.

Ecosystem service	Annual physical flow	Annual monetary flow £M(2021)	Present value over 50 years (£M)
Air quality regulation (*tPM$_{2.5}$*)	163	42.12	1,526.17
Carbon balance (*tCO$_2$e*)	1,219	0.09	5.22
Recreation (*Visits*)	11,818,761	35.83	884.76
Physical health (*QALY*)	885	13.28	481.04
Recreational angling (*no. trips*)	101,196	7.43	183.50
Agricultural production (*Hectares*)	15,879	0.76	18.80
Timber/woodfuel production (*m^3*)	26,245	0.44	10.97
Flood reduction by woodland (*m^3*)	890,034	0.41	10.09
Amenity value (*no. houses*)	93,043	-	255.5
Mineral extraction (Mt)	2.54	-	-
Total values:	-	**100.36**	**3,376.05**

NB. Figures shown to 2 decimal places. Any discrepancies due to rounding.

Table 8 Annual physical flows, annual monetary flows £(2021) and present values over 50 years of ecosystem services in Doncaster.

Ecosystem service	Annual physical flow	Annual monetary flow £M(2021)	Present value over 50 years (£M)
Air quality regulation (*t$PM_{2.5}$*)	321	83.24	3,016.19
Carbon balance (*tCO_2e*)	-106,787	-8.09	-457.09
Recreation (*Visits*)	11,273,406	35.37	873.43
Physical health (*QALY*)	844	12.66	458.84
Recreational angling (*no. trips*)	73,923	5.43	134.10
Agricultural production (*Hectares*)	34,515	1.66	40.87
Timber/woodfuel production (*m^3*)	35,900	0.63	15.66
Flood reduction by woodland (*m^3*)	1,198,558	0.55	13.59
Amenity value (*no. houses*)	97,354	-	267.35
Mineral extraction (Mt)	4.15	-	-
Total values:	-	**131.45**	**4,362.94**

NB. Figures shown to 2 decimal places. Any discrepancies due to rounding.

5.1 Sensitivity analysis

A sensitivity analysis examined the low, central and high estimates of all the benefits we valued at the scale of South Yorkshire (Table 9). This demonstrates the overall sensitivity of the natural capital values. The overall natural capital value ranges from a present value (over 50 years) of 8.08 billion under the lowest benefits estimates up to £45.35 billion under the highest benefits estimates. This large difference highlights the challenges of placing a monetary value on some services.

This analysis shows the high levels of uncertainty inherent in valuing ecosystem service benefits. Valuation of ecosystem services should be seen as appropriate at indicating the approximate magnitude of benefits, but not their exact values. It has allowed the comparison of values for a broad suite of services to be compared across South Yorkshire. It also demonstrates the range of benefits that the natural environment can provide. However, these results need to be interpreted with care, and in the knowledge that whilst the highest quality and most readily available data and methods were used, there are limitations and assumptions that need to be borne in mind.

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. Some are highly location specific, for example water flow and impact on downstream flood risk. This can be quantified and valued by running detailed hydrological and flood risk modelling, but it is difficult to generalise. The quantification of flood reduction by woodland is included here, and is a measure that can be useful in gaining an understanding of how one habitat can contribute to delivering this service, but it only tells part of the story and is reasonably crude. Others, such as water quality can be modelled, but are very difficult to value, while there are additional cultural services, such as aesthetic experiences, cultural heritage, spiritual experience and sense of place that are difficult to even quantify. It should, therefore, be borne in mind that the valuations presented in this section place values on several key benefits, but these are necessarily incomplete.

For the services that have been included here, a range of assumptions have been made, and these are outlined when describing the methodology (see Technical Appendix). In addition, a summary of the main uncertainties is provided for each service in Table 10 below, along with a RAG rating highlighting the overall confidence in each estimate. For most ecosystem services these assumptions are minimal, as established production functions exist linking natural capital to ecosystem service production, and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for physical health, and this estimate should, therefore, be used with care.

Table 9 Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets of South Yorkshire.

Ecosystem service	Annual values (2020) (£M)			Present value (over 50 years) (£M)		
	Low	Central	High	Low	Central	High
Air quality regulation	49.62	236.85	729.48	1,797.90	8,582.33	26,432.61
Carbon balance	-3.98	-7.98	-11.96	-215.03	-450.74	-686.45
Recreation	140.96	187.94	234.93	3,480.56	4,640.75	5,800.94
Physical Health	34.05	68.11	272.44	1,233.97	2,467.95	9,871.78
Recreational angling	21.12	28.17	35.21	521.62	695.49	869.37
Agricultural production	-0.15	3.30	14.12	-3.67	81.38	348.76
Timber/woodfuel production	1.78	2.37	2.97	43.94	58.59	73.24
Flood reduction by woodland	1.51	2.01	2.51	37.26	49.68	62.1
Amenity value	-	-	-	998.09	1,330.79	1,663.49
Mineral extraction	22.13	29.50	36.88	182.13	728.51	910.64
Total value:	**267.04**	**550.27**	**1,316.58**	**8,076.77**	**18,184.73**	**45,346.48**

NB. Figures shown to 2 decimal. Any discrepancies due to rounding.

Table 10 Summary of uncertainties in the calculation of physical flows and monetary values of each natural capital benefit, and an overall assessment of confidence, using a red, amber, green (RAG) rating.

Natural capital benefits	Assessment of uncertainties	RAG rating
Air quality regulation	Biophysical estimates based on averages for broadleaved and coniferous trees and grassland. Valuation follows ONS guidance.	
Carbon sequestration/emission	Well studied. standardised carbon lookup tables available. Emissions accounting receiving increasing attention as part of climate change accounting. Valuation uses UK Government non-traded carbon price.	
Recreation	Welfare values from a welfare function model from the ORVal tool. This is a good model and based on a travel cost method. but it is nonetheless a model.	
Physical health	The most uncertain of the services measured. High uncertainty over who would make frequent and active visits to the green spaces and the monetary value of these benefits.	
Recreational angling	Costs per trip take from an Environment Agency survey of freshwater fishing in England and its associated economic activity.	
Agricultural production	Based on extensive data collected by Defra annually and market prices.	
Timber production	Well studied over many years as part of forestry management. Valuation uses market prices.	
Flood reduction by woodland	Method from the new Environment Agency Natural Capital Register and Account Tool, Version 1[26], using data derived from a Forest Research study[27], and also outlined in Defra ENCA[22]. Despite this it is a relatively crude assessment as it is value transfer from England scale data.	
Amenity value	Follows the latest ONS study on the effect on house values of proximity to greenspaces. This uses travel to work area estimates of impact on house values for South Yorkshire. These estimates may vary across the region. There is potential here for double counting with the physical health service (see Technical Appendix for discission).	
Mineral extraction	Based on county level GVA data and mineral quota data from each local authority from ONS.	

[26] Environment Agency Natural Capital Register and Account Tool, Version 1. (January 2021).
[27] Broadmeadow, S. et al. (2018) Valuing flood regulation services of existing forest cover to inform natural capital accounts. Forest Research.

6. Biodiversity network mapping

6.1 Introduction

Biodiversity network mapping, or habitat opportunity mapping, is a Geographic Information System (GIS) based approach used to identify potential areas for the expansion of key habitats. It aims to pinpoint possible locations where new habitat can be created that will be able to deliver particular benefits whilst taking constraints (such as existing land uses or historic sites) into account. This approach was used as a way of establishing a first version of a nature recovery network map (in combination with areas where habitat condition could be increased Section 9) and a woodland creation map for South Yorkshire (Section 10).

The importance of landscape-scale conservation and ecological networks has become increasingly recognised over recent years. Many wildlife sites have become isolated in a landscape of unsuitable habitats and efforts are now being directed towards linking existing habitat patches and increasing connectivity. Species are more likely to survive in larger habitat networks, can move and colonise new sites, and are more resilient to climate change and other detrimental impacts.

Habitat opportunity mapping to enhance biodiversity follows this ethos by using ecological networks to identify potential areas for new habitats. Identified areas will be ecologically connected to existing habitats, thereby expanding the size of the existing network, increasing connectivity and resilience, and potentially increasing the ecological quality of the new site. It was performed for five key habitat groupings, incorporating the main semi-natural habitats across South Yorkshire. The broad habitats and their constituent types are shown in the table below:

Broad habitat	Specific habitats included
Mire	Bogs and upland flushes, fens and swamps.
Semi-natural grassland	Acid, neutral, calcareous, rough and semi-improved grasslands.
Heathland	Includes all heathland types (including wet and dry heaths) and grass-heath mosaics.
Broadleaved and mixed woodland	Broadleaved and mixed woodland types (excludes coniferous woodland, parkland or individual trees).
Wet grassland and wetlands	Marshy grassland, floodplain grazing marsh, lowland fen and swamp (reedbed)

6.2 Method

Biodiversity opportunity mapping followed a four-step process, as explained below, and was based on the approach developed by Catchpole (2006)[28] and Watts et al. (2010)[29]. Note that opportunity areas for the four broad habitats often overlap, and no attempt has been made to ascertain the most suitable habitat at a particular location.

[28] Catchpole, R.D.J. (2006). Planning for Biodiversity – opportunity mapping and habitat networks in practice: a technical guide. *English Nature Research Reports*, No 687

[29] Watts, K., Eycott, A.E., Handley, P., Ray, D., Humphrey, J.W. & Quine, C.P (2010). Targeting and evaluating biodiversity conservation action within fragmented landscapes: an approach based on generic focal species and least-cost networks. *Landscape Ecology,* 25: 1305–1318.

1. *Landscape permeability*

This step involves assessing the permeability of the landscape to typical species from each habitat type and builds on work carried out by JNCC, Forest Research and others. Generic focal species are assessed for each habitat type as there is a lack of ecological knowledge to be able to repeat the process for multiple different individual species, and generic species provide an average assessment for species typical of each habitat type.

It is assumed that a species will have optimal dispersal capabilities in the habitat in which it is associated, and hence the landscape is fully permeable if it consists only of this primary habitat. Each of the remaining habitat types is then assigned a permeability score that shows how likely and how far the species will travel through that habitat. Habitats are scored on a scale from 1 (most permeable) to 50 (least permeable). Permeability scores were based on expert scores compiled by JNCC. Once tables had been compiled showing permeability scores for each habitat, high resolution maps were then produced using bespoke modelling, showing the permeability of the landscape for generic species from each broad habitat type.

2. *Habitat networks*

Step 2 uses the permeability map created above, along with information on average dispersal distances, to map which habitat patches are ecologically connected and which are ecologically isolated from each other. Dispersal distances were obtained from JNCC, which had performed a review of the scientific literature to ascertain the dispersal distances of a range of species for each habitat type. These were typically species of small mammals, smaller birds, butterflies, and plants. The average dispersal distance for each habitat is shown in the table below:

Dispersal distance in optimal habitat:	
Mire	1.0 km
Semi-natural grassland	2.0 km
Heathland	1.2 km
Broadleaved and mixed woodland	3.0 km
Wet grassland & wetlands	2.0 km

3. *Identifying constraints*

The habitat network map created in Step 2 can be used to indicate where new habitat could be created; any habitat created within the existing network would be ecologically connected to existing patches. However, in reality a number of constraints exist that need to be taken into account when producing opportunity maps. The aim of this step, therefore, is to produce a series of maps of constraints that can be used to show where habitat cannot or should not be created. The following constraints were used in the mapping:

(i) Land-use constraints – infrastructure (roads, railways, and paths), urban (all buildings), gardens, and water (standing and running), as it is highly unlikely that these would be available for habitat creation.

(ii) Historic sites – data were obtained from the client on the location of Scheduled Monuments and Registered Parks and Gardens across the study area and a 30m buffer was applied around each individual site, as recommended by Historic England.

(iii) National Grid gas pipelines, overhead lines and cables – data were obtained from the National Grid and a 10m buffer was applied around both features. This constraint was only applied when woodland opportunities were being mapped, as it would not be possible to plant trees in these areas, although grassland and wetland habitats would be feasible.

(iv) Priority habitats – data from Natural England was used as a constraint to ensure that opportunities to create new habitats did not occur in habitats that are already considered to be important for biodiversity.

(v) High quality habitats – existing habitats of high nature conservation interest were identified from the basemap as it would not make sense to destroy existing high-quality habitat to create new habitat of a different type. This did not include upland bogs because we used this for the creation of the woodland creation map (Section 10).

Constraints (i)-(iv) were applied to the nature network mapping (Map 21). Constraint (iii) was only applied to woodland habitats. Constraints (i)-(iii) and (v) were applied to the woodland creation map (Map 22). The client wanted to see the full range of opportunities, particularly for clough woodland that would not appear if the priority habitats were used as a constraint.

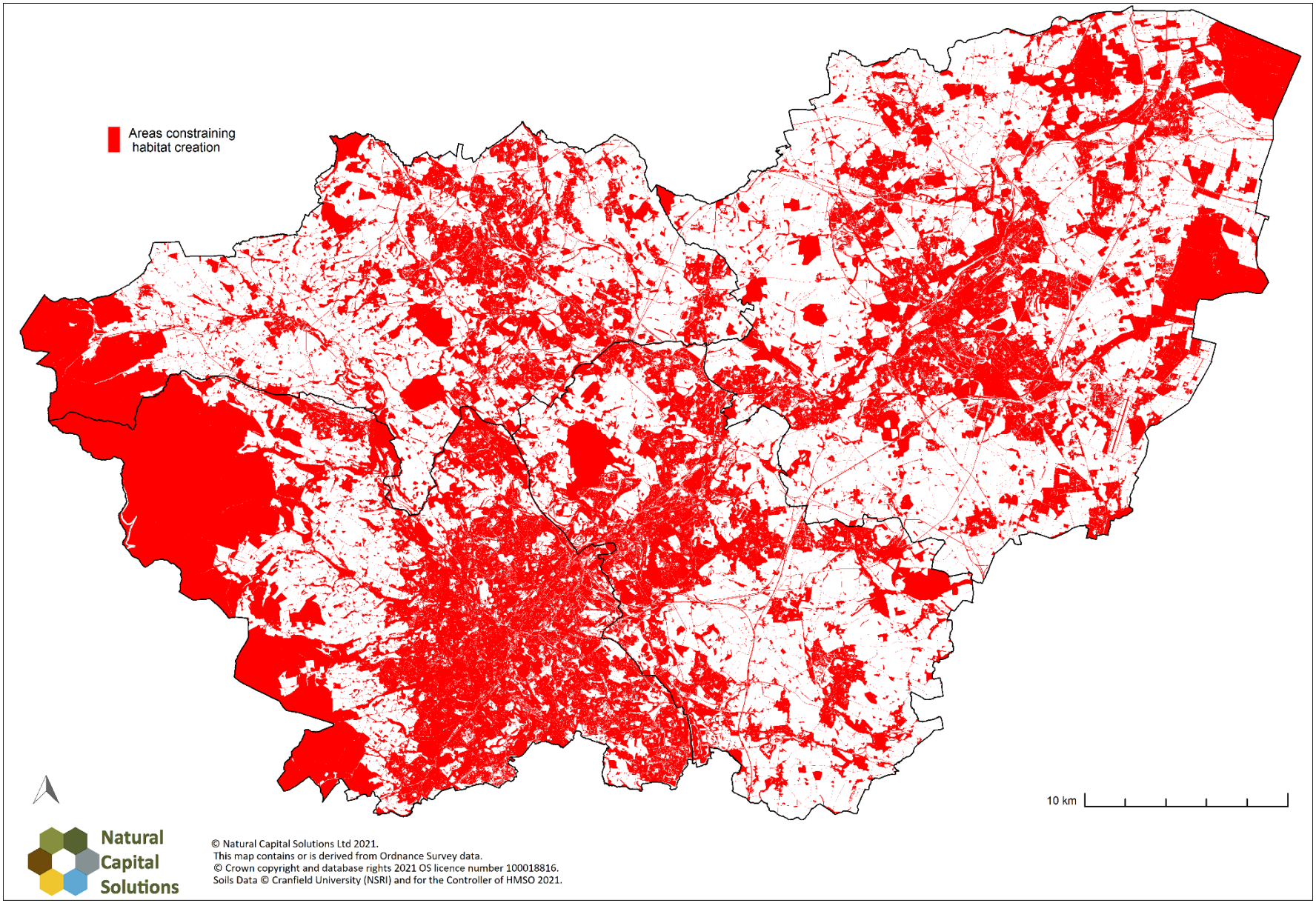
4. Habitat opportunity for biodiversity

In the next step, the constraints map was used to exclude areas that would be unsuitable or unavailable for new habitat. Two layers of habitat opportunity were then created:

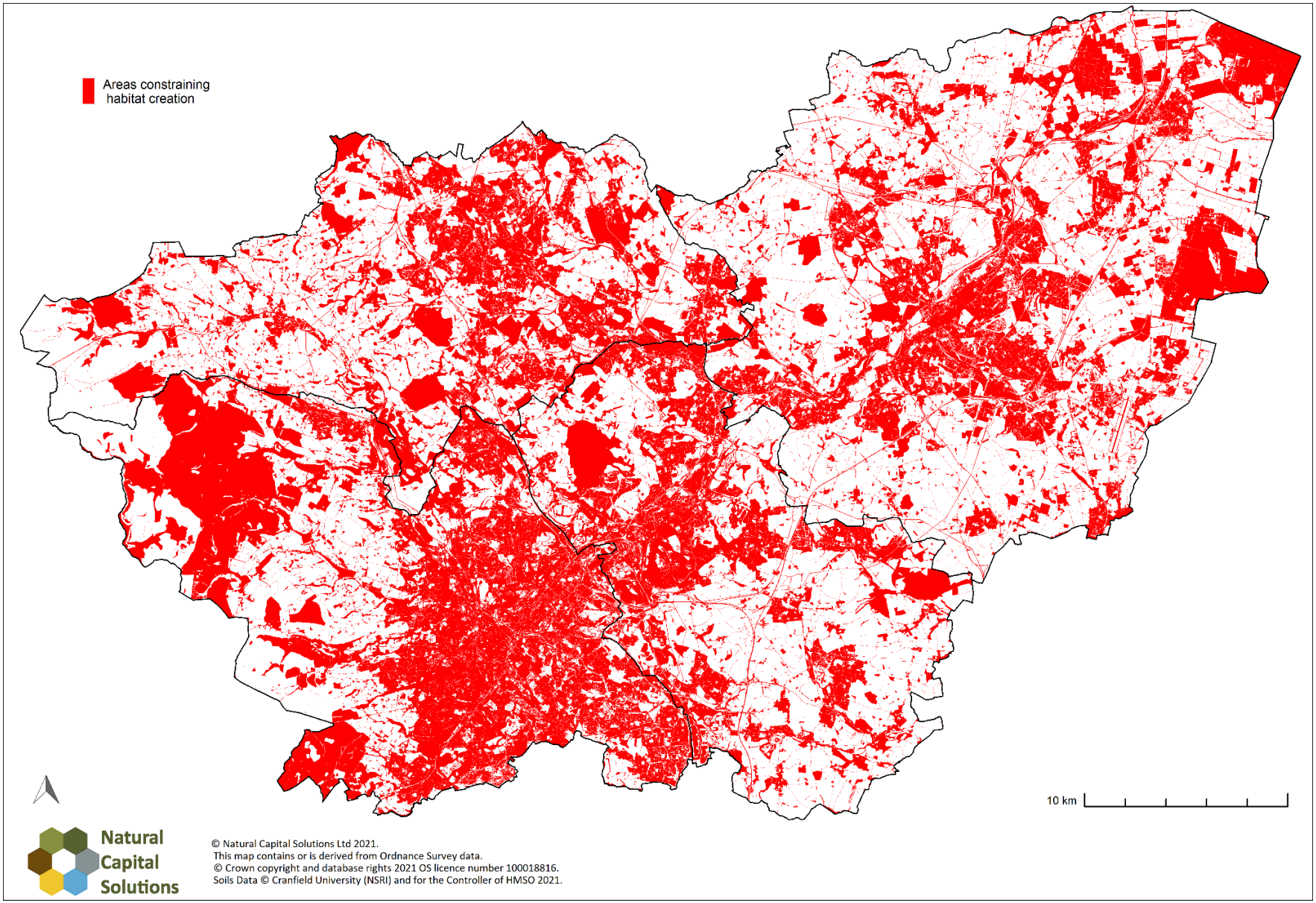
- **Buffer opportunity** – this layer identified habitat opportunity areas that are immediately adjacent to existing habitat patches and fall within the previously identified ecological network.
- **Stepping-stone opportunity** – this layer identified potential sites that fall outside of the ecological network, but are immediately adjacent to it. These areas could potentially be used to create stepping-stone habitats that could link up more distant habitat patches.

For both opportunity layers, a minimum threshold size was set at 0.1 ha, to remove tiny fragments of land and to replicate the minimum sizes of habitat creation grant schemes.

Map 21 The areas of key constraints taken into account during habitat opportunity mapping for nature recovery networks.



Map 22 The areas of key constraints taken into account during habitat opportunity mapping for woodland creation.



6.3 Results

The results are illustrated here for broadleaved and mixed woodland habitats, with the mire, heathland and semi-natural grassland presented in Annex 1.

The permeability of the landscape for typical woodland species is shown on Map 23. Darker areas are more permeable, meaning that typical species are expected to travel further across these habitats and hence will be less of a barrier to movement. For semi-natural grassland species arable fields and urban centres are the most significant barrier to movement. For woodland, improved grasslands and wetland habitats arable and urban centres are the most significant barriers. For the mire and heathland species, improved grassland, arable and grassland habitats, as well as urban areas and gardens are a barrier (Maps 25, 27, 29, 31).

The broadleaved woodland opportunity map (Map 25) shows the opportunity zones as buffers and stepping stones around existing sites where habitats could be created. Existing woodland habitat is shown in dark brown. Habitats that are ecologically connected are linked within a network shown in two lighter brown shades that show the buffer and the stepping stone network. White space between habitat patches indicates that they are not ecologically connected and dispersal between the patches is less likely to occur.

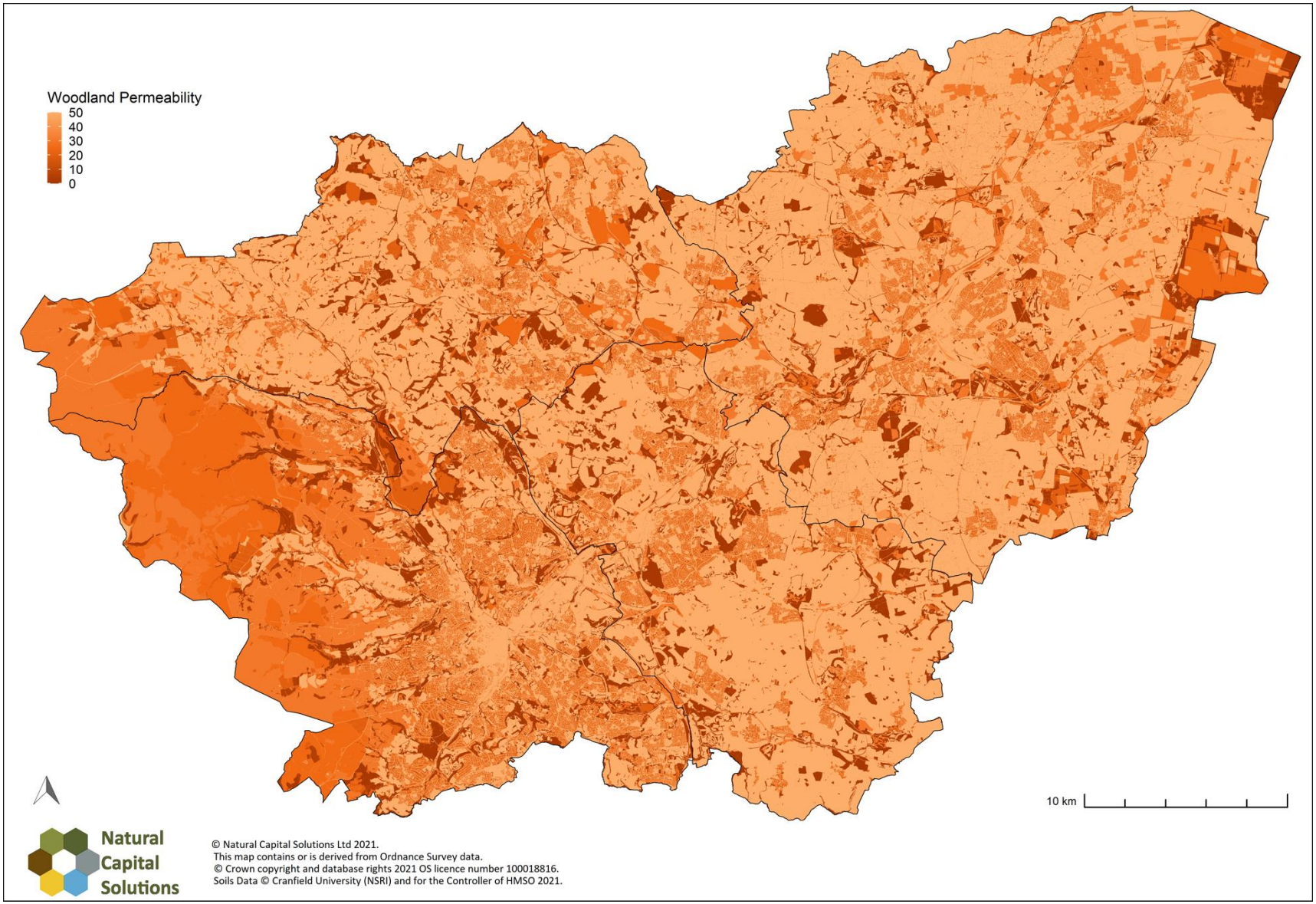
The maps show that there are multiple areas in the west and north of Sheffield, and through central and eastern Barnsley, where field-scale creation of woodland could considerably enlarge and connect existing woodland networks, making them more resilient. This is also the case in the north of Rotherham and the west of Doncaster. In the south of Rotherham and the east of Doncaster there are numerous opportunities to enlarge existing woodland patches, but due to the more fragmented nature of the woodland here, connecting up networks will be more difficult.

The biodiversity opportunity areas for semi-natural grassland are shown in Map 26. Existing grassland habitat is shown in dark green. Habitats that are ecologically connected are linked within a network shown in two lighter shades of green that show the buffer and the stepping stone network. There are opportunities to enlarge existing patches of semi-natural grassland across the South Yorkshire. However, the opportunities to connect up existing grassland networks are greatest in the west of the region (western Sheffield and Barnsley), with another significant area in the east of Barnsley. Opportunities are more fragmented across Rotherham and Doncaster where arable fields are dominant, but numerous nonetheless.

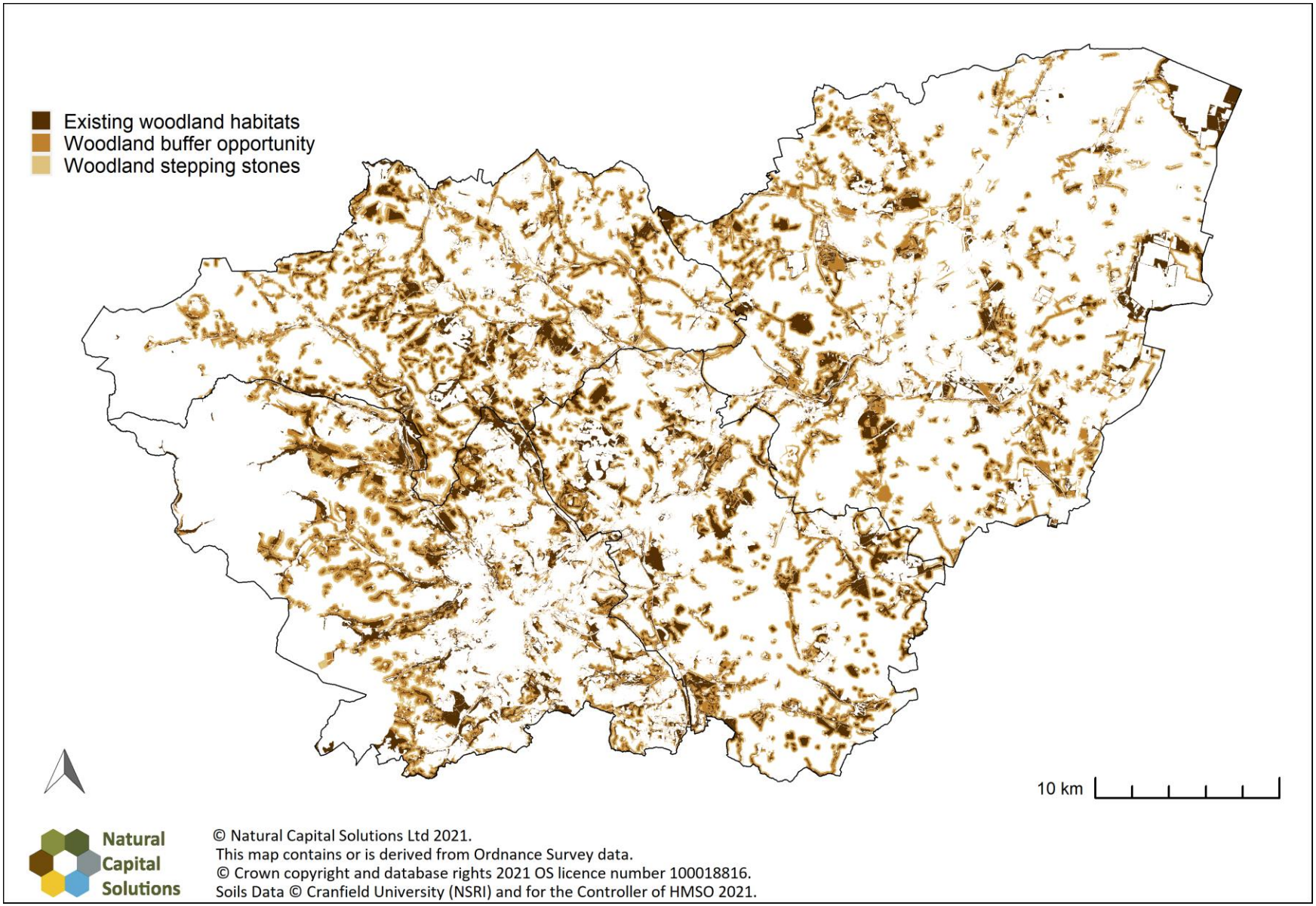
The biodiversity opportunity areas for heathland are shown in Map 28. Existing heathland habitat is shown in orange. Habitats that are ecologically connected are linked within a network shown in light orange and yellow that show the buffer and the stepping stone network. Opportunities for this habitat are much more geographically restricted than for woodland and grassland. Opportunities for creating further heathland habitat occur across the western area of South Yorkshire (western Sheffield and Barnsley), as well as east Barnsley and east Doncaster. This would certainly make patches larger, but it is difficult to connect up the existing heathland network, as it is too fragmented.

The biodiversity opportunity areas for bog habitats are shown in Map 30. Existing blanket and raised bog habitats are shown in dark purple. Habitats that are ecologically connected are linked within a

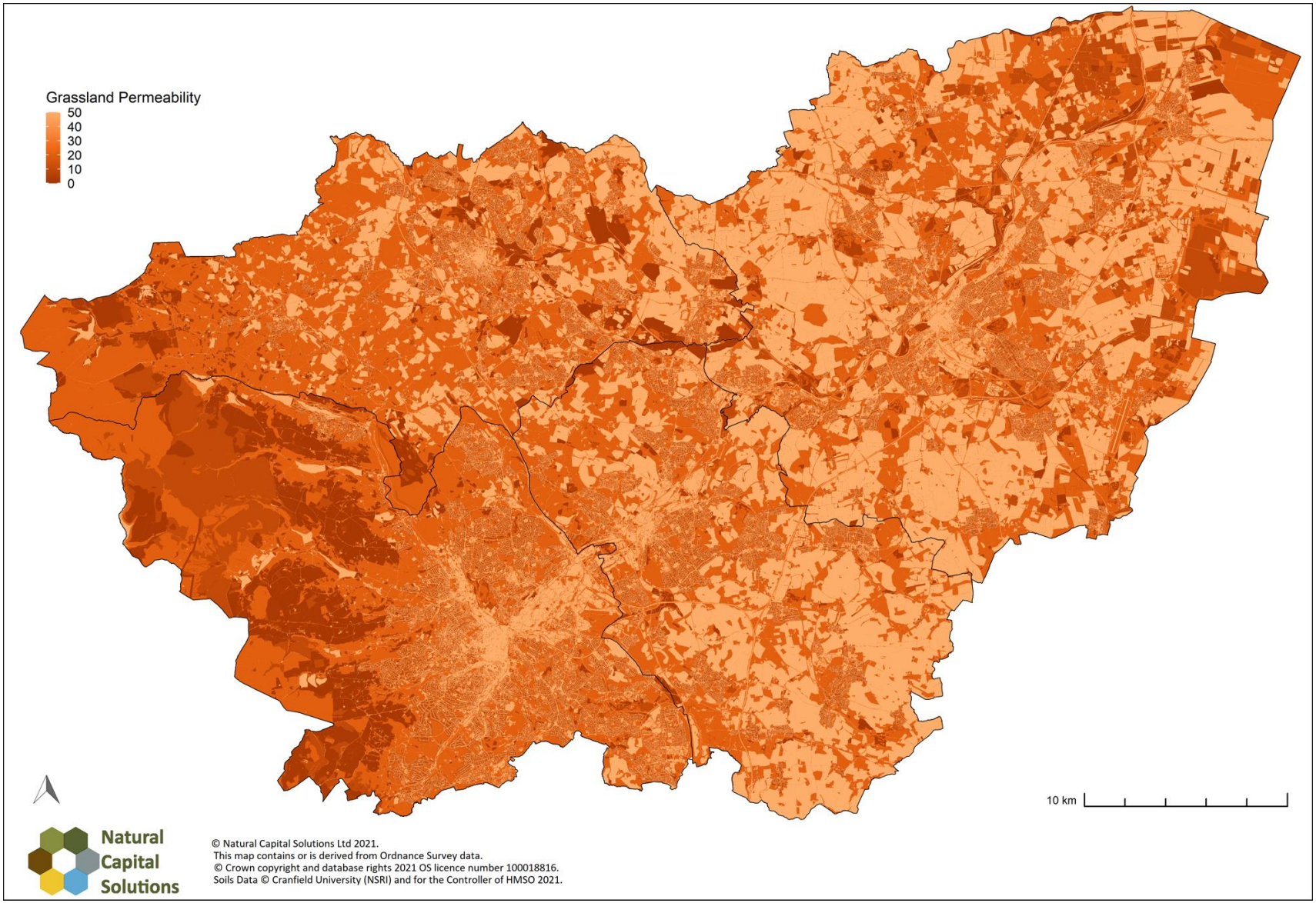
Map 23 Landscape permeability for typical woodland species across South Yorkshire (a score of 1 is most permeable from dark brown and orange, through to 50 being least permeable light orange).



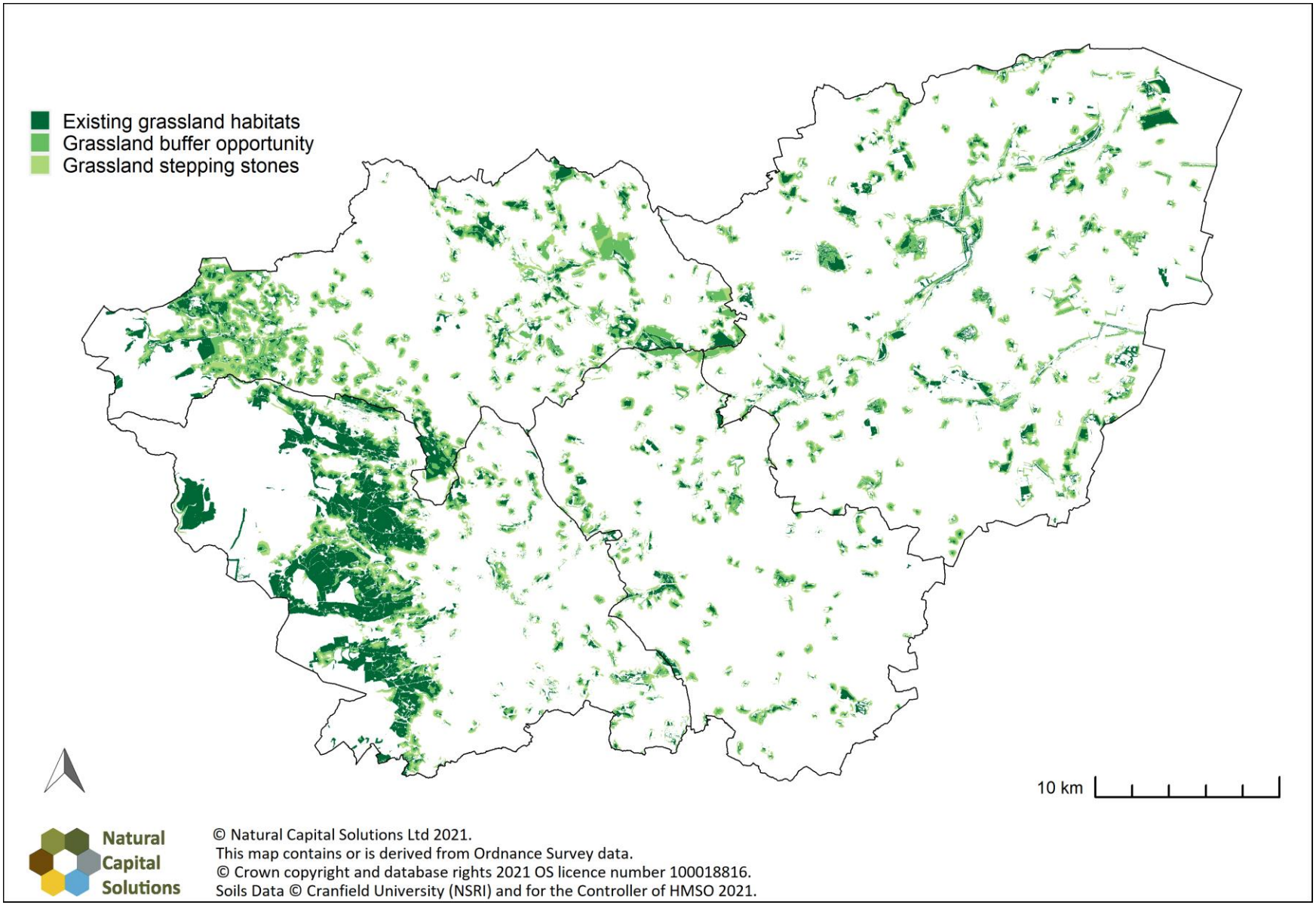
Map 24 Woodland buffer and stepping stone opportunities across South Yorkshire.



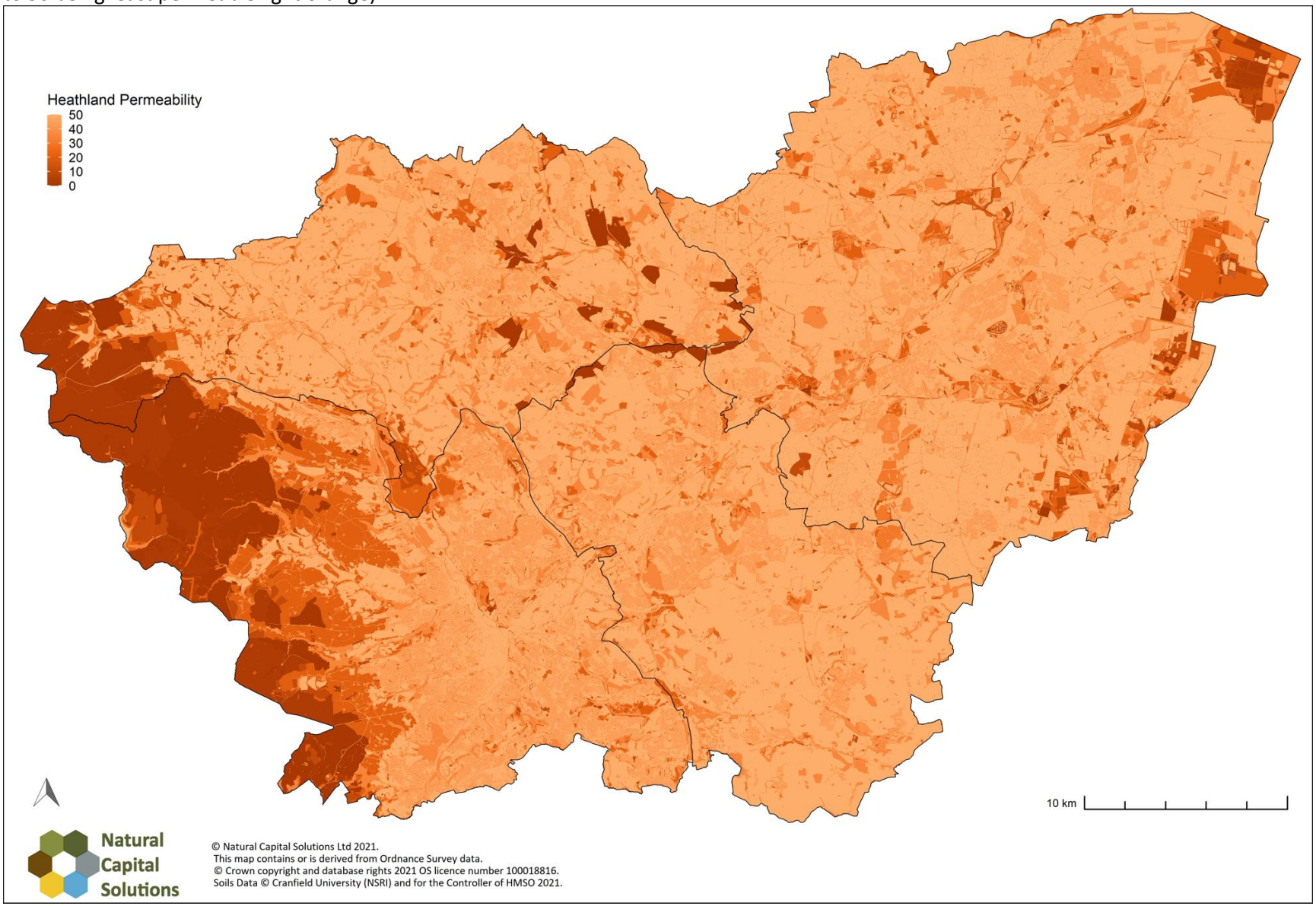
Map 25 Landscape permeability for typical semi-natural grassland species across South Yorkshire (a score of 1 is most permeable from dark brown and orange, through to 50 being least permeable light orange).



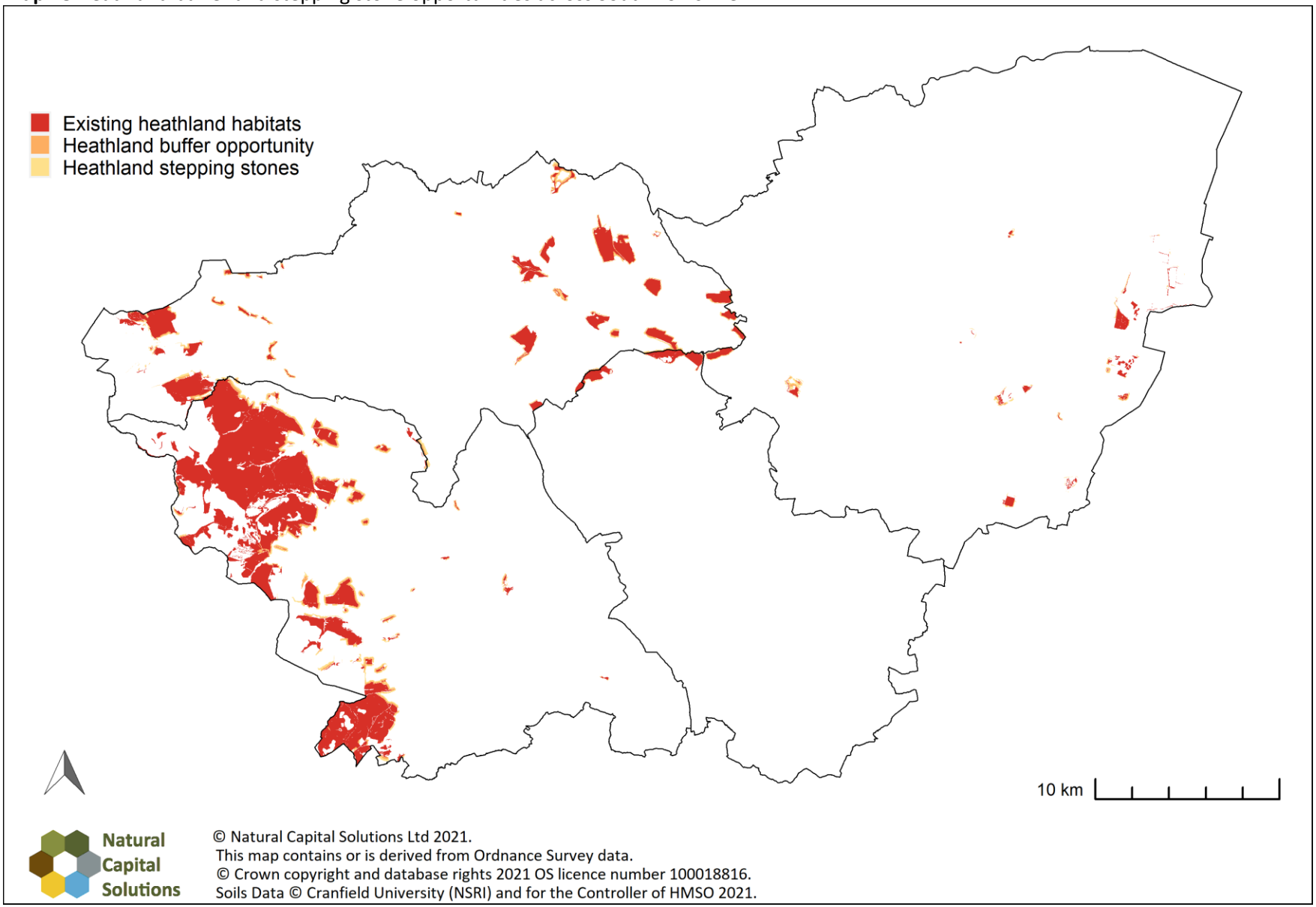
Map 26 Grassland buffer and stepping stone opportunities across South Yorkshire.



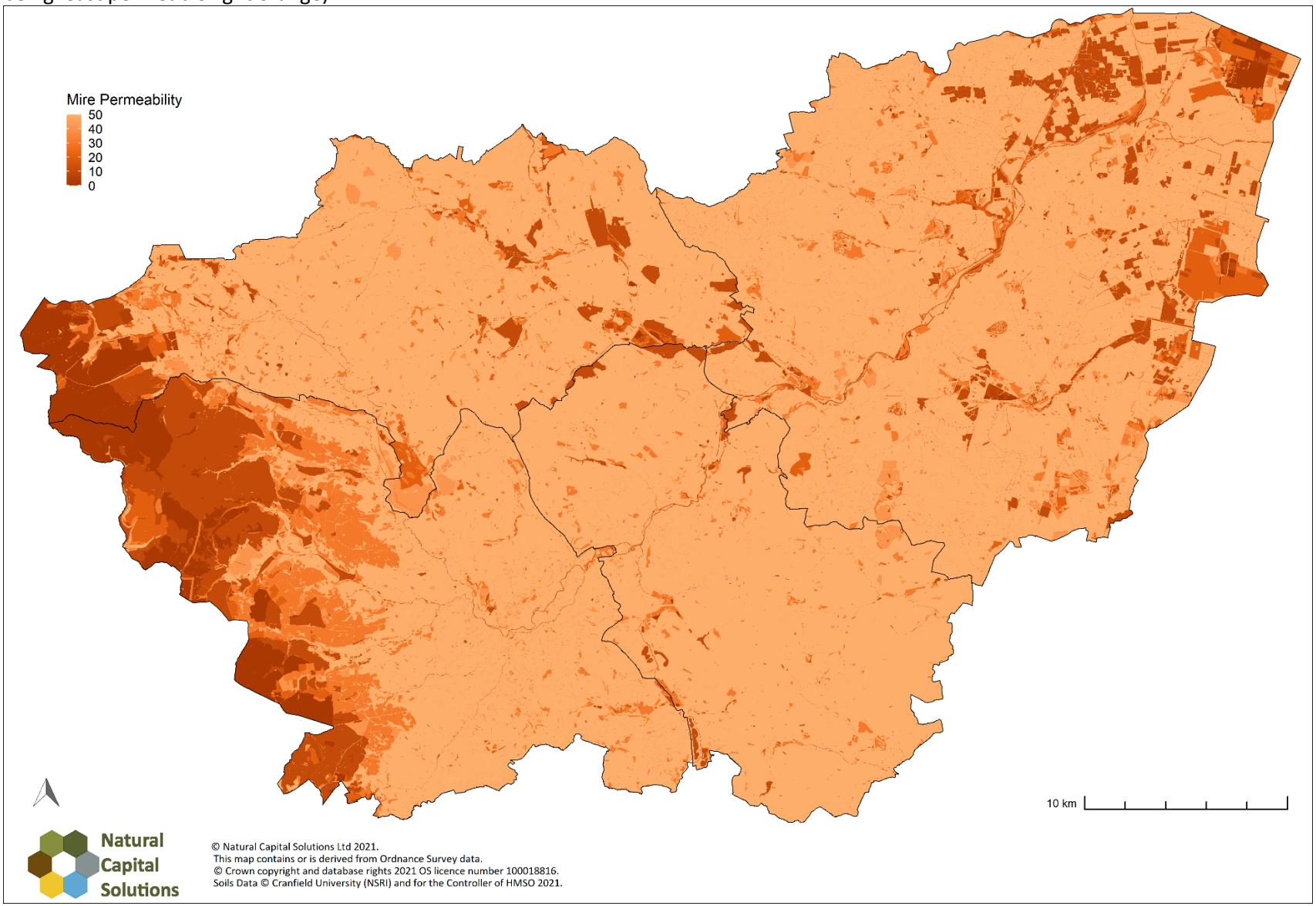
Map 27 Landscape permeability for typical heathland species across South Yorkshire (a score of 1 is most permeable from dark brown and orange, through to 50 being least permeable light orange).



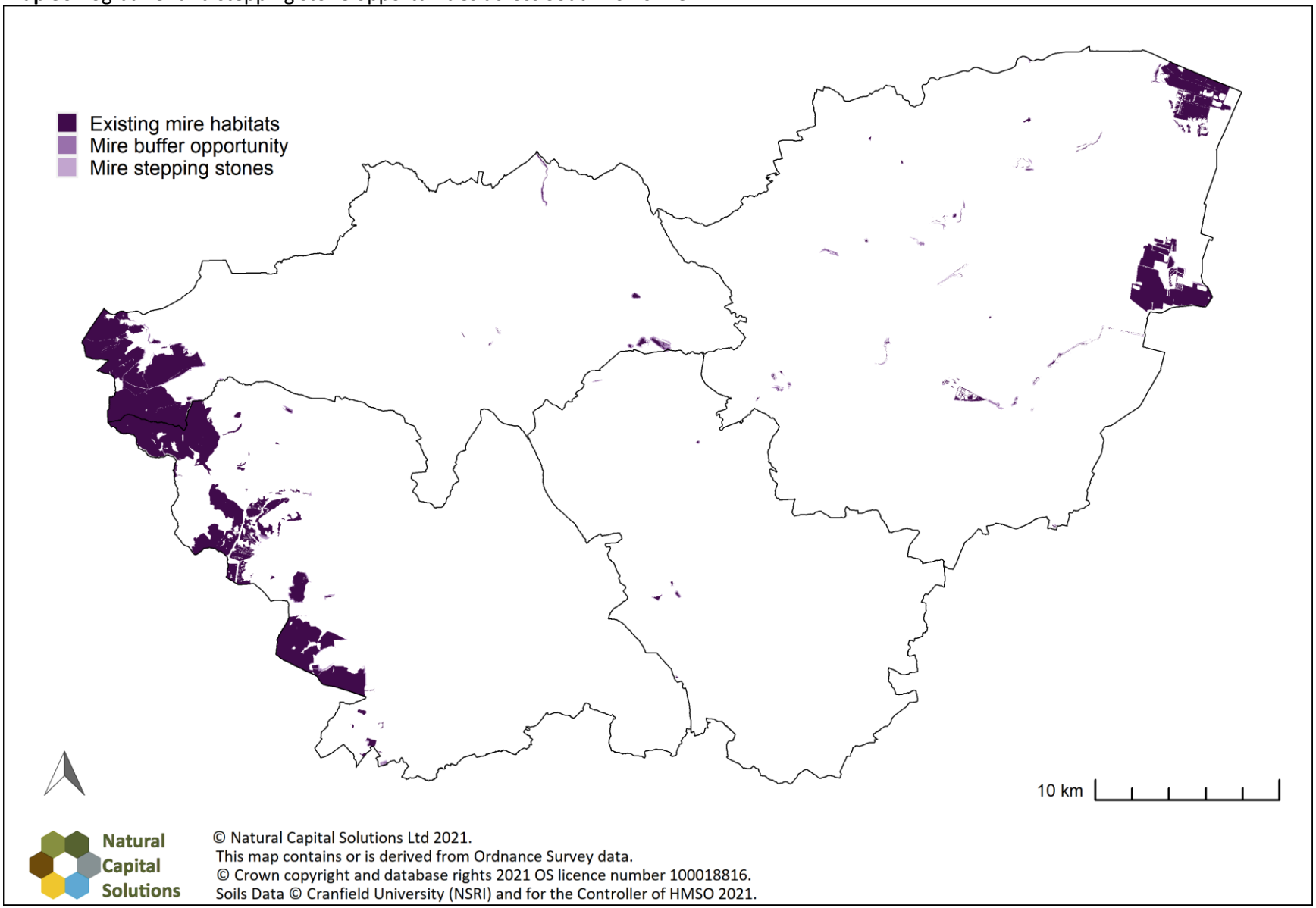
Map 28 Heathland buffer and stepping stone opportunities across South Yorkshire.



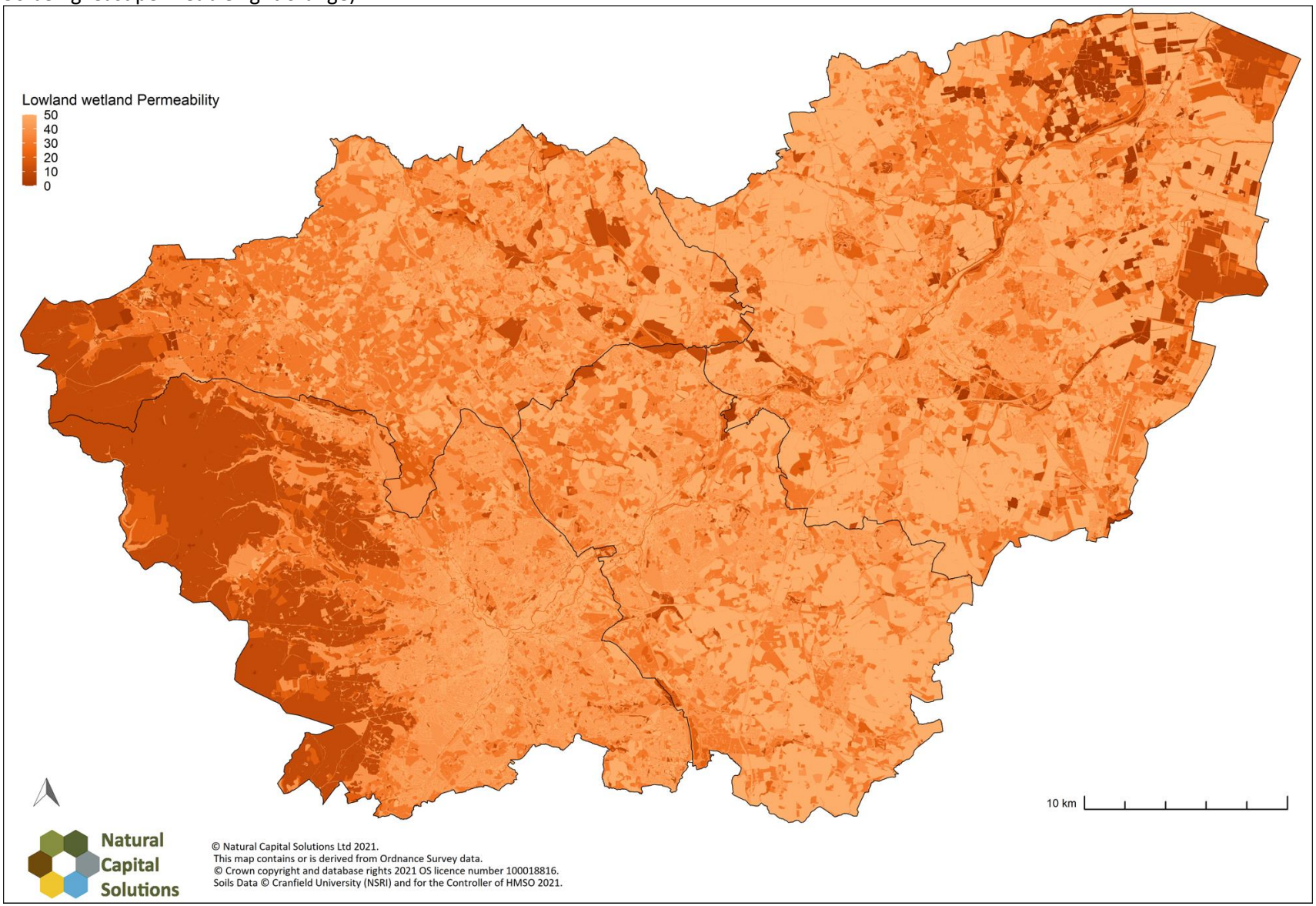
Map 29 Landscape permeability for typical bog species across South Yorkshire (a score of 1 is most permeable from dark brown and orange, through to 50 being least permeable light orange).



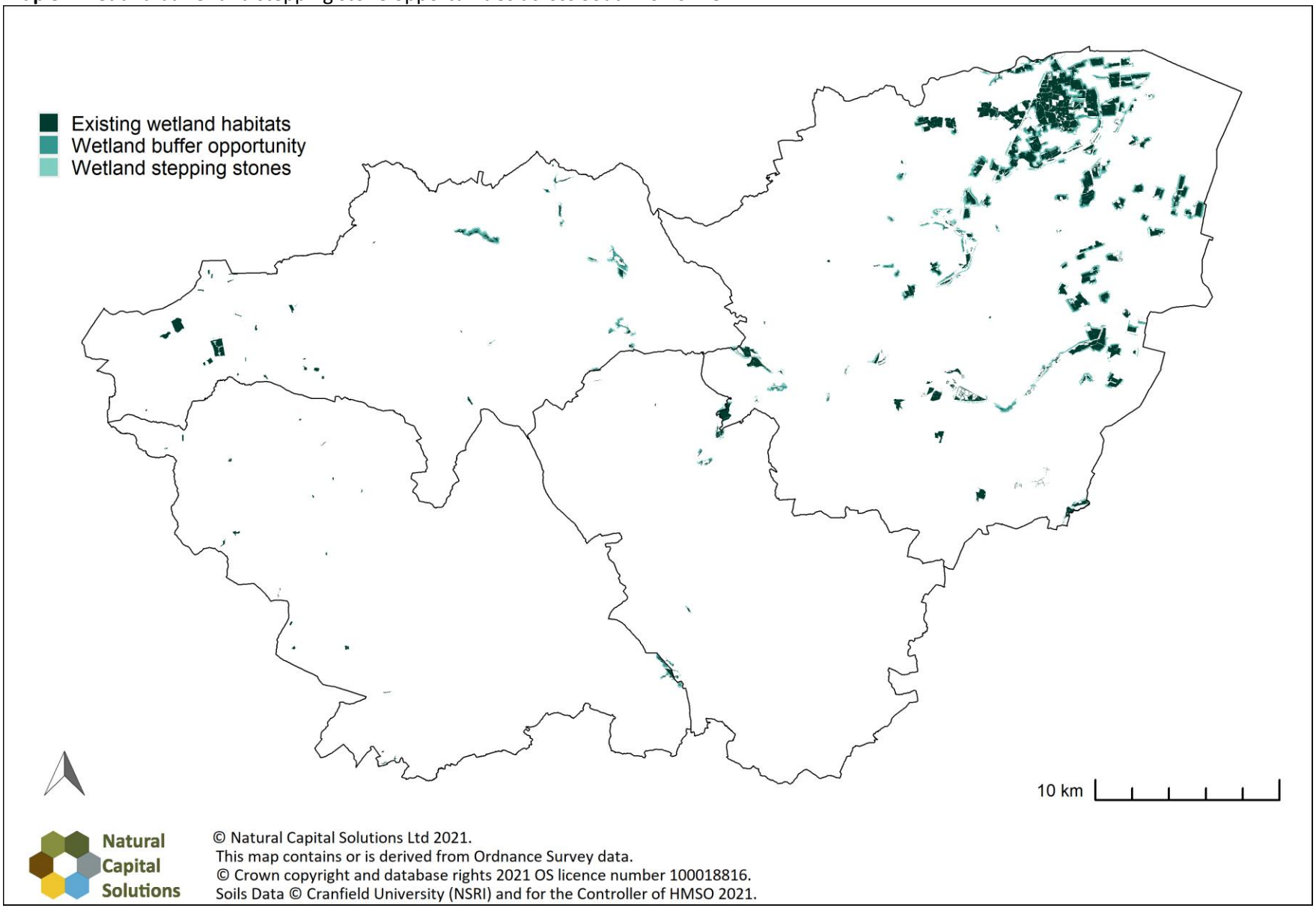
Map 30 Bog buffer and stepping stone opportunities across South Yorkshire.



Map 31 Landscape permeability for typical wetland species across South Yorkshire (a score of 1 is most permeable from dark brown and orange, through to 50 being least permeable light orange).



Map 32 Wetland buffer and stepping stone opportunities across South Yorkshire.



network shown in lighter purple that show the buffer and the stepping stone network. Opportunities for creating bog habitat is restricted to areas adjacent to the existing raised bog in the east and the upland blanket bog in the west. This will extend existing bog habitat, but would be unable to connect these habitats, as they occur in discrete blocks. Efforts are better focused on restoring the condition of these bog habitats for increasing biodiversity, reducing GHG emissions, retaining water and reducing erosion and sedimentation (therefore increasing water quality).

The biodiversity opportunity areas for wetland grasslands and wetlands are shown in Map 32. Existing wetland habitat is shown in dark blue. Habitats that are ecologically connected are linked within a network shown in light blues that show the buffer and the stepping stone network. Opportunities are restricted to the wetter areas of South Yorkshire, most notably in the eastern half of Doncaster. Here the existing network of marshy grassland on the River Don floodplain could be connected to create a larger network that extends into the centre of Doncaster along the River Don, and also to the south along the River Torne. Creation of this habitat on the north-eastern fringes of Doncaster would also benefit connectivity into the rest of the Humberhead Levels. There are other opportunities for habitat creation with some opportunities scattered throughout Barnsley (along the River Dearne), and on the border of Sheffield and Rotherham on the River Rother, and on the border of Rotherham and Doncaster on the River Don. Creating habitat here would enlarge the size of these existing habitats.

Please note that the mapping identifies areas based on landscape-scale ecological principles and does not take into account local site-based factors that may impact suitability. Any areas suggested for habitat creation will require ground-truthing before implementation. The maps should be seen as a tool to highlight key locations and to guide decision making rather than an end in themselves.

7. Ecosystem services opportunity mapping

Ecosystem services opportunity mapping is similar to the nature network mapping, in that the mapping process identifies opportunities where habitat can be created to enhance the provision of particular ecosystem services, whilst taking constraints (such as existing land uses or historic sites) into account. Here, opportunities for new habitats across the following range of benefits were mapped:

1) To reduce surface runoff
2) To reduce soil erosion and improve water quality
3) To ameliorate air pollution
4) To reduce noise pollution
5) To regulate local climate (reduce urban heat)
6) To increase access to natural greenspace

The approaches taken, and results obtained, for each of these services are described in turn below. Maps have also been combined with the habitat opportunities to show areas that could deliver multiple benefits, and this is described in Section 8.

7.1 Opportunity mapping to reduce surface runoff – slowing the flow

There is a growing interest in working with natural processes to reduce downstream flood risk. These projects aim to "slow the flow", reduce surface water runoff and retain water away from the main river channels for as long as possible. The most likely approach to achieve this aim will involve planting woodland, although measures could also include woody debris dams and attenuation ponds in upstream areas. Opportunity mapping to reduce surface runoff was undertaken based on the water flow model described in Section 4.9 and highlights areas across the whole catchment where changing land-use would have the greatest impact on reducing runoff.

7.1.1 Method

Constraints were identified and mapped in the same way as described in Section 6.2 for the nature network mapping (constraints (i)-(iv) (Map 21). These locations were then erased from the water flow regulation map developed in Section 4.9 to leave a map showing water flow regulation in all unconstrained locations. This was then classified into quartiles and the top quartile was extracted into a different map layer. Therefore, this shows the top 25% of areas of land across the study area where surface water runoff is currently highest and where there are no constraints on potentially altering land use. Note that it would also be possible to produce maps showing the top 10% of areas, or any other value, to show a narrower range of sites, if desired.

The final opportunity map identifies a large number of very small polygons and many polygons do not coincide with fields, the scale over which management and land use change is likely to take place. Therefore, as for biodiversity opportunity areas, it was considered beneficial to identify whole fields offering the greatest opportunity to reduce surface water runoff. To do this, all the previously identified constraints were removed or erased from the underlying habitat basemap. The degree of intersection between the opportunity map and the underlying fields (polygons) in the basemap was then calculated. Fields where at least 50% of the field overlapped with the opportunity map were selected and exported to a new layer. Finally, very small polygons were deleted so that only fields and plots at least 0.1 ha in size were included in the final map.

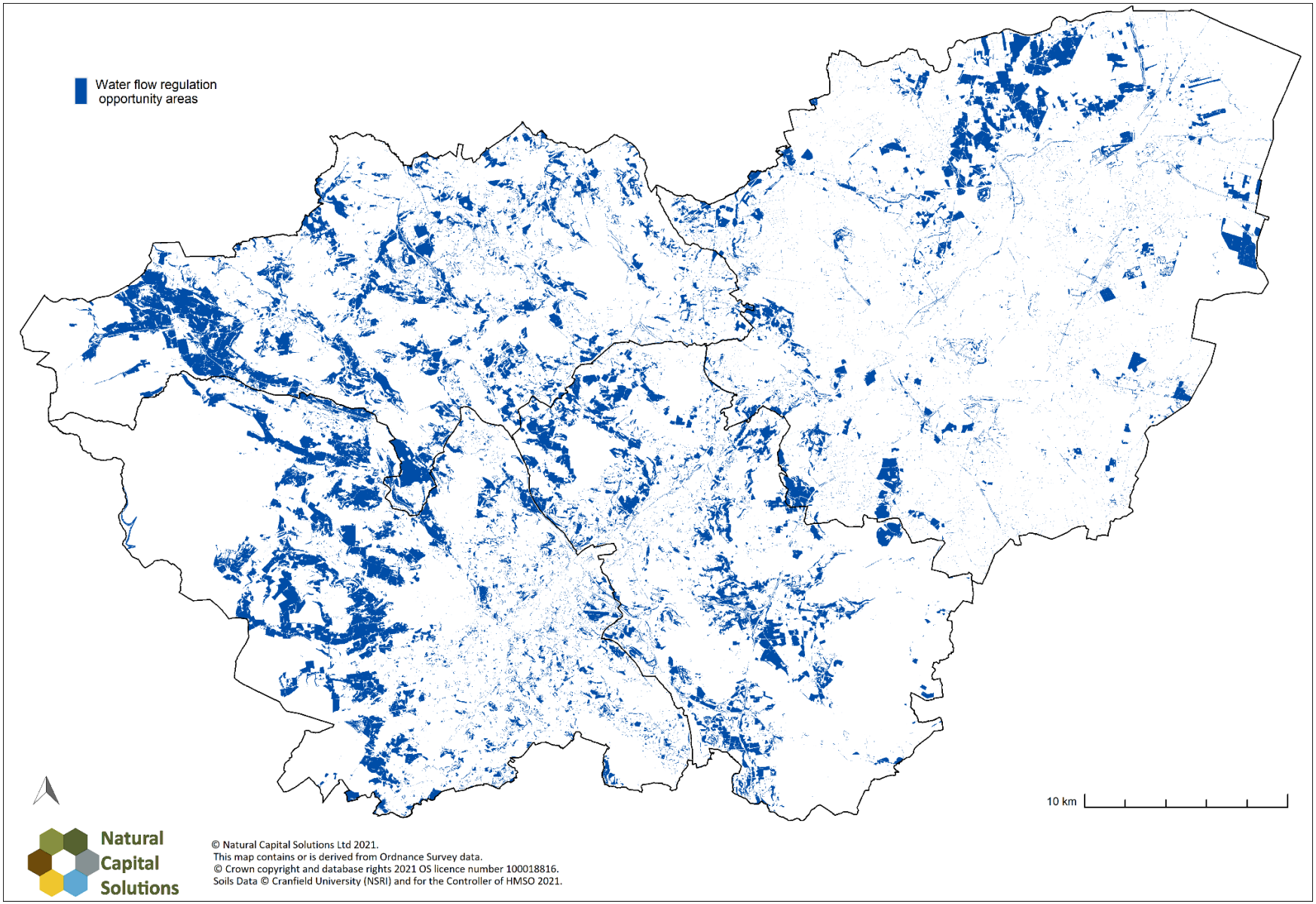
7.1.2 Results

Once land use constraints were removed, many areas that are currently poor for surface water runoff remained and these were identified as opportunity areas on Map 33. Opportunities are present throughout much of South Yorkshire, with most of the opportunities being on improved fields on slopes in the west and north, and on arable fields on slopes in the east. The opportunity areas have been displayed in relation to fields and plots of land in Map 34.

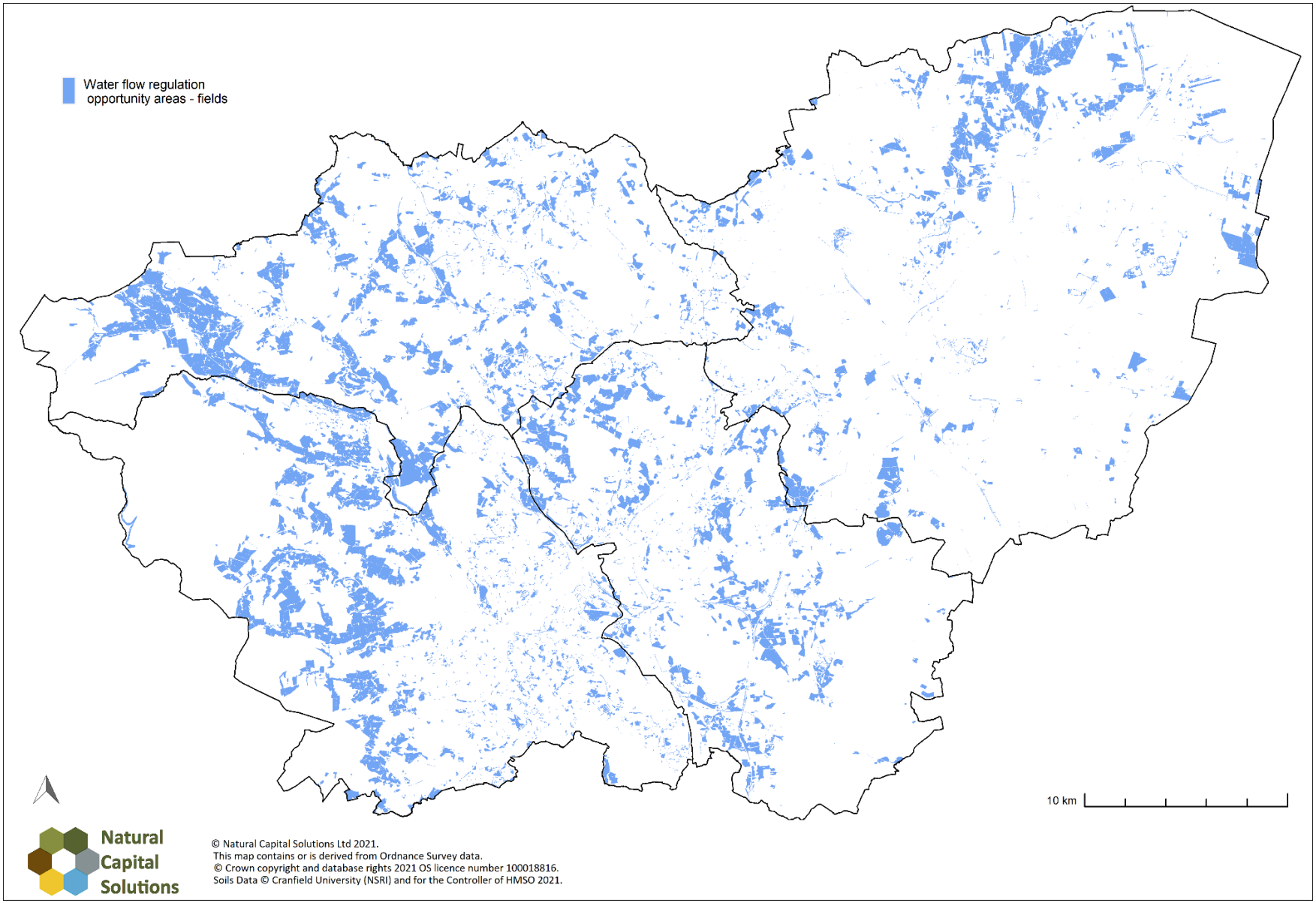
On the western and eastern moorlands, as we mentioned in Section 4.9, the model does not pick up on the differences in the condition/quality of habitats, or the impact of artificial drainage systems. It is evident from the condition assessment map (Map 4) that there is variation in the condition of the blanket and raised bog in South Yorkshire, and they tend to be largely in moderate condition. Restoration of the dry and wet modified bog to active sphagnum bog will increase the capacity of the site to hold water and reduce water flow. This should be seen as a priority opportunity here for reducing water flow, increasing the flood alleviation surface, with benefits to the wider catchment.

Note that some of the worst areas for water flow regulation highlighted in Map 14 relate to buildings and infrastructure, which were not assessed as part of this project, although could be suitable for the installation of green roofs and other types of retrofitted Sustainable Drainage Systems (SuDS).

Map 33 Water flow regulation opportunity areas / opportunities to slow the flow of water across South Yorkshire.



Map 34 Field scale water flow regulation opportunity areas across South Yorkshire.



7.2 Opportunity mapping to reduce soil erosion and improve water quality

Agricultural and diffuse urban pollution have a major impact on water quality in lowland areas in the UK. Hard engineered solutions such as water treatment plants are much less effective in these circumstances than when dealing with point source pollutants, and there is growing interest in catchment sensitive farming and working with natural processes to tackle this issue. These aim to reduce the amount of sediment and pollutants entering the watercourses in the first place by, for example, adjusting farming practices and planting riparian buffer strips. Opportunity mapping focussed on identifying areas at the highest risk of sedimentation and soil erosion based on catchment land use characteristics, distance to a watercourse, slope length and land use erosion risk. It highlights areas across the whole catchment where changing land use would have the greatest impact on reducing soil erosion and hence improving water quality. Note that the focus is on sedimentation risk from agriculture, and built-up areas are not as well accounted for in the existing model.

7.2.1 Method

Constraints were identified and mapped in the same way as before. These areas were erased from the water quality regulation map to leave a map showing water quality regulation in all unconstrained locations. This was then classified into quartiles and the top 25% were extracted into a different map. Therefore, this shows the top 25% of areas of land across the study area where sedimentation risk and soil erosion is currently highest and where there are no constraints on potentially altering land use.

As for water flow, the final opportunity map identifies a large number of very small polygons and long thin polygons that do not coincide with fields. The long thin polygons usually follow watercourses and are useful at identifying locations where riparian buffer stirps would be appropriate. However, there may also be opportunities for whole fields to be converted to other habitats (especially woodland). Therefore, whole fields offering the greatest opportunity to reduce soil erosion were identified. To do this, all the previously identified constraints were removed or erased from the underlying habitat basemap. The degree of intersection between the opportunity map and the underlying fields (polygons) in the basemap was then calculated. Fields where at least 50% of the field overlapped with the opportunity map were selected and exported to a new layer. Finally, very small polygons were deleted so that only fields and plots at least 0.1 ha in size were included in the final map.

7.2.2 Results

Arable farmland scores particularly badly when mapping water quality regulation (Section 4.10) at both a coarse and a fine scale of assessment, and these areas are, therefore, highlighted as the areas with the greatest opportunity to reduce sediment loads and enhance water quality on the opportunity map (Map 35). In addition, distance to watercourses is another key factor. The opportunities to create habitat to improve water quality are, therefore, located predominantly in the east of Barnsley, throughout Rotherham and Doncaster.

Sediment loads, and therefore opportunity areas, can be variable across short distances as it is partly dependent upon slope and distance to a watercourse, which changes rapidly over short spaces, and is why many of the identified areas are linear stretches adjacent watercourses. These areas would be ideal places to install riparian buffer strips, ideally of woodland, but any habitat offering year-round cover would help.

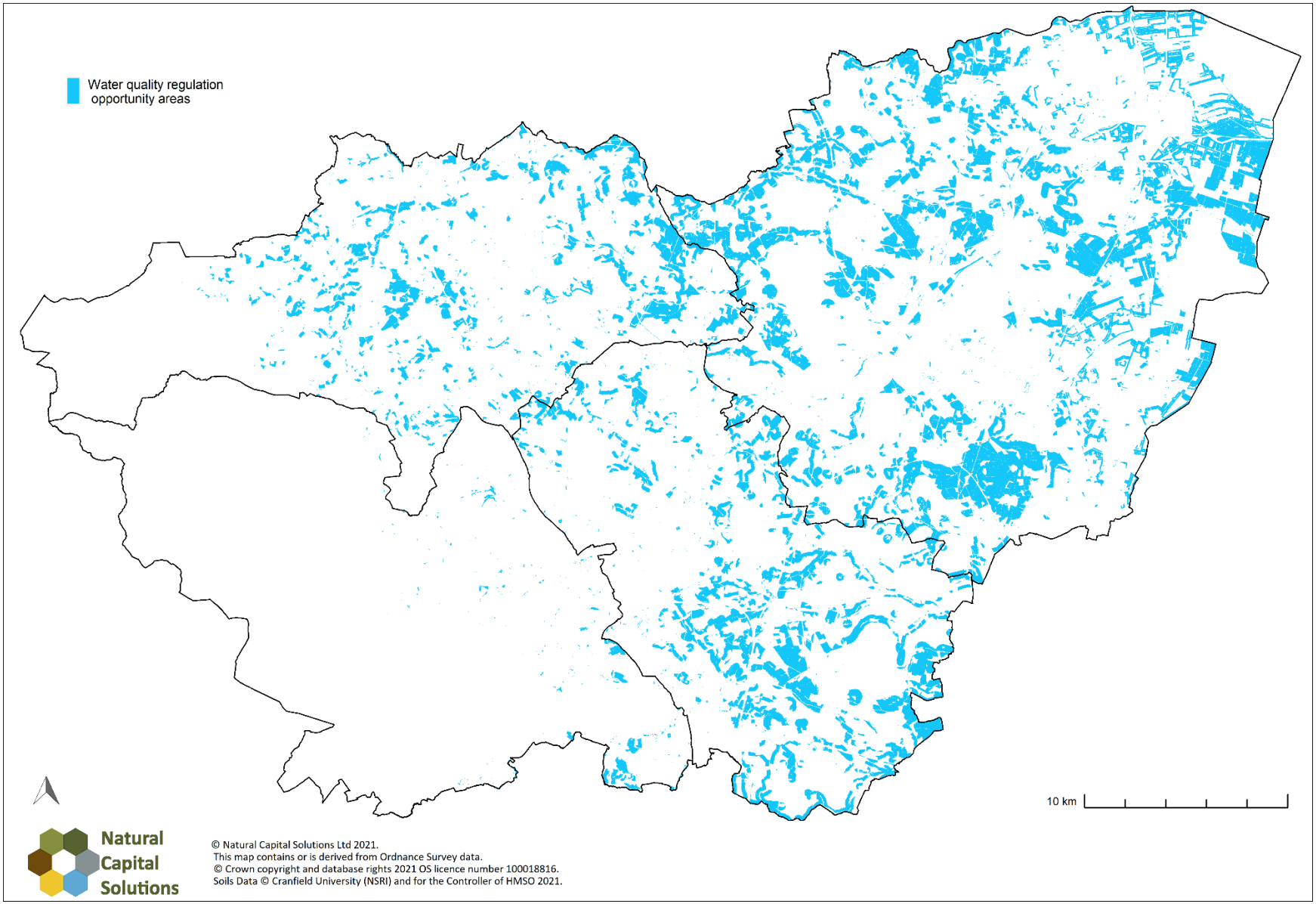
A map of whole fields where opportunities for reducing soil erosion and enhancing water quality would be most effective has been created (Map 36). As noted, however, the areas that would be most effective for

tackling water quality are often zones adjacent to watercourses, and changing land use in riparian buffer strips may be the most effective solution, rather than converting whole fields.

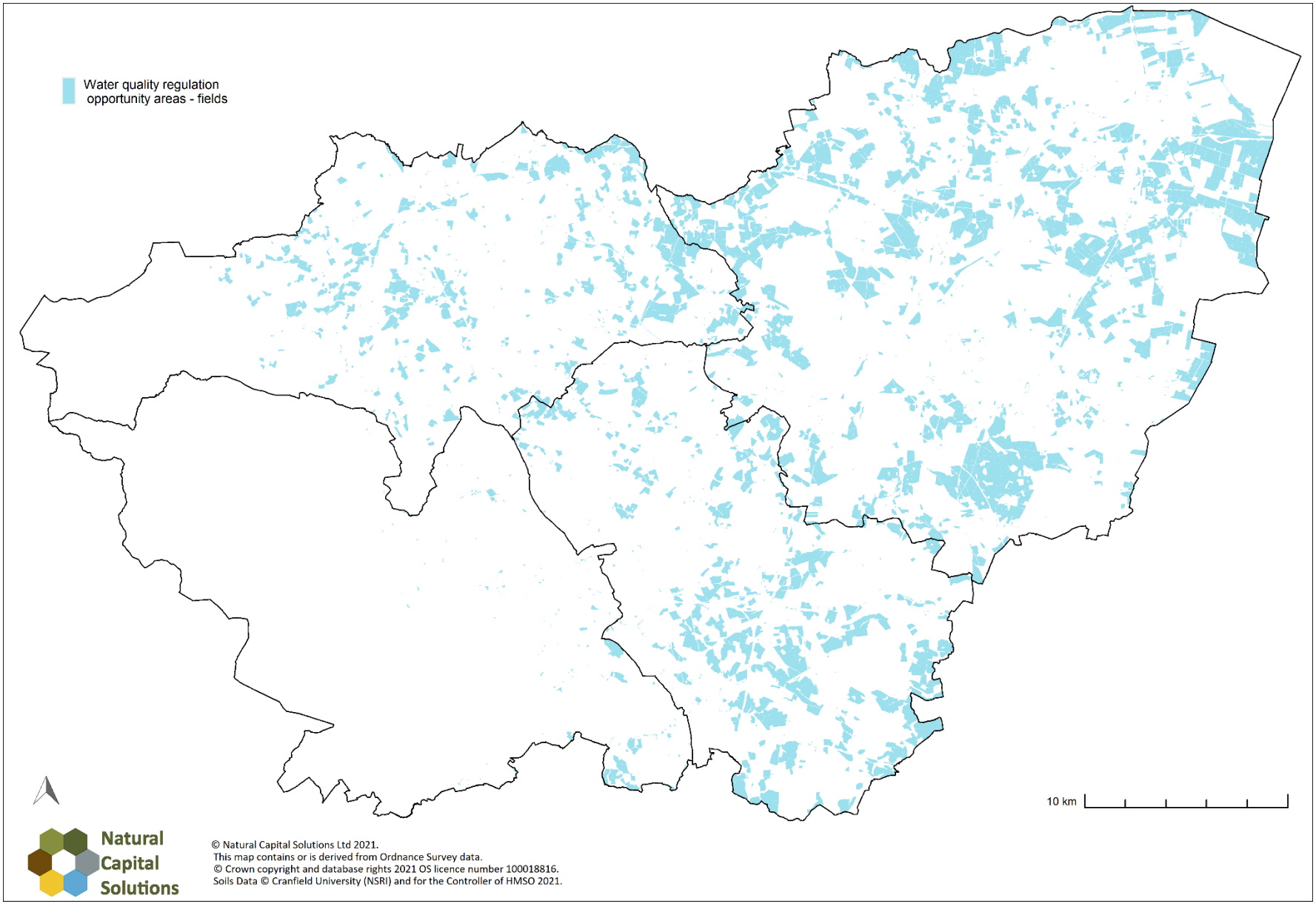
Comparing the opportunity maps for water flow (Map 33) with water quality (Map 35) reveals that opportunities to improve these ecosystem services do not always overlap. This is because the most effective locations for reducing surface water runoff tend to occur on slopes, whereas the most effective areas to enhance water quality are immediately adjacent to watercourses on arable fields. It is likely that habitat features created for one will still enhance the other; it is simply that the top 25% of target areas do not overlap in many locations. Woodland would be the most effective habitat to deliver these opportunities, although semi-natural grasslands would also deliver benefits.

There have been no opportunities identified in the western moors. This is because the constraints process has been set up to ensure that the priority habitats are not selected as opportunities, but also because the main areas of arable land that are the worst for providing this service, do not tend to occur in the western uplands. However, in reality there will be opportunities on the moor for increasing water quality, mainly by reducing erosion. Erosion can be reduced by restoring degraded blanket bog (re-wetting through blocking grips) as discussed for water flow opportunities, reducing grazing pressure and rotational burning. There will also be opportunities for increasing water quality in the raised bog areas in the east of the region, particularly by focusing on restoring areas of bare peat, especially on Hatfield Moor.

Map 35 Water quality regulation opportunity areas across South Yorkshire.



Map 36 Field scale water quality regulation opportunity areas across South Yorkshire.



7.3 Opportunity mapping to ameliorate air pollution

When mapping air pollution regulation a slightly different approach was used compared to water flow and water quality. Air pollution is often highly localised, and vegetation is most effective at mitigating pollutants when planted close to pollution sources. Opportunities to ameliorate air pollution were therefore focussed around areas with the greatest demand. As described in Section 4.4, demand is assumed to be highest in areas where there are likely to be high air pollution levels and where there are lots of people who could benefit from the air quality regulation service. The opportunity maps, therefore, highlight areas that currently have no trees but where it would be most beneficial to plant them.

7.3.1 Method

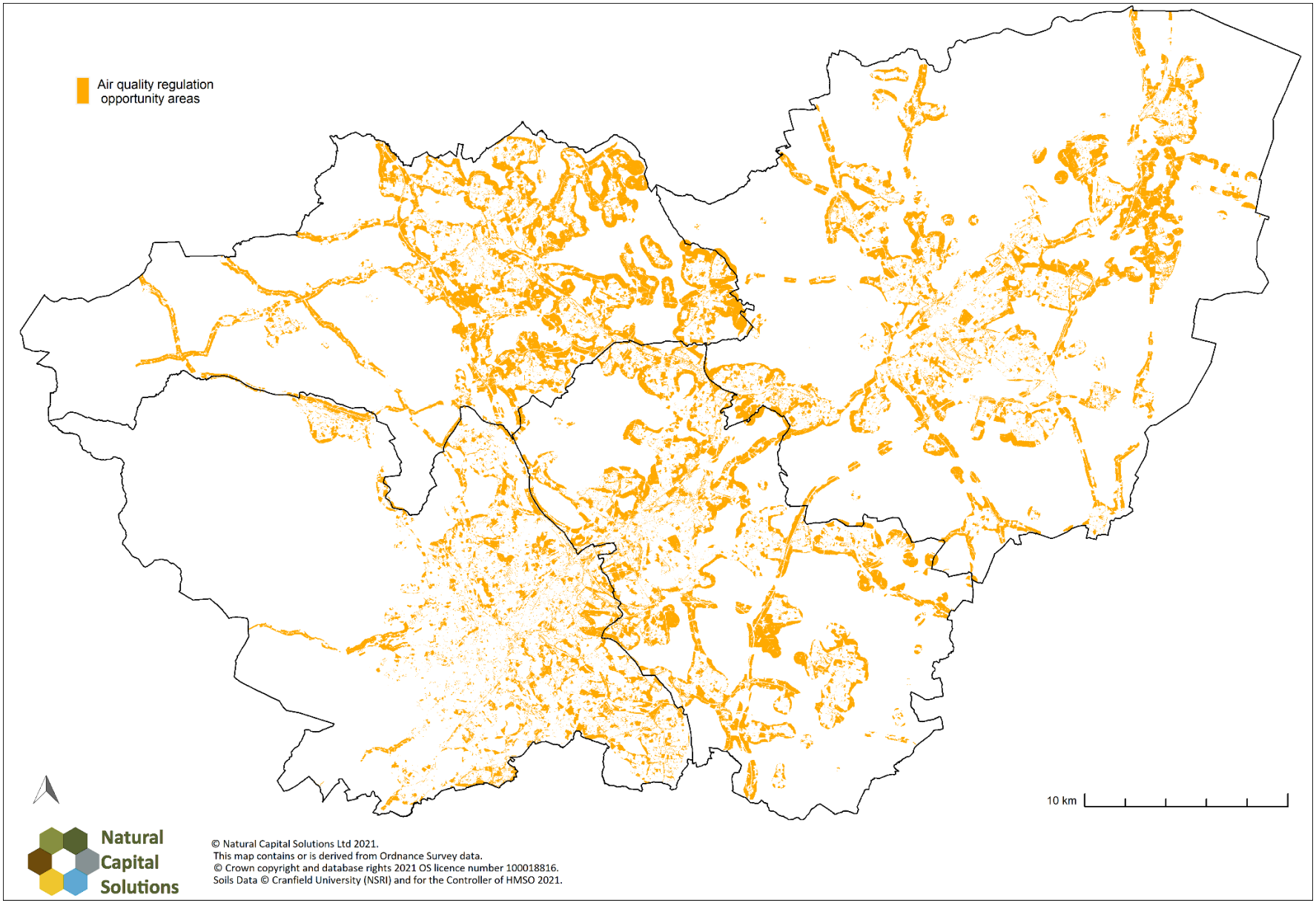
The constraints identified previously were erased from the air quality regulation demand map to leave a map showing demand in all unconstrained locations. As before, this was then classified into quartiles and the top quartile was extracted into a different map. This map, therefore, highlights the top 25% of areas of land across the study area where demand for air quality amelioration is greatest and where there are no constraints on potentially altering land use. As previously, it would also be possible to produce maps showing the top 10% or 5% (or any other value), to focus on the worst pollution hotspots with the greatest demand.

To match the other ecosystem services, the opportunity map was used to identify whole plots and fields in the basemap where the degree of intersection was at least 50% and a new layer was created. On this occasion very small polygons were not deleted, as it may be possible to plant an individual tree in very small plots of land.

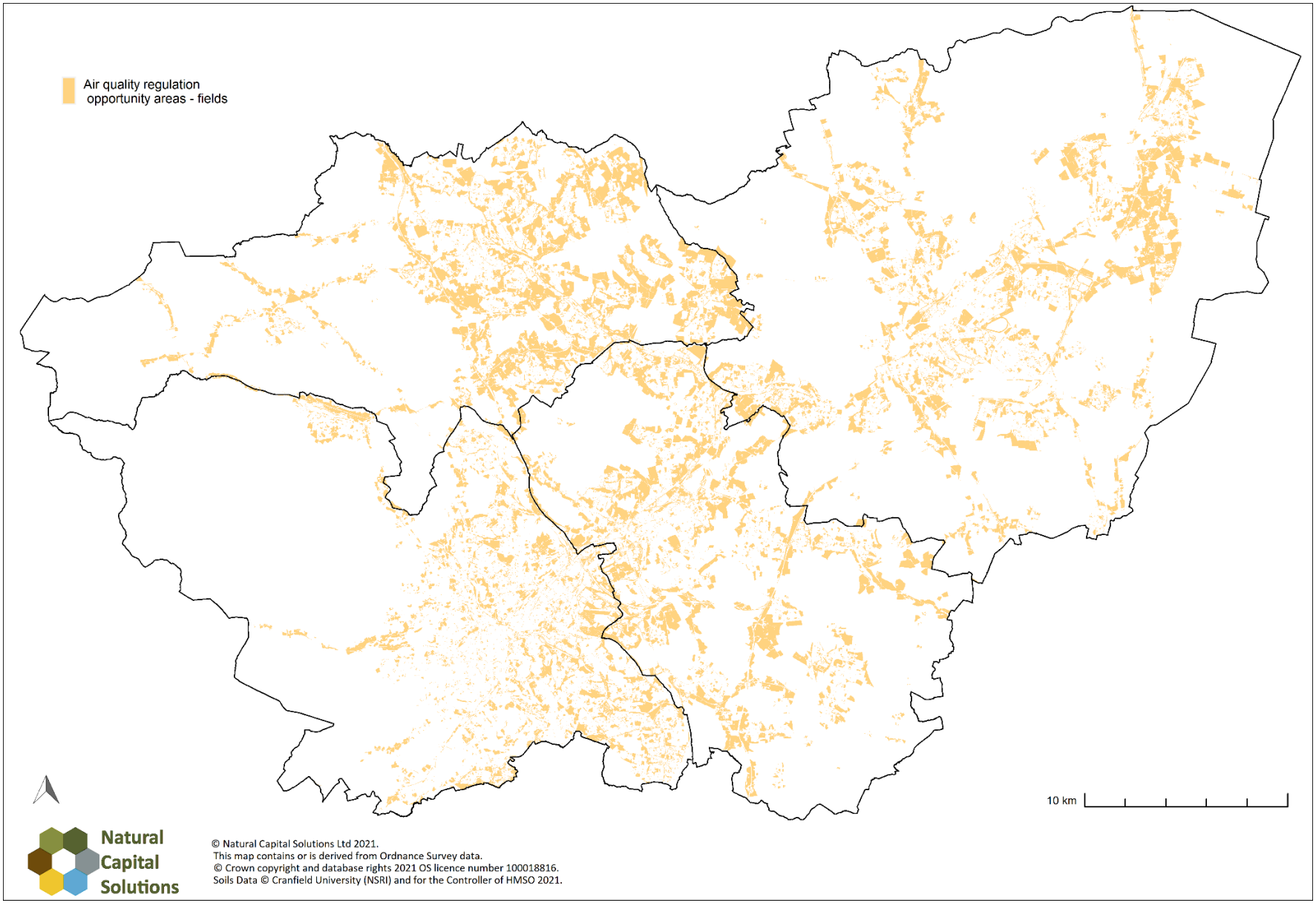
7.3.2 Results

As described previously, demand for air quality regulation (Map 9) is highest in urban areas, as these have both higher air pollution levels and higher populations that would benefit from better air quality, and also along the main road networks. Inevitably, when the focus on air quality regulation is in the towns, large areas are constrained as it would not be possible to plant trees or other green infrastructure. However, unconstrained areas do remain, and these are highlighted on the opportunity map (Map 37). Opportunity areas along the main roads were also highlighted, for example on the A-roads leading into the main urban centres of Sheffield, Barnsley, Rotherham and Doncaster, the roads that link these centres and the motorways that run through the region, e.g. the M1, M18 and the A1(M). Whole plots were also identified (Map 38), although on this occasion this was similar to the previous map. These locations potentially provide the opportunity to plant trees that could trap air pollution in areas where there is the greatest need for this service.

Map 37 Air pollution regulation opportunity areas across South Yorkshire.



Map 38 Field scale air pollution regulation opportunity areas across South Yorkshire.



7.4 Opportunity mapping to reduce noise pollution

Opportunities to reduce noise pollution were mapped in a very similar way to the air quality regulation opportunity mapping just described. This was focussed around areas with greatest demand for noise regulation, as described in Section 4.6. Dense plantings of trees and scrub are the habitat type that could potentially reduce noise pollution; the opportunity maps therefore highlight areas that currently have no trees, but where it would be most beneficial to plant them.

7.4.1 Method

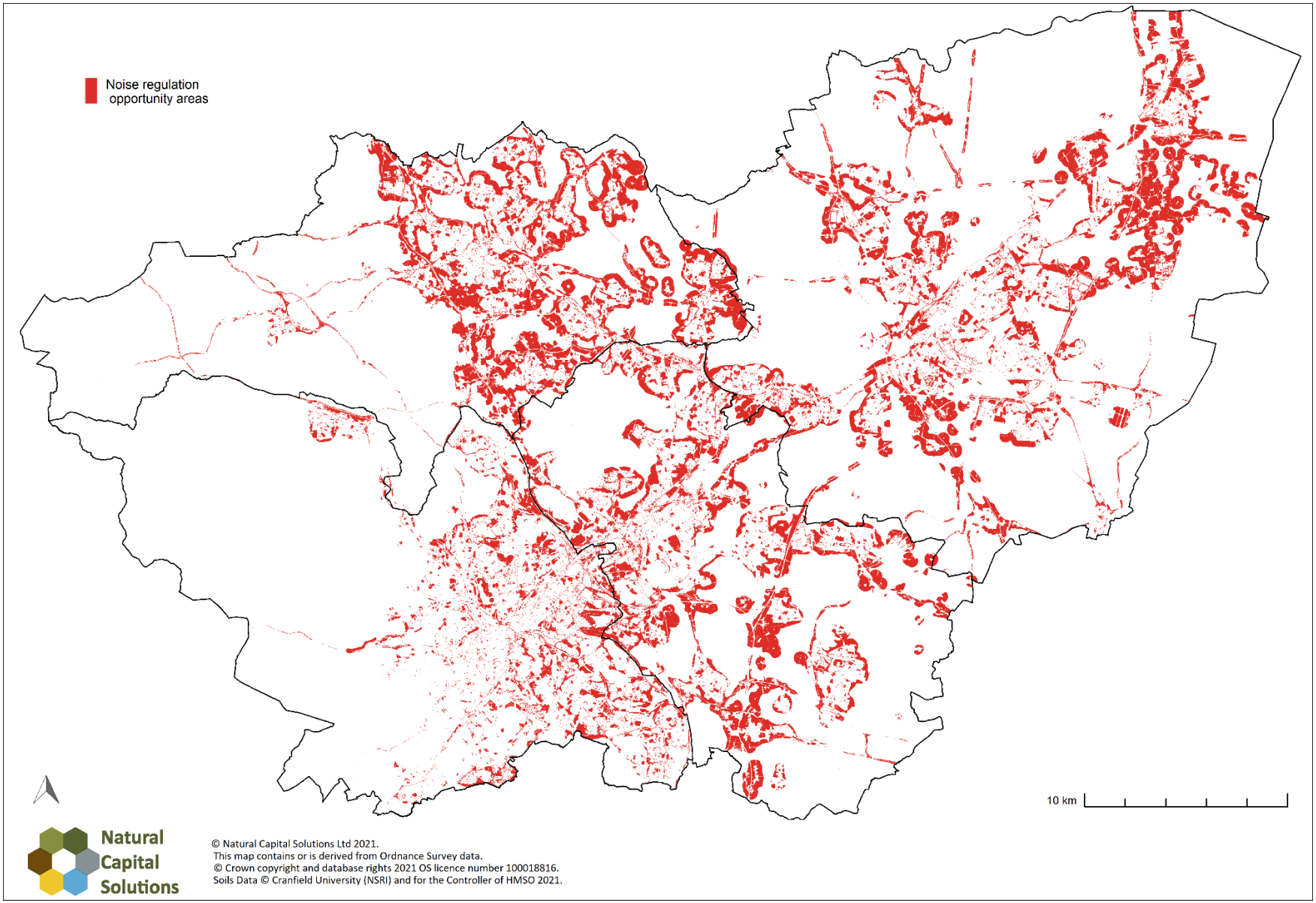
The constraints identified previously were erased from the noise regulation demand map, to leave a map showing demand in all unconstrained locations. As before, this was then classified into quartiles and the top quartile was extracted into a different map. This map therefore highlights the top 25% of areas of land across the study area where demand for noise regulation is greatest and where there are no constraints on potentially altering land use.

As before, the opportunity map was used to identify whole plots and fields in the basemap where the degree of intersection was at least 50% and a new layer was created. As individual trees or very small groups of trees are largely ineffective at blocking noise, polygons less than 200m^2 were deleted.

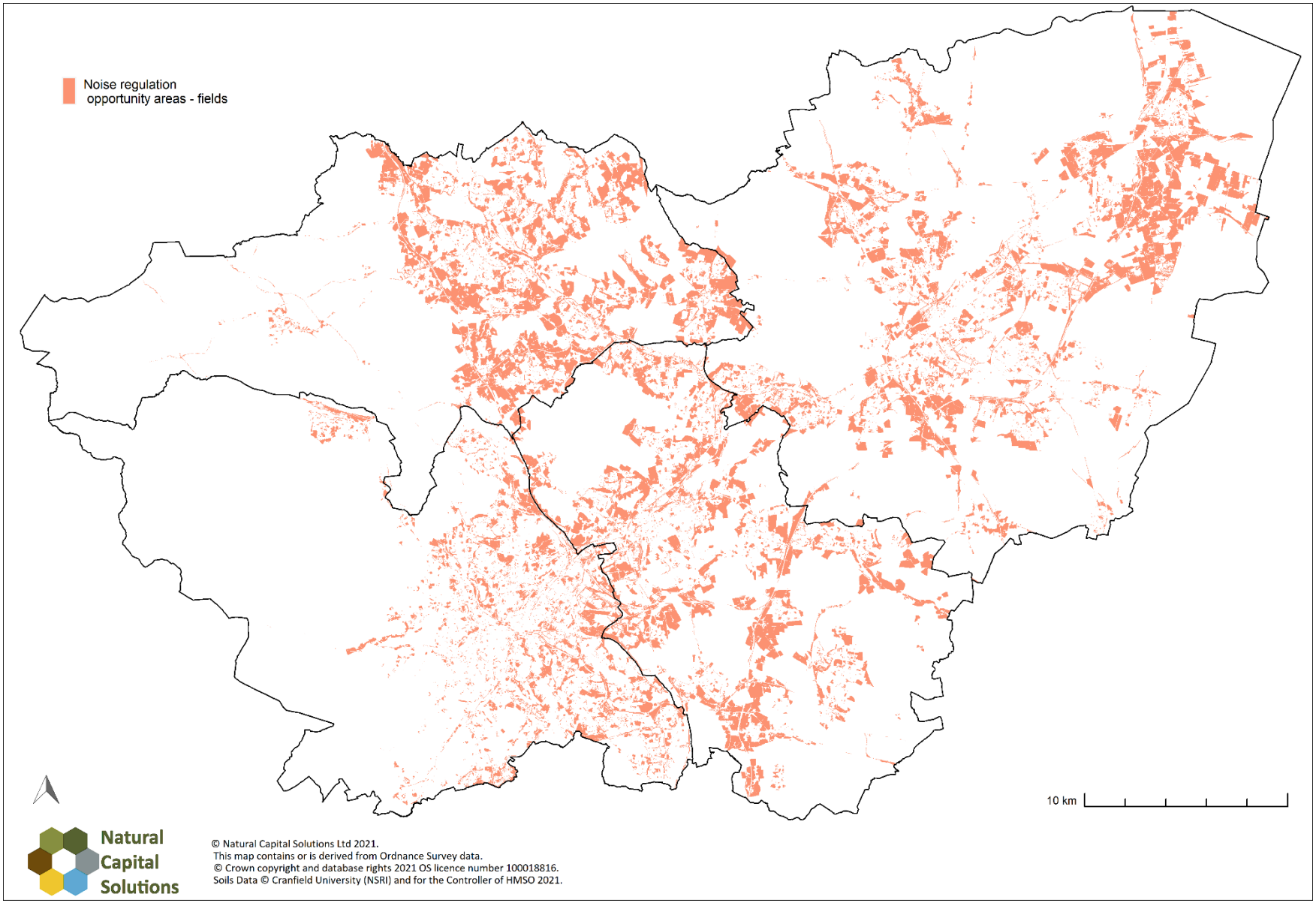
7.4.2 Results

Similarly to air quality regulation, demand for noise regulation (Map 11) is highest in the main urban centres and adjacent to the road and rail network, as these have both higher noise pollution levels and higher populations that would benefit from noise screening. Given the large number of constraints in urban centres, the majority of the opportunity areas identified fall on the outer fringes of urban areas and adjacent to the road network, although a number of urban centre locations have also been identified (Map 39). Whole plots were also identified and shown in Map 40. These locations potentially provide the opportunity to plant trees and scrub belts that could help to block and screen noise pollution.

Map 39 Noise regulation opportunity areas across South Yorkshire.



Map 40 Field scale noise regulation opportunity areas across South Yorkshire.



7.5 Opportunity mapping to regulate local climate (reduce urban heat)

Opportunities to regulate local climate were mapped using the same approach as for air quality regulation and noise regulation. This, therefore, focuses on areas of highest demand, where there is currently low capacity. Using the natural environment to regulate local climate can best be achieved by either plating trees / woodland, or creating waterbodies such as ponds and lakes. The larger the area of habitat created, the greater the effect that it will have on urban temperatures, although even individual trees will have a small positive impact.

7.5.1 Method

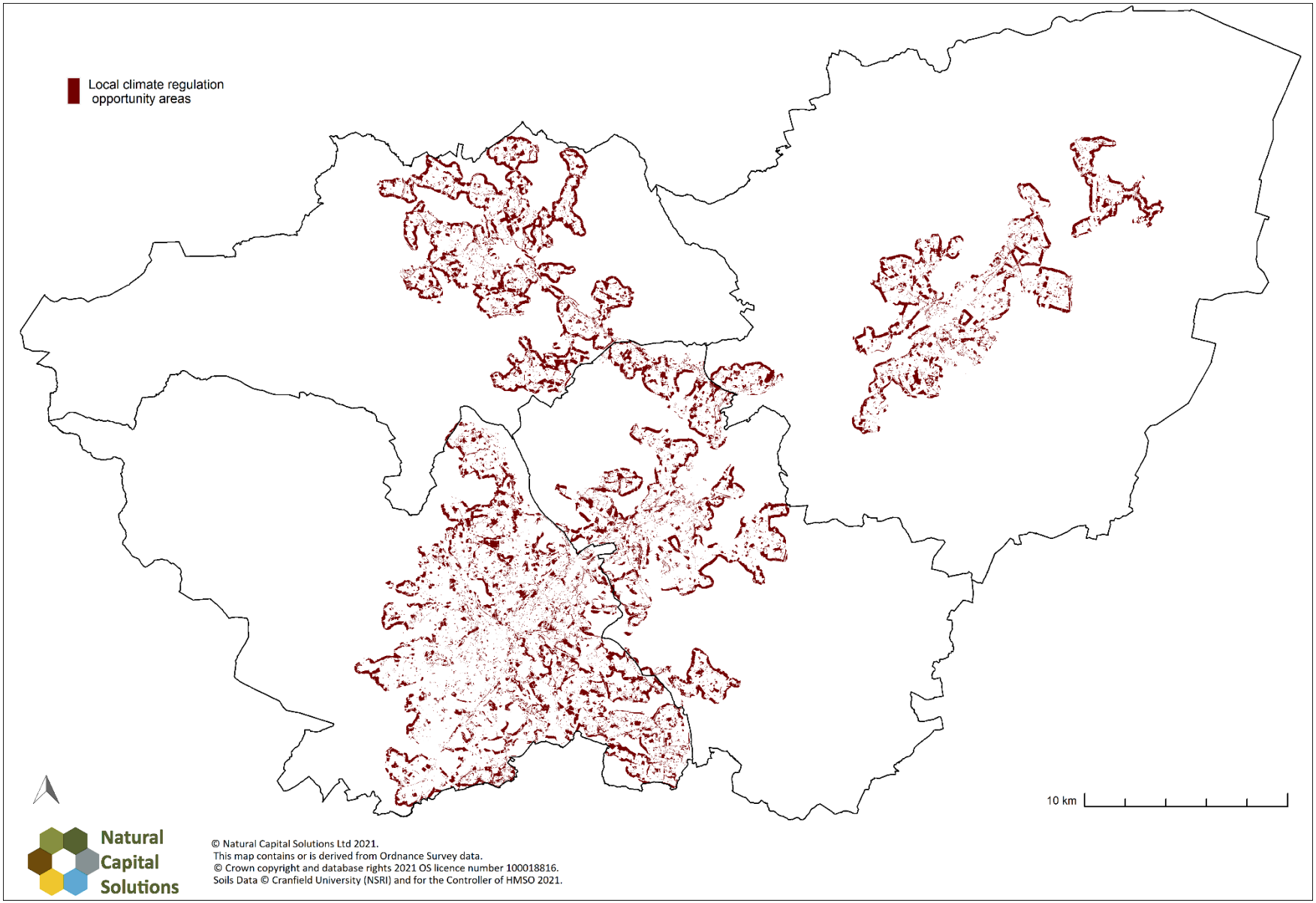
The constraints identified previously were erased from the local climate regulation demand map (Section 4.8), to leave a map showing demand in all unconstrained locations. This was then classified into quartiles and the top quartile was extracted into a different map. This map therefore highlights the top 25% of areas of land across the study area where demand for local climate regulation is greatest and where there are no constraints on potentially altering land use.

As before, the opportunity map was used to identify whole plots and fields in the basemap where the degree of intersection was at least 50% and a new layer was created. All polygons were retained, as even planting individual trees could be beneficial, although will have a smaller effect.

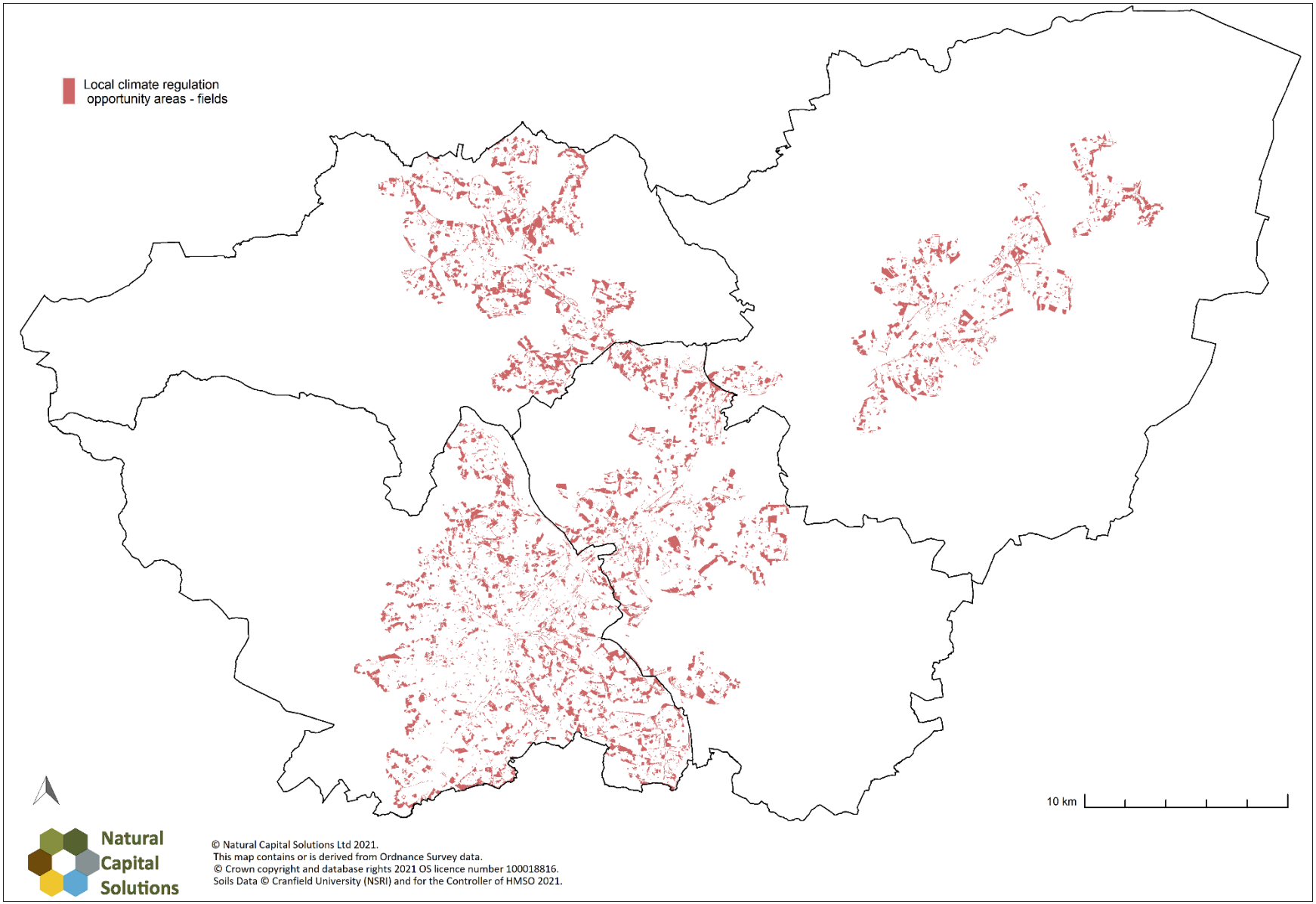
7.5.2 Results

Demand for local climate regulation (Map 13) is highest in the main urban centres, and the size of the urban heat island effect increases with size of urban area and amount of sealed surface. As with air pollution regulation and noise regulation, the majority of the opportunity areas identified fall on the outer fringes of urban areas, due to the large number of constraints in urban centres, although some of the urban centre locations have also been identified (Map 41). As for the other services, whole plots were also identified and shown in Map 42. These locations potentially provide the opportunity to plant trees and woodland or to create water features that could help to reduce the urban heat island effect.

Map 41 Local climate regulation opportunity areas across South Yorkshire.



Map 42 Field scale local climate regulation opportunity areas across South Yorkshire.



7.6 Opportunity mapping to enhance recreation in the natural environment

There are many benefits of enhancing public access to natural greenspaces and the key features that maximise benefits are proximity to where people live and the naturalness of the habitats. Here, opportunities to provide accessible natural greenspace were mapped, first based on creating new habitats at new sites, based purely on demand, and then by also considering opening up access to existing sites, by taking into account the naturalness of existing habitats.

7.6.1 Method

1. *Identifying constraints*

It may be possible to create accessible natural greenspace simply by opening up public access to existing areas, rather than changing habitats. Therefore, many of the constraints that would need to be taken into account when planting new habitats for water flow, water quality or air quality regulation, do not need to be taken into account. For example, opportunities do not need to be constrained by existing high quality habitats and historic sites, although these areas would need to be carefully considered on a case-by-case basis to avoid any damage to existing features. The only constraints taken into account were, therefore, the land use constraints identified previously – buildings, infrastructure, gardens and water. It would be possible to include water features as part of larger sites, but that was not investigated here. A map was created showing all the land use constraints on one map.

In addition to these constraints, a map was created from the basemap showing all areas of green infrastructure currently existing across South Yorkshire.

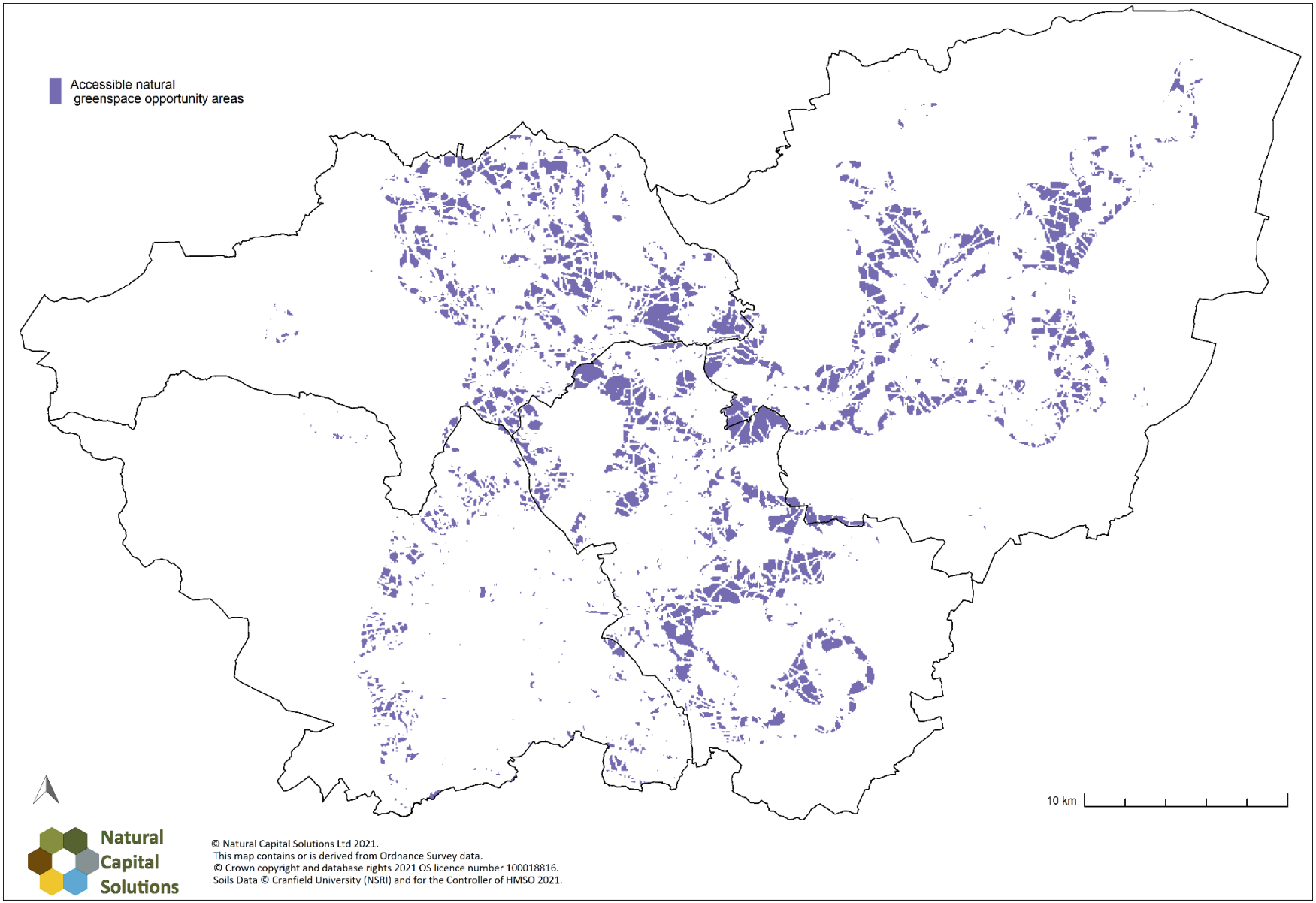
2. *Identifying opportunity areas*

The land use constraints identified above were erased from the accessible natural greenspace demand map, along with the existing areas of green infrastructure, to leave a map showing demand in all unconstrained locations where there is currently no green infrastructure. As before, this was then classified into quartiles and the top quartile were extracted into a different map. This map highlights the top 25% of areas of land across the study area where demand for accessible natural greenspace is greatest and where there are no constraints on potentially creating this. As before, the opportunity map was used to identify whole plots and fields in the basemap where the degree of intersection was at least 50%.

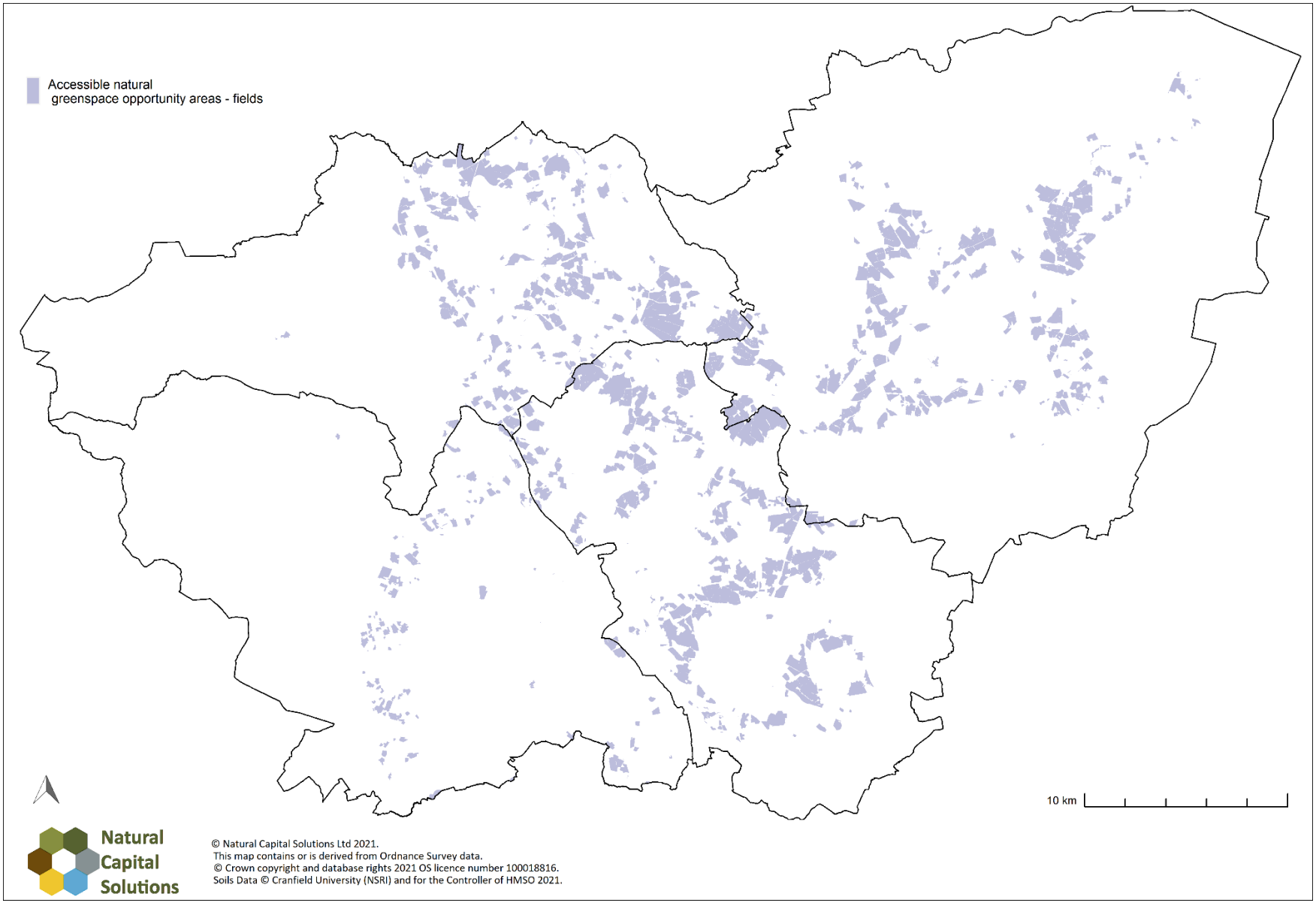
7.6.2 Results

Demand for accessible natural greenspace was described in Section 4.13 and is strongly focussed around the urban areas in the study area. Therefore, it is perhaps unsurprising that the majority of the opportunity areas identified (Maps 43 and 44) are centred around the major and minor towns across the study area. As opportunities for new greenspaces are usually highly constrained within towns, opportunity areas tend to form a ring around the edges of these towns. These are also often locations that have been targeted for sustainable urban extensions and other development, so it is important that planners and developers take into account the strong demand for greenspace at these sites from both the new developments and from the existing population.

Map 43 Accessible natural greenspace opportunity areas across South Yorkshire.



Map 44 Field scale accessible natural greenspace opportunity areas across South Yorkshire.



8. Combined opportunities

In addition to mapping the individual opportunities presented in Sections 7, it is also possible to examine multiple opportunities, which are areas where new habitat can be created that provides opportunities to enhance more than one of the services mapped previously. This is assessed by overlaying each individual opportunity map already created to determine the degree of overlap, examining each of the main habitat types in turn. This is focussing on the top 25% of opportunity areas for each ecosystem service, so is only considering the higher levels of service provision. In reality, creating any new habitat for one ecosystem service is likely to provide benefits for other services, even if this does not fall within the top 25%.

We have combined maps restricting combined opportunities to **areas that present a biodiversity opportunity. Hence opportunities are only included for areas that are ecologically connected to existing habitats.** This follows the ethos of environmental net gain being focused on biodiversity net gain first, and then natural capital net gain as an additional feature. Note that it is possible to map treating biodiversity and all opportunities equally with this data, but restricting these to the areas that present a biodiversity opportunity was more appropriate given this was a process towards the creation of a South Yorkshire nature recovery network map.

It would also be possible to create maps with different weightings for different services (which was the topic of discussion in the workshop associated with this project. For example, if stakeholders considered water flow and access to nature as being the most important local priorities, then these opportunities could be given greater weighting. We demonstrated this approach in the workshop associated with this project (see workshop report in Annex 2). The map layers produced can be layered up and combined with other pre-existing data, for example, climate vulnerability data, flood risk areas, Environment Agency riparian woodland opportunities and socio-economic data.

8.1 Combined opportunities for new broadleaved and mixed woodland

Opportunities to deliver enhancement to water flow, water quality, air quality, noise, and local climate regulation (Sections 7.1-7.5), can all be best achieved through planting trees and woodland. Woodland is also one of the best habitats for creating high quality accessible natural greenspace (Section 7.6). Therefore, the opportunity maps for all of these services were overlain with the opportunity map for biodiversity enhancement through the creation of broadleaved and mixed woodland (Map 24). Note that creating woodland habitats will also deliver benefits in the form of **carbon sequestration**. These have not been mapped separately as location is not especially important for carbon sequestration (although there will be some difference in the growth rate of trees in different places). Hence all of the locations identified in the maps below would also deliver this service.

The results are shown on Map 45, where all the ecosystem service opportunities are constrained to areas that present biodiversity opportunities. The maps highlight the number of different opportunity areas that overlap (out of a maximum of seven – all of the 6 ecosystem service opportunities listed in Section 7, and the biodiversity opportunities) for each pixel across the study area. The results show multiple opportunities even when restricting them to the woodland opportunity areas only. The results show that while there are large areas that only offer one opportunity, there are many areas that offer multiple opportunities. Locations at the edges of the urban centres are most often highlighted as being able to

deliver multiple services. If the aim of woodland creation was to maximise the delivery of as many ecosystem services as possible, then it is these locations that would deliver the greatest benefits to society.

8.2 Combined opportunities for new semi-natural grassland

Creating semi-natural grassland will not be as effective at reducing water flow or enhancing water quality as planting woodland, but it is likely to be significantly better than arable and is likely to enhance the provision of these services. It will not, however, be very effective at ameliorating air pollution, reducing noise pollution, or regulating local climate (although better than sealed surfaces for each of these services). Hence combined opportunities were examined for four out of the seven services: water flow, water quality, accessible natural greenspace, and biodiversity enhancement, while air quality, noise, and local climate regulation were not included.

Combined opportunities for new semi-natural grasslands are not quite as extensive as for woodland, but are spread across the whole county (Map 46). There area in the west of the region (west Sheffield and Barnsley) holds the most opportunities. Similarly to woodland, there are many areas that support multiple opportunities, with the highest number of benefits being in sites close to the urban centres.

8.3 Combined opportunities for new heathland

As with the grasslands, opportunities for creating new heathland were examined for four out of the seven services: water flow, water quality, accessible natural greenspace, and biodiversity enhancement, while air quality, noise, and local climate regulation were not included. Again heathland is likely to reduce water flow and enhance water quality better than arable so is likely to enhance the provision of these services.

The location of opportunities for this habitat type is more restricted than for the previous two (Map 47), with opportunities for between one and four services being delivered across the west of South Yorkshire, in the central area in the heathland in the east of Barnsley, and in the east of Doncaster.

8.4 Combined opportunities for bog habitats

Opportunities for new bog habitats were mapped in the same way as for heathland, including four out of the seven services: water flow, water quality, accessible natural greenspace, and biodiversity enhancement. Bog habitats are particularly important for reducing water flow.

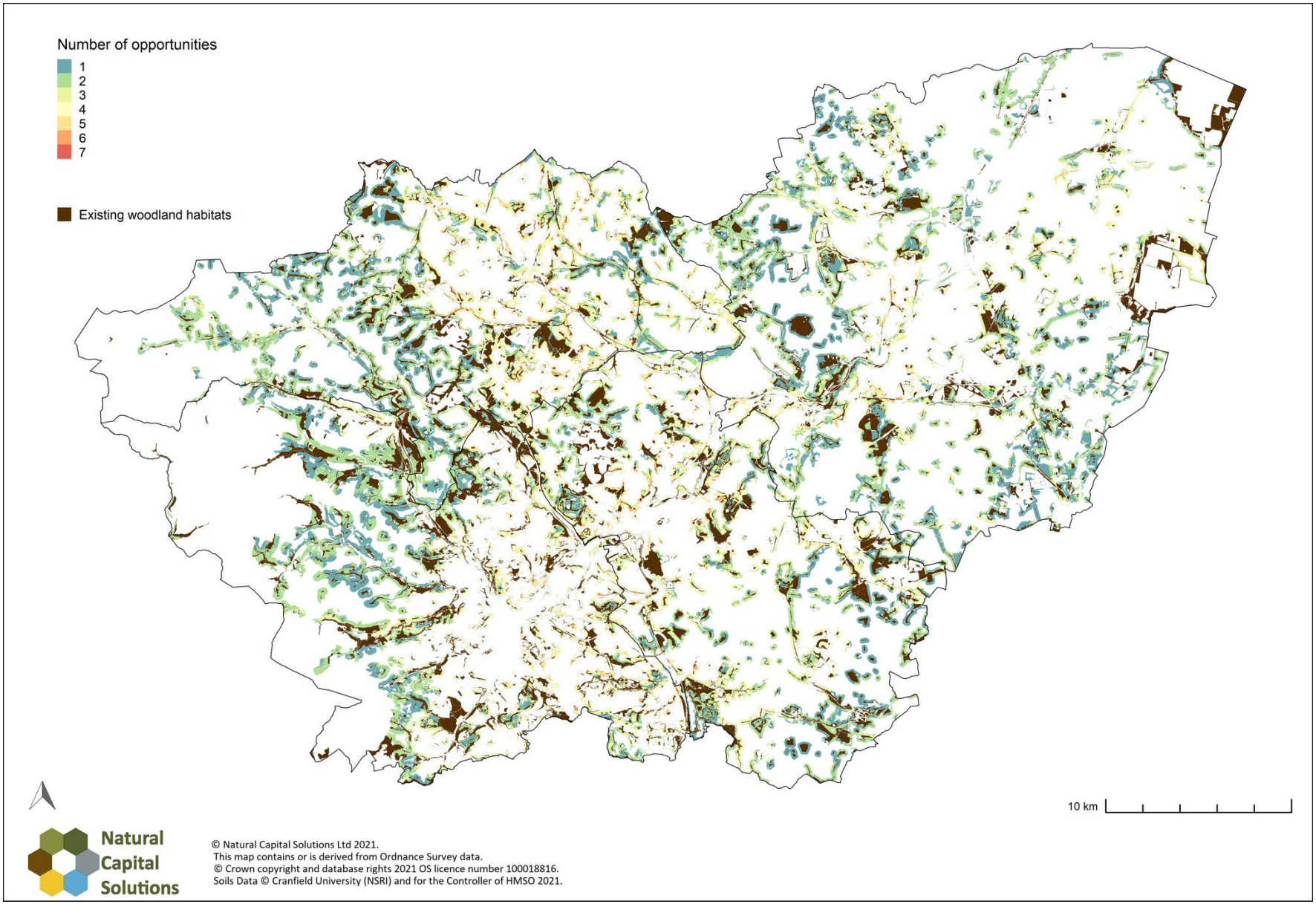
The location of opportunities for this habitat type is more restricted than for heathland (Map 48 below), and opportunities are few overall. Nevertheless they occur mainly in the western moors and in the east of Doncaster, with opportunities for mainly 2 ecosystem services but 3 or 4 in isolated places around Hatfield Moor in the east.

8.5 Combined opportunities for new wet grassland and wetlands

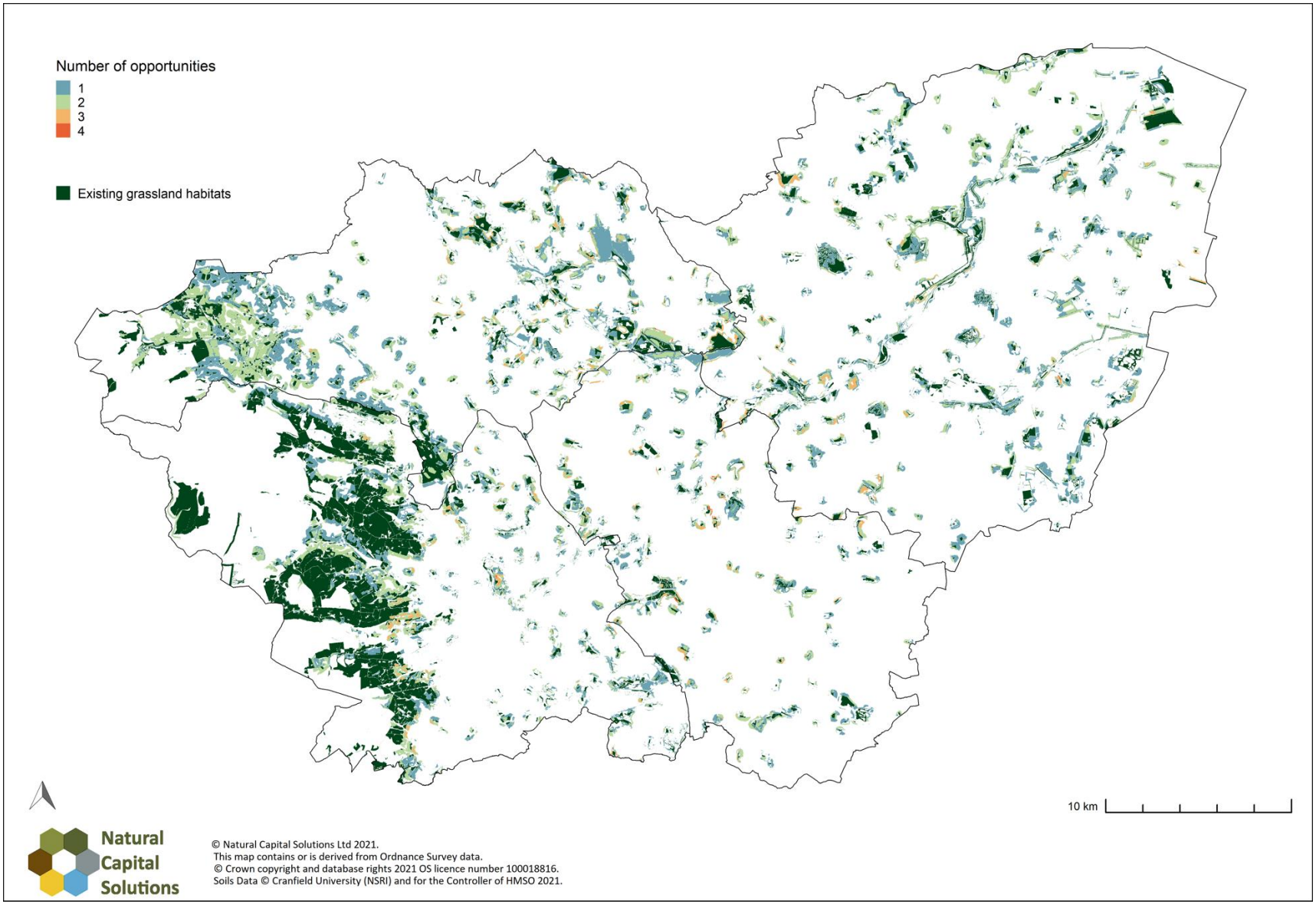
Opportunities for new wet grassland and wetlands were mapped in the same way as the heathland and bog habitats, except that all opportunities were restricted to areas within the indicative floodplain. Thus four out of the seven services were included, with air quality, noise, and local climate excluded. Wetland habitats can be effective at reducing water flow and enhancing water quality.

The location of opportunities providing multiple benefits (Map 49 below) are located on floodplains on the River Don, with the delivery of 3 or 4 ecosystem services near Doncaster town, and around the border with Rotherham, and on the River Torne as it runs near to the south-east of urban Doncaster. There are also multiple benefits on the River Dearne just to the north and the east of urban Barnsley.

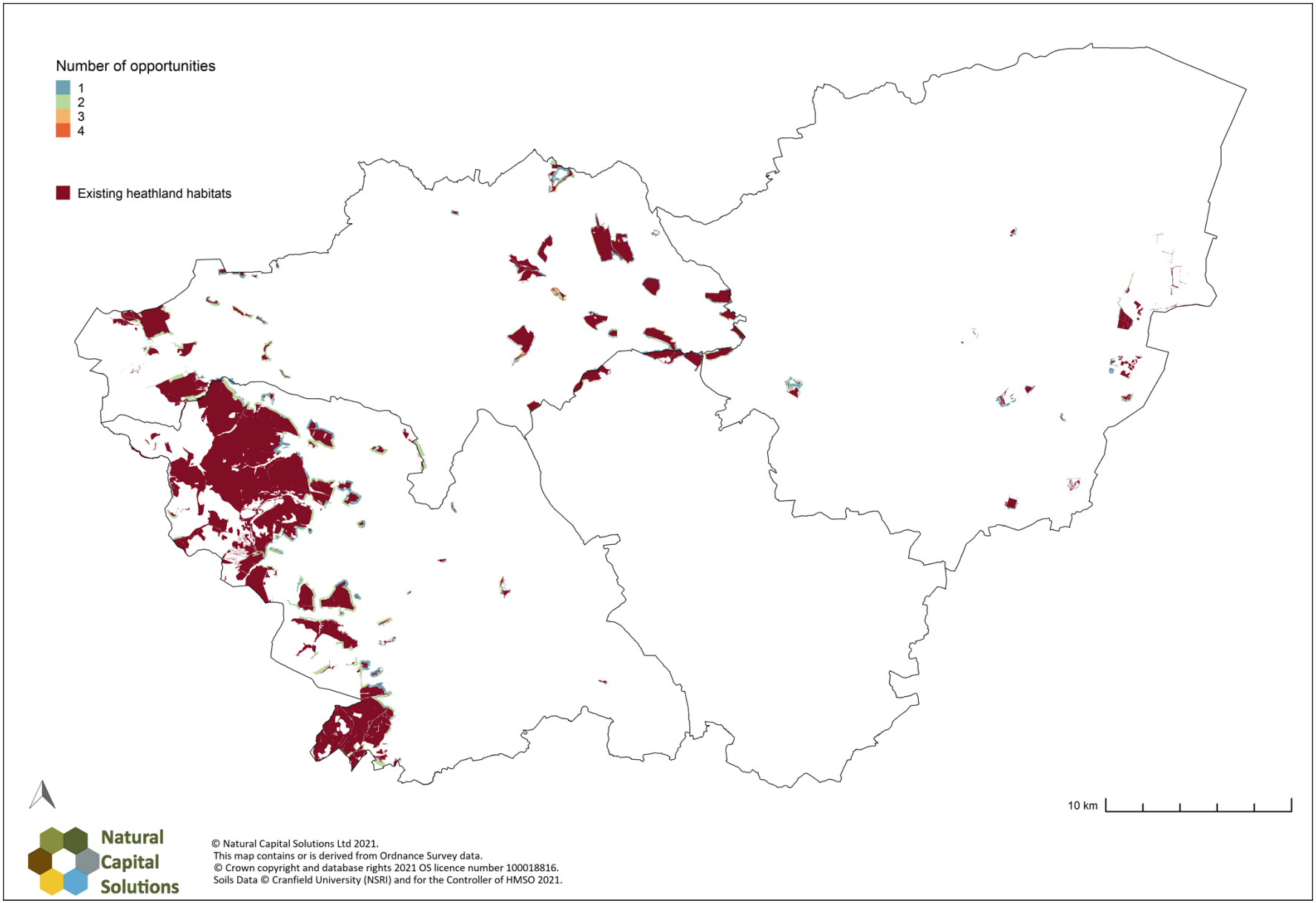
Map 45 Combined opportunities for new woodland across South Yorkshire, restricted to areas that are ecologically connected to existing woodlands.



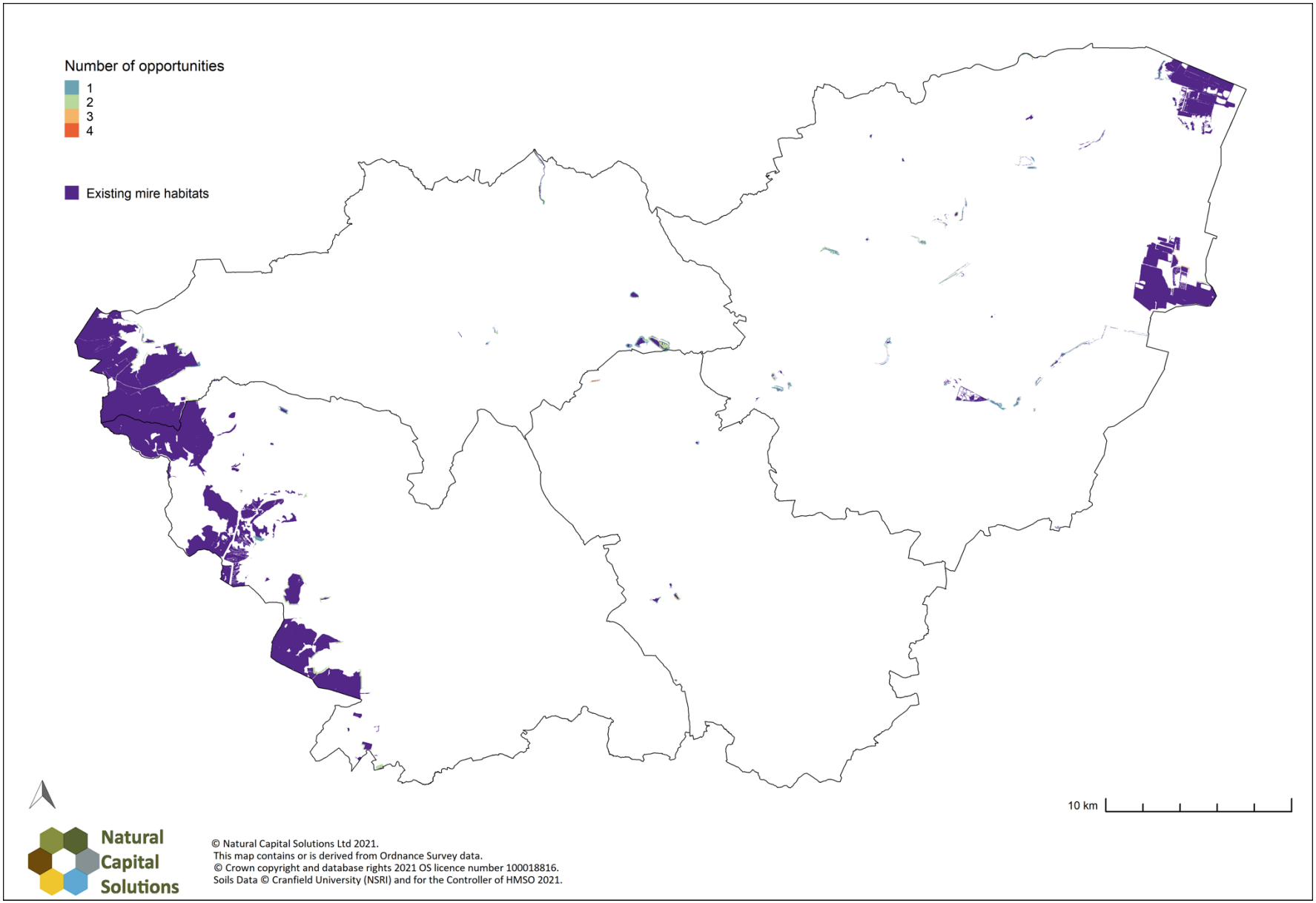
Map 46 Combined opportunities for new semi-natural grasslands across South Yorkshire, restricted to areas that are ecologically connected to existing grasslands.



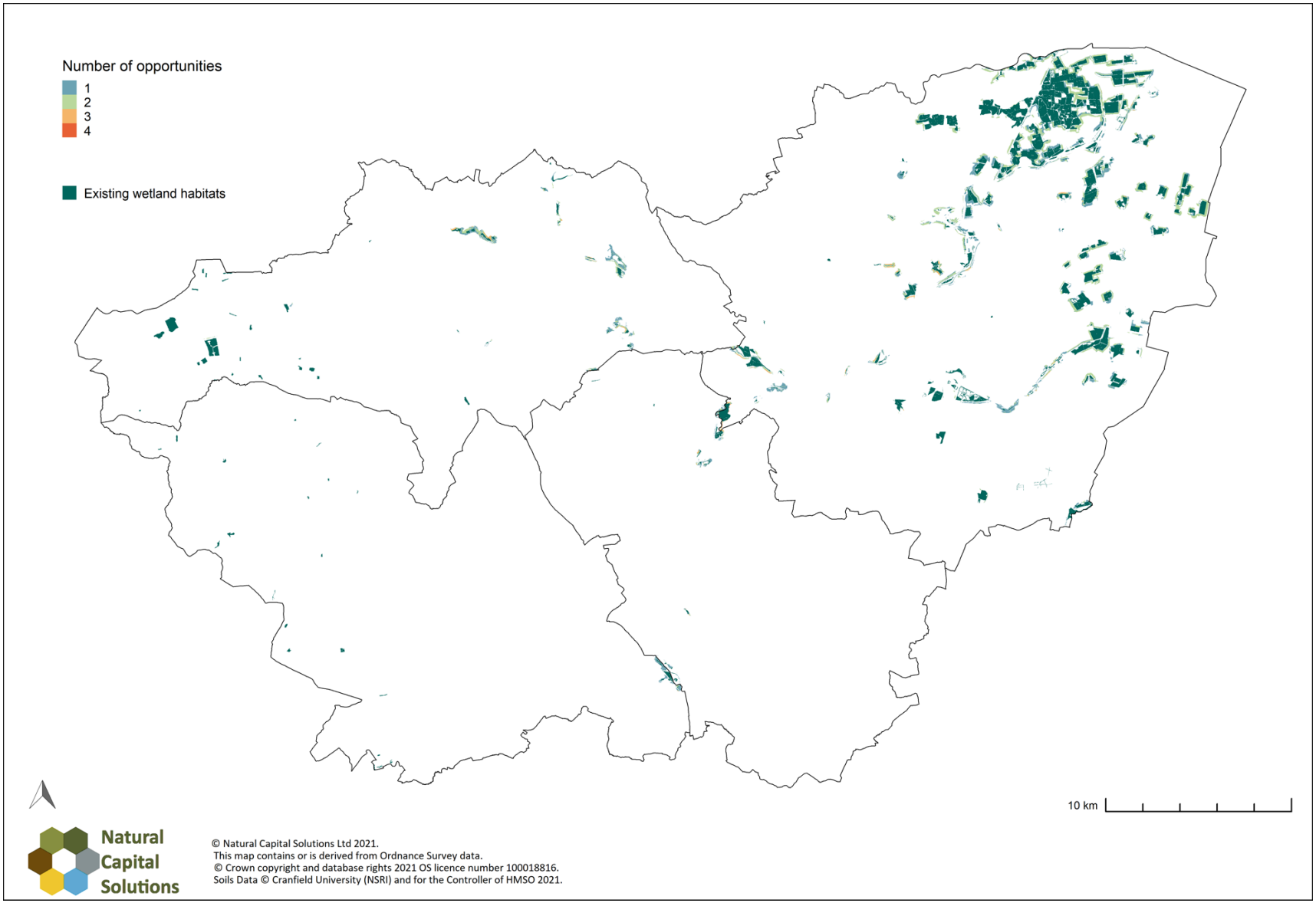
Map 47 Combined opportunities for new heathlands across South Yorkshire, restricted to areas that are ecologically connected to existing heathlands.



Map 48 Combined opportunities for new bog habitats across South Yorkshire, restricted to areas that are ecologically connected to existing bog habitat.



Map 49 Combined opportunities for new wet grasslands and wetlands across South Yorkshire, restricted to areas that are ecologically connected to existing wetlands.



9. Nature recovery network for South Yorkshire

The Environment Bill sets out a requirement for a Local Nature Recovery Strategy that delivers nature recovery networks. The following definition of a nature recovery network is taken from the Natural England publication "Nature networks: a summary for practitioners"[30]:

"An ecological network can be understood as a number of core, well connected, high quality areas of well-functioning ecosystems, together with those parts of the intervening landscape that are 'wildlife-friendly' and which, collectively, allow wildlife to thrive."

"A nature network should also enhance natural beauty and conserve geodiversity and opportunities should be taken to deliver benefits for people, such as flood alleviation, recreational opportunities and climate change adaptation and mitigation."

Beyond this there are no guidelines as yet on requirements for a nature recovery network.

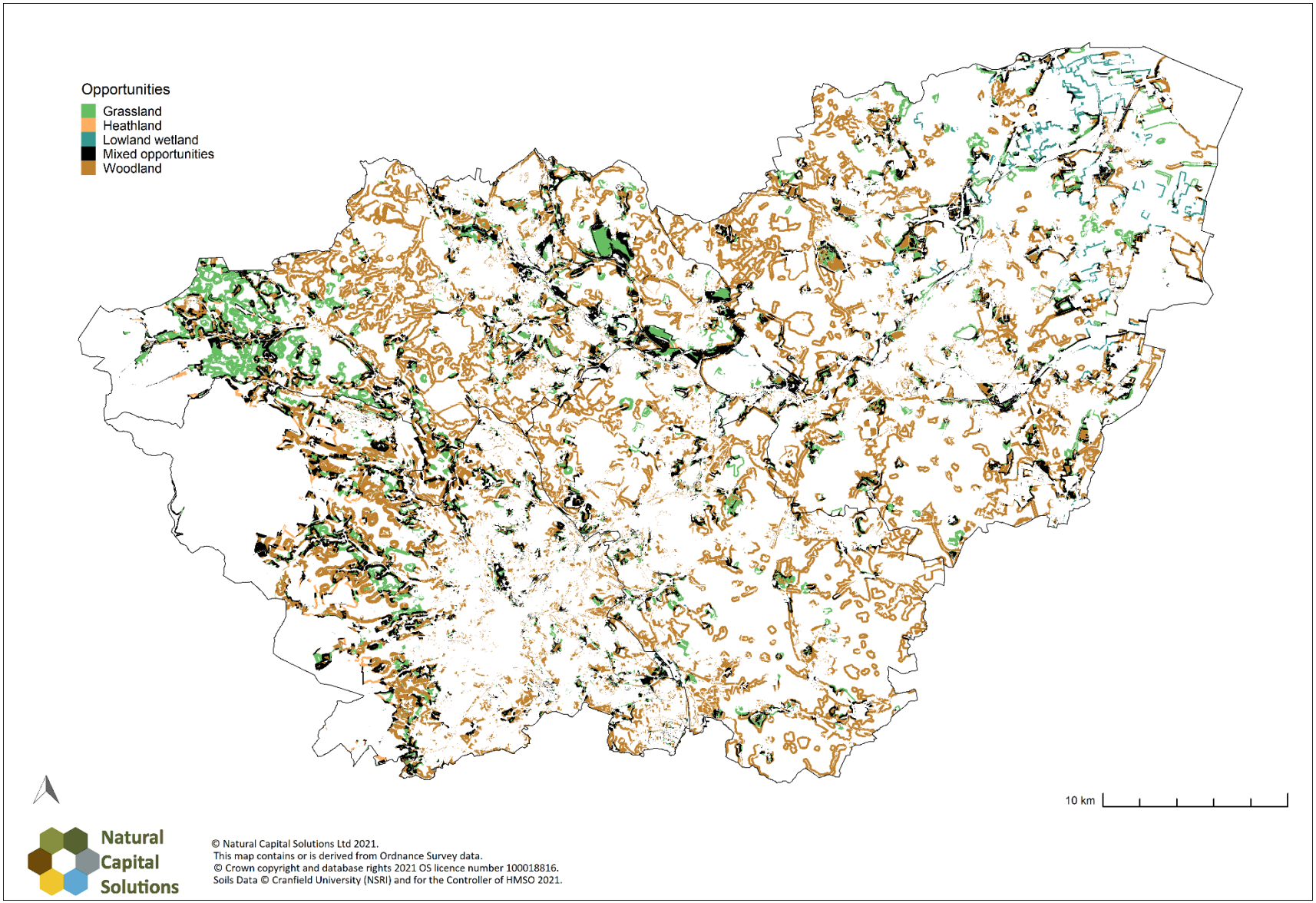
The habitat opportunity mapping completed for South Yorkshire provides a sound and scientifically robust approach to identifying a nature recovery network for the region. Here we present an extensive range of potential opportunities to create new habitat to extend existing semi-natural habitat networks in South Yorkshire. These maps provide the basis from which to begin to explore what a nature recovery network in South Yorkshire might look like. It is not a blueprint but a guide to explore real opportunities. It is based on the biodiversity network mapping (Section 6) so indicates opportunities that are ecologically feasible, that is that typical species from the broad habitats are able to disperse to. It identifies both buffer and stepping stone opportunities to make existing core habitats bigger, better and more joined up, to create a coherent and resilient ecological network, in line with the Lawton principles. It is, therefore, functionally linking the core areas of semi-natural habitats in South Yorkshire, which means that species from existing sites of conservation importance are more linked up to other similar habitat patches, helping to maintain their populations. The mapping does not take into account local site-based factors that may impact suitability. Any areas suggested for habitat creation will require ground-truthing before implementation.

Here we present a first nature recovery network map indicating opportunities across all broad habitats in the region, including existing core semi-natural habitats that are not in 'good' condition, that could be managed more effectively or restored. We show the maps in different ways to help inform decisions around the creation of a South Yorkshire nature recovery network. All of these maps are available as GIS layers and can be manipulated to explore these opportunities further, and to add other data sets from other sources. For example, it can be layered with the Natural England climate change vulnerability model GIS data to explore vulnerable habitats and to aid selection of more resilient habitat opportunities.

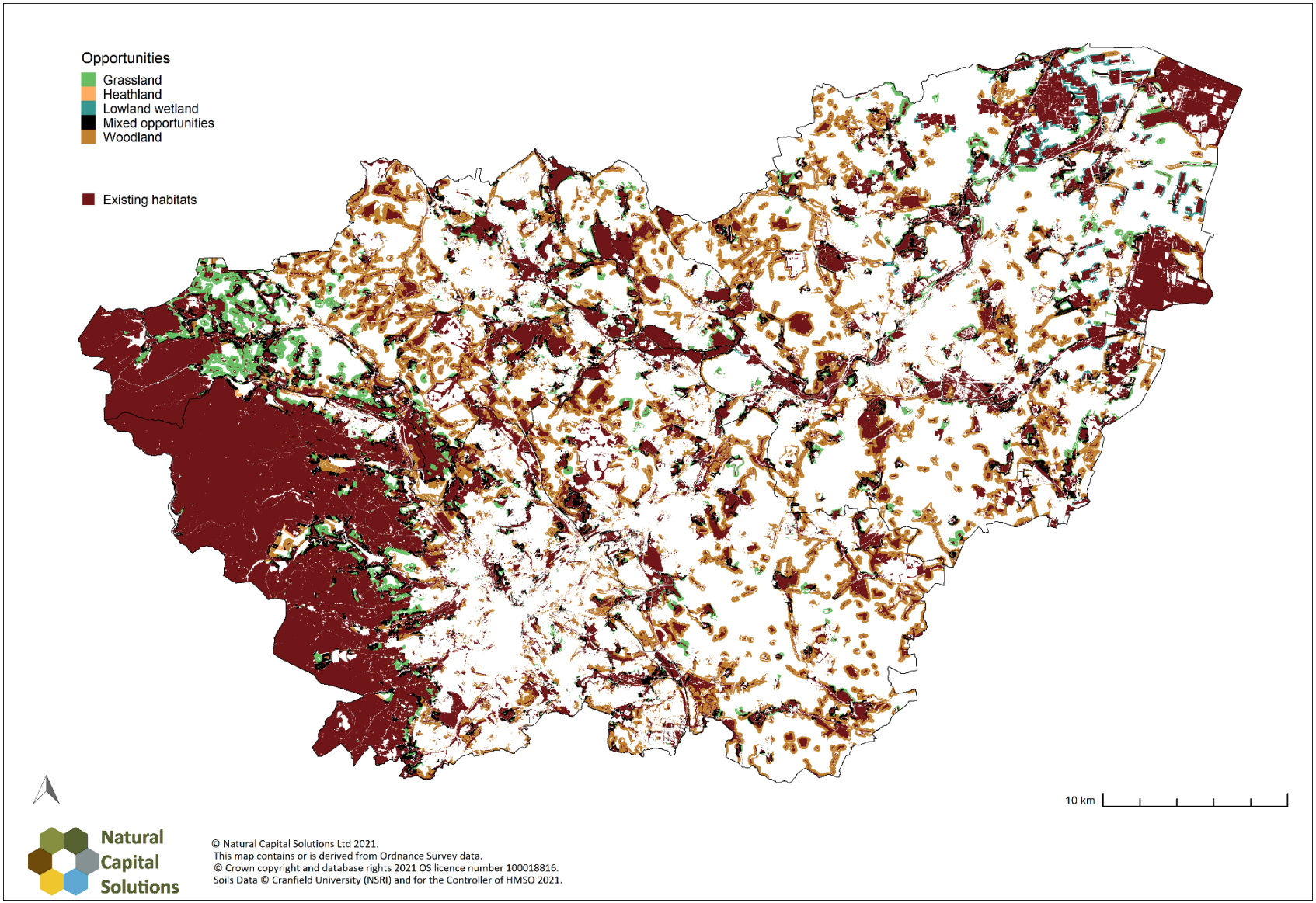
Map 50 shows the habitat creation opportunities for South Yorkshire (Section 6) combined onto one map. There are sites where opportunities for the broad habitats overlap (in black), that is, there are fields where more than one habitat could potentially be created. Map 51 shows these opportunities along with the existing core semi-natural habitats.

[30] Crick et al. (2020) Nature networks: A summary for practitioners. Natural England Research Report NERR082. http://publications.naturalengland.org.uk/publication/5144804831002624

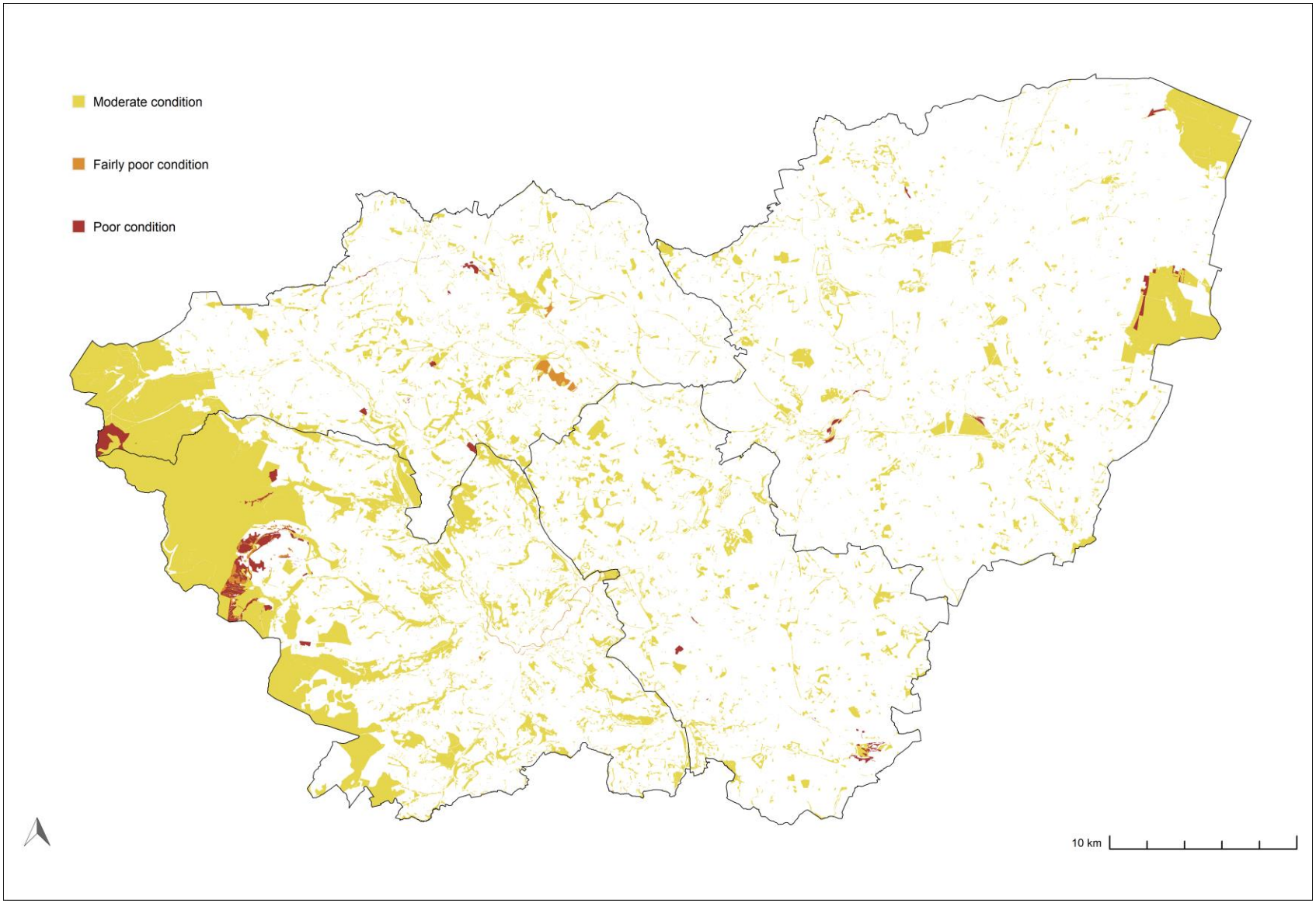
Map 50 Combined broad habitat (woodland, semi-natural grassland, heathland, bog and wetland) buffer and stepping stone opportunities across South Yorkshire.



Map 51 Combined broad habitat (woodland, semi-natural grassland, heathland, bog and wetland) buffer and stepping stone opportunities and existing core semi-natural habitats across South Yorkshire – a first nature recovery network for South Yorkshire.



Map 52 Core semi-natural habitats that were estimated as being in poor or medium condition. Sites in the nature recovery network that can be better managed or restored.



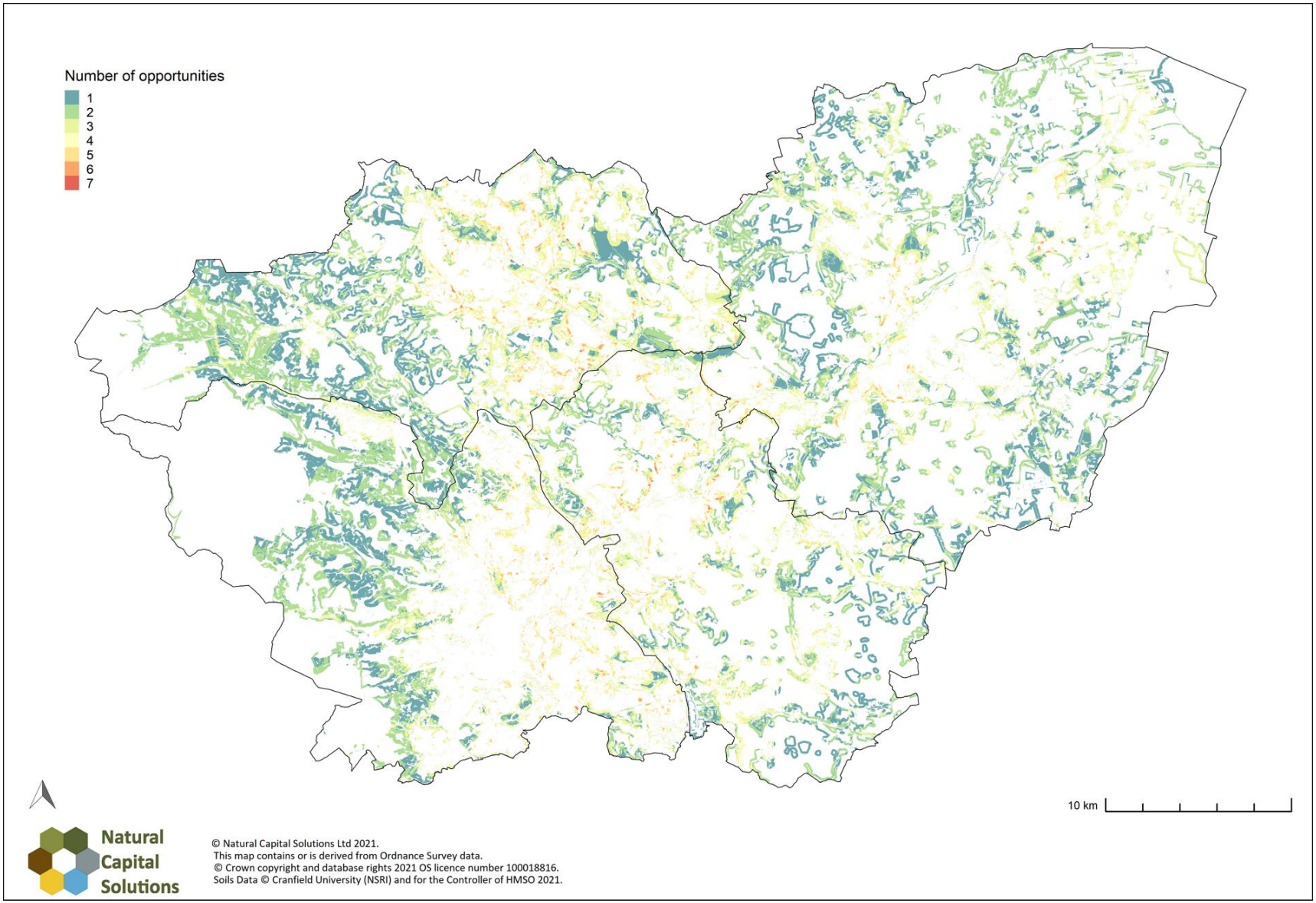
Map 52 shows the core semi-natural habitats (as in Map 51) that were estimated as being in poor or medium condition as part of the biodiversity baseline assessment in Section 3. The map shows core areas that could be targeted for restoration or alternative management to improve the condition of the habitat. This map does not include coniferous woodland, as management improvement would not increase the condition score for this habitat. The arable and improved grassland fields have been taken out, to leave the first stage options for improving management. It is possible that there will be opportunities in improved fields to increase condition, but this will be dependent on the co-operation of farmers, and will have to be discussed as part of their plans for meeting Environmental Land Management Scheme requirements.

In relation to the second quote from the Natural England nature networks report, it is important that a nature recovery network for South Yorkshire delivers for biodiversity but also benefits to the people who will live in and around it. It will be possible to do this, and we demonstrate the additional benefits that can be delivered by each opportunity associated with each broad habitat separately in Section 8. Map 53 shows these additional (ecosystem service) benefits that could be delivered by these opportunities all in one map – across the nature recovery network.

These maps can be seen as the basis for further investigations into how to deliver the nature recovery network on the ground. The next steps are to begin to prioritise which opportunities to take forward in the short, medium and long-term, and what are the policy areas that these opportunities can deliver on, in additional to allowing the recovery of nature. Sites can be prioritised by biodiversity targets and then by specific ecosystem services, for example targeting riparian woodland planting in certain areas of the region, or creating new accessible greenspaces for people to visit. Alternatively, or in addition, sites can also be prioritised by the number of services they will provide.

It will be difficult to know how to prioritise these opportunities unless there is a strategy in place that has a vision for South Yorkshire, and that this has buy-in from the broad interests of the majority of stakeholders in the region (e.g. Local Authorities, land owners and farmers, conservation groups and many more). This would constitute the Local Nature Recovery Strategy (LNRS) for South Yorkshire. Once a vision is in place, or targets have been set, it will be possible to prioritise which opportunities to take forward, and to further investigate these by using this South Yorkshire natural capital evidence along with additional environmental and socio-economic data from other sources to target specific policy agendas. The workshop associated with this project attempted to start this process (Annex 2).

Map 53 Combined opportunities for new habitats across South Yorkshire – the nature recovery network and delivery of multiple benefits (up to seven including biodiversity).



10. Woodland creation map for South Yorkshire

In addition to being important habitats for biodiversity, woodlands provide a wide range of benefits, to people. They sequester carbon, provide cooling in high temperatures, they can improve water quality and provide flood alleviation, capture air pollutants, reduce noise pollution, provide opportunities for recreation and increasing health and well-being, and are key contributors to landscape character and heritage. This report demonstrates their importance in South Yorkshire, as they are key habitats in the provision of the majority of ecosystem services quantified, mapped and valued (Sections 4 and 5).

The Committee on Climate Change's recommendations for woodland creation is to increase UK forestry cover from 13% to at least 17% by 2050[31]. The England Trees Action Plan 2021-2024[32], outlines the UK Government's planned contribution to this target to treble the current woodland creation rate in England by 2024. The Local Authorities of South Yorkshire all have their own targets, and South Yorkshire is committed to woodland creation.

One of the main aims of this project was to deliver a woodland creation map that could guide practitioners on where they can focus their efforts to create woodland in South Yorkshire. This has been done ensuring that opportunities for creation would deliver for biodiversity by connecting and buffering existing woodland habitats, but also to ensure the provision of multiple benefits for people.

As with the nature recovery network, this is not presented here as the final woodland creation map. The maps should be seen as a guide to what is possible and a tool for decision-making. Decisions of what constitute real and practical opportunities for woodland creation need to be made from here. It is also important to note that the mapping identifies areas based on landscape-scale ecological principles and does not take into account local site-based factors that may impact suitability. Any areas suggested for habitat creation will require ground-truthing before implementation.

Through discussions with key individuals involved in this project, it was decided that the woodland creation map would be produced with slightly different constraints to the nature network mapping (see Section 6 and Map 22). This means that the priority habitats in the region were not included as a constraint. The reason for this was to enable all potential opportunities to be viewed, including clough woodland opportunities in the uplands (west of South Yorkshire), opportunities for which would not be visible using the constraints set for the biodiversity network mapping (Map 21) that formed the nature recovery network. The woodland creation map with the same constraints as the nature network mapping is equivalent to the woodland opportunity map shown in Map 24. So both are available to compare.

Map 54 shows the woodland creation map created with the alternative constraints (i.e. not including priority habitats). It shows that there are numerous opportunities for woodland creation across South Yorkshire. These exist across a range of habitats, in rural and urban areas, and include opportunities for riparian woodland – which can be seen clearly in Doncaster and to the west of Sheffield. The trends in this map are similar to those of Map 24, there are multiple areas in the west and north of Sheffield, and through central and eastern Barnsley, where field-scale creation of woodland could considerably enlarge and connect existing woodland networks, making them more resilient. This is also the case in the north of

[31] Committee on Climate Change (2020) Land use: Policies for a net zero UK. Committee on Climate Change Copyright 2020.
[32] The England trees action plan 2021-2024. UK government. Crown Copyright 2021. https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/987432/england-trees-action-plan.pdf

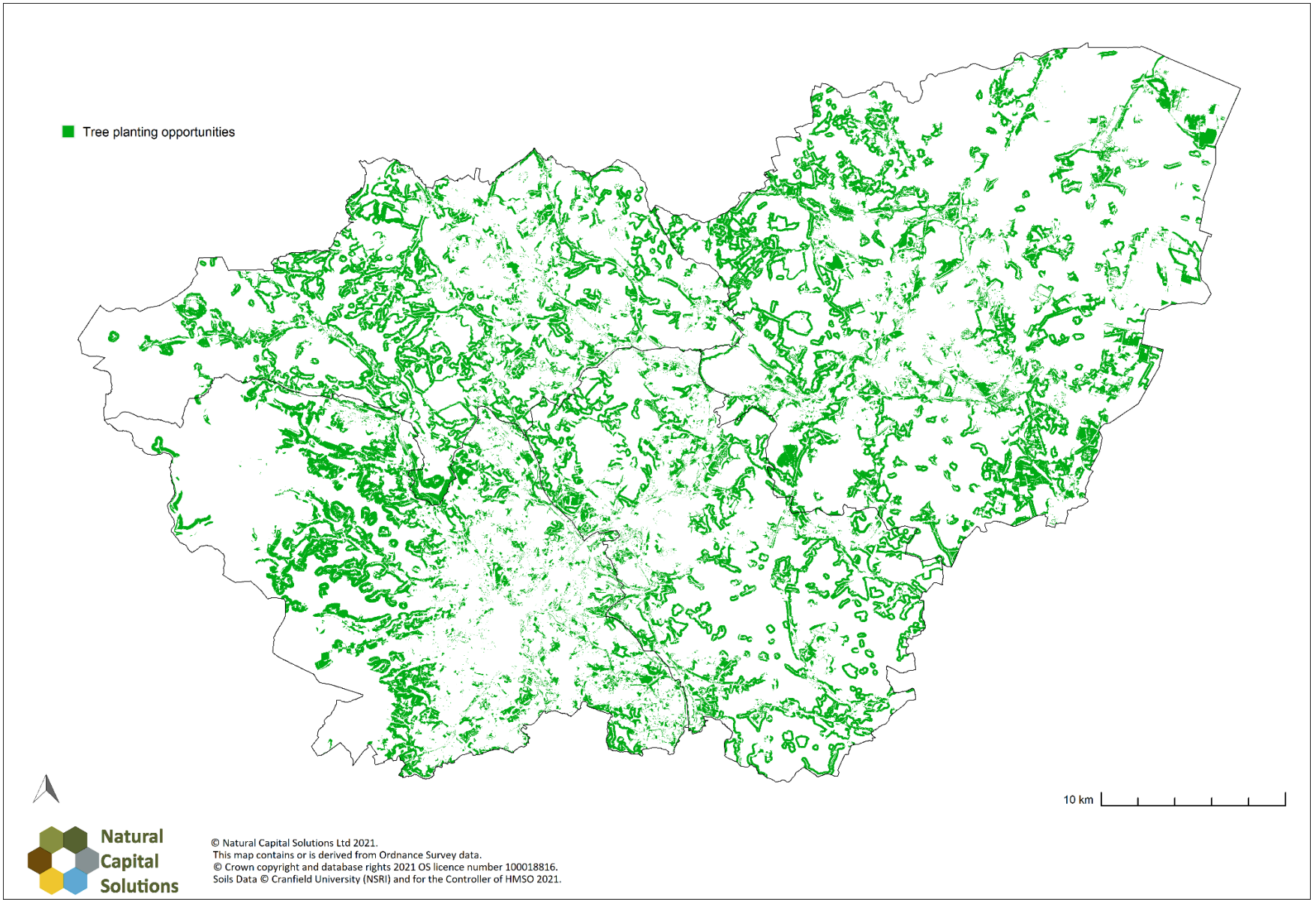
Rotherham and the west of Doncaster. In the south of Rotherham and the east of Doncaster there are numerous opportunities to enlarge existing woodland patches, but due to the more fragmented nature of the woodland here, connecting up networks will be more difficult. The main difference is that there are more opportunities in the uplands in the west of the region.

Map 55 shows the combined opportunities for new woodland across South Yorkshire. This shows the additional ecosystem service benefits that will be delivered if woodland were to be created at those sites. This will aid decision-making for prioritising sites for planting. While the objectives may be to increase woodland cover, this will allow strategic decisions to be made on the basis of ecological connectivity, and the ability of the site to deliver a number of ecosystem services (flood alleviation, water quality, air pollution, noise and local climate regulation, slowing the flow, water quality and access to nature). Woodland opportunities that would deliver specific services can be targeted, or sites that deliver the most services could be prioritised.

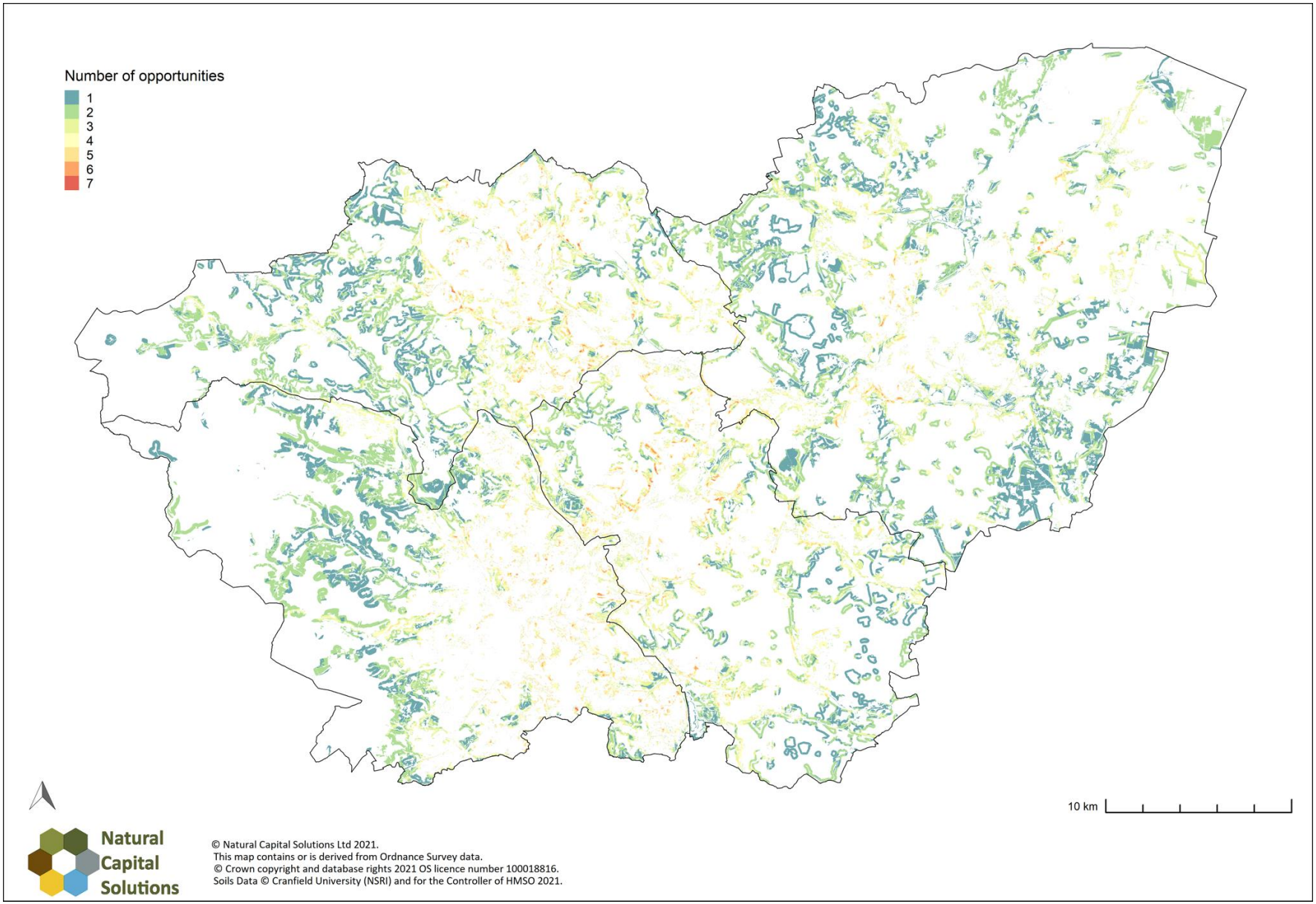
Creating woodland to connect up existing patches is not just good for biodiversity, but is also important for building the resilience of the woodland asset. The threat from pests and diseases, as well as from a changing climate, is set to increase. Opportunities for woodland creation, therefore, need to include a diversity of species, and come with plans for appropriate woodland management.

These woodland creation maps are based on increasing ecological connectedness between existing patches of woodland. There are a number of aims for woodland creation, and whilst it may be optimum to gain benefits and expand the existing woodland network, it may not always be the primary aim. If it is of interest to look into woodland blocks outside of networks, there may be other information sources that can supplement and add to this woodland creation map. All the GIS layers are available for the woodland creation map to be adapted in the future, tailored to any specific strategy.

Map 54 Woodland buffer and stepping stone opportunities across South Yorkshire - a woodland creation map.



Map 55 The woodland creation map for South Yorkshire and multiple benefits that can be delivered.



11. Policy analysis

11.1 Summary of approach and findings

The policy analysis has focused on SYMCA strategies, including:

- Net Zero Work programme (2020)
- Strategic Economic Plan (SEP) (2021-2041) and associated evidence (also evidence used for the Local Industrial Strategy/Plan for Growth)
- Draft SCR Monitoring and Evaluation Framework
- Active Travel Implementation Plan
- SCR Integrated Rail Plan
- Renewal Action Plan
- Transforming Cities Fund – Tranche 2 business case submission
- SCR Transport Strategy

The policy analysis focuses on the overall goal of the various strategies and policies, targets associated with those strategies, gaps that exist or changes that are needed and the evidence behind them, and the proposed actions and level of investment identified.

The vision from the Strategic Economic Plan (2021-2040) is for 'sustainable places that are healthy, safe, and vibrant places offering climate and environmental resilience alongside a quality of life offer'. Sustainability is focused around the drive to deliver a net-zero carbon target by 2040 but also captures the need to improve local resilience and health and well-being. Active travel (walking and cycling) is a key ambition with targets increase levels of walking by 21% and cycling by 350% (Active Travel Implementation Plan). The post Covid-19 Renewal Action plan identifies the level of investment needed to deliver a stronger, greener and fairer economy. The aim of the 'greener' element is to decarbonise the economy, improve the environment and revolutionise transport. An estimated £570 million of investment is needed to achieve this green transformation, with this including enhancements to biodiversity and natural capital.

Opportunities include identifying how investment in natural capital can help deliver the overall vision from the Strategic Economic Plan and Renewal Plan, helping to address issues such as localised air pollution while supporting growth in active travel and maximising the value of the natural environment in both attracting and retaining skilled people. Consideration of the natural environment could help encourage a more coordinated approach to tackling climate change and the impacts of climate change, at the same time growing the currently under-represented environmental sector.

11.2 Key findings of the policy analysis

The policy analysis is summarised through assessment of goals and incentives, targets, gaps to the current targets and proposed actions to meeting the targets (see the detailed analysis in Section 11.6). There are three main goals that arise from the policy analysis:

1. **Economic transformation**: this is focused on increasing productivity, improving innovation, developing new skills and decarbonising the economy.
2. **Green transformation**: this is also focused around decarbonising the economy, but also on improving the environment and revolutionising transport by moving away from car-based transport to active travel and greener options.

3. **Fairer society**: this is designed around sustainable, healthy, vibrant places with climate and environmental resilience and a reduction in poverty and deprivation.

These goals are supported by targets, where these include:

- Net zero emissions by 2041
- Creation and support of 6,000 jobs
- Increasing walking by 21% and cycling by 350% by 2040
- Improving resilience and well-being

The gaps to the current targets provide an indication of the level of change that is likely to be required, which then highlights the likely challenges that will be faced. The key gaps include:

- An estimate that there will be an additional 500,000 transport trips per day by 2040: this highlights the challenge that the transport system faces, but also emphasises the need to move these trips from car to active and more sustainable travel options. Given the current development has little, if any, focus on public transport, again highlights the challenge associated with this (growing) gap. Green corridors that enable traffic-free walking and cycling routes could be of benefit here.
- Localised air pollution means that there are some communities that face potential health risks. This further highlights the importance of addressing the sustainable transport issue, as growth in trips that are made by car will likely exacerbate existing air pollution issues. Local action to reduce air pollution through investment in woodlands could help, but the goal to revolutionise transport will also be key in helping to reduce the gap associated with localised air pollution, with this then influencing the move to more healthier places and communities.
- Productivity gap per worker is currently £6,260 compared to the rest of the UK (excluding London). This highlights the need to attract and retain more skilled workers. A high quality, natural environment can help to attract people, linked to the green transformation goal.

The policy analysis itself identifies a range of actions proposed that are aligned with investment in natural capital, and where there can be synergies that can help reduce the above gaps and move towards delivering the goals:

- Support for the circular and green economy: this can help attract businesses in growing sectors, as well as encouraging 'greener' development of existing businesses.
- Investment in sustainable connectivity: this could include investment in active and sustainable travel options that could offer opportunities to develop green corridors. As well as providing greener travel options, these can also be designed to help address other issues such as air and noise pollution, but also provide recreational opportunities that can improve the vibrancy of places and encourage more active, healthy lifestyles.
- Reconfiguration of urban centres: this can be linked with sustainable connectivity but also development around making places more attractive to live and work in, as well as easier to move around without a reliance on carbon-based transport.

11.3 SWOT based on the policy analysis

The key strengths and weaknesses of existing policies are summarised in the top row of the SWOT analysis diagram in Figure 3. The opportunities and threats for natural capital arising from the policy analysis are then presented in the bottom row in Figure 3. This analysis is intended to be a high-level overview, rather than a comprehensive assessment.

Strengths	Weaknesses
• Focus on net zero carbon emissions, low carbon transport and improved air quality • Commitment to healthy and safe environments that improve wellbeing • Commitment to accessibility, so all people can access sustainable travel and natural environments • Recognition of the need for climate change resilience and the role of green infrastructure • Reiterated commitment to increasing active travel (walking, cycling, etc.) across the region	• Lack of integration across policies to support natural capital assets. High levels of car dependency • Focus on urban areas and city centres • Current transport system is not fit for the 21st century and will require significant investment • SCR has physical inactivity levels higher than the national average • Significant focus on transport infrastructure and emissions • Plans will only lead to half the of the MML being electrified • Business inertia in moving towards carbon neutrality/energy efficiency
Opportunities	**Threats**
• Work with partners and communities to enable them to better understand active transport modes to reduce carbon emissions and improve health. • Improving sustainable transport links to natural areas such as Peak District National Park will support other areas such as health and wellbeing, accessibility, tourism economy and low carbon emissions. • Grow environmental sector and innovation • Restoration/regeneration of urban environments and planned refurbishments	• Lack of region-wide systems analysis and evidence • Defragmented approach to tackling climate change • Growing the economy in a way the doesn't damage or compromise the natural environment • Increased journeys (extra 500,000 by 2026) on the transport system which is described as not fit for purpose will add additional strain • Funding for active travel is piecemeal and complex • Pockets of deprivation and inequality • Existing environmental risks including air pollution, flood risk, ecological decline

Figure 3 SWOT analysis.

11.4 Funding and funding mechanisms

This section identifies natural capital investment opportunities that could be used to improve the success and reach of the policy goals. It seeks to explore new innovative development investments that build on the area's natural capital advantage, based on the high quality natural environment and surroundings.

The Government's 25-year plan for the environment and its ambitious goals aim to achieve a wide range of complex goals. This includes climate change mitigation and adaption, addressing the decline of biodiversity as well as the management of opportunities and threats imposed by Brexit. In order to achieve the array of goals, natural capital investment will be vital to make a broader business case for these investments. Natural capital investment draws from public and increasingly private finance to fund investment in projects which increase or enhance natural capital. A combination of public and private

funding is also known as blended finance, enabling project opportunities and impact investments with varying levels of risk. The diversity of funding streams allows a greater environmental (and social) impact.[33] Most recently, the Greater Manchester Natural Capital Investment Plan offered insights into suitable finance options for the region to promote a positive impact on natural capital that provides a return to the investor (see Figure 4 for the blended finance model).

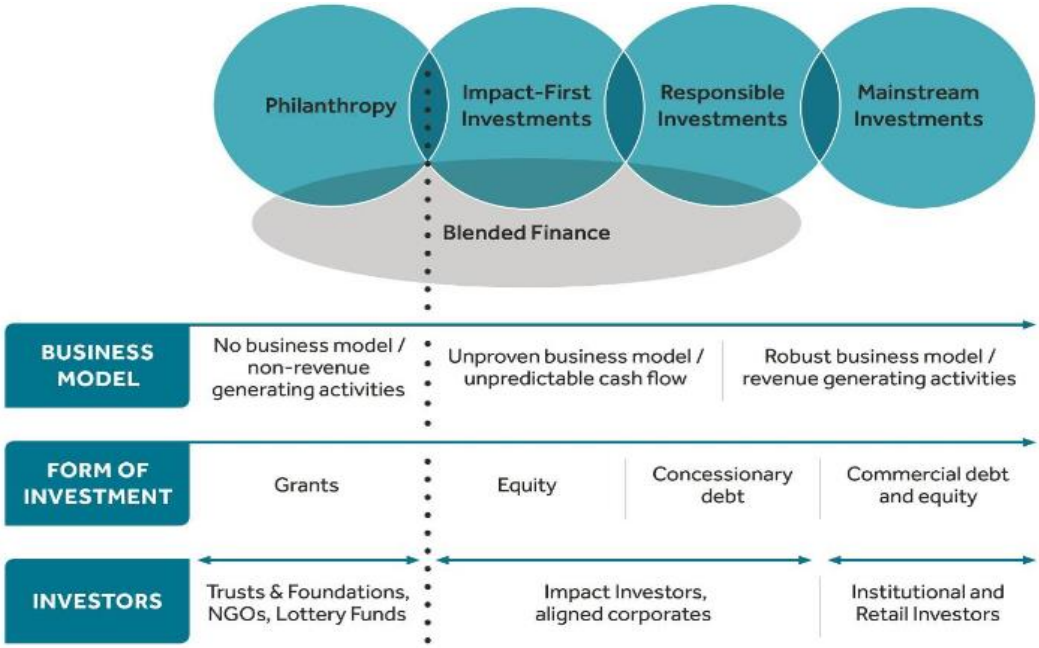


Figure 4 Types of potential investors in natural capital (eftec, 2019)
Eftec et al (2019): Greater Manchester Natural Capital Investment Plan, final report, January 2019, available at: https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf on 20 October 2020

A wide range of funding mechanisms have been reviewed as potential sources of investment into natural capital in the SYMCA:

- Environmental Impact Bond
- Woodland Equity Fund
- Green Bond
- Place-based Portfolio
- Green Improvement District
- Habitat Bank
- SuDS
- ELMs
- Investment Readiness Fund
- Nature for Climate Fund (as announced 18 May 2021)
- Biodiversity Net Gain

[33] Global Impact Investing Network (2018): A Resource for Structuring Blended Finance Vehicles. Available at: https://thegiin.org/assets/upload/Blended%20Finance%20Resource%20-%20GIIN.pdf on 22 December 2020

- Environmental Net Gain
- Levelling Up
- Woodland Code
- Peatland Code
- Forestry Commission Woodland Creation
- Biodiversity Banking
- Nature Recovery Networks/Strategy

Further details on each of these is provided in Annex A.

Funding mechanisms can help achieve different objectives depending on their underlying suitability criteria. As such, these criteria differ depending on project characteristics, funding needs, sources and models. For example, some projects may be long-term, mainly involving non-market public goods and land use change targeting climate change objectives at landscape scale and thus mainly appeal to off setters, and corporate ESG (Environmental, Social and Governance) interests. Other projects may focus on green space in local areas, linked to air quality in urban areas, and can be integrated within infrastructure/regeneration projects.

The funds have been assessed in terms of their potential application to different ecosystem services. This information is then used as the basis for a spreadsheet that enables the most appropriate funds to be identified depending on the ecosystem services that are the main focus of a project, programme or policy. Table 11 provides the summary scores assigned to each funding mechanism according to its use in delivering different ecosystem services. The 'fund selector' spreadsheet is used to assess likely funding sources that could apply to the types of ecosystem services that may be of particular interest in the SYMCA to help deliver the goals and targets identified through the policy analysis.

11.5 Potential funding sources to deliver SCR goals

The policy analysis identifies a number of goals, targets and proposed actions that need to be taken for the SYMCA to develop and provide a future that meets the needs of existing and future communities. An approach is needed to assess how investment in natural capital could be used to support such a future. This require the following to be identified:

- What needs to be achieved: what are the ecosystem services that are the key targets for change, linked to policy goals and targets?
- What needs to happen for this to be achieved: what level of change is needed and how can this be delivered through investment in natural capital?

The selection of the most appropriate funding sources uses the 'fund selector' spreadsheet and is applied as follows:

1. Select up to three core ecosystem services: the main ecosystem services that are being targeted for delivery or improvement
2. Select up to three secondary ecosystem services: additional services that are good to have but which do not form the primary aim of a natural capital plan

Table 11 Ecosystem services and habitats covered by funding mechanisms (scores as applied following review of mechanisms and examples in June 2021).

	Environmental Impact Bond	Woodland Equity Fund	Green Bond	Place-based Portfolio	Green Improvement District	Habitat Bank	SuDS	ELMs	Investment Readiness Fund	Nature for Climate Fund	Biodiversity Net Gain	Environmental Net Gain	Levelling Up	Woodland Code	Peatland Code	Forestry Commission Woodland Creation	Biodiversity Banking	Nature Recovery Networks/Strategy
Provisioning services																		
Agricultural outputs	2	0	2	0	1	3	0	3	3	0	0	0	0	0	0	0	0	2
Timber/wood fuel production	2	4	2	2	0	3	0	3	3	2	0	0	0	4	0	2	0	1
Water supply	3	2	4	1	1	3	3	3	3	0	0	1	0	0	2	0	0	0
Renewable energy	2	1	3	1	1	0	0	1	2	1	0	0	1	0	0	0	0	0
Regulating services																		
Air quality regulation	3	3	4	3	3	3	3	3	4	2	2	2	3	3	0	3	2	2
Carbon avoided and sequestration	3	4	2	2	2	3	2	4	4	4	3	1	2	4	4	4	2	2
Local climate regulation	3	3	3	3	2	3	2	3	3	3	2	3	1	3	2	3	2	1
Water flow regulation	3	3	2	2	2	3	4	3	4	2	1	2	0	2	3	3	2	1
Water quality regulation	3	3	2	4	2	3	3	4	4	0	0	1	0	1	2	3	2	1
Pollination	3	3	2	3	3	3	1	3	3	2	4	4	1	2	2	2	3	2

Cultural services																		
Access to nature (recreation)	1	3	2	4	4	3	0	2	4	3	3	3	2	2	1	3	2	1
Phys./psych. experiences	3	3	2	3	3	3	1	2	3	3	3	3	3	2	2	3	2	1
Learning and inspiration	3	3	3	3	3	3	3	3	3	2	1	1	2	1	2	2	2	1
Identity and quality of place	3	3	3	3	4	3	3	3	3	4	3	3	3	2	2	3	2	2
Biodiversity	2	2	3	2	2	4	2	2	4	4	4	4	1	3	4	3	4	3

Key								
4	Main focus of funding mechanism	**3**	Good examples of use of funding mechanisms	**2**	Potential use but not many examples	**1**	Possible use but no real examples as yet	**0**	Not applied

3. Determine the weight that should be placed on secondary ecosystem services: this is set to 50% in the spreadsheet so that there is greater emphasis on the core ecosystem services.

The spreadsheet then identifies the ranking of the funds and funding mechanisms (this is based on the scores set out in Table 11, so these should be reviewed and updated to take account of new developments, new examples of application of funding mechanisms and likely application of the funding mechanisms to the location in question). The policy analysis identifies that the three core ecosystem services are:

- Carbon avoided and sequestration
- Air quality regulation
- Access to nature (linked to encouraging sustainable travel)

Additional issues are identified with a number of secondary services (although these will be locally as, if not more important, than the core services):

- Renewable energy (linked to net zero and green transformation)
- Biodiversity (linked to existing high-quality habitats and retaining and improving the condition of these and buffer locations)
- Identify and quality of place (linked to developing a fairer society, through sustainable, healthy, vibrant places)

A screenshot from the application of the fund selector spreadsheet using these ecosystem services is shown as Figure 5. This shows that the most appropriate funds are identified as:

1. Investment Readiness Fund
2. Woodland Equity Fund
3. Green Improvement District, Nature for Climate Fund, Forestry Commission Woodland Creation (three ranked equal third)

Combining funds to deliver more and wider outcomes across the SYMCA could be achieved through blended finance. An organisation such as a Special Purpose Vehicle could bring together different sources of funds in order to deliver a wider range, and potentially more beneficial overall, scale of natural capital change. The investment readiness fund itself closed to applications at the March 2021, but a fund with similar design and goals provides the scope to cover many of the goals and targets identified in the policy analysis. The initial targeting of public funds may be required in order to provide the 'seed funding' needed to establish a Special Purpose Vehicle such that this can then be used as the catalyst for applying for and attracting additional investment.

Choose services to be delivered (select up to three)		
Core services (the main services you are looking to deliver)	**Secondary services (additional useful but not core)**	**Weight on secondary services**
Carbon avoided and sequestration	Renewable energy	50%
Air quality regulation	Biodiversity	
Access to nature (recreation)	Identity and quality of place	
Best funding mechanisms to deliver that suite of services:	**Rank for core services**	**Rank for core and secondary services**
Environmental Impact Bond	12	11
Woodland Equity Fund	2	2
Green Bond	10	6
Place-based Portfolio	4	6
Green Improvement District	4	3
Habitat Bank	4	9
SuDS	16	16
ELMs	4	6
Investment Readiness Fund	1	1
Nature for Climate Fund	4	3
Biodiversity Net Gain	10	11
Environmental Net Gain	14	14
Levelling Up	12	13
Woodland Code	4	10
Peatland Code	16	17
Forestry Commission Woodland Creation	2	3
Biodiversity Banking	14	15
Nature Recovery Networks/Strategy	16	17

Figure 5 Screenshot from application of the fund selector spreadsheet to the core services identified from the policy analysis.

11.6 Policy analysis - detailed

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
Source document and sectors covered	***What are the policies' overall goals/incentives? Including risks to NC***	***How could the policy promote enhancement of NC?***	***Where/how can NC be promoted within existing policies? Including opportunities for NC/risks to economy***	***What measures can be implemented to realise opportunities? Or which gaps remain?***
Net Zero Work programme (2020)	Projects intended to enable businesses and citizens to reduce their emissions	18 potential projects to start a work programme to achieve net zero carbon emissions in South Yorkshire by 2040	Projects intended to be front-loaded or balanced	• Financial and capability barriers • Strategic challenges including a lack of region-wide systems analysis and evidence • Defragmented approach to tackling climate change
Strategic Economic Plan (2021-2041)	Challenges include low productivity, too few businesses innovating or operating in national or global supply chains, need for improvement to transport and urban centres, low level of qualifications, work does not translate into wellbeing, need to decarbonise Vision for sustainable places that are healthy, safe, and vibrant places offer climate and environmental resilience alongside a quality of life offer. Measured through environmental quality and cultural participation rise	• Nurturing economy while protecting people and the environment • Generate own clean energy • Reach net-zero emissions by 2041 • Invest in urban centres, arts, culture and natural capital • Build a fairer, more inclusive economy, linked more closely to wellbeing • Remove barriers so everyone has a chance to prosper • Develop the transport infrastructure • Invest in a net zero-carbon public transport system with cycling and	• Health inequalities • Underdeveloped creative sector in South Yorkshire • Collaboration with anchor institutions, communities and other partners • Many SMEs not actively improving their energy efficiency • Size of green economy smaller than in other city regions • Only 20% of electricity consumed in SCR is generated in the region • 2/3 of houses have EPC rating below C • Localised air pollution • Transport network needs to keep pace with planned growth	• Providing a framework to consider the spatial impact of development • Releasing/unlocking sites by overcoming barriers to viability • Providing the framework to benefit from land value capture and ensure a return on investment to fund infrastructure needed • Deploying innovative finance, policy and delivery mechanisms to improve the stock of natural capital (and biodiversity) • Develop infrastructure investment place packages

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
	whilst poverty and deprivation decline	walking central to how to get about the region • Make homes and land available for families and businesses to locate, maximising natural environment • Invest where there is social value	• Capacity on key transport routes is an issue • Locations outside of urban areas earmarked for development with little public transport provision	
Draft SCR Monitoring and Evaluation Framework	Based on SCR Strategic Economic Plan but summarises sustainability vision and policy objectives	Sustainability to drive forward environmental sustainability to achieve the net zero carbon target by 2040 • Maintained cycling and walking routes • Uplift in urban footfall and spend • Created/ supported 6,000 new jobs across infrastructure programmes • Improved local economic resilience and health and well-being		• Support businesses to reduce emissions • Drive a circular economy where appropriate • Adapt and enhance resilience to the changing climate • Invest in net-zero carbon energy options for domestic and industrial users • Grow environmental sector and opportunities • Invest in sustainable connectivity opportunities to reduce emissions
Active Travel Implementation Plan (links to Government-led encouragement to LAs to develop Local Cycling and Walking Infrastructure Plans (LCWIPs)	Pedestrians and cyclists to be at the centre of transport plans	Increase levels of walking by 21% and cycling by 350% by 2040	Estimated that there will be up to half a million extra trips per day across the transport network, which is not sustainable if these are by car Funding for active travel is piecemeal and complex, often	Creating environments and transport networks that promote and enable walking and cycling as part of everyday life

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
			released on a competitive basis and for a limited timeframe. This limits the capacity for long-term funding commitments	
SCR Integrated Rail Plan	Priorities including making the SCR cleaner and greener, and making the transport network safe, reliable, and accessible - a transport system that works for everyone	Improve air quality across SCR to meet legal thresholds, with the aim of supporting improved health and activity, especially in designated Air Quality Management Areas and Clean Air Zones. Move towards a low carbon transport network. To have a transport network that offers sustainable and inclusive access.	Poor rail connections limit the flow of people and businesses within the region. The quality of services, station facilities and the surrounding environment is variable. Urgent need for investment in sustainable transport to encourage a shift from car to public transport. Only the southern half of the MML will be electrified, whereas full electrification of the MML would be more efficient and cost-effective in the long term. Peak District National Park is it is currently only served by two fast trains per hour and one train which stops at the intermediate local stations.	An upgrade scheme within the Peak District National Park will enable a third fast train to be introduced each hour, as well as improve reliability and maintain freight capacity (servicing the Hope Cement Works and the Peak Forest quarries).
SEP & LIS evidence		Current economy: £35bn Economic activity rate: 73.2% Productivity: £43,500 per worker	Size of economy if productivity matched UK (minus London): £40bn Size of economy if productivity matched UK (with London): £44bn	

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
		Wages: £517 per week (annual growth of 1.7%)	Size of economy if matched South East: £46bn Size of economy if matched London: £62bn Economic activity rate in England: 74.9% (gap 1.7%), but closing since 2016 Productivity UK (without London): £49,760 per worker. Current gap: £6,260 and increasing Wages UK: £569 per week, annual growth 2%	
Renewal Action Plan	Stronger – economic transformation to create not just a bigger economy but a better one: higher tech, higher skill, higher value Greener – green transformation to decarbonise our economy, improve our environment, and revolutionise transport Fairer - transformation of wellbeing and inclusion, raising quality of life, reducing inequality and widening opportunity	£770m investment needed to help people find jobs and adapt to the new economy £380m investment needed to support employers to adapt, survive and thrive despite Covid-19 £570m investment needed in infrastructure to level up the economy, create jobs and transform communities		Green transformation decarbonising the economy, improving the environment and transforming transport infrastructure Focus is on reconfiguring urban centres including physical infrastructure changes (widening pathways, one-way pedestrian systems) 620 miles of accessible walking and cycling routes Trial of low-traffic neighbourhoods Acceleration of Active Travel Infrastructure programme, with estimated costs of £490 per person

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
				Enhancements to biodiversity and natural capital Tree planting programme closely tied to flood prevention but also to improving neighbourhoods and habitats
Transforming Cities Fund – Tranche 2 business case submission	Programme of transport infrastructure investment that better connects the areas of transport poverty with areas of opportunity in a safe and sustainable way. Produce a shift away from private car use towards making cycling and walking for shorter journeys. Achieve aims (above) in ways that address current health issues and improve air quality across the SCR	Residents should be able to walk, cycle, drive or use public transport from their home to their nearest town centre in no more than 15 minutes. Journey times to between the region's major town and city centres of Barnsley, Doncaster, Rotherham and Sheffield in no more than 30 minutes. Journey times to at least four major cities in the North will take no more than 75 minutes. Create healthy streets where people feel safe, and the quality of the outdoor environment is improved. More walking and cycling journeys across the SCR.	By 2026 there will be an extra 500,000 journeys on the transport system, leading to worsened congestion and hotspots of poor air quality will remain. The existing trend of car commuting, and declining bus use will continue if no action is taken. Due to a lack of infrastructure and a perception of poor safety, levels of walking and cycling are relatively low. The majority of SCR has physical inactivity levels higher than the national average for the adult population.	Buses, taxis, vans and lorries that do not meet necessary emissions standards will have to pay to drive in and around the Clean Air Zone. Define a consistent set of standards at each of the City Region's rail stations to provide customers with safe and secure facilities. 24km of improved walking and cycling infrastructure, and 72km of new walking and cycling infrastructure. 13km of new infrastructure to benefit buses and 12km of new bus lanes. 20 junction improvements to benefit non-car modes.

Policy analysis framework				
Strategy/ policy	**Anticipated approach**	**Target**	**Gap**	**Proposed actions/requirements**
		Improved air quality.		
1SCR Transport Strategy	Three priorities including making the SCR cleaner and greener, and making the transport network safe, reliable and accessible	To have a transport network that supports the SCR's visitor economy, including the Peak District National Park and the Yorkshire Wildlife Park. Influence people's behaviour towards healthy and sustainable travel choices such as walking and cycling.	Current transport system, including the supporting infrastructure is not yet fit for the 21st century; this restricts access to services, retail and leisure opportunities (such as green spaces). Without sustainable transport linkages to green/natural areas, a significant proportion of visitors will continue to travel by car; this will continue to damage the natural environment and habitats.	Improve air quality across SCR to meet legal thresholds. Work towards a low carbon transport network, including a zero-carbon public transport network. Work with the planning and development community to create attractive places. Enhance our multi-modal transport system to encourage sustainable travel, particularly for active travel. Ensure transport network offers sustainable and inclusive access for all to green and recreational spaces.

12. Conclusions and recommendations

12.1 Conclusions

This project has produced a detailed habitat basemap using the best available data to assign Phase 1, and UKHab, habitat types to each plot of land and building across the whole of South Yorkshire. It provides the most comprehensive and detailed coverage that is possible at this time and should have a wide range of applications. South Yorkshire has a diversity of habitats within its boundary, but is dominated by arable land and improved grassland (44%). However, there are also extensive areas of woodland across the county. Tree and woodland categories take up 10.6% of the county, which is below the national average. There are significant areas of heathland (5%), bog (4%), and semi-natural grasslands and marshy grasslands (8.4%). Rivers and reservoirs are also an important feature of the South Yorkshire landscape (1.5%). Built up areas, infrastructure and gardens make up a combined 20.5% of the area.

The habitats in each polygon of the South Yorkshire basemap were assigned a distinctiveness and condition score so that the Biodiversity Metric 2.0 could be applied, and a total biodiversity baseline score has been calculated for South Yorkshire. We were able to estimate the condition for 91% of the region. Much of the area is in poor condition (score 1) due to the predominance of arable and improved grassland habitat, the extent of domestic gardens and amenity grasslands. There were patches of moderate, fairly good and good condition habitats scattered throughout the region, but mainly in the west in the uplands, and the lowland bogs in the east. The overall biodiversity score was 517,734 units. A way of increasing the biodiversity score across the region is to focus on increasing the condition of the habitats that are in poor or moderate condition, for example, restoring areas of modified blanket bog, by enhancing woodland management, maintaining hedgerows and field margins in agricultural areas. Some of these habitats could also be transformed to more distinctive habitat types, particularly in agricultural areas under the ELMs scheme, or if the site lies within the South Yorkshire nature recovery network as part of a Local Nature Recovery Strategy.

The ecosystem service maps demonstrate the spatial pattern of provision of eleven different ecosystem services, and the demand for four. The maps show that the South Yorkshire woodlands are important for high levels of provision of carbon storage, carbon sequestration, air quality, noise, local climate and water flow regulation, and timber/woodfuel production benefits. The mapping also shows that woodlands provide hotspots of access to nature on the outskirts of the city, particularly in Sheffield, and are often important areas for recreation. The upland heathland and bog habitats in the west and the lowland raised bog in the east are also important areas for carbon storage, but also have a high level of provision for access to nature. Unfortunately, they are a source of GHG emissions, but this can be reduced significantly through restoration. Reducing emissions means protecting these important carbon stores into the future. Food production is clearly dominant in the region and there is a higher provision of this service in the eastern half of the region.

The demand maps of air quality, noise, local climate regulation, and accessible nature show clearly the importance of ecosystem service delivery to the urban centres of South Yorkshire, with the highest demand in the largest conurbation of Sheffield. Urban areas adjacent to the road network are also hotspots for demand. The capacity to provide these services can be quite high on the outskirts of the urban centres, which will be important to meet some of the demand, but not the majority of it. These habitats should be protected and expanded, even if they are not important for biodiversity. It is likely that urban

trees play a role in meeting this demand in the urban centres, and data on these could not be included in this study. As a result it is not clear whether these trees are located in area that will maximise the provision of these services.

The monetary value of the benefits provided by natural capital are large: £550 million per annum across the whole of South Yorkshire, representing an asset value (present value) of £18 billion over 50 years. Benefits in terms of air quality regulation, recreation, physical health and amenity value are particularly large. Overall the total natural capital value, and the value per ha, are larger for Sheffield, that benefits from less agriculture than the other regions, more woodland and accessible green spaces for providing multiple benefits that are valuable to society.

Habitat opportunity maps have been created showing where new habitats could be created for biodiversity enhancement for five broad habitat types, as well as for six different ecosystem services. Note, however, that the maps have not been ground-truthed or checked against other data, and so individual locations will need to be assessed further before being taken forward. The maps should be considered as an evidence base to highlight potential locations for habitat creation or restoration projects, rather than as an end in themselves. The maps are best examined on a Geographic Information System, and GIS layers at the South Yorkshire scale and the local authority level have been provided to project Steering Group.

The biodiversity network mapping highlights areas that are best located in terms of their connectivity with existing habitat patches and are, therefore, most appropriate from an ecological point of view. Enhancing connectivity and expanding habitat networks is a key priority for biodiversity conservation and climate change adaptation at present. The maps show that there are numerous opportunities across South Yorkshire. They highlight areas where biodiversity offsetting should be focussed, under the new requirement to achieve biodiversity net gain for all new developments. Furthermore, the opportunity maps for ecosystem services highlight the best areas to create habitats to enhance the delivery of each ecosystem service in turn, based on where demand is high and capacity is currently low. These will be invaluable for exploring biodiversity and specific ecosystem service enhancements, for meeting multiple policy objectives at both at the county and sub-regional scales.

The biodiversity and ecosystem service opportunity maps have been combined, showing where creating habitat for biodiversity can simultaneously deliver multiple benefits. These maps have enabled the creation of a potential nature recovery network for South Yorkshire. It has also allowed the creation of a woodland creation map. Having a nature recovery network in place means that a Local Nature Recovery Strategy can be formed to deliver it. Such a network also means that biodiversity net gain off-setting projects can be directed to optimal sites for nature recovery, but also where they will deliver other benefits at the same time. The woodland creation map allows discussions to begin around where trees can be planted in the region, and the range of outcomes that are desired. Further data can be layered with this map to ensure that trees are planted in suitable locations and deliver multiple benefits where they are needed the most.

The policy analysis focussed on the overall goals of the South Yorkshire Mayoral Combined Authority strategies (Net zero work programme, the Local Industrial Strategy through to the Renewal Action Plan and Active Travel Implementation Plan) and analysed the strengths, weaknesses, opportunities and threats of these in the context of how investment in natural capital can help deliver these. The main goals of the SCR policies are to transform the economy whilst decarbonising it and moving away from car-based transport, and creating a fairer society designed around sustainable, healthy and environmentally resilient places. Whilst the strengths are the clear commitment of the SCR to key issues like decarbonising,

increasing access to green spaces and travel, and the need to build in resilience to climate change, policy must respond to the evolving situation in order to deliver the transformative change needed. For example, more integration across policies to support natural capital assets; investment in sustainable connectivity to address car-dependency and to create green corridors which will provide greener travel, cleaner air, reduced noise pollution and recreational opportunities, increasing health and well-being and a sense of place; grow the environmental and innovations sectors to support a circular and green economy. This analysis then identifies natural capital investment opportunities that could be used to fund activity that will ensure this change can happen.

12.2 Recommendations

The natural capital and biodiversity assessment results have pointed to some key areas where action can be taken to increase the quality and extent of the natural capital assets of South Yorkshire. The recommendations below have been developed on the basis of offering the most significant potential for improving the delivery of ecosystem services, and aligning with local and national policy priorities. These recommendations have also been informed by discussions with the Steering Group, and through the visioning and prioritisation workshop (see Annex 2 for the report on this).

A move to sustainable agriculture: Agriculture is dominant in South Yorkshire which impacts on natural capital quality and the range of benefits that can be provided in those areas. Whilst food production is an important service, there needs to be a balance between this and the provision of other services including habitat for biodiversity. A move to more sustainable practices in both arable and livestock farming will be key, and it is the aim of the new Environmental Land Management Scheme to promote sustainability and incentivise land management for the provision of public goods. Emissions reduction from farming is key, especially in Doncaster, so a focus on this and simultaneously increasing the sequestration capacity of the farmed landscape will be important. Interventions that will improve water quality, slow the flow of water, provide increased access to nature will also be important in these areas. The ecosystem services opportunity mapping (Section 7) should be used to identify areas where new habitats can be created to improve the delivery of some of the services just mentioned. The potential nature recovery network maps (Section 9) can be used to identify where farms may fall within this network, and what potential opportunities could be gained. The food production map (Section 4.11, Map 16) can be used as a guide to identify fields where habitat creation will have least impact on agricultural productivity (as arable, horticulture, and improved grasslands have been weighted by Agricultural Land Class).

Expanding woodland: Woodland is a key asset and there is a plan to expand this habitat at the county scale. Using the combined opportunity maps (Section 8) and the woodland creation maps (Section 10), it will be possible for woodland to be created to connect up existing woodland networks, but also to help slow the flow of water, to increase water quality and opportunities for recreation. Section 7.1 has specifically focused on where habitat can be created to slow the flow of water and the maps show many opportunities to create new habitat along rivers, and trees would be particularly beneficial here. This can also be combined with existing data on riparian woodland opportunities to possibly expand options (this has been done in the maps associated with the project workshop, reported on in Annex 2.) The role of woodland and trees in the urban centres of the region is also vital. Urban trees are key to providing multiple benefits in towns and cities, but the urban tree stock needs to be reviewed to ensure the right species of tree are in the right locations for delivering services where they are needed.

Restore grassland habitats: This is also important and links to agriculture. There is a huge area of improved grassland in the region. A move away from intensively managed fields to a more diverse grass sward that has lower, or even no inputs, would increase the biodiversity value of these fields. In combination with lower livestock densities these habitats will be able to sequester more carbon, increase water quality and water flow capacity.

Restore bog habitats: These habitats are a significant regional asset, and an important carbon store. It is important to protect this store by ensuring these habitats are in the best condition possible. Even a well restored bog will emit a low level of GHGs, and in degraded habitats this can be high. Restoration of these habitats is, therefore, vital and will contribute to the overall reduction of GHG emissions from the land. Agricultural activity and planting woodland on peat soils should be avoided as the GHG emissions associated with this is very high, this is an issue in the west of Sheffield and in the east of Doncaster. A focus on bog restoration is also important for slowing the flow of water and increasing water quality.

New natural and biodiverse green spaces: There should be a focus on the creation of new of these in areas where access is currently low. This will be important for increasing recreational opportunities and enhancing the health and well-being of the inhabitants of South Yorkshire (physical inactivity was highlighted as a particular issue in the policy analysis (Section 11)). This project also demonstrates that health and recreational benefits have a high economic value.

Enhancing biodiversity: There is a good deal of opportunity in South Yorkshire for increasing the quality of existing semi-natural habitats. The biodiversity assessment in Section 3, and Map 52 in Section 9 can be used to direct efforts to this end. In addition, the biodiversity network mapping (Section 6) the basis of the nature recovery network in Section 9 shows areas where new habitat can be created to connect up existing core habitat to increase resilience. These sites can be prioritised in a number of ways to meet both existing habitat and species level strategies, and formulate future ones. In addition, using the combined opportunities maps (Section 8) and the nature recovery combined opportunities map (Map 53) allows these strategies to be met at the same time as providing multiple benefits. Semi-natural habitats are inherently multi-functional, meaning that an investment focussing on one benefit (e.g. natural flood risk management), can deliver multiple additional benefits, hence offering excellent value for money. Woodland is obviously the habitat that tends to offer a wider range of benefits provision, however, there is a need to ensure that there are a diversity of habitats created, and discussion on which to create where will need broad stakeholder input. The linking of biodiversity strategies and the need to provide important ecosystem service benefits from the natural capital of South Yorkshire can come together in a Local Nature Recovery Strategy (LNRS) for the region. This should provide a route to delivering a nature recovery network that enhances biodiversity, at the same time as directing investment into natural capital to deliver key benefits where they are most required. The project workshop (outlined in Annex 1) was an initial step towards this, and there is a good deal of work to be done to formulate a strategy with broad regional stakeholder buy-in. Broadening the remit of the LNRS not just to connecting nature, but also connecting humans to nature, could also go some way to achieving the sustainable connectivity that the policy analysis highlighted will be required in the region (Section 11).

An LNRS and the existence of a nature recovery network will help direct **biodiversity net gain** (BNG) off-set opportunities to key sites that can deliver biodiversity and multiple benefits. Once 10% BNG is compulsory in the development sector, South Yorkshire will be able to use the biodiversity units assigned to each polygon in the basemap in combination with the nature recovery maps (Section 9) to create a strategically located set of sites for these off-sets (this is in effect a South Yorkshire habitat bank). This also

allows opportunities for BNG to be packaged up in advance to fit in with any scheme that the local planning authorities develop to facilitate biodiversity net gain delivery.

This detailed evidence base for South Yorkshire should be used both at the strategic regional scale, and to meet environmental and socio-economic plans and aspirations at the sub-regional level. It should be used to move towards a suite of prioritised projects that meet the needs of key issues in the region, different funding priorities and investor interests. The funding mechanisms analysis (Section 11 and Annex 1) and selector spreadsheet should be used to find the most appropriate funding sources that could apply to these projects, to ensure the delivery of the goals and targets.

13. Next steps

Integrating a natural capital approach into the environmental, economic and social development ambitions of South Yorkshire requires transformative change. It requires integrated decision-making based on evidence. This project has delivered the natural capital and biodiversity evidence base. It is important to ensure that this evidence base is taken up and used in decision-making. To facilitate the future use of the evidence base Natural Capital Solutions will be providing a training session in how to use the data to inform decisions across a broad range of policies in September 2021.

Designing a LNRS and natural capital investment strategy: A process is now required by which a strategy for the region can be designed to deliver the nature recovery network (LNRS) and to direct natural capital investment. It is not until there is a strategy in place that the numerous opportunities that have been identified in this project can be prioritised, matched up with appropriate funding and taken forward. The project workshop outlined what was required to set a vision, and how the data can be used to help identify short, medium and long term projects. One option is that the South Yorkshire Local Nature Partnership can do this with support from SYMCA. There is a great deal of work to do to set up a process to create an appropriate strategy at the same time as ensuring representation and buy-in from a broad range of stakeholder groups. Learning from other areas in England that have embarked on this process, and the Natural England LNRS pilots will be helpful.

The opportunity maps created in this project should be considered as a tool to guide decision making regarding the best locations to target for habitat creation projects, and those that enhance existing habitats that are not in good condition. A number of steps are recommended in terms of taking this process forward:

- The maps should be compared to other studies such as green infrastructure plans, national maps created by Natural England, as well as Local Plan policies and strategies, to target particular areas to take forward (approaches have been demonstrated in the project workshop and are outlined in Annex 2).
- It is recommended that further workshops are held with a broad set of stakeholders to consider priorities for creating a suite of projects to take forward in South Yorkshire. For example, the current biodiversity opportunity maps overlap, which means that in some areas two or three the different habitats could be created in the same location. In addition, different ecosystem services may be considered more important in particular areas. Simple rules could be created to target certain habitats or certain ecosystem services in different locations. The workshops could also be

used to consider prioritising particular areas (projects) to take forward or to weight criteria to assess projects.

- Priority locations can be taken forward in a number of different ways and matches with different funding options. Some examples are:
  - A number of specific habitat creation projects could be worked up into costed proposals. These could be offered as biodiversity offsetting and biodiversity net gain projects funded through the development process.
  - Opportunity areas could be targeted through agri-environment schemes, particularly the new Environmental Land Management Scheme which will be paying farmers for environmental enhancements that deliver a range of public goods.
  - Woodland areas could be taken forward through the new England Woodland Creation Offer, the Woodland Carbon Guarantee Scheme or other carbon offsetting initiatives, as well as more traditional woodland grant schemes.
  - A range of additional mechanisms exist for taking forward projects that deliver ecosystem services benefits. This includes projects that focus on working with natural processes for slowing the flow (natural flood risk management) and water quality, such as catchment sensitive farming. Opportunities for planting trees to enhance air quality could be part of air pollution reduction strategies, and increasing public access to natural greenspace could be incorporated into wellbeing initiatives and ideas around green prescribing.

Data sharing: A data sharing protocol is important to establish. Who will have access to the data and in what form will need to be agreed among the project Steering Group. Another key issue is whether an online data sharing system is required. A central place where the shared data sits, where updates can be placed, and where all those who have access to the data can download GIS files, and / or view the data via a web portal would be ideal. Such portals can take many forms, and the exact form will depend on the users and their needs. There may be various access arrangements allowing some to download the raw GIS data and others just to view maps and download pdfs. Some counties have used their Biological Records Centres as the data hub from which private or commercial customers can access pdf maps for a small fee. This fee can then be used to cover admin costs and be directed towards the updating of the evidence base.

Updating the evidence base: The natural capital evidence base will need updating periodically. The natural capital asset map (Map 1) is the baseline for South Yorkshire, from which change can be tracked. A collective decision needs to be made on when this data is updated. Usually at this scale every 3-5 years is sensible, or when it is considered that substantive land cover change may have occurred. A protocol needs to be agreed by the project Steering Group for updates, when they should occur and by whom. The new version can then be issued to all data users.

The condition map from which the biodiversity units are calculated was created as a first step to recording the condition of habitats across the region. It would be sensible to ground truth key areas of this and to update condition estimates when they assessments occur. Other counties have approached this by using volunteer biological recorders that already submit records to Biological Record Centres. An online form can be created and sent out to the volunteers asking for information about habitat type and condition at selected sites across a county. This has the advantage of ground-truthing the habitats (i.e. the natural capital asset baseline map) and the condition estimates.

Further analyses: A baseline scenario for biodiversity and natural capital has been created during this project. The baseline can now be used to track success towards specific targets. For example, there may be goals to ensure a biodiversity and natural capital (environmental) net gain for South Yorkshire, or for specific areas within the region. Once the natural capital asset map has been updated (3-5 years) and the condition has been ground truthed, the biodiversity units and the ecosystem service maps can be re-run and the new scores compared to the baseline scores (average ecosystem service scores for South Yorkshire can be derived from the maps). Ecosystem service opportunities can be re-run easily, but we see less need to update the biodiversity network mapping in the near future.

Natural Capital Investment Plan: This would involve identifying key projects / locations where new habitat can be created, or existing habitat enhances, determining the costs and monetary benefits of habitat creation or enhancement at these sites and hence the return on investment, considering appropriate financial mechanisms and funding sources, and then presenting the plans in the form of a prospectus. This should be a plan that sits alongside the Local Nature Recovery Strategy.

More in depth analysis can also be targeted at specific policy areas, such as access to green space. Access to greenspace in South Yorkshire or any of the Local Authorities can be analysed against Natural England's Accessible Natural Greenspace Standard (ANGSt). This will give the number and percentage of residents in the area that meet the ANGSt criteria and the average level of deprivation for areas that do not meet these criteria.

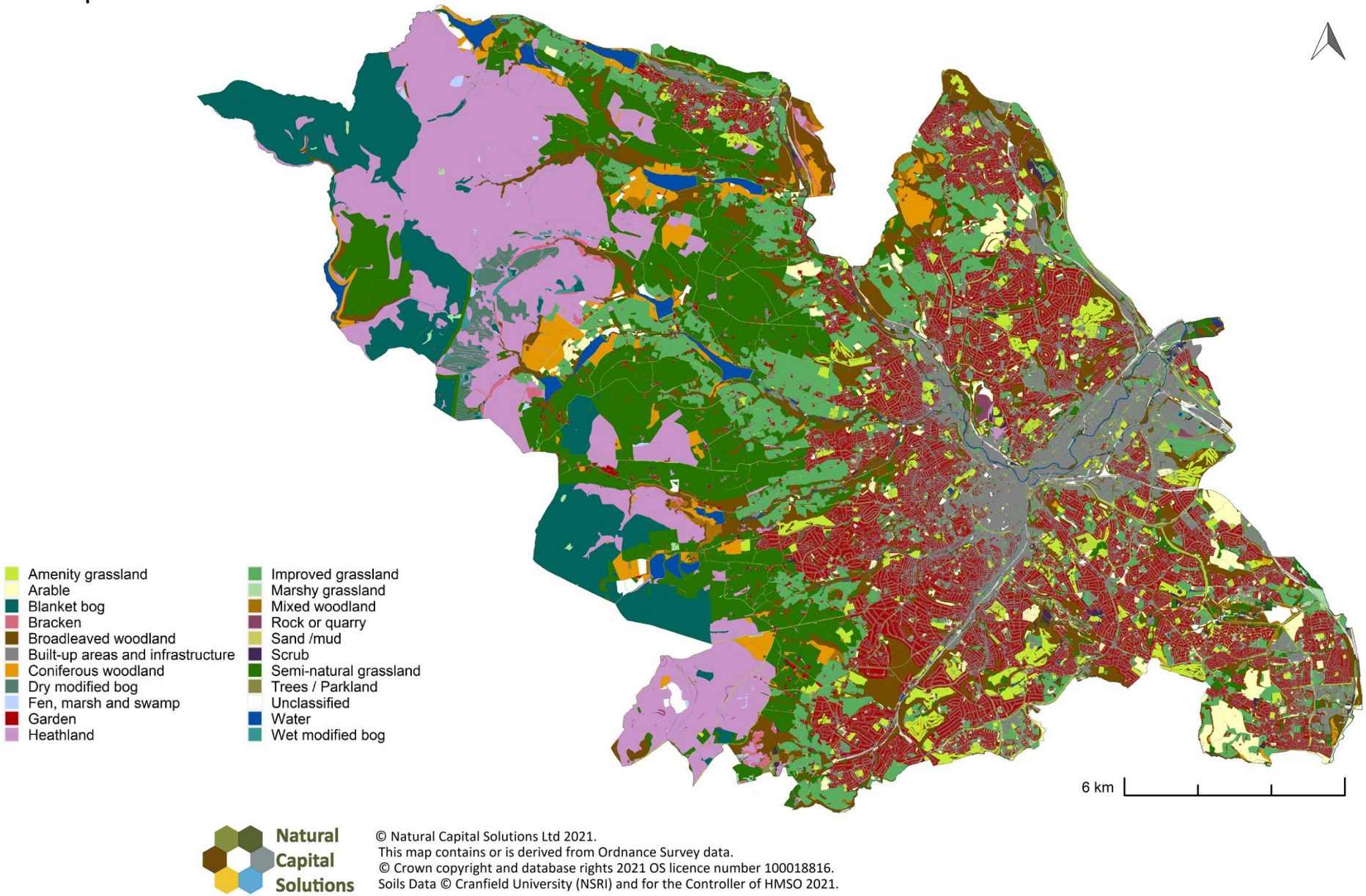
Appendices

A. Local authority level carbon balance and basemaps

Table A1.1 Carbon balance for each South Yorkshire borough:

Sheffield	
Woodland	20,413.76
Agriculture	-20,278.24
Other habitats	12,844.67
Total	**12,980.19**
Barnsley	
Woodland	21,377.62
Agriculture	-42,721.45
Other habitats	8,627.11
Total	**-12,716.72**
Rotherham	
Woodland	27,028.65
Agriculture	-31,687.20
Other habitats	5,877.75
Total	**1,219.20**
Doncaster	
Woodland	20,693.31
Agriculture	-121,512.31
Other habitats	-5,967.84
Total	**-106,786.84**

Map A1.1 Broad habitats across Sheffield.



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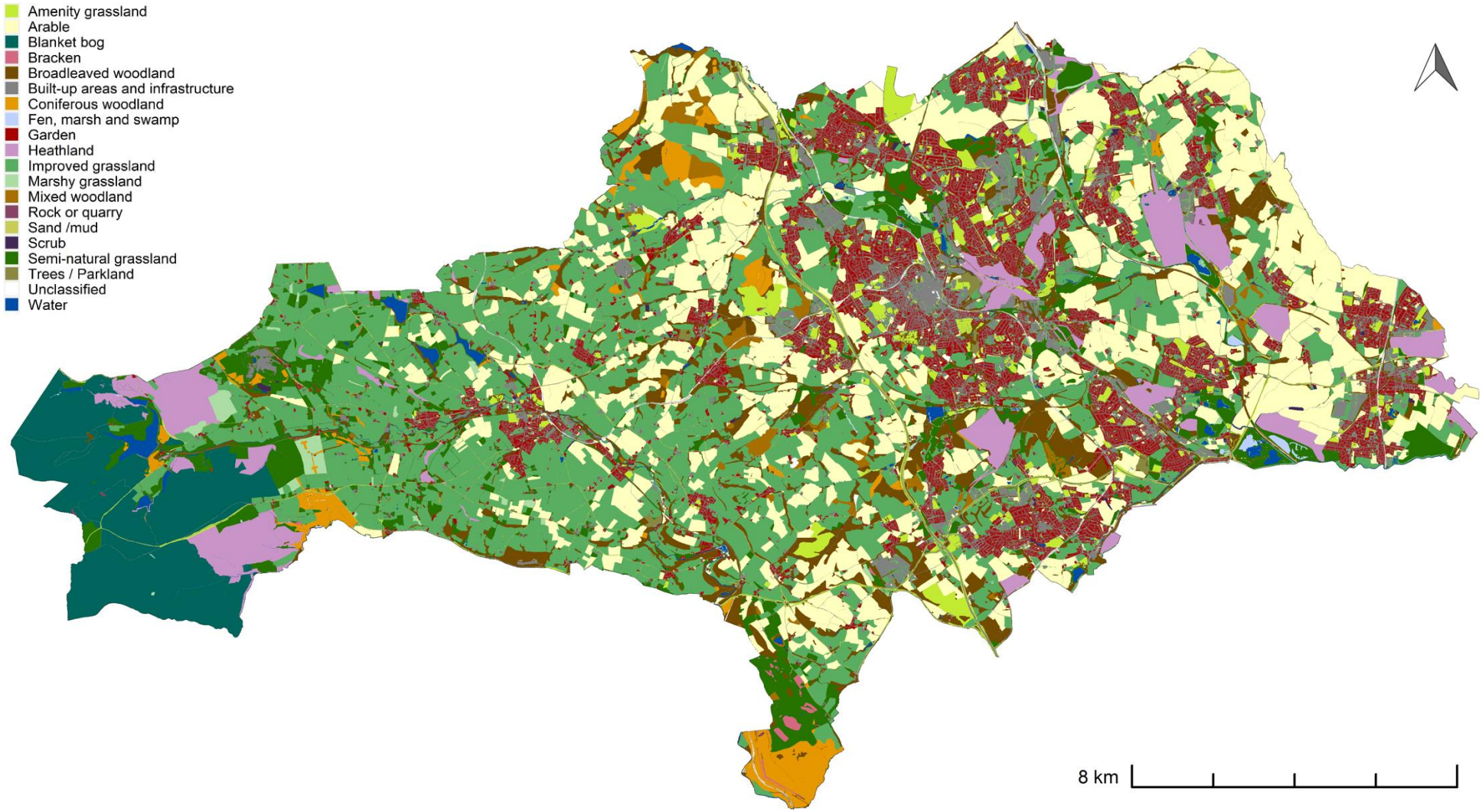
Map A1.2 Broad habitats across Barnsley.



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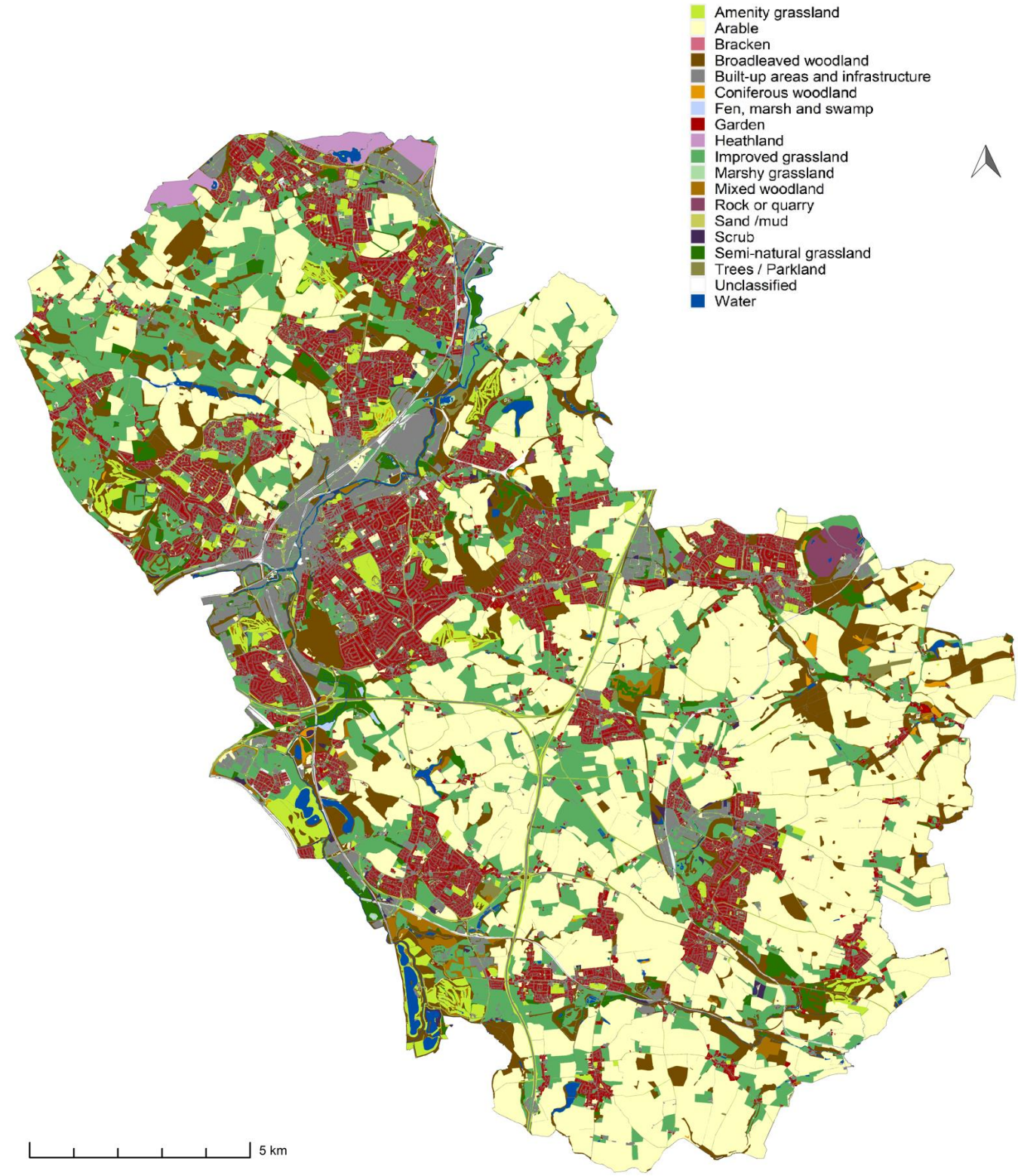
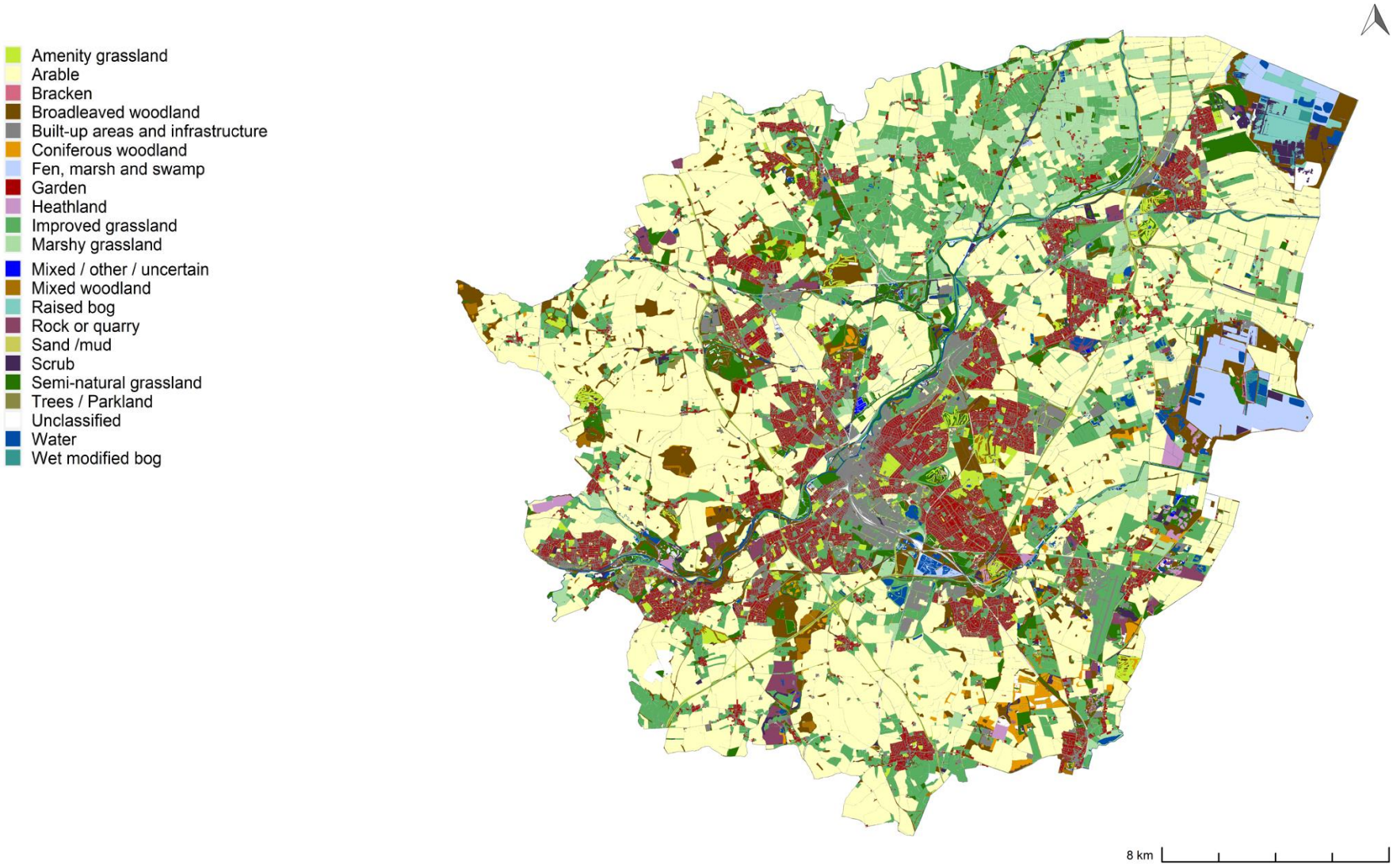
Map A1.3 Broad habitats across Rotherham.



Map A1.4 Broad habitats across Doncaster.



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B. Technical appendix: ecosystem service valuation

1. Air quality regulation

The ability of the woodland, hedges, scrub, grassland and heathland vegetation across South Yorkshire to absorb particulate matter ≤2.5µm in diameter ($PM_{2.5}$) was measured. Quantifying the physical flow of the air quality regulation service provided by the woodland and grassland was based on the absorption calculation in Powe & Willis (2004)[34] and the method in ONS (2016)[35]. The deposition rates for $PM_{2.5}$ in coniferous woodland, deciduous woodland, and grassland were taken from Powe & Willis (2004). Average background pollution concentrations for $PM_{2.5}$ were calculated using Defra data (Modelling of Ambient Air Quality 2018 and 2001). The surface area index of coniferous and deciduous woodlands in on-leaf and off-leaf periods was taken from Powe & Willis (2004). The proportion of dry days in 2020 (rainfall <1mm) for the north of England was estimated using MET office regional value data (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using the Woodland Trust data averages tool.

The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2019)[36]. These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of absorbed pollutant by the woodland and grassland habitats was equal to the average damage cost of that pollutant. The $PM_{2.5}$ damage cost estimates depend on the location (urban size or rural) and source of pollution. The The Local Enterprise Partnership rural urban classification for South Yorkshire was used to match up the damage cost location categories. All rural villages, hamlets and towns in South Yorkshire were categorised as 'rural' for the damage cost calculation, urban city and town categories were classed as 'urban small', urban minor as 'urban medium' and urban major as 'urban large'. When calculating the present value over 50 years, the absorption rate was assumed to be constant. The Defra damage cost of $PM_{2.5}$ is in 2017 prices, and so was adjusted to reflect inflation up to 2021. The value was also subject to an uplift of 2% per annum to reflect the assumption that willingness to pay for health will rise in line with economic growth, as recommended by Defra (2019). The central damage cost figures are presented in the monetary flow estimates, low and high damage costs from Defra (2019) were used in the sensitivity analysis.

2. Carbon balance

The annual physical flow of the carbon sequestration service was calculated by using the sources of data outlined in the carbon sequestration capacity map created in Section 4.2. This provided a positive (sequestration) or negative (emissions) value for each habitat type across South Yorkshire. The carbon sequestration capacity on peat soils were calculated as outlined in Section 4.2. We supplemented this by calculating the carbon sequestration for woodland on mineral soils as follows:

Carbon sequestration from woodland, parkland, hedges and scrub were calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2018)[37]. Coniferous woodland sequestration rates were averaged over a 60-year period and deciduous woodland

[34] Powe, N., A., & Willis, K.G. (2004) Mortality and morbidity benefits of air pollution (SO2 and PM10) absorption attributable to woodland in Britain. *Journal of Environmental Management,* 70, 119-128.
[35] ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts.
[36] Defra (2019) Air quality damage costs guidance. Crown Copyright.
[37] Woodland Carbon Code (2018) Carbon calculation guidance v2. March 2018. Forestry Commission.

sequestration rates were averaged over a 100-year period, as this is the length of a typical forestry cycle for these woodland types. Information on species composition was taken from the client's forest management data, and the Forestry Commission's National Inventory of Woodland and County report for South Yorkshire (2002)[16]. Yield classes for each tree species across South Yorkshire were derived from Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). The annual sequestration rate for each woodland type were then multiplied by the area of each and added together to give the total annual sequestration estimate for woodland at the site. Parkland areas were assumed to have 20% tree cover, hedges and scrub were set at 50% of the sequestration rate of woodland.

GHG emissions agriculture were calculated as follows:

Agricultural activities release CO_2 and other greenhouse gasses such as methane and NO_2 into the atmosphere, with emissions highly variable depending on the type of farming practices employed. These emissions can therefore negate the benefits obtained through carbon sequestration of habitats within a site.

The greenhouse gas emissions of the site were calculated by multiplying the area of each crop type and the numbers of livestock by emissions figures for each crop type and livestock type in Bateman et al. (2013[38]). These emission figures are based on three types of agricultural emissions:

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N_2O from fertilizers
3. Emissions of N_2O and methane from livestock, caused by enteric fermentation and the production of manure

The total physical flow of greenhouse gas emissions was calculated by adding crop type and livestock emissions (in tCO2e). These were monetised using the DBEIS (2019) non-traded central carbon price, as described for carbon sequestration above, and discounted at the standard rate. The low and high non-traded carbon prices were used for the sensitivity analysis.

The monetary flows were calculated using the Government's non-traded central carbon price for 2020 (DBEIS 2019)[39]. We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of carbon sequestration. The present value (PV) of the ability of the woodland to sequester carbon into the future was calculated by summing the values for each year over a 50-year period, after discounting using the discount rate suggested in HM Treasury (2019)[40] of 3.5%. The HM Treasury also provides low and high estimates of current and future non-traded carbon prices. These were used to provide a sensitivity analysis to the economic valuation of this ecosystem service.

[38] Bateman, I. J. et al. (2013) Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. Science 341 45-50.
[39] DBEIS (2019) Carbon priced and sensitivities 2010-2100 for appraisal in HM Treasury (2018) The Green Book. Central Government guidance on appraisal and evaluation, version 3. London.
[40] HM Treasury (2019) The Green Book. Crown Copyright.

3. Recreation

The annual physical and monetary flows of recreation were estimated for each of the Local Authorities within South Yorkshire using the University of Exeter's Outdoor Recreation Valuation Tool (ORVal) version 2.0 (https://www.leep.exeter.ac.uk/orval/). This tool uses a statistical model called a Recreational Demand Model to predict the number of visits that are made to currently accessible greenspaces by adult residents of England. The number of visits are modelled using data from the Monitor of Engagement with the Natural Environment (MENE) survey, and adjusted based on factors such as socioeconomic characteristics of people, the day of the week, attributes of the greenspace, the availability and quality of any alternative greenspaces. The model, through a welfare function, also describes the welfare an individual derives from making different recreational choices, and the welfare values are, therefore, provided by the tool. The welfare gained from a particular greenspace will depend on a number of factors (e.g. socio-economic status, month of the year) and the benefits experience at a site is traded-off against the costs of travelling to the site. The overall annual physical flow and monetary value for recreation in each of the South Yorkshire Local Authorities was the sum of the visit estimates and the welfare values for each accessible greenspace in those areas. For further details of the ORVal model see the advanced technical report for details: https://www.leep.exeter.ac.uk/orval/pdf-reports/ORValII_Modelling_Report.pdf. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

4. Physical health

There is now a growing body of evidence to show the positive effect that the natural environment can have on human health and well-being. Physical health is more commonly valued, although methods are still being refined. The physical flow of health benefits delivered by the South Yorkshire were valued using an approach developed by White et al. (2016)[41], who analysed the implications of recreational physical activity in the natural environment on health in England. The method relies on estimates of visitors to natural environments who meet recommended activity guidelines (based on both duration and intensity of physical activities).

The recreational visit data used in the recreation service calculation (above) was converted from visits (which includes repeat visits by the same individuals) to the number of visitors (individuals), using a visit rate calculated from the latest 5 years of national MENE survey data from Natural England. These can be translated into Quality Adjusted Life Years (QALYs) scores, with 30 minutes of moderate to intense physical activity (if taken 52 weeks a year) being equal to 0.0107 of a QALY. QALY scores have an associated monetary value through estimated savings in health care costs. This physical health benefit can, therefore, be estimated by calculating the total number of QALYs by active visitors to sites that meet guidelines, and multiplying this by the QALY value. The social value of one QALY remains under review. It has been estimated to be worth £20,000 (White et al. 2016), and £60,000 (HM Treasury 2019). However, the recent Defra ENCA[22] project suggests a more conservative value of £15,000 should be used, and this is what is used here. We use the £60,000 estimate for the upper estimate of value in the sensitivity analyses, highlighting that the value of physical health could be considered to be much higher. The lower estimate was 50% of the central value.

The present value (PV) of the area to deliver physical health benefits into the future was the sum of annual values over the 50-year period, using the discount rates suggested in HM Treasury (2019). Discount rates

[41] White, M.P. et al. (2016) Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. Preventative Medicine 91 383-388.

for QALY effects are recommended at 1.5%, (differing from the 3.5% rate recommended for other service indicators). Also see amenity value below for discussion of double counting issue.

A number of assumptions are used in these calculations and the results should therefore be interpreted with caution; it the ecosystem service with the greatest degree of uncertainty out of all those assessed (see Section 5.1, Table 10).

5. Recreational angling

Data on type of fishing, average number of trips, and average spend per trip in South Yorkshire taken from RPA (2017): A survey of freshwater angling in England and associated economic activity and value, Phase 1 final report, Angling activity and expenditure, report to the Environment Agency, March 2017. Data on rod licences by postcode were from the EA for 2015. Expenditure per trip was estimated at £63.10 (2015), which includes food and drink, transport costs (public and car including parking and fuel), hire of tackle and boats, fishing guides, bait and day ticket, match fee. This value was uplifted to 2021 prices using the Government Deflator Index. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

6. Agricultural production

The physical annual flow of agricultural production for South Yorkshire was simply measured as the area of land under agriculture derived from the asset register (Section 2, Table 1). These were classified to an appropriate Defra farming system, that is the proportion of different livestock and crops, using data on the structure of the farming system in England for the South Yorkshire region.

The monetary value of agricultural production was calculated as the economic value of land, net of all non-land costs. Net Farm Income (NFI), the return to farm operators once all expenses have been deducted, were obtained from Defra's Farm Accounts in England (Farm Business Survey) for the South Yorkshire region. This takes into account yields and farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, husbandry, feed and forage costs) and fixed costs (labour, machinery, fuel, buildings). Annual NFI estimates were obtained over 5 years for the period 2015/16 to 2019/2020. These were then adjusted to remove the effects of Basic Farm Payments (income support), to remove any charges for imputed (unpaid) rent, and to include charges for the imputed value of unpaid family labour. This gives a return (an economic rent) to the land resource itself after deducting all costs associated with production except for land ownership and rental costs, and excluding income support subsidies. The annual estimates of adjusted NFI were inflation adjusted to 2021 prices, and a mean estimate per hectare was derived for the period for each of the farming systems. Low and high estimate were also calculated. The per hectare estimates were multiplied by the area of land under each of the farming systems, to derive the total annual value of agricultural production. Present Value was calculated over 50 years using the standard discount rate and assumes that the mix of crops and livestock numbers stays approximately the same. The low and high production values were used for the sensitivity analysis.

7. Timber/woodfuel production

For existing woodland, annual physical flows of timber/woodfuel production were calculated in terms of average annual yield, by multiplying the yield class of the different species by the area of each woodland type see Section 4.11.

The annual monetary flows for the woodland areas were calculated by multiplying the yield by the standing price of timber or woodfuel. The average price for softwood in 2021 was taken from the Forestry

Commissions Coniferous Standing Sales Price Index (Forestry Commission 2021[42]). The price for broadleaved timber in 2015 ranged from £15 to high quality timber reaching £250 per m^3 standing (ABC 2015[43]). We assume the lowest value here for woodfuel, and convert this to 2021 prices using Government deflators. To convert to a present value the annual value was multiplied by the standard government discount rate (3.5%) for each respective year up to 50 years. It was assumed that the area of woodland remains static and the unit price was also assumed to be constant. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

8. Flood reduction by woodland

All natural surfaces can take up water, but it remains difficult to quantify and value for most habitats. A study by Forest research[24], that has been included in the Defra ENCA service data book[22], and has been used in the new Environment Agency Natural Capital Register and Account Tool (NCRAT) V1, allows this to be quantified and valued for woodland. The physical flow is measured as the m^3 of annual flood water storage provided by woodland, derived from Broadmeadow et al. (2018)[24]. This is valued using a replacement-cost (rather than damage cost) approach, which applies annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service. The total area of woodland cover in South Yorkshire was simply multiplied by the annual flood storage provided by woodland (274 m^3). It was then valued by multiplying by the central estimate of the replacement cost (£0.42 m^3/yr) adjusted to 2021 prices. To convert to a present value the annual value was multiplied by the standard government discount rate (3.5%) for each respective year up to 50 years. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

9. Amenity value

The proximity of greenspace can have a positive effect on residential property values. House prices show significant positive price variations with greater proximity to greenspace and water considered separately and together (ONS 2019[44], Moranto et al. 2010[45]). Conversely, increasing distance to natural amenities is 'unambiguously associated with a fall in prices' (Moranto et al. 2010). A recent study by the Office for National Statistics has looked at this relationship in some depth, and has provided an average uplift in house value across Great Britain of 1.2% for residences within 500 metres of publicly accessible green spaces. They looked in detail at the effect of 100, 200 and 500 metre distances, at different residential property types and sizes, and the proximity to greenspaces of varying size. The analyses also included the average uplift in house value from proximity to greenspace in travel to work areas in England and Wales, because this varies considerably across these areas. We have been able to extract the value of 1.95% for South Yorkshire.

We used GIS software to locate the number of residential buildings within 500 metres of greenspaces over 2.5 ha in area. We extracted average house prices for each of the Local Authorities from 'House price statistics for small areas' from ONS, and applied the % uplift associated with South Yorkshire. The house prices were adjusted to 2021 prices, and the total annual value was discounted using the standard government discount rate (3.5%) for each respective year up to 50 years. Low and high estimates were

[42] Forestry Commission (2021) Timber price indices. Data to March 2021.
[43] ABC (2015) The agricultural budgeting and costing book. 81st edition, Argo Business Consultants.
[44] ONS (2019) Valuing green spaces in urban areas: a hedonic price approach using machine learning techniques. ONS.
[45] Mourato, S. et al. (2010) Economic analysis of cultural services. UK NEA Economic Analysis Report.

calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

We are aware of the potential for double counting here: it is incorrect for example to value increases in property value if the benefit streams responsible for this increase have already been accounted for. This is potentially the case with amenity value and the physical health service. Physical health depends on access to greenspace for exercise, and people may purchase houses due to close proximity to greenspace specifically so they can exercise in them. However, the amenity value estimate also captures other important reasons why people buy near greenspace, such as tranquillity, green views, air quality etc, that will also be factored into the property price uplift. We have, therefore, decided to keep these values in the study, but they should be interpreted with caution. It is not possible to establish the magnitude of this double counting issue without significant further study.

10. Mineral extraction

The physical flow of mineral extraction for each local authority area are the annualised average allocations for each aggregate type (sand and gravel and crushed rock). These were derived from the Core Strategy / Local Plan documents for each local authority. The annual monetary value could not be broken down by local authority, so is presented for South Yorkshire only. The value was taken from the regional gross value added (balanced) by industry figures from the ONS (2021). The most recent value was for 2019, and this was uprated using the Consumer Price Index to 2021 prices. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

Annex 1. Funding review – detailed review of mechanisms

The following tables outline the different funding schemes in development or that currently exist that could be used to deliver investment in natural capital in South Yorkshire. This was completed as part of the policy analysis and links to Section 11.4 above, and the fund selector spreadsheet that will be supplied along with the GIS layers.

1.1 Forestry Commission Woodland Creation

Table 0-1: Fund review			
Fund name	**Forestry Commission Woodland Creation/England Woodland Creation Offer**		
Date review completed	**16/06/2021**	**Reviewed by**	**RPA (MM)**
Key aspects	**Details**		
Summary of the fund	Tree planting scheme to provide greater incentives to landowners and farmers to plant and manage trees. Announced on the 9th of June 2021, this scheme is managed by the Forestry commission[1].		
How the fund is designed	A grant will cover 100 per cent of eligible standard capital costs of woodland creation. This includes the costs for buying and planting the trees, and maintaining them for 10 years. Additional financial benefits will be provide for woodland creation that is deemed beneficial to public and wider environmental benefits. Other Contributions include: • Nature and species recovery – between £1,100/ha to £2,800/ha available where woodland creation will help woodland-dependent priority species to recover; • Tree planting near watercourses and rivers (riparian buffers) – £1,600/ha available where the creation of native broadleaved woodland along water courses will improve river habitats; • Reduced flood risk - £500/ha available where woodland creation can help reduce the risk of flooding; • Improved public access - £2,200/ha available where woodland creation will provide long-term permissive access to the public to enjoy • Close to settlements - £500/ha available where woodland creation will provide social and environmental benefits by being close to people; and • Improved water quality - £400/ha available for woodlands that clean our water by reducing pollutants through land use change by intercepting pollution and sediment before it reaches watercourses.		
Lead organisation(s)	Forestry Commission, DEFRA		
Total value of fund	£15.9 million in the first year. Although funding has only been announced for one year, the government have pledged over 500m in future funding for trees and woodlands, so likely to be renewed. Also funded can be secured for 10 years of maintenance for woodland created.		
Timescale over which it operates (where applicable)	Funding has been announced for the first year. Funding for the maintenance of woodland creation can be obtained for 10 years.		
Further details			

Ecosystem services that are the main focus						
		Agricultural outputs	+	Timber/wood production		Water supply
		Renewable energy	++	Air quality regulation	++	Carbon avoided and sequestration

Table 0-1: Fund review						
Fund name	**Forestry Commission Woodland Creation/England Woodland Creation Offer**					
Date review completed	**16/06/2021**			**Reviewed by**		**RPA (MM)**
Key aspects	**Details**					
	++	Local climate regulation	++	Water flow regulation	+	Water quality regulation
		Pollination	++	Access to nature (recreation)	+	Physical and psychological experiences
		Learning and inspiration		Identity and quality of place	++	Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
	+	Pollination		Access to nature (recreation)		Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link the fund and specific ecosystem services	The fund has only just been launched so examples evidencing the link between the fund and ecosystem services are yet to be delivered. However, additional funds are available through the Woodland Creation Offer to specifically deliver ecosystem services, including: • Nature and species recovery (biodiversity); • Reduced flood risk (water flow regulation); • Improved public access; • Social benefits (wellbeing); and • Improved water quality. Previous Forestry commission grants similar to this fund have demonstrated the ability to deliver multiple ecosystem services. One such scheme is the 800 Wood in Cambridgeshire; this is now a well-established multi-purpose wood, spanning 10ha and was funded by the England Woodland Grant Scheme. Ecosystem services delivered to date include: • Public access making the wood a recreational asset for the local community, providing health and wellbeing benefits; • Biodiversity delivered through the planting of a diverse range of tree and shrub species. This variety attracts a wide range of invertebrates, birds and mammals to the wood; • Various research projects, ecological studies and a Forest School within the wood provide opportunities for education and inspiration; and • Small scale hazel coppicing (timer production) has the potential to provide a commercial return and supports traditional skills (heritage)[2].					
References/ links	1. UK Government (2021): Landmark £15 million woodland creation grant opens for applications. Accessed at: https://www.gov.uk/government/news/landmark-					

Table 0-1: Fund review			
Fund name	**Forestry Commission Woodland Creation/England Woodland Creation Offer**		
Date review completed	**16/06/2021**	**Reviewed by**	**RPA (MM)**
Key aspects	**Details**		
	15-million-woodland-creation-grant-opens-for-applications on 9th June 2021 2. The Forestry Commission (2021): Woodland Creation Case Study Wood, Cambridge. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/992130/FC_Case_Study_800.pdf on 16th June 2021 3. Nature-based Solutions (2020): UK Government Budget 2020. Accessed at: https://www.naturebasedsolutionsinitiative.org/news/uk-government-budget-2020/ on 9th June 2021 4. The Guardian (2021): Forestry Commission Reveals Plan to Create New English Woodlands. Accessed at https://www.theguardian.com/environment/2021/jun/09/forestry-commission-reveals-plan-to-create-new-english-woodlands on 10th June 2021		

1.2 Biodiversity Banking

Table 0-2: Fund review						
Fund name	**Biodiversity Banking**					
Date review completed	**09/06/2021**		**Reviewed by**		**RPA (MM)**	
Key aspects	**Details**					
Summary of the fund	Biodiversity Banking is part of the governments Biodiversity Net Gain (BNG) strategy. Also known as Biodiversity offsetting, it is a policy approach that seeks to minimize the environmental impacts of a development project by ensuring that any damage in one place is compensated elsewhere. This includes placing monetary values on environmental factors. In the UK it has been defined as conservation activities that are designed to give biodiversity gain to compensate for residual losses. It is generally considered to be a last resort[1]. During 2012 and 2014, the government ran six biodiversity offsetting pilot areas, and ran public consultations on biodiversity offsetting[2],[3].					
How the fund is designed	Biodiversity offsetting is a feature of BNG and does not appear to have its own funding.					
Lead organisation(s)	Defra and Natural England					
Total value of fund	Total costing “£239,733” (2)					
Timescale over which it operates (where applicable)	N/A					
Further details						
		Agricultural outputs		Timber/wood production		Water supply

Table 0-2: Fund review						
Fund name	**Biodiversity Banking**					
Date review completed	**09/06/2021**		**Reviewed by**		**RPA (MM)**	
Key aspects	**Details**					
Ecosystem services that are the main focus		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
	+	Pollination	+	Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration	+	Identity and quality of place	++	Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
	+	Local climate regulation	+	Water flow regulation		Water quality regulation
		Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity
Examples demonstrating the link the fund and specific ecosystem services						
References/ links	1. Cambridge University (2020): Biodiversity Offsetting Policy Brief No. 1. Accessed at: https://www.geog.cam.ac.uk/research/projects/biodiversityeconomy/policybrief1.pdf on 20th June 2021 2. DEFRA (2012): Evaluation of the Biodiversity Offsetting pilot phase - WC1051. Accessed at: http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=18229&FromSearch=Y&Publisher=1&SearchText=WC1051&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description on 16th June 2021 3. DEFRA (2013): Exploring the Growth of the Biodiversity Offsetting Markets in Other Countries - WC1098. Accessed at http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=19152&FromSearch=Y&Publisher=1&SearchText=wc1098&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description on 16th June 2021					

1.3 Nature Recovery Networks/Strategy

Table 0-3: Fund review			
Fund name	**Nature Recovery Networks/Strategy**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MM)**
Key aspects	**Details**		
Summary of the fund	The Nature Recovery Network/Strategy (NRN) is a policy by the UK government that aims to "do more to recover nature and increase the benefits that it provides to our people and our economy[1]. Nature Recovery networks are a part of the governments wider 25 year Environment plan with the aim to "improve the environment within a generation." There is also the creation of NRN Delivery partnership programme. This aims to create a broad network of cross sectoral organisation who would work together to carry out action for nature supported by partnership management group. Private businesses, charities and the government sector can join this join **Objectives of NRN Partnership** • Land for nature recovery • Financial investment • Advice, time or expertise • Partners will have networking opportunities, including an annual NRN conference, workshops and meetings.		
How the fund is designed	No Specific funding announced, although the policy is linked to other funds. The government are also planning on encouraging private and third sector businesses to invest in the natural environment, including by mandating biodiversity net gain. Part of the government's general environment plan, NRN is underpinned by the Environment bill which: • sets the framework for at least one legally binding biodiversity target; • establishes spatial mapping and planning tools to identify Existing and potential habitat for wildlife and agrees local priorities for enhancing biodiversity in every area of England (LNRS); and • creates duties and incentives, including mandatory biodiversity net gain. A range of funding and duties to underpin the NRN has been or will be established. This includes Countryside Stewardship and Environmental Land Management. As part of the Environmental Land Management scheme, over the next 4 years, 10 Landscape Recovery projects to restore wilder landscapes will be created, with a focus on large-scale sites. In 2020, the government announced further funding for nature. The Nature for Climate Fund will provide significant funding with the goal of creating, restoring and managing woodland and peatland habitats. The Green Recovery Challenge Fund, which has recently been doubled to a total of £80 million, will create a pipeline of nature-based projects to restore nature, tackle climate change and connect people with the natural environment.		
Lead organisation(s)	Defra and Natural England		
Total value of fund	N/A		
Timescale over which it operates (where applicable)	Part of government's 25 Year Environment Plan and objectives are set to be achieved by 2042.		

<table>
<tr><td>Further details</td><td colspan="6"></td></tr>
<tr><td rowspan="7">Ecosystem services that are the main focus</td><td></td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td></td><td>Water supply</td></tr>
<tr><td></td><td>Renewable energy</td><td></td><td>Air quality regulation</td><td></td><td>Carbon avoided and sequestration</td></tr>
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<tr><td rowspan="7">Other ecosystem services that are covered</td><td></td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td></td><td>Water supply</td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Examples demonstrating the link between the fund and specific ecosystem services</td><td colspan="6">The NRN is still in its infancy in terms of timescales (targets are set to be achieved by 2042) and therefore examples demonstrating links between the NRN and ecosystem services are limited. However, the NRN has been developed to address three challenges facing the UK, biodiversity loss, climate change and wellbeing. It is set to achieve a wide range of ecosystem services, including:
Biodiversity through the creation and enhancement wildlife-rich places. This should lead to pollination and wellbeing benefits too (enjoying and connecting with nature);
Climate change resilience through natural solutions will reduce carbon and manage flood risk (water flow regulation). Improved landscape resilience to climate change is anticipated to lead to improved soil, clean water and clean air; and
Improved welling, not only through improved biodiversity, but also the protection of the historic environment and better connections to nature[8].
“Coronavirus is shining a light on the importance of our natural world, and the positive impact nature can have on our health and well-being. These first pilots will be a key part of our green recovery and help kick-start the creation of over a million acres of joined up habitats that people can enjoy across the country.” [2]

“As with Biodiversity 2020, the strategy will seek to recover nature, both because people value and are concerned about it in its own right, and because nature – our ecosystems and their component species – underpins many of the economic and social benefits that enrich people’s lives.” [3]</td></tr>
<tr><td>References/links</td><td colspan="6">1. DEFRA (2020)- Nature Recovery Network</td></tr>
</table>

	https://www.gov.uk/government/publications/nature-recovery-network/nature-recovery-network on 24th June 2021 2. CIEEM (2020): Natural England Launch Local Nature Recovery Strategy https://cieem.net/natural-england-launch-local-nature-recovery-strategy-in-england/ 13th June 2021 3. DEFRA (2019): Nature Recovery Network: Discussion Document. Accessed at: https://www.confor.org.uk/media/247417/nature-recovery-network_discussion-document_defra-group_april2019.pdf on 20th June 2021 4. DEFRA (2018): Policy Paper. 25 Year Environment Plan. Accessed at: https://www.gov.uk/government/publications/25-year-environment-plan on 26th June 2021 5. Defra (2020): Policy Paper. Nature Recovery Network. Accessed at: https://www.gov.uk/government/publications/nature-recovery-network/nature-recovery-network on 16th June 2021

1.4 Levelling up

Table 0-3: Fund review			
Fund name	**Levelling Up Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MA)**
Key aspects	**Details**		
Summary of the fund	Announced at the 2020 Spending Review[1], the £4.8 billion Levelling Up Fund is the Government's headline regeneration initiative, providing grants for capital investment projects across Great Britain. The fund aims to "invest in infrastructure that improves everyday life across the UK", supporting town centre, high street and urban regeneration, local transport projects, and cultural and heritage assets[2].		
How the fund is designed	The Fund is jointly managed by HM Treasury (HMT), the Ministry of Housing, Communities and Local Government (MHCLG) and the Department for Transport (DfT). The fund is available for all parts of the UK. In Great Britain, applications for funding can come from: 1) Unitary authorities (including metropolitan borough councils), London borough councils and district councils in two tier areas in England; and unitary authorities in Scotland and Wales, who may submit bids of all types; and 2) County councils with transport powers, combined authorities, mayoral combined authorities and the Greater London Authority (GLA), who may submit one transport bid. Unitary authorities in Scotland and Wales, and unitary authorities in England with transport powers are allowed to submit one additional bid provided it is for transport. Local Members of Parliament are expected to back one bid that they see as a priority for their area. The number of bids that a local authority in the first list can make will be based on the number of MPs in that area, meaning that a local authority may submit one bid for every MP whose constituency is located fully within their boundary. Every local authority can submit at least one bid. Where an MP's constituency crosses multiple local authorities, one local authority will be designated as the responsible lead bidder, with local areas collaborating together to decide which will be the lead bidder. The MHCLG will work with local government to ascertain whether further guidance is needed on how to establish which authority should be designated 'lead bidder' in such circumstances. The amount of funding each area receives is to be decided on a competitive basis, with the assessment process focussing on the following assessment criteria:		

Table 0-3: Fund review			
Fund name	**Levelling Up Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MA)**
Key aspects	**Details**		
	• **Characteristics of the place** (with each local authority being placed into one of three categories indicating different levels of prioritisation, based on an assessment of the level of identified need in an area, with Category 1 being the highest priority category of the three, and Category 3 the lowest). • **Deliverability** (taking into account any additional financing in place, management structures' delivery and procurement plans, project costings). • **Value for money** (including demonstrating the economic case for a project and how it provides public value to society). The first round of funding will prioritise bids that are able to demonstrate that they have additional investment in place or that they are able to begin delivery on the ground in the coming financial year (2021-22). Capacity funding of £125,000 will be allocated to those local authorities in England deemed most in need of investment (i.e., Category 1), as identified in the index published alongside the prospectus, as well as to all local authorities in Scotland and Wales (with a different approach established for capacity funding in Northern Ireland). This capacity funding is designed to assist relevant local authorities in developing high-quality funding bids and ensure that investment is directed towards those areas most in need. Doncaster and Rotherham have been designated Category 1, while Barnsley and Sheffield are in Category 2. The fund will focus on projects that require up to £20m of funding. However, there is also some scope for investing in larger transport projects. Bids above £20m and below £50m will be allowed for transport projects only and can be submitted by any local authority. These bids will be subjected to a more detailed business-case process and will need to score highly overall.[3]		
Lead organisation(s)	HM Treasury		
Total value of fund	£4.8 billion (£4 billion for England; £800 million Scotland, Wales and Northern Ireland)		
Timescale over which it operates (where applicable)	Over four years: up to 2024-25.		
Further details	In developing their investment project and their funding bid, local authorities are encouraged to consult a wide range of local stakeholders across the full geography of the area(s) for which they are responsible. Relevant local stakeholders and partners could include local businesses, public transport providers, police and emergency services, community representatives, environmental representatives, private sector stakeholders, such as developers, that could be impacted by a specific project, universities and FE colleges, associated local authorities, and stakeholders from harder to reach rural communities (where relevant), as well as local MPs. The first round of funding focusses on three themes: smaller transport projects that make an important difference in local areas; town-centre and high-street regeneration; and maintaining and expanding cultural and heritage: • **Transport investments** such as **public transport**, **active travel**, bridge repairs, **bus priority lanes**, local road improvements and major structural maintenance, and accessibility improvements. High-impact small, medium and by exception larger		

<table>
<tr><th colspan="7">Table 0-3: Fund review</th></tr>
<tr><td>Fund name</td><td colspan="6">Levelling Up Fund</td></tr>
<tr><td>Date review completed</td><td colspan="2">09/06/2021</td><td colspan="2">Reviewed by</td><td colspan="2">RPA (MA)</td></tr>
<tr><td>Key aspects</td><td colspan="6">Details</td></tr>
<tr><td></td><td colspan="6">local transport schemes to reduce carbon emissions, improve air quality, cut congestion, support economic growth and improve the experience of transport users.
• <u>Regeneration and town centre investment</u> by upgrading eyesore buildings and dated infrastructure, acquiring and regenerating brownfield sites, investing in secure community infrastructure and crime reduction, and bringing public services and safe community spaces into town and city centres.
• <u>Cultural investment</u> through maintaining, regenerating, or creatively repurposing museums, galleries, visitor attractions (and associated green spaces) and heritage assets as well as creating new community-owned spaces to support the arts and serve as cultural spaces.

“Projects should be aligned to and support Net Zero goals: for instance, be based on low or zero carbon best practice; adopt and support innovative clean tech and/or support the growth of green skills and sustainable supply chains. Where applicable, bids may also seek to demonstrate compliance with relevant Publicly Available Specifications such as PAS 2080 and PAS 2035. Bids should also consider how projects can work with the natural environment to achieve project objectives – considering at a minimum the project’s impact on natural assets and nature, as well as the resilience of the project to potential hazards such as flooding.”[3]</td></tr>
<tr><td rowspan="7">Ecosystem services that are the main focus</td><td></td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td></td><td>Water supply</td></tr>
<tr><td></td><td>Renewable energy</td><td>++</td><td>Air quality regulation</td><td>++</td><td>Carbon avoided and sequestration</td></tr>
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<tr><td>+</td><td>Pollination</td><td>++</td><td>Access to nature (recreation)</td><td>++</td><td>Physical and psychological experiences</td></tr>
<tr><td>+ +</td><td>Learning and inspiration</td><td>++</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
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<tr><td></td><td>Learning and inspiration</td><td></td><td>Identity and quality of place</td><td>+</td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Examples demonstrating the link between the</td><td colspan="6">• “Investments in new or existing cycling provision” will contribute to air quality regulation, carbon avoidance, physical and psychological experiences, and quality of place.</td></tr>
</table>

Table 0-3: Fund review			
Fund name	**Levelling Up Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MA)**
Key aspects	**Details**		
fund and specific ecosystem services	• "Improving the public realm including high streets, parks and green spaces, designing out opportunities for crime and anti-social behaviour" will contribute to air quality regulation, carbon sequestration, local climate regulation, pollination, access to nature (recreation), physical and psychological experiences, inspiration, and quality of place. "Upgrading and creating new cultural and creative spaces including sports or athletics facilities, museums, arts venues, theatres, libraries, film facilities, prominent landmarks or historical buildings, parks or gardens" will contribute to physical and psychological experiences, learning and inspiration, and identity and quality of place."[3]		
References/links	1. UK Government: (2020): Spending Review 2020. Accessed at: https://www.gov.uk/government/publications/spending-review-2020-documents/spending-review-2020 on 9th June 2021 2. UK Government (2021): Policy paper: Levelling Up Fund: prospectus. Accessed at: https://www.gov.uk/government/publications/levelling-up-fund-prospectus on 9th June 2021 3. UK Government (2021): Levelling Up Fund: prospectus. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/966138/Levelling_Up_prospectus.pdf on 9th June 2021 4. UK Government (2021): New levelling up and community investments. Accessed at: https://www.gov.uk/government/collections/new-levelling-up-and-community-investments on 9th June 2021		

1.5 Woodland Code

Table 0-4: Fund review			
Fund name	**Woodland Carbon Code**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MA)**
Key aspects	**Details**		
Summary of the fund	The Woodland Carbon Code (WCC) is the UK's voluntary quality assurance carbon standard for woodland creation projects in the UK. With the backing of the UK government, the forest industry and carbon market experts, the Code, uniquely, generates independently verified woodland carbon units. The Woodland Carbon Code is also endorsed by ICROA, the global umbrella body for carbon reduction and offset providers in the voluntary market. Woodland Carbon Units from verified WCC projects can be purchased by companies from project developers to compensate for their UK-based carbon emissions. The WCC provides: • carbon buyers with the reassurance they have invested in a responsible scheme with clear benefits; • project developers with recognised woodland management and carbon accounting procedures and standards to work within.[1] WCC-certified projects are acknowledged as a contribution to the UK meeting its greenhouse gas emissions reduction commitments and can be reported as part of a UK business' net greenhouse gas emissions.		
How the fund is designed	Woodland Carbon Code projects generate Woodland Carbon Units, which once verified can be sold by landowners of approved projects and bought and used by UK businesses to help compensate for their gross carbon emissions. Gaining validation / verification that a woodland carbon project meets the code means that the project: - is responsibly and sustainably managed to national standards; - can provide reliable estimates of the amount of carbon that will be sequestered or locked up as a result of the tree planting; - must be publicly registered and independently verified; - meets transparent criteria and standards to ensure that real carbon benefits are delivered. To certify a project to the Woodland Carbon Code, a project developer must: - register it with the Forestry Commission within two years of the start of planting; - predict carbon capture using woodland carbon models; - prepare a Project Design Document outlining how it meets Code requirements; - have it 'validated' by an accredited certification body; and - have it 'verified' periodically to show that it continues to meet the required standards. To meet the requirements of the code, projects must: - register their project, stating the exact location and long-term objectives of their project; - meet national forestry standards to ensure they are sustainably and responsibly managed; - have a long-term management plan; - use standard methods for estimating the carbon that will be sequestered; - demonstrate that the project delivers additional carbon benefits than would otherwise have been the case. - maintain verification for the duration of the project.		

	Projects that meet all these requirements can carry the Woodland Carbon Code label of approval. The Code works for everyone involved: - Carbon buyers have reassurance that they have invested in a responsible scheme and can see the benefits that will be provided. - Projects have recognised procedures and standards to work to, and can use their verified status as an attractive selling point for potential customers. - Woodland managers have clearly set out standards of forest management to follow. The Woodland Carbon Code issues carbon units which represent measurable amounts of carbon dioxide (CO2) removed from the atmosphere by trees as they grow – one unit is 1 tonne of carbon dioxide equivalent removed from the atmosphere. As trees take a while to grow and sequester carbon dioxide, we have two types of unit available to purchase. Companies can compensate for their UK-based emissions using carbon units from WCC projects, but not for their emissions overseas or emissions from international aviation or shipping. A Woodland Carbon Unit (WCU) represents one tonne of CO2e which has been sequestered in a WCC-verified woodland. It has been independently verified, is guaranteed to be there, and can be used by companies to report against UK-based emissions or to use in claims of carbon neutrality or Net Zero emissions. A Pending Issuance Unit (PIU) is a promise to deliver a Woodland Carbon Unit in future, based on predicted sequestration. It is not guaranteed and cannot be used to report against UK-based emissions until verified. However, it allows companies to plan to compensate for future UK-based emissions, or make credible CSR statements in support of woodland creation. Units are held in the UK Land Carbon Registry, managed by IHS Markit. Every 10 years, projects are checked and, if performing well, verified. At each of these points, PIUs delivered are converted to WCUs. As of March 2020, over 3.7 million tCO2e had been validated for sale as PIUs by March 2020 and the number continues to increase. There's now a growing number of verified projects with a small amount of WCUs - the number of WCUs available will increase as woodlands grow and mature.[2]
Lead organisation(s)	Forestry Commission
Total value of fund	Companies in the UK pay between £7 and £20 /tCO2e for purchases of Pending Issuance Units.[2] In its 2016 report, Assessing the Wider Benefits of Woodland Carbon Code Projects, commissioned by the Forestry Commission, EFTEC estimated that, on average, each carbon unit (tCO2e) purchased from a Woodland Carbon Code project also delivers at least a further £100/tCO2e of value through recreation, biodiversity, air quality and benefits to the local economy. EFTEC also estimated 12.5% of projects to be within areas identified as priorities for reducing water pollution/flood risks, and that a small percentage were accessible to communities in the lowest 20% of social deprivation areas. [3]
Timescale over which it operates (where applicable)	Since 2011, ongoing.
Further details	Creating new woodland sequesters carbon dioxide from the atmosphere and provides other social and environmental benefits, such as: - biodiversity and habitat creation

<table>
<tr><td></td><td colspan="6">- flood prevention, water quality
- air quality
- health, wellbeing and enjoyment
- shelter for livestock
- timber and wood fuel
- skilled jobs
- community engagement and staff volunteering, education and development[2]</td></tr>
<tr><td rowspan="7">Ecosystem services that are the main focus</td><td></td><td>Agricultural outputs</td><td>++</td><td>Timber/wood production</td><td></td><td>Water supply</td></tr>
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<tr><td>+</td><td>Local climate regulation</td><td>++</td><td>Water flow regulation</td><td>+</td><td>Water quality regulation</td></tr>
<tr><td></td><td>Pollination</td><td>+</td><td>Access to nature (recreation)</td><td></td><td>Physical and psychological experiences</td></tr>
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<tr><td rowspan="7">Other ecosystem services that are covered</td><td>+</td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td>+</td><td>Water supply</td></tr>
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<tr><td>+</td><td>Learning and inspiration</td><td>+</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Examples demonstrating the link between the fund and specific ecosystem services</td><td colspan="6">• Bennan Hill, Balbeg Estate: “The new plantation is more than just woodland creation. This project has provided a mosaic ecosystem that will not only sequester carbon but provide a variety of ecosystem services that play a vital part in improving biodiversity, along with water and air quality. In addition, this woodland specifically provides the creation of increased leisure opportunities, local community engagement and an opportunity to attract tourism into a secret part of South Ayrshire. Bennan Hill woodland within Balbeg Estate will provide connectivity to surrounding habitats which in turn will provide a network of footpaths to allow the local community and tourists to enjoy the rugged landscape South Ayrshire has to offer. The beauty of this plantation is that while providing natural capital benefits it will also provide a commercial timber supply to the UK market in turn contributing to the rural economy. Carbon investors will be supporting the regeneration of poor agricultural grazing land into a diverse, multi-beneficial ecosystem that will create income to allow reinvestment to support further expansion of the public access network.”.[4]
• Warner’s Wood: “A 100 year Broadleaf woodland for biodiversity, covering 32 hectares in the heart of rural Leicestershire”.[5]
• Buccleuch Group: “All of the projects will involve cessation of grazing and permanent removal of livestock and deer. This will result in an improvement of woodland vegetation where light levels permit and of woodland bird and invertebrate species. In most cases it will result in riparian improvement and elimination of diffuse pollution. All of the projects will provide public access. In the case of Boughton none existed</td></tr>
</table>

	before. Most sites are intended for timber production which will help preserve rural employment and provide sustainable materials and wood-fuel".[6]
References/links	1. UK Government (2018): The Woodland Carbon Code scheme for buyers and landowners. Accessed at: https://www.gov.uk/guidance/the-woodland-carbon-code-scheme-for-buyers-and-landowners#:~:text=The%20Woodland%20Carbon%20Code%20(WCC,quality%2C%20robust%20voluntary%20carbon%20standard on 9th June 2021 2. Woodland Carbon Code: UK Woodland Carbon Code: Accessed at: https://woodlandcarboncode.org.uk/ on 9th June 2021 3. Scottish Forestry (2016): Assessing the Wider Benefits of the Woodland Carbon Code. Accessed at: https://forestry.gov.scot/publications/sustainable-forestry/economic-research/588-assessing-the-wider-benefits-of-the-woodland-carbon-code on 9th June 2021 4. Woodland Carbon Code: Bennan Hill, Balbeg Estate. Accessed at: https://woodlandcarboncode.org.uk/case-studies/woodland-carbon-projects/bennan-hill on 28th June 2021 5. IHS Markit (2018): Warner's Wood (ID: 103000000004606). Accessed at: https://mer.markit.com/br-reg/public/project.jsp?project_id=103000000004606 on 9th June 2021 6. Woodland Carbon Code: Buccleuch Group. Accessed at: https://woodlandcarboncode.org.uk/case-studies/woodland-carbon-projects/buccleuch-group on 9th June 2021

1.6 Peatland Code

Table 0-5: Fund review			
Fund name	**Peatland Code**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (MA)**
Key aspects	**Details**		
Summary of the fund	The Peatland Code is a voluntary certification standard for UK peatland projects wishing to market the climate benefits of peatland restoration and provides assurances to voluntary carbon market buyers that the climate benefits being sold are real, quantifiable, additional and permanent. The Peatland Code specifies requirements for the validation and verification of a Greenhouse Gas (GHG) assertion from voluntary UK based projects that reduce GHG emissions through peatland restoration. Peatland Code emissions reduction accounts for both GHG from, and sequestered by, peatland.[1]		
How the fund is designed	The Peatland Code is a voluntary standard issued by the IUCN UK National Committee and is managed on its behalf by an Executive Board. The Executive Board is facilitated by IUCN UK Peatland Programme staff and supported by a Technical Advisory Board including additional stakeholder groups, when required. Verification will regularly evaluate the project and its actual GHG emissions reduction against both the requirements of the Peatland Code and its validated project plan and GHG assertion. The Peatland Code validation/verification pathway is as follows: - registration; - site survey; - restoration plan & GHG assertion; - validation; - implementation of the restoration plan; - ongoing verification. Eligible activities shall be those relating to restoration of either blanket bog or raised bog with an associated baseline condition category of 'Actively Eroding' or 'Drained' and a minimum peat depth of 50 cm. The Peatland Code sets out a series of best practice requirements including a standard method for quantification of GHG benefit. Independent validation to this standard provides assurance and clarity for buyers with regards the quantity, quality of emissions reductions purchased. Recognising that carbon benefits arise for many years after the initial restoration activities are implemented, the Peatland Code also ensures the carbon benefit will be regularly measured and monitored over the lifetime of the project (minimum 30 years). Buyers can therefore be confident in purchasing peatland carbon units upfront, enabling the restoration project to take place. Funding obtained from the sale of climate benefit can sit alongside traditional public sources of funding, providing cost effective peatland restoration and ensuring management and maintenance of restoration projects over the long term. The Peatland Code is currently designed to attract private purchases motivated by corporate social responsibility. The funding received from the sale of carbon benefit will depend on the extent of damage prior to restoration, the size of the project and the length of the management agreement. The Peatland Code works for everyone involved: - Carbon buyers have reassurance that they have facilitated a responsible scheme, which will result in additional climate benefits. - Projects have recognised procedures and standards to work to, and can use their validated/verified status as a means to market the carbon benefits to potential buyers.		

<table>
<tr><td></td><td colspan="6">- Society will benefit from enhanced climate mitigation and the restoration of the natural landscape.

The Peatland Code Registry shows available projects or alternatively buyers can use the services of a specialist carbon broker to actively search for a suitable project on their behalf. Projects can market the benefits of their project at any time over its duration, with the majority selling the total upfront once their peatland restoration plan has received validation.[1]</td></tr>
<tr><td>Lead organisation(s)</td><td colspan="6">IUCN UK National Committee</td></tr>
<tr><td>Total value of fund</td><td colspan="6">-</td></tr>
<tr><td>Timescale over which it operates (where applicable)</td><td colspan="6">Ongoing. Minimum project duration is 30 years.</td></tr>
<tr><td>Further details</td><td colspan="6">The wider associated ecosystem service benefits of restoration include improvement in biodiversity, cleaner water, water flow management.</td></tr>
<tr><td rowspan="7">Ecosystem services that are the main focus</td><td></td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td>+</td><td>Water supply</td></tr>
<tr><td></td><td>Renewable energy</td><td></td><td>Air quality regulation</td><td>++</td><td>Carbon avoided and sequestration</td></tr>
<tr><td></td><td>Local climate regulation</td><td>++</td><td>Water flow regulation</td><td>+</td><td>Water quality regulation</td></tr>
<tr><td></td><td>Pollination</td><td></td><td>Access to nature (recreation)</td><td></td><td>Physical and psychological experiences</td></tr>
<tr><td></td><td>Learning and inspiration</td><td></td><td>Identity and quality of place</td><td>+</td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">Other ecosystem services that are covered</td><td>+</td><td>Agricultural outputs</td><td>+</td><td>Timber/wood production</td><td></td><td>Water supply</td></tr>
<tr><td>+</td><td>Renewable energy</td><td>+</td><td>Air quality regulation</td><td></td><td>Carbon avoided and sequestration</td></tr>
<tr><td>+</td><td>Local climate regulation</td><td></td><td>Water flow regulation</td><td></td><td>Water quality regulation</td></tr>
<tr><td>+</td><td>Pollination</td><td>+</td><td>Access to nature (recreation)</td><td>+</td><td>Physical and psychological experiences</td></tr>
<tr><td>++</td><td>Learning and inspiration</td><td>++</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Examples demonstrating the link between the fund and specific ecosystem services</td><td colspan="6">• Ceannacroc (Phase 1): “Drained and actively eroding blanket bog to be restored through drain blocking and revegetation”.[2]
• Corriemulzie (Phases 1-3): “Three phases of restoration of degraded blanket bog on Corriemulzie Estate. Restoration will mainly consist of the reprofiling of haggs/gullies and peat dams. Timber dams may also be used where appropriate. Sphagnum will be spread across the site to encourage revegetation”.[3]
• Fleet Moss: “The restoration of a severely degraded moorland involving the damming of grips and gullies with peat dams, stone and timber sediment traps and coir logs; the brashing and revegetation of bare peat areas with heather brash, dwarf shrub seed, cotton grass plugs, crowberry plugs; and the inoculation of bare peat areas with sphagnum”.[4]</td></tr>
<tr><td>References/links</td><td colspan="6">1. IUCN UK: Peatland Programme. Accessed at: https://www.iucn-uk-peatlandprogramme.org/ on 9th June 2021
2. IHS Markit: Ceannacroc (Phase 1) (ID: 104000000026983). Accessed at https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026983 on 9th June 2021</td></tr>
</table>

	3. IHS Markit: Corriemulzie (Phases 1-3) (ID: 104000000027139). Accessed at: https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000027139 on 9th June 2021 4. IHS Markit: Fleet Moss (ID: 104000000026998). Accessed at: https://mer.markit.com/br-reg/public/project.jsp?project_id=104000000026998 on 9th June 2021

1.7 Woodland Equity Fund

Table 0-6: Fund review			
Fund name	**Woodland Equity Fund**		
Date review completed	**01/06/2021**	**Reviewed by**	**RPA**
Key aspects	**Details**		
Summary of the fund	New woodland creation: supported by revenues from timber and carbon credits. This is clearly aligned to 25-year plan objectives and follows an established business model, reducing risks. The facility's role will be to create the conditions to further strengthen this business model. For instance, interventions by the facility may mitigate policy risk around carbon credits, aggregate projects to achieve economies of scale in finance, and address the mismatch between project return time scales and candidate investors' time horizons.[1] Established business model for forestry and forest bonds financing track record, Woodland creation a policy priority, UK government considering a forest carbon guarantee scheme, The Woodland Carbon Code provides a standard for UK afforestation projects MRV, Converting 0.5% of UK agricultural land to forestry could represent a £1.2bn -£1.5bn opportunity, Potential for increased share of home-grown timber in consumption, Potential monetisation of leisure, habitat creation and catchment services		
How the fund is designed			

"Capital item	**Payment rate (100%)**	**Available for PAWS**	**Available for native woodland creation**[2]
Tree planting	£1.60 / tree	Yes	Yes
Tree shelters	£2.00 / tree	Yes	Yes
Temp deer fencing	£6.50 / m	Yes	Yes
Stock fence	£5 / m	Yes	Yes
Rabbit netting	£3.13 / m	Yes	Yes
Field gate	£487.50/ gate	Yes	Yes
Stone wall top netting	£4.50 / m	Yes	Yes
Badger gate	£168.75 / m	Yes	Yes

	Leaky woody dams 1-3m	£576.75 / m	Yes	Yes
	Leaky woody dams 3-5m	£995.54 / m	Yes	Yes
	Deer high seats	£375 / seat	Yes	No
	Deer exclosure plot	£136 / plot	Yes	No
	Deer fencing	£8.55 / m	Yes	Yes
	Invasive species control list A	£3,500 / ha	Yes	No
	Invasive species control list A 2.5-4m	£4,000 / ha	Yes	No
	Invasive species control list A 4+m	£5,500 / ha	Yes	No
	Invasive species control list B	£324 / ha	Yes	No
	Invasive species control list C	£171.60 / ha	Yes	No
	Invasive species control list D	£394.63 / ha	Yes	No
	Deer impact assessments	£300 up to 25 ha	Yes	No
	Deer vehicle gates (3m x 1.8m)	£430.76/ gate	Yes	Yes
	Deer pedestrian	£339.85/ gate	Yes	Yes

<table>
<tr><td></td><td>
<table>
<tr><td>gates (0.9m x 1.8m)</td><td></td><td></td><td></td></tr>
<tr><td>Ground prep for natural regeneration</td><td>£121.85 / ha</td><td>Yes</td><td>No</td></tr>
<tr><td>Squirrel management cage trap</td><td>£15 / unit</td><td>Yes</td><td>No</td></tr>
<tr><td>Squirrel management multi-catch cage trap</td><td>£89.50 / unit</td><td>Yes</td><td>No</td></tr>
<tr><td>Squirrel management spring trap (mid-range)</td><td>£46.93 / unit</td><td>Yes</td><td>No</td></tr>
<tr><td>Squirrel management automatic self-setting trap</td><td>£159.99/ unit</td><td>Yes</td><td>No”</td></tr>
</table>
</td></tr>
<tr><td>Lead organisation(s)</td><td>Main organisation includes the Forestry Commission</td></tr>
<tr><td>Total value of fund</td><td>Fund expected to cost £500 million, minimum investment of £30-£50 million</td></tr>
<tr><td>Timescale over which it operates (where applicable)</td><td>Anywhere between 10 and 25 years</td></tr>
<tr><td>Further details</td><td>Economic activities against taxonomy, NACE level, growth-yield model, CO2 stock, certification[5]

e.g. the Woodland Carbon Fund (not equity fund but could support blended financing): The land must meet the following size thresholds:
- 10 hectares or more to be planted as woodland
- either one continuous standalone block of 10 hectares or more, or at least 10 hectares of new planting in stands that are no more than 50 meters from either one another or, else from existing woodland, where the objective of the new planting clearly remains to establish productive woodland
- for any given block of woodland, integral open space is no more than 20 meters wide, no more than 0.5 hectares in extent, and completely surrounded by woodland or forest</td></tr>
<tr><td>Ecosystem services that are the main focus</td><td>
<table>
<tr><td>+</td><td>Agricultural outputs</td><td>+</td><td>Timber/wood production</td><td>+</td><td>Water supply</td></tr>
<tr><td>+</td><td>Renewable energy</td><td>+</td><td>Air quality regulation</td><td></td><td>Carbon avoided and sequestration</td></tr>
<tr><td></td><td>Local climate regulation</td><td></td><td>Water flow regulation</td><td></td><td>Water quality regulation</td></tr>
</table>
</td></tr>
</table>

		Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production	+	Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination	+	Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	- Northern Forest: As part of the 25-Year Environment Plan, the government committed to creating the Northern Forest with an estimated overall cost of £500m. The scale of this opportunity and the nature of the long investment horizons of woodland projects warrant the creation of a specific woodland fund. This could be structured as an equity fund through drawing in a blend of philanthropic capital alongside repayable finance to invest in woodland projects before they are revenue generating. Modest investor returns earlier could be generated through agri-forestry schemes and cross-subsidisation from mature woodland and increase to commercial returns in the long-term. This model is potentially suitable for financing the entire Northern Forest. If the Northern Forest in GM is funded in isolation predominantly through urban tree planting, a place-based portfolio model would be more suitable.[2] - WCF: Landowners, land managers, local authorities and public bodies can apply to the Forestry Commission for support to plant large-scale productive woodland under the Woodland Carbon Fund (WCF). Up to 40% of the remaining fund will be made available to public bodies and the remaining 60% will be available for applications from private owners. Public bodies other than Forestry England are now also eligible to include the second stage payment in their applications.[3] - HS2 Woodland Fund: Apply for funding to support native woodland creation or the restoration of Plantations on Ancient Woodland Sites (PAWS) within a 25-mile zone surrounding the HS2 route - currently in Phase One, from London to the West Midlands.[4]					
References/links	1. Finance Earth (2021) Enabling Investment into Conservation Climate and Communities https://www.environmentalfinance.co.uk/wp-content/uploads/2019/04/Defra-Natural-Environment-Impact-Fund-Business-Case-June-2018.pdf on 1st June 2021 Forestry Commission (2021). Outline Business Case for a Natural Environment Impact Fund 2. GOV.UK (2021) HS2 Woodland Fund (www.gov.uk) on 25th June 2021 3. EFTEC Greater Manchester (2019) Greater Manchester Natural Capital Investment Plan https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf on 1st June 2021 4. Forestry Commission (2018) Woodland Carbon Fund https://www.gov.uk/guidance/woodland-carbon-fund on 1st June 2021 5. PRI (2020) EU Taxonomy alignment case study: International Woodland Company https://www.unpri.org/eu-taxonomy-alignment-case-studies/eu-taxonomy-alignment-case-study-international-woodland-company/6258.article on 1st June 2021					

1.8 Environmental Impact Bond

Table 0-7: Fund review						
Fund name	**Environmental Impact Bond**					
Date review completed	**01/06/21**		**Reviewed by**		**RPA**	
Key aspects	**Details**					
Summary of the fund	Beneficiaries of interventions could be contracted to become payers for a positive outcome from specific interventions. Investment is raised from private investors to carry out interventions to achieve financial savings as a result of improvements. Investors returns are linked to the performance of the interventions. They enable investors to focus on outcomes rather than specific activities and the financial return is tied to the success of the project					
How the fund is designed	Once the bonds have been issued, the issuer uses the obtained funds to pay for their planned interventions. The principal amount of the bonds and interest must be remitted on scheduled payment dates. Following an evaluation period, the issuer pays the investors an outcome profit when there is demonstrable proof that the project has performed better than expected. If it underperforms, however, then the investor must pay the issuer a 'risk-sharing' payment. This usually means that the investor receives little or no interest					
Lead organisation(s)	[Washington] D.C Water Environmental Impact Bond[1]					
Total value of fund	US examples are set between $14 and $25 million					
Timescale over which it operates (where applicable)	Timetables not given in US examples					
Further details	Funds come from investors and require an issuer to set up and administer the EIB					
Ecosystem services that are the main focus	+	Agricultural outputs	+	Timber/wood production	+	Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
	+	Renewable energy		Air quality regulation		Carbon avoided and sequestration
	+	Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	Washington DC EIB (https://waterfm.com/a-closer-look-at-environmental-impact-bonds/) Atlanta Bond was issued to public markets (https://waterfm.com/atlanta-dwm-completes-first-publicly-issued-environmental-impact-bond/)					

References/links	1. Goldman Sachs (2021): FACT SHEET: DC Water Environmental Impact Bond. Accessed at: https://www.goldmansachs.com/media-relations/press-releases/current/dc-water-environmental-impact-bond-fact-sheet.pdf on 15th June, 2921 2. Goldman Sachs, Calvert Foundation (2021) District of Columbia Water and Sewer Authority Public Utility Subordinate Lien Revenue Bonds Series 2016B (Environmental Impact Bonds)

1.9 Green Bond

Table 0-8: Fund review						
Fund name	**Green Bond**					
Date review completed	**01/06/21**		**Reviewed by**		**RPA**	
Key aspects	**Details**					
Summary of the fund	A green bond is a type of fixed-income instrument that is specifically earmarked to raise money for climate and environmental projects. These bonds are typically asset-linked and backed by the issuing entity's balance sheet, so they usually carry the same credit rating as their issuers' other debt obligations. Green bonds finance projects aimed at energy efficiency, pollution prevention, sustainable agriculture, fishery and forestry, the protection of aquatic and terrestrial ecosystems, clean transportation, clean water, and sustainable water management. They also finance the cultivation of environmentally friendly technologies and the mitigation of climate change. (1) Any organisation with bonding authority may issue Green Bonds, including private companies, financial institutions and municipal governments. (5) There are six different forms of green bonds: Corporate bond, Project bond, Asset-backed security (ABS), Supranational, sub-sovereign and agency (SSA) bond, Municipal bond, Financial sector bond (2)					
How the fund is designed	Issuers should follow the Green Bonds Principles (GBP). Collectively they relate to 1. use of proceeds, 2. process for project evaluation and selection, 3. management of proceeds, 4. reporting. Following the GBP is key in ensuring transparent disclosure and effective management. (5) Issuers can be municipalities, utilities, public-private partnerships, and private companies building green infrastructure, including low-carbon buildings (7)					
Lead organisation(s)	Anglian Water Green Bond. Paris Green Bond. Barclays Green Bond					
Total value of fund	Total volume of USD 91.6bn (3). Issuance: USD 259bn (2018: USD171.2bn), Number of deals: 1,802 (2018: 1,591), Number of issuers: 506 (2018: 347) (4)					
Timescale over which it operates (where applicable)	Funding runs from between 3-5 years					
Further details	Green bonds are a natural source of financing for issuers who have a financing or refinancing requirement for a green project.					
Ecosystem services that are the main focus		Agricultural outputs		Timber/wood production		Water supply
	+	Renewable energy		Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity

Other ecosystem services that are covered	+	Agricultural outputs	+	Timber/wood production	+	Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	Greater Anglia's Green Bond programme aims to save or avoid "160,736 tonnes of carbon - a 61% reduction from the company's 2010 capital carbon baseline" (8) Paris Green Bonds advocated for a "scale up investment in green bonds, climate bonds and other bonds financing mitigation of and adaptation to climate change" (9)					
References/links	1. Segal, Troy, Investopedia (2021): What is a Green Bond? Accessed at: https://www.investopedia.com/terms/g/green-bond.asp on 1st, June 2021 2. Bloomberg Philanthropies (2016): Green Bonds Mobilising debt capital markets for a low-carbon transition. Accessed at https://www.oecd.org/environment/cc/Green%20bonds%20PP%20%5Bf3%5D%20%5Blr%5D.pdf on 1st June 2021 3. Climate Bonds Initiative (2020): Green Bond Market Summary. Accessed at: https://www.climatebonds.net/files/reports/h1_2020_highlights_final.pdf on1st June 2021 4. Climate Bonds Initiative (2019): Climate Bond releases Global Green Bonds 2019 report: In depth analysis of record year for green finance. Accessed at: https://www.climatebonds.net/2020/07/climate-bonds-releases-global-green-bonds-2019-report-depth-analysis-record-year-green on 1st June 2021 5. Deloitte (2018): Green Bonds Issuance and Support Offering. Accessed at: https://www2.deloitte.com/lt/en/pages/legal/articles/Green-Bonds-Issuance-and-Support-Offering.html on 1st June 2021 6. KPMG (2016): Green Bonds The Process. Accessed at: https://assets.kpmg/content/dam/kpmg/pdf/2016/04/green-bonds-process.pdf on 1st June, 2021 7. Green City Bonds (2015): How To Issue A Green City Bond The Green City Bond Overview. Accessed at: https://www.climatebonds.net/files/files/How-to-Issue-Green-City-Bonds.pdf on 5th June 2021 8. Anglia Water (2019): Anglian Water funds 850 capital investment projects through Green Bonds. Accessed at: Anglian Water funds 850 capital investment projects through Green Bonds on 29th May 2021 (9) The Climatebond.net (2015): The Paris Green Bonds Statement. Accessed at: Paris_Investor_Statement_9Dec15.pdf (climatebonds.net) on 29th May 2021					

1.10 Place-Based Portfolio

Table 0-9: Fund review			
Fund name	**Place-Based Portfolio**		
Date review completed	**02/06/21**	**Reviewed by**	**RPA**
Key aspects	**Details**		
Summary of the	"This model has considerable promise to improve the management of natural capital assets in a manner that engages communities and could potentially be applied very widely." It "can		

fund	provide a sustainable funding for natural capital assets where revenue-generating activities can be used to cross-subsidise the provision of other ecosystem services."[1] Transfer network of urban green (and blue) spaces into a dedicated management vehicle e.g. Charitable Trust to achieve greater public benefit.[2]					
How the fund is designed	A "charity or social enterprise that manages a natural capital asset portfolio, such as urban parks, beaches or a woodland, under a mandate to balance ecosystem services, including monetisable and non-monetisable (public health, amenity value, improvement of air quality) benefits."[1] For the place-based portfolio model, the first step would be the appointment of a project manager who would be in charge of engaging stakeholders to explore the feasibility of transferring the ownership or management of assets into a charitable trust; then, a project team would explore and carry out financial planning, legal structuring and stakeholder management. Advice could be taken from initiatives currently underway, such as Newcastle-upon-Tyne's 'People's Parks Trust'[3]					
Lead organisation(s)	There are two lead organisers, Royal Parks in London and the Milton Keynes Park Trust					
Total value of fund	Value of the fund is between £1 million and £5 million					
Timescale over which it operates (where applicable)	The fund is investible for 1 to 3 years					
Further details	Individual assets, such as city parks and urban green and blue infrastructure, may not be investable on their own. However, they can be grouped into a portfolio and leased to a Trust which must maintain them but can also undertake activities to realise multiple revenue streams. This structure could give access to funds that the Council may be unable to bid for (e.g., corporate investments) thus making them potentially investable and able to cross-subsidise management of natural assets that may not currently generate a revenue stream.[2]					
Ecosystem services that are the main focus		Agricultural outputs	+	Timber/wood production		Water supply
		Renewable energy	+	Air quality regulation		Carbon avoided and sequestration
	+	Local climate regulation		Water flow regulation	+	Water quality regulation
		Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration		Identity and quality of place		Biodiversity

Examples demonstrating the link between the fund and specific ecosystem services	Royal Parks London details their aims as being to maintain and develop biodiversity, including the protection of wildlife and the natural environment together with promoting sustainability in the management and use of the Royal Parks. [4]					
References/ links	1. Vivid Economics (2018): The Outline Business Case for a Natural Environment Impact Fund. Accessed at: http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=20096 on 29th June 2021 2. EFTEC Greater Manchester (2019): Greater Manchester Natural Capital Investment Plan. Accessed at: https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf 2nd June 2021 3. Finance Earth (2021) Enabling investment into conservation climate and communities. Accessed at: https://www.environmentalfinance.co.uk/wp-content/uploads/2019/04/WWF-North-Devon-Sustainable-Finance-Mechanisms-Report-June-2018.pdf on 1 June 2021 4. The Royal Parks: What we do. Accessed at: https://www.royalparks.org.uk/about-us/what-we-do on 1 June 2021 (no date given)					

1.11 Nature for Climate Fund

Table 0-10: Fund review			
Fund name	**Nature for Climate Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
Summary of the fund	The Nature for Climate Fund was announced in the UK Government budget in 2020. The fund makes available £640 million to restore 35,000 hectares of peatland and plant 40 million trees in England by 2025[1], therefore increasing the rate of tree planting by over 600%[2].		
How the fund is designed	No clear funding map has been identified, however it appears that the Nature for Climate Fund has been made available to organisations to run pilots schemes and projects, as well as grant funding. Below are schemes and grants identified as being funded by the Nature for Climate Fund: • **Project** - £120,000 has been given to the new National Woodland Creation Partnership to drive regional tree planting in Cornwall[3]; • **Project** - £1.4 million has been awarded to the Environment Agency to fund 'woodlands for water' projects[4]; • **Pilot** - £2.5 million will support pilot schemes delivered on the ground by Local Authorities to establishing new ways of planting trees in urban and rural locations[5]; • **Project** - £12.1 million has been awarded to the Trees for Climate programme to plant trees in ten Community Forests[6]; • **Grant** – The Harvesting and Processing Grant is partly funded under this fund (with other funds coming from the Scottish Government) to assist tree nurseries in England that supply trees to Scotland (grants between £1,000 and £50,000 are available)[7];		

Table 0-10: Fund review			
Fund name	**Nature for Climate Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
	• **Grant** - The England Woodland Creation Offer (EWCO) will be administered by the Forestry Commission to support landowners and land managers to create over 10,000 hectares of new woodland[8]; • **Project** -National Forest has received £2.26 million to double the number of trees planted for the next year[9;] • **Grant** - The Urban Tree Challenge Fund (UTCF) is funded under the Nature for Climate Fund, and will support the planting of 44,000 large 'standard' trees over a two-year period[10]; • **Grant** - £2.7 million is available through the Local Authority Treescapes fund, which is available to Local Authority-led tree planting and natural colonisation of trees outside woods (i.e. riverbanks, hedgerows, parklands, urban areas, beside roads and footpaths, in copses and shelterbelts)[11]; • **Grant** - Woods into Management Forestry Innovation Funds aim to restore vulnerable woodland habitats, help woodlands adapt to a changing climate and recover from the impacts of pests and diseases[12;] • **Grant** - Nature for Climate Peatland Grant Scheme provides funding to restore peatlands in the uplands and lowlands of England[13]; and • **Grant** - £40 million is available through the Green Recovery Challenge Fund (£30 million from the Nature for Climate Fund)[14,15].		
Lead organisation(s)	Defra (other organisations are distributing some of the grant schemes, such as the Forestry Commission)		
Total value of fund	£640 million		
Timescale over which it operates (where applicable)	The fund has the deadline of 2025 by which to achieve the target of restoring 35,000 hectares of peatland and planting 40 million trees. Some partnerships receiving funding also have their own deadlines (i.e. Cornwall Council have a target of being carbon neutral by 2030 and the funding received by the National Woodland Creation Partnership will go towards achieving this).		
Further details	Nature-based Solutions Initiative felt that the fund was too small to cover the costs of the restoration targets and would require significant private investment[1].		

Ecosystem services that are the main focus						
		Agricultural outputs	++	Timber/wood production		Water supply
		Renewable energy	+	Air quality regulation	++	Carbon avoided and sequestration
	+	Local climate regulation	++	Water flow regulation	+	Water quality regulation
		Pollination	+	Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place	++	Biodiversity
Other ecosystem services that are covered	+	Agricultural outputs		Timber/wood production	+	Water supply
	+	Renewable energy		Air quality regulation		Carbon avoided and sequestration

<table>
<tr><th colspan="7">Table 0-10: Fund review</th></tr>
<tr><td>Fund name</td><td colspan="6">Nature for Climate Fund</td></tr>
<tr><td>Date review completed</td><td colspan="3">09/06/2021</td><td>Reviewed by</td><td colspan="2">RPA (JM)</td></tr>
<tr><td>Key aspects</td><td colspan="6">Details</td></tr>
<tr><td rowspan="4"></td><td></td><td>Local climate regulation</td><td></td><td>Water flow regulation</td><td></td><td>Water quality regulation</td></tr>
<tr><td>+</td><td>Pollination</td><td></td><td>Access to nature (recreation)</td><td>+</td><td>Physical and psychological experiences</td></tr>
<tr><td>+</td><td>Learning and inspiration</td><td>+</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Examples demonstrating the link the fund and specific ecosystem services</td><td colspan="6">This is a new fund with limited project examples with demonstrated links/outputs. However, some of the projects and partnerships have anticipated potential benefits, these are listed below.
The National Woodland Creation Partnership anticipate that the fund will help[3]:
to provide shade in urban areas;
to provide well-being benefits in areas of high deprivation;
encourage visitors to the area; and
to enhance nature's recovery and flood mitigation.
The Environment Agency Woodlands for Water will help[5]:
to improve water quality;
to help slow the flow of water and improve habitat connectivity;
to improve water quality, alleviate flooding, capture carbon and create wildlife habitat;
to create and re-connect habitats and improve water quality by reducing surface run-off; and
to improve wildlife habitat and connectivity.</td></tr>
<tr><td>References/links</td><td colspan="6">Nature-based Solutions (2020): UK Government Budget 2020. Accessed at: https://www.naturebasedsolutionsinitiative.org/news/uk-government-budget-2020/ on 9th June 2021
HM Treasury (2020): Budget 2020 Delivering on Our Promises to the British People. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/871799/Budget_2020_Web_Accessible_Complete.pdf on 9th June 2021
Forestry Journal (2021): Nature for Climate Fund: DEFRA announces funding boost and partnership with Forest for Cornwall. Accessed at: https://www.forestryjournal.co.uk/news/19174555.defra-announces-funding-boost-new-partnership-forest-cornwall/ on 9th June 2021
Defra (2020): Defra in the media. New funding for tree planting as National Tree Week comes to a close. Accessed at: https://deframedia.blog.gov.uk/2020/12/07/new-funding-for-tree-planting-as-national-tree-week-comes-to-a-close/ on 9th June 2021
Defra (2020): Press release. £3.9 million to drive innovative tree planting. Accessed at: https://www.gov.uk/government/news/39-million-to-drive-innovative-tree-planting on 9th June 2021
Defra (2020): Press release. 500 hectare planting boost for England's Community Forests. Accessed at: https://www.gov.uk/government/news/500-hectare-planting-boost-for-englands-community-forests on 9th June 2021</td></tr>
</table>

Table 0-10: Fund review			
Fund name	**Nature for Climate Fund**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
	7. Forestry Commission (2021): Create woodland: overview. Accessed at: https://www.gov.uk/guidance/create-woodland-overview on 9th June 2021 8. Forestry Commission (2021): England Woodland Creation Offer. Accessed at: https://www.gov.uk/guidance/england-woodland-creation-offer on 9th June 2021 9. The National Forest (2021): The National Forest celebrates planting its 9 millionth tree. Accessed at: https://www.nationalforest.org/blog/news/national-forest-celebrates-planting-its-9-millionth-tree on 9th June 2021 10. Forestry Commission (2021): Urban Tree Challenge Fund. Accessed at: https://www.gov.uk/guidance/urban-tree-challenge-fund on 9th June 2021 11. Defra (2021): Press release. New tree fund for local communities announced. Accessed at: https://www.gov.uk/government/news/new-tree-fund-for-local-communities-announced on 9th June 2021 12. Forestry Commission (2021): Woods into Management Forestry Innovation Funds. Accessed at: https://www.gov.uk/government/collections/woods-into-management-forestry-innovation-funds on 9th June 2021 13. GSC Grays (2021): The Nature for Climate Peatland Grant Scheme. Accessed at: https://www.gscgrays.co.uk/2021/04/21/the-nature-for-climate-peatland-grant-scheme/ on 9th June 2021 14. Defra (2020): Press release. Government announces £40 million green jobs challenge fund. Accessed at: https://www.gov.uk/government/news/government-announces-40-million-green-jobs-challenge-fund on 9th June 2021 15. Heritage Fund (2020): Government's £40million Green Recovery Challenge Fund opens for applications. Accessed at: https://www.heritagefund.org.uk/news/governments-ps40million-green-recovery-challenge-fund-opens-applications on 9th June 2021		

1.12 Biodiversity Net Gain

Table 0-11: Fund review			
Fund name	**Biodiversity Net Gain**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
Summary of the fund	Biodiversity Net Gain is part of the National Planning Policy Framework NPPF and has been developed to ensure that future developments leave biodiversity in a better state than before[1]. Developers should ensure that schemes are designed to retain and improve existing habitats or create new habitats, ultimately having an overall positive impact on biodiversity and ecological networks in comparison to the pre-development condition. The improvements and/or restoration need to be measurable, however the NPPF does not specify how much of an improvement is required by developers. Requirements have been included in the most recent Environment Bill, that mean developers will need to ensure that new schemes exceed the pre-development biodiversity value by at least 10% and this improvement is maintained for at least 30 years. If this is not possible, developers will be able to purchase biodiversity credits to off-set their development.		
How the fund is designed	Once the Environmental Bill and subsequent transition period has passed, developers in England will only be granted planning permission if the requirement for 10% Biodiversity Net Gain is met. Biodiversity Gain Plans will need to be approved by		

Table 0-11: Fund review			
Fund name	**Biodiversity Net Gain**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
	Local Planning Authorities and should show the pre and post biodiversity value of the site, with biodiversity gains calculated using the Natural England Biodiversity Metric (i.e. if a site is worth 40 biodiversity units before development, it should see an increase of 4 units post development). Any works to improve habitats at the development site are likely to be placed under a "conservation covenant" to ensure that the habitat/environment will be maintained for at least 30 years after the development is completed. Should developers not be able to demonstrate a 10% biodiversity net gain on site, they will be able to improve biodiversity off site by contributing towards a local habitat compensation scheme (local habitat markets). As a last option, developers will be able to purchase biodiversity credits from Defra (for £11,000 per credit[2]), the funds from this will be put towards strategic ecological networks and long-term environmental benefits[3]; this system is known as a mitigation hierarchy. Once the Environmental Bill and subsequent transition period has passed, developers in England will only be granted planning permission if the requirement for 10% Biodiversity Net Gain is met. Biodiversity Gain Plans will need to be approved by Local Planning Authorities and should show the pre and post biodiversity value of the site, with biodiversity gains calculated using the Natural England Biodiversity Metric (i.e. if a site is worth 40 biodiversity units before development, it should see an increase of 4 units post development). Any works to improve habitats at the development site are likely to be placed under a "conservation covenant" to ensure that the habitat/environment will be maintained for at least 30 years after the development is completed. • Should developers not be able to demonstrate a 10% biodiversity net gain on site, they will be able to improve biodiversity off site by contributing towards a local habitat compensation scheme (local habitat markets). As a last option, developers will be able to purchase biodiversity credits from Defra (for £11,000 per credit[2]), the funds from this will be put towards strategic ecological networks and long-term environmental benefits[3]; this system is known as a mitigation hierarchy.		
Lead organisation(s)	Central Government (Defra), although Local Planning Authorities will be responsible for granting planning applications and checking Biodiversity Gain Plans are implemented and maintained.		
Total value of fund	Defra have estimated that it will cost developers £19,698/ha to create and maintain sites over a 30-year lifecycle. Ongoing costs were estimated at £9.5 million per year for local government. For central government, the estimated ongoing costs were estimated at £1.8m for Natural England, and £1.3m for Defra with one-off capital costs of £0.5m[4].		
Timescale over which it operates (where applicable)	Developers will be required to maintain the net gain for a period of at least 30 years.		
Further details	Concerns have been raised that ability to buy credits will may not encourage developers to consider environmentally sensitive scheme designs and it could be seen as a "license to trash"[1]. The Environmental Bill is currently at the committee stage at the House of Lords[5] and the Act will only come into effect after a two-year transition period which begins when the Environment Bill receives Royal Assent. Natural England are currently running nine Natural England Biodiversity Net Gain pilot projects to support the design of the credits scheme[6].		

Table 0-11: Fund review						
Fund name	**Biodiversity Net Gain**					
Date review completed	**09/06/2021**		**Reviewed by**		**RPA (JM)**	
Key aspects	**Details**					
Ecosystem services that are the main focus		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
	++	Pollination	+	Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration	++	Identity and quality of place	++	Biodiversity
Other ecosystem services that are covered		Agricultural outputs	+	Timber/wood production		Water supply
		Renewable energy	++	Air quality regulation	+	Carbon avoided and sequestration
	++	Local climate regulation	+	Water flow regulation	+	Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration		Identity and quality of place		Biodiversity
Examples demonstrating the link the fund and specific ecosystem services	Ecosystem services provided by Biodiversity Net Gain will be specific to the individual sites and measures put in place. However, in Defra's Biodiversity Net Gain and local nature recovery strategies Impact Assessment, they highlighted natural capital and ecosystem services that could be delivered by additional habitat and biodiversity, these included: • **provisioning:** energy (renewable and non-renewable sources), wild animals, minerals, wild plants, timber, navigation, agricultural production and caught fish, water; • **regulating:** carbon sequestration, wastewater cleaning, air pollution removed by vegetation, mediation of smell, noise and pollution removed by water, flood, erosion and landslide protection, temperature regulation, water flow control and water condition regulation; • **recreation and cultural services**: setting for outdoor, scientific and educational interactions, heritage and aesthetic interactions, value place on nature simply existing, settings for outdoor physical activity (health benefits). The Elmsbrook residential development is anticipated to be completed in 2021 and has incorporated Biodiversity Net Gain within the scheme plans. On the site, 40% green space has been provided to promote a healthy lifestyle (access to outdoor recreation) and achieve Biodiversity Net Gain[7].					
References/links	1. The Landmark Practice (2020): What is Biodiversity Net Gain? Accessed at: https://thelandmarkpractice.com/what-is-biodiversity-net-gain/ on 9th June 2021					

Table 0-11: Fund review			
Fund name	**Biodiversity Net Gain**		
Date review completed	**09/06/2021**	**Reviewed by**	**RPA (JM)**
Key aspects	**Details**		
	2. Environment Analyst (2019): Full costs of biodiversity net gain revealed. Accessed at: https://environment-analyst.com/global/83704/full-costs-of-biodiversity-net-gain-revealed on 9th June 2021 3. Firstplan (2021): Introducing the Environment Bill. Accessed at: https://www.firstplan.co.uk/news/introducing-the-environmental-bill/ on 9th June 2021 4. Defra (2019): Biodiversity net gain and local nature recovery strategies. Impact Assessment. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/839610/net-gain-ia.pdf on 9th June 2021 5. UK Parliament (2021): Environment Bill. Accessed at: https://bills.parliament.uk/bills/2593 on 9th June 2021 6. Natural England (2020): Introducing the Biodiversity Credits Scheme Pilot-Call for Projects. Accessed at: https://cieem.net/wp-content/uploads/2020/07/Introducing-the-Biodiversity-Credits-Scheme-Call-for-Projects_01.07.20.pdf on 9th June 2021 7. UK Green Building Council (nd): Elmsbrook. Accessed at: https://www.ukgbc.org/ukgbc-work/case-study-elmsbrook/ on 9th June 2021		

1.13 Environmental Net Gain

Table 0-12: Fund review						
Fund name	**Environmental Net Gain**					
Date review completed	**09/06/2021**		**Reviewed by**	**RPA (JM)**		
Key aspects	**Details**					
Summary of the fund	Environmental Net Gain is similar to Biodiversity Net Gain, however it is intended to go further by not only improving biodiversity, but also the wider condition of and benefits flowing from the natural environment with a development site. There is no formal definition of Environmental Net Gain, although Defra have defined it as "*Achieving environmental net gain means achieving biodiversity net gain first, and going further to achieve increases in the capacity of affected natural capital to deliver ecosystem services and make a scheme's wider impacts on natural capital positive*"[1]. A developer looking to adopt Environmental Net Gain may improve biodiversity as a first step but then go further to incorporate and deliver wider natural capital benefits (i.e. flood risk alleviation and local air quality improvement). Environmental Net Gain is not a mandatory requirement of developers and therefore can been seen as voluntary. However, there is legislation that may be used to encourage Environmental Net Gain, including the National Planning Policy Framework, Public Services (Social Value) Act 2012 and the Agriculture Act 2020[1].						
How the fund is designed	Developers should follow the mitigation hierarchy (same as Biodiversity Net Gain)[2]: • Avoiding impacts as far as possible; • Minimising unavoidable impacts; or • Compensating for unavoidable losses either locally or nationally (a last resort option). Developers would be expected to fund Environmental Net Gain as part of their scheme costs and there is currently no credit scheme available from Defra (as will be available for Biodiversity Net Gain).					
Lead organisation(s)	N/A					
Total value of fund	N/A					
Timescale over which it operates (where applicable)	N/A					
Further details	There is currently no agreed methodology for Environmental Net Gain assessment. Widening the scope beyond biodiversity, means that there are many interactions and interdependencies to consider, this linked with the need for specific tools and expertise may mean that opportunities are missed.					
Ecosystem services that are the main focus	+	Agricultural outputs	+	Timber/wood production	+	Water supply
	+	Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
	+	Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination	+	Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place	+	Biodiversity

Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy		Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
		Pollination		Access to nature (recreation)		Physical and psychological experiences
		Learning and inspiration		Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	Ecosystem services provided by Environmental Net Gain will be specific to the individual sites and measures put in place.					
References/links	1. Chartered Institute of Ecology and Environmental Management (2021): Briefing Paper: Environmental Net Gain. Accessed at: https://cieem.net/wp-content/uploads/2021/05/CIEEM-Environmental-Net-Gain-Briefing-Apr2021-FINAL-1.pdf on 9th June 2021 2. National Infrastructure Commission (2021): Natural capital and environmental net gain: A discussion paper. Accessed at: https://nic.org.uk/app/uploads/Updated-Natural-Capital-Paper-Web-Version-Feb-2021.pdf on 9th June 2021					

1.14 Green Improvement District

Table 0-13: Fund review			
Fund name	**Green Improvement District**		
Date review completed	**01/06/2021**	**Reviewed by**	**RPA**
Key aspects	**Details**		
Summary of the fund	A GID is based on, and may be a subset of, the Business Improvement District (BID) concept (and may be incorporated within an existing BID), whereby a voluntary levy would be secured from businesses operating in the local area that derive benefit from high quality greenspace. This would be invested to enhance urban greenspaces such as parks, canals and sustainable travel networks. The GID would take responsibility for managing a predetermined area and leverage the levy with other forms of investment to achieve wider impact. A green approach within existing business improvement districts. Such improvement districts are considered unlikely to be exclusively environmental in their objectives, but the actions these could put in place could be part of the services and income streams developed under the place-based finance model (1).		
How the fund is designed	2018 GLA grant gave between £5,000 and £50,000 as part as the Community Tree Planting and Community Green Space Improvements GID.		
Lead organisation(s)	Greater London Authority GLA (other organisations are distributing some of the grant schemes, like Austin Green)		
Total value of fund	$995 million		

Timescale over which it operates (where applicable)	Application materials indicate that the financial model is based on a 30-year development build out schedule.					
Further details	Anything that needs to be in place for the fund to be accessed/used (e.g. legal vehicle) and risks					
Ecosystem services that are the main focus		Agricultural outputs		Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	++	Carbon avoided and sequestration
		Local climate regulation		Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production		Water supply
		Renewable energy	+	Air quality regulation		Carbon avoided and sequestration
		Local climate regulation		Water flow regulation		Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration		Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	>290 Business Improvement Districts in local authorities across the UK. No examples supporting natural capital specifically (1) The Greater London Authority (GLA) is working with Business Improvement Districts (BIDs) in central London to identify and then deliver opportunities for increasing green cover. The Greening the BIDs project has supported 15 green infrastructure audits and part-funded demonstration projects with the aim of catalysing urban greening in central London. (2)					
References/links	(1) EFTEC Greater Manchester (2019) Greater Manchester Natural Capital Investment Plan https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf 2nd June 2021 (2) C40 Cities (2015) Greening the Bids: Private-public collaboration to deliver green infrastructure opportunities https://www.c40.org/case_studies/greening-the-bids-private-public-collaboration-to-deliver-green-infrastructure-opportunities on 5th June 2021 (3) Greater London Authority (2018) Greener City Fund https://glagrants.org.uk/home/greener-city-fund/ on 28th June 2021					

1.15 Habitat Bank

Table 0-14: Fund review						
Fund name	**Habitat Bank**					
Date review completed	**01/06/2021**		**Reviewed by**		**RPA**	
Key aspects	**Details**					
Summary of the fund	Under the Environment Bill, projects involving the development of land will need to deliver a 10% biodiversity net gain. Whatever number of 'conservation credits' are needed to achieve this can be bought 'off the shelf' by the developer at the point of planning permission. His payment then goes to funding the long-term conservation management of the habitat bank, the location and management of each being approved by the local planning authority using it. Habitat/carbon banking combines potential revenue streams for carbon and biodiversity credits. There is a large synergy in delivery of these credits through additional project activities to enhance natural capital (e.g. through habitat creation and restoration)16. They are complimentary revenue streams, because habitat banking is a one-off asset purchase (compensating for a lost biodiversity (habitat) asset), but carbon revenue is an ongoing purchase, buying credits from the flow of sequestration (or avoided emissions) to offset emissions from operations over time.					
How the fund is designed	UK Governments have responded to peatland restoration opportunities through a range of funding mechanisms for peatland restoration, principally operating in the uplands. Together these represent potentially hundreds of millions of pounds of investment, and include Defra's invested £10M in peatland restoration in 2017-18, and their £640 million Nature For Climate Fund launched in 2020, which focuses on woodland creation but includes peatland restoration in its remit. Scottish Government has funded Peatland Action via Scottish Natural Heritage since 2012, with £20M restoration work planned for 2020/21 and a commitment to invest £250 million over the next ten years, and Welsh Government has funded restoration via a series of LIFE projects. In the future, the ELMS programme in England may provide an additional source of government funds. (2)					
Lead organisation(s)	The UK Habitat Bank Limited, Greater Manchester Wetlands, Peatland restoration in Cumbria, Peatland ACTION project Scotland, Grants for Peatlands Restoration					
Total value of fund	£250 million					
Timescale over which it operates (where applicable)	Project will run through the "next 10 years" (2)					
Further details	N/A					
Ecosystem services that are the main focus	+	Agricultural outputs	+	Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences
		Learning and inspiration	+	Identity and quality of place		Biodiversity

Other ecosystem services that are covered	+	Agricultural outputs	+	Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences
		Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	The UK Habitat Bank Limited (https://find-and-update.company-information.service.gov.uk/company/11475458); The Habitat Bank (https://acjecology.co.uk/habitat-bank); Habitat Bank LLC (http://www.habitatbank.com/) Greater Manchester Wetlands (https://www.lancswt.org.uk/great-manchester-wetlands) Peatland restoration in Cumbria (https://www.cumbriawildlifetrust.org.uk/about/what-we-do/living-landscapes/wildlife-conservation-projects/peatland-restoration) Peatland ACTION project Scotland (https://www.nature.scot/climate-change/nature-based-solutions/peatland-action-project) Grants for Peatlands Restoration (https://www.gov.uk/government/news/grants-for-peatlands-restoration) Projects maps https://www.iucn-uk-peatlandprogramme.org/projects-map					
References/links	(1) EFTEC Greater Manchester (2019) Greater Manchester Natural Capital Investment Plan https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf 2nd June 2021 (2) 3 Keel, Forrest Carbon, Newcastle University (2020) https://www.iucn-uk-peatlandprogramme.org/sites/default/files/header-images/Resources/Optimising%20Public%20Private%20funding%20of%20Peatland%20Restoration.pdf on 1st June 2021 (3) The Environment Bank (2020) Habitat Banks will be the way to deliver Biodiversity Net Gain (https://www.environmentbank.com/blog/habitat-banks-will-be-the-way-to-deliver-biodiversity-net-gain/#:~:text=The%20latest%20update%20to%20the,those%20enhancements%20for%20thirty%20years.) 14th June 2021 (4) The Environment Bank (2020) https://www.environmentbank.com/blog/the-environment-bill-and-biodiversity-net-gain-delivery-what-planning-authorities-need-to-know/ June 25th 2021					

1.16 SuDS

Table 0-15: Fund review			
Fund name	**SuDS**		
Date review completed	**01/06/2021**	**Reviewed by**	**RPA**
Key aspects	**Details**		
Summary of the fund	Sustainable Drainage Systems (SuDS) have an established revenue mechanism, through a reduced water company drainage connection charge for developments. A special purpose vehicle(SPV)could deploy appropriate capital at different project stages, allowing SuDS to be deployed and the cash flows aggregated to enable investment to be scaled-up as part of the Water Resilient Cities programme. An SPV can achieve greater returns than existing bilateral transactions through specialist skills and overcoming knowledge gaps. Standardised		

	contracting for SuDS works and an extended contractual commitment to water company charging rates period could improve returns under this model. (1) Sustainable Drainage Systems (SuDS): Retrofitting green and blue infrastructure to manage surface water, delivering cost savings through a reduction in water company drainage charges (1)					
How the fund is designed	There are three key phases of SuDS project delivery: development, construction and operation. Different forms of capital are required at each phase to suit the associated level of risk. A single Special Purpose Vehicle (SPV) could be set up to raise and deploy the appropriate form of capital for each phase over the project lifetime. After a suitable pipeline of construction-ready projects has been identified and risk levels are quantifiable, short-term project debt finance can be raised to construct the SuDS projects over a 12–24-month period. (1)					
Lead organisation(s)	Project is lead by DEFRA (assisted by the Welsh Government, Natural Resources Wales, and the Environment Agency) (3)					
Total value of fund	Potential delivery of over £82 million of social and environmental benefit from the proposed additional green and blue space (1) Key cost components are likely to be the enabling costs (procurement, planning and design), capital construction costs and post construction monitoring and maintenance costs. (2) Cost calculator: http://geoservergisweb2.hrwallingford.co.uk/uksd/costintro.aspx					
Timescale over which it operates (where applicable)	Project will run for a "12-24-month period" (1)					
Further details	The key requirement is that financing delivered is aligned to project lifetime cash flows, enabling overall financing to be leveraged as efficiently as possible. (1)					
Ecosystem services that are the main focus		Agricultural outputs		Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Other ecosystem services that are covered		Agricultural outputs		Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
		Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link between the	Trial site in Trafford but not deployed at scale (1)					

fund and specific ecosystem services	"James Jones & Sons invests GBP 3 million ($4 million) in Stevens Croft site" (https://www.lesprom.com/en/news/James_Jones_%26_Sons_invests_GBP_3_million_4_million_in_Stevens_Croft_site_96437/) Water Resilient Cities (https://waterresilientcities.eu/)
References/links	(1) EFTEC Greater Manchester (2019) Greater Manchester Natural Capital Investment Plan https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf 2nd June 2021 (2) FCERM (2021) Long-term costing tool for flood and coastal risk management https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/411509/Cost_estimation_for_SUDS.pdf on 1st June 2021 (3) DEFRA (2015) Delivering Benefits Through Evidence Heading 1 (publishing.service.gov.uk) on 1st June 2021

1.17 ELMs

Table 0-16: Fund review			
Fund name	**ELMs**		
Date review completed	**01/06/2021**	**Reviewed by**	**RPA**
Key aspects	**Details**		
Summary of the fund	The Environmental Land Management scheme (ELMs). ELM will provide farmers, foresters and other land managers with an opportunity to secure financial reward in return for delivering environmental benefits. ELM will be a powerful vehicle for achieving the goals of the 25 Year Environment Plan and our net zero target and ensure a strong mechanism for addressing and averting the environmental crisis. As such it will support the rural economy and help maintain food security. Tier system: Tier 1 - encouraging environmentally sustainable farming and forestry, Tier 2 - locally targeted environmental outcomes, Tier 3 - landscape scale land-use change projects (2)		
How the fund is designed	Options for financing ELMs include administrative price setting, with rates set by government, and market-based price setting, where payments are determined using mechanisms such as competitive tendering or auctions. Other options are innovative approaches, such as payment-by-results and blending public with private finance within ELM. (1) e.g. The Somerset Rivers Authority will be allocating a special local authority tax revenue to fund the reverse auction, creating a link between businesses and communities that will benefit from the provision of the service of flood mitigation. A variety of government bodies are working to prevent further catastrophic flooding of the Somerset Levels and supporting farmers to identify what they can do to help alleviate flooding (2)		
Lead organisation(s)	Project is lead by DEFRA (assisted by the Welsh Government, Natural Resources Wales, and the Environment Agency) (3)		
Total value of fund	Estimates of the overall costs of meeting environmental land management priorities in the UK total £2,538 million annually (3)		
Timescale over which it operates (where applicable)	Project plans to run for “25 year[s]” (4)		

<table>
<tr><td>Further details</td><td colspan="6">The key requirement is that financing delivered is aligned to project lifetime cash flows, enabling overall financing to be leveraged as efficiently as possible. (1)</td></tr>
<tr><td rowspan="7">Ecosystem services that are the main focus</td><td>+</td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td>+</td><td>Water supply</td></tr>
<tr><td></td><td>Renewable energy</td><td>+</td><td>Air quality regulation</td><td>+</td><td>Carbon avoided and sequestration</td></tr>
<tr><td></td><td>Local climate regulation</td><td></td><td>Water flow regulation</td><td></td><td>Water quality regulation</td></tr>
<tr><td>+</td><td>Pollination</td><td></td><td>Access to nature (recreation)</td><td>+</td><td>Physical and psychological experiences</td></tr>
<tr><td>+</td><td>Learning and inspiration</td><td>+</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">Other ecosystem services that are covered</td><td>+</td><td>Agricultural outputs</td><td></td><td>Timber/wood production</td><td>+</td><td>Water supply</td></tr>
<tr><td></td><td>Renewable energy</td><td>+</td><td>Air quality regulation</td><td>+</td><td>Carbon avoided and sequestration</td></tr>
<tr><td></td><td>Local climate regulation</td><td></td><td>Water flow regulation</td><td></td><td>Water quality regulation</td></tr>
<tr><td>+</td><td>Pollination</td><td></td><td>Access to nature (recreation)</td><td>+</td><td>Physical and psychological experiences</td></tr>
<tr><td>+</td><td>Learning and inspiration</td><td>+</td><td>Identity and quality of place</td><td></td><td>Biodiversity</td></tr>
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<tr><td>Examples demonstrating the link between the fund and specific ecosystem services</td><td colspan="6">Using blended finance and reverse auctions for multi-functional land and water management on the Somerset Levels (2)</td></tr>
<tr><td>References/links</td><td colspan="6">1. Clarke, Phillip Farmers Weekly (2021) Environment Land Management: The detail unpicked https://www.fwi.co.uk/news/farm-policy/environmental-land-management-scheme-the-detail-unpicked Accessed 27th May 2021
2. DEFRA (2021) Environment Land Management Policy discussion document https://consult.defra.gov.uk/elm/elmpolicyconsultation/supporting_documents/ELM%20Policy%20Discussion%20Document%20230620.pdf Accessed 1st June 2021
3. Rayment Consulting Services Ltd (2019) Paying for public goods from land management: how much will it cost and how might we pay? https://www.wildlifetrusts.org/sites/default/files/2019-09/Paying%20for%20public%20goods%20final%20report.pdf on 3rd June 2021
4. DEFRA (2020) Environmental Land Management Policy discussion document ELM Policy Discussion Document 230620.pdf (defra.gov.uk) on 1st June 2021</td></tr>
</table>

1.18 Investment Readiness Fund

Table 0-17: Fund review						
Fund name	**Investment Readiness Fund**					
Date review completed	**01/06/2021**		**Reviewed by**		**RPA**	
Key aspects	**Details**					
Summary of the fund	The Government are introducing a natural environment Investment Readiness Fund (IRF) to support the development of natural environment projects that can generate revenue from ecosystem services and attract repayable investment. This is part of HMG's 25 Year Environment Plan and Green Finance Strategy commitments to explore the potential for a natural environment impact fund and work with a range of partners on stimulating innovation in designing and implementing projects that can directly protect/enhance the domestic natural environment and generate revenue. (1) To implement the natural capital investment plan, detailed business plans reflecting financial, legal and other expertise will be required for the investment structures (e.g. a Parks Trust or SuDS special purpose vehicle) and/or the projects (e.g. prescribed health activities) that could be invested in. Risk funding may also be required to progress the preparation of investor-or project-level business plans to evidence feasibility and provide more certainty of the ability to generate financial returns. An IRF could provide the required technical assistance and capacity funding to make a detailed case for these business plans and identify appropriate finance mechanisms through which to draw in investment. (2) The primary focus will be on supporting projects that directly protect/enhance the domestic natural environment, but wider enabling activities that will help the development of natural capital markets will also be considered. (1)					
How the fund is designed	A much more focused fund, like Investment Readiness Fund (IRF) on preparing projects for investment, can be much smaller and hence the recommended figure of £1 million, as the transaction costs would be relatively low (2) From 2021, this three-year £10 million programme will provide grants which project developers can use to build capacity and procure the specialist support and advice they need to develop their natural environment project to an investable level (1)					
Lead organisation(s)	The primary lead organization is the Environment Agency, assisted by the Flood Hub					
Total value of fund	Total estimate of overall cost is valued at £10 million for the 3 year programme (1)					
Timescale over which it operates (where applicable)	3 years[1]					
Further details	The key requirement is that financing delivered is aligned to project lifetime cash flows, enabling overall financing to be leveraged as efficiently as possible. (1)					
Ecosystem services that are the main focus	+	Agricultural outputs	+	Timber/wood production	+	Water supply
	+	Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences

	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Other ecosystem services that are covered	+	Agricultural outputs	+	Timber/wood production	+	Water supply
		Renewable energy	+	Air quality regulation	+	Carbon avoided and sequestration
		Local climate regulation	+	Water flow regulation	+	Water quality regulation
	+	Pollination		Access to nature (recreation)	+	Physical and psychological experiences
	+	Learning and inspiration	+	Identity and quality of place		Biodiversity
Examples demonstrating the link between the fund and specific ecosystem services	Fund was used as part of Nature Green Manchester Natural Capital Investment Plan to Improve Greater Manchester's local "air quality and eco-system" [2]					
References/links	1. The Environment Agency (2020) Investment Readiness Fund https://thefloodhub.co.uk/wp-content/uploads/2020/09/Natural-Environment-Investment-Readiness-Fund.pdf Accessed 26th June 2021 2. EFTEC Greater Manchester (2019) Greater Manchester Natural Capital Investment Plan https://naturegreatermanchester.co.uk/wp-content/uploads/2019/01/GM-Natural-Capital-Investment-Plan-Final180119.pdf 2nd June 2021					

Annex 2. South Yorkshire natural capital visioning and prioritisation workshop

A workshop was held on the 17th June from 9.30 am to 1pm via the MS Teams video conferencing system. The main aims of the workshop were to:

(i) Raise awareness of the evidence base that has been created by the South Yorkshire natural capital and biodiversity mapping project.
(ii) Begin a collaborative stakeholder process for formulating a combined Local Nature Recovery Strategy and Natural Capital Investment Plan for South Yorkshire.
(iii) Define a vision and scope for the combined strategy.
(iv) Begin to formulate a framework for, or route to, delivering the strategy.

The workshop consisted of three sessions, the first presented the South Yorkshire natural capital evidence base and how it can be used, the second was focused on seeking consensus on a vision for South Yorkshire, and the third was concerned with prioritising the opportunities revealed from the mapping work. Here, the outcomes of the visioning and prioritising sessions are outlined. A list of those who participated is in Table A2.1.

Session 2. Vision and strategy scoping

This session was run by Liz Ballard in her capacity as chair of the South Yorkshire Local Nature Partnership. There was an introduction to the session that led into two break-out groups. The introduction raised the idea of developing a high level strategic South Yorkshire natural environment plan, a combination of a local nature recovery strategy and a natural capital investment plan. The evidence base that has come from the South Yorkshire mapping project would be the foundation for this plan. It emphasised that a joined-up approach is needed at the county scale to respond to key policy drivers, for example, biodiversity net gain, nature recovery networks, Environmental Land Management Scheme (ELMs), net zero, woodland creation, Covid-19 recovery, climate emergencies, transport and infrastructure projects, and local authority spatial plans.

Break out session 1. The first break-out group was concerned with these key policy drivers, and asked the following questions:

- What is your initial response to the proposal of a high-level natural environment plan for South Yorkshire?
- What are your views on the key drivers already highlighted?
- Are there other critical key drivers you want to raise now?

Across the three break-out groups there was support for the idea of a high-level plan for South Yorkshire, providing there was good buy-in from a range of stakeholders including community groups; the approach to developing the plan would need effective collaboration and good representation; it would require clear governance of the process and senior buy-in from the South Yorkshire Mayoral Authority and the Local Authorities; it should be seen as a way of reducing competition for grants at the county scale; participants agreed that thought needs to be given to how it links in with other plans at the sub-regional level, and those across South Yorkshire boundaries. The groups concurred that the key drivers covered in the introduction to the session were quite comprehensive, but ones it considered to be missing were links to health and well-being, specifically mental health and obesity, more focus on water resources, and

economic drivers of change. Overall key points were the need for broad engagement with the community level, including land owners and farmers, and that any strategic plan needs to connect to, and work at, the sub-regional level also.

Break out session 2. This second break-out group focused on what would be the scope of a strategic natural environment plan. The following points were suggested as an example for discussion:

- Strategic framework: vision, priorities, ambitions, targets
- Local level action plans
- Natural Capital Investment Plan and Local Nature Recovery Strategy
- Thinking at UK, regional and local levels
- Prioritisation process
- Decision-maker tools
- Drawing together funding opportunities
- Drawing on input, advice and support: locally, nationally
- Engaging politician, land owners, local people, agencies, organisations
- Multidisciplinary

The session considered these questions:

- What is your response to this initial scope of the South Yorkshire Natural Environment Plan?
- What would you add – or take away?

The participants thought the example scope was ambitious. There was discussion of the need for a solutions focussed and well-rounded approach using quality and quantity targets, recognising that each local authority area will have different natural capital assets; funding would be required and maybe this could be brought in through biodiversity net gain schemes; public involvement was thought to be important; that dedicated resource would be required to drive the plan. A need to be careful not to just have numerical targets (e.g. hectares of land in recovery) but to also include the cultural/human element that is less easily measured, was identified. It was thought that conflicts and priorities of interest would need to be identified early on in the process, there would be a need for political engagement, and that it was important to use the plan to address disadvantage.

Further areas to be included were: transport infrastructure should be added, support through the combined authority to cover the planning remit, impacts of disease and pests (e.g. ash die back).

Session 3. Prioritising opportunities

This session was run by Alison Holt of Natural Capital Solutions. There was an introduction followed by one break-out session.

The introduction was designed to illustrate the different ways that the opportunities for creating new habitat for a nature recovery network (see Sections 6-10 of the report) could be prioritised. Three ways were presented, the first was to use the combined opportunities for new habitats across South Yorkshire, (the nature recovery network and delivery of multiple benefits map (Map 54)). It would be possible in the short term to create habitat at the sites that deliver for biodiversity and the maximum number ecosystem service benefits. A second way to prioritise the opportunities could be by a suite of socio-economic and environmental issues in the region. The top 20% most deprived areas in the county were mapped, along

with the Environment Agency flood risk zones 2 and 3, existing green infrastructure corridors and the most vulnerable habitat to climate change from the Natural England Climate Vulnerability model. These were combined to show zones where habitat could be created to deliver on all of these challenges within existing green infrastructure corridors in South Yorkshire (Figure A2.1). A third way to prioritise opportunities is to focus on particular ecosystem services that are considered important in South Yorkshire. Using the example of flood alleviation, maps were presented illustrating the EA's riparian and floodplain woodland potential, and the top 25% of opportunities for slowing the flow of water from the ecosystem services opportunities analysis (Section 7.1). These were combined to show areas where the opportunities to create habitat for slowing the flow in this project, coincided with the creation of riparian and floodplain woodland (Figure A2.2).

The session considered these questions:

How should we approach prioritising habitat creation opportunities from the nature recovery network?
1. Do we focus on opportunities to create habitat that fall within the location of socio-economic and environmental priorities?
    - If so what other priorities should be considered?
    - How do we weight the different priorities?
2. Do we focus on opportunities related to specific priority ecosystem services ?
    - If so what other ecosystem services should be considered?
    - Do we focus on certain key benefits or maximise the number of benefits?
    - How do we weight the different priorities?

There was a suggestion that opportunities should be explored on a site by site basis using careful judgement. It was thought that social justice and deprivation factors should feature more in how priorities are decided. As the mapping project showed that many benefits come from the riparian environment, or river corridors, a focus should be on buffering the rivers as this will deliver multiple benefits. There was some call for the creation of a decision-making tool using the mapped evidence base from this project as the foundation, and using landowner and expert knowledge as well. This would feed into a top down and bottom up approach - identifying opportunities and ground truthing them. Nature-based solutions projects were thought to be popular and to respond to this, there was a feeling that South Yorkshire should prepare a suite of projects to meet requirements of different investors – projects for different funding priorities. At the same time a long-term delivery plan for projects would be necessary. It was thought that some projects at ward level would harness community buy-in. The idea of a register of landowners was suggested, so it would be possible to involve the landowners in this process.

Other ideas were around setting strategic targets, for example, the amount of agricultural land that is required to be put over to biodiversity and benefits delivery, and how much needs to stay agricultural. Some raised that there was a need to consider how South Yorkshire's natural capital assets extend over boundaries into neighbouring counties. This was particularly in relation to the tidal River Don and upland moorland areas. Overall, it was thought that the mapped evidence base can be a flexible tool-kit to sharpen existing strategies and plans, and that there is a need to collate and co-ordinate localised outputs to contribute to an overall delivery plan, with an emphasis on the delivery of diverse ecosystem services, with multi-agency contribution.

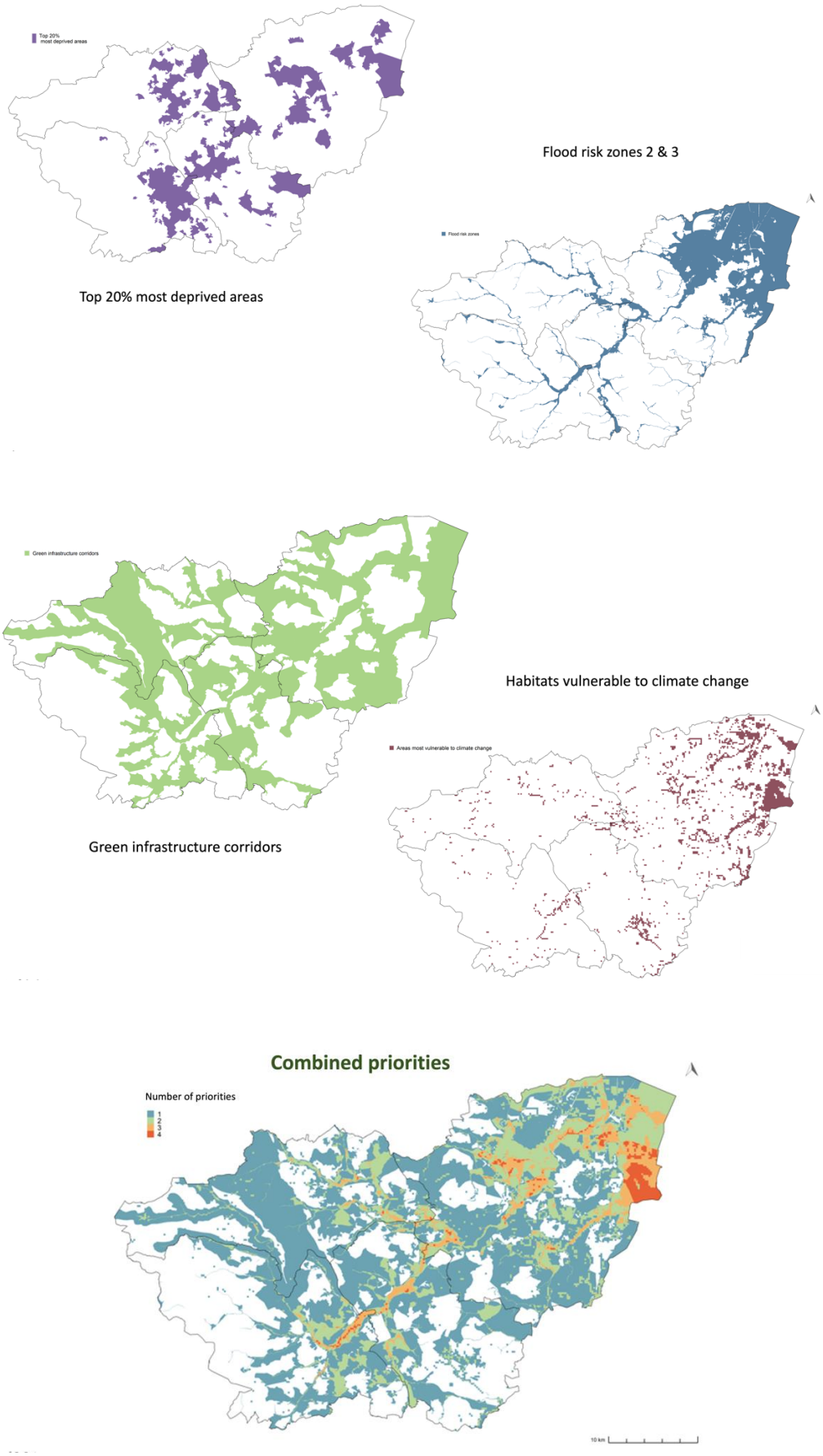

Figure A2.1 Combining priorities by socio-economic and environmental issues using additional data.

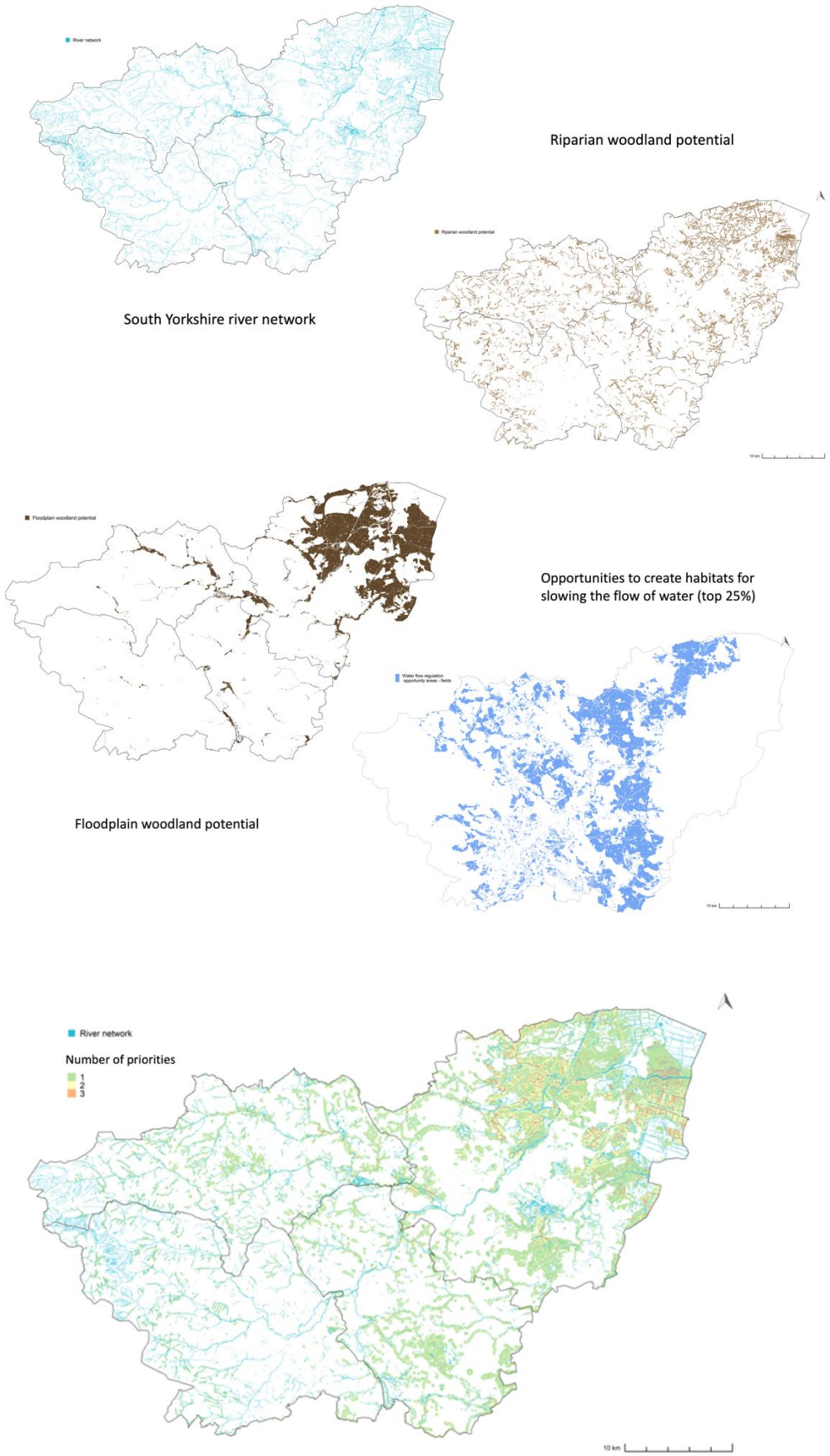

Figure A2.2 Combining priorities by specific ecosystem services. Slowing the flow of water was used as an example.

Workshop poll

A poll was also included in the workshop in between sessions 2 and 3. It posed the following questions:

1. How important are the following benefits (ecosystem services) when selecting opportunities in South Yorkshire? Score the following from 1-5, 5 extremely important and 1 low importance.

- Agricultural production, timber production, mineral extraction, carbon sequestration, air quality regulation, regulating local climate, water flow regulation, water quality regulation, noise attenuation, pollination, recreation and tourism, health and well-being, supporting identity and sense of place.

2. Are we trying to maximise the number of benefits delivered or focus on certain key benefits? Select the most appropriate:

- Maximise number of benefits
- Focus on certain key benefits
- Depends on the location.

The participants clearly thought that carbon sequestration and storage, water flow regulation, water quality regulation, health and well-being, local climate and air quality regulation, pollination and supporting identity and sense of place were very important services in South Yorkshire (Figure A2.3). Agriculture, timber production and noise attenuation were considered of medium importance. There was no clear agreement on the importance of recreation and tourism, although the balance is just tipped in favour of reasonably high importance. Mineral extraction was considered to be of low importance. Some feedback was given on this question. There was a suggestion that education and communication should be considered, and also a respondent didn't feel that it was their place to make such decisions. Biodiversity was deliberately not included as an option to rate the importance of, because in the context of a local nature recovery strategy biodiversity is the primary concern.

When participants were asked whether the aim was to maximised the number of benefits delivered or to focus on certain key benefits, 62.5% of respondents agreed that this depended on the location of interest (Figure A2.4). Twenty-five percent of people thought that there should be a focus on certain key benefits. A minority of respondents considered the aim of the strategy should be to maximise the number of benefits (12.5%).

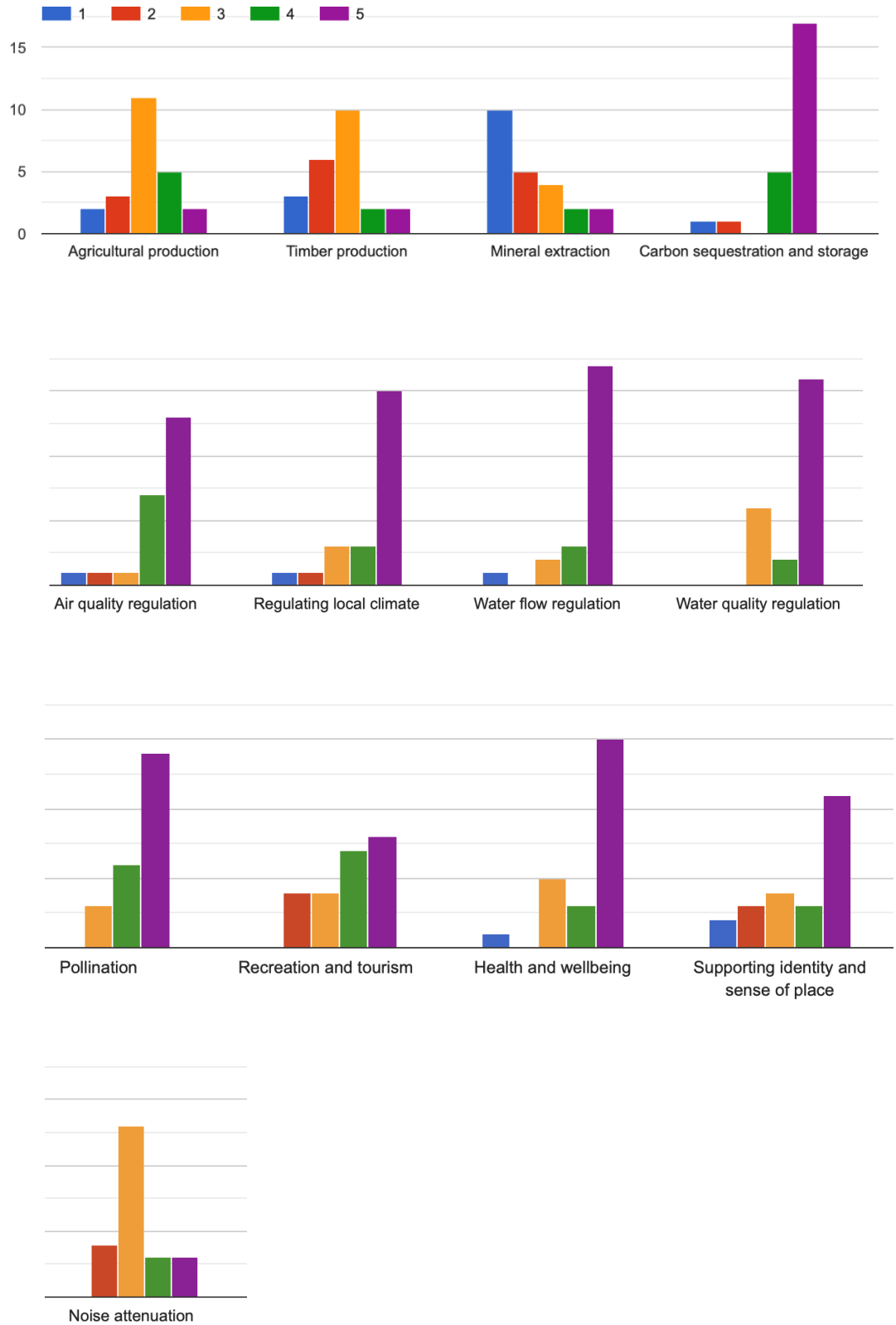

Figure A2.3 Responses to poll question 1. *How important are the following benefits (ecosystem services) when selecting opportunities in South Yorkshire? Score the following from 1-5, 5 extremely important and 1 low importance.* There were 24 responses.

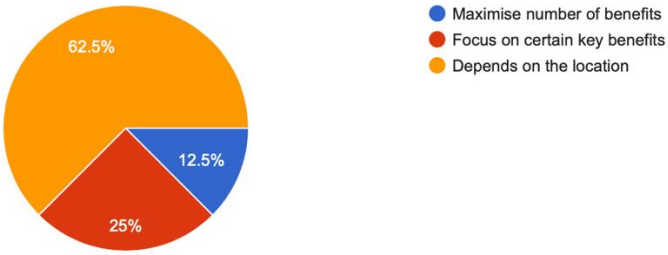

Figure A2.4 Responses to poll question 2. *Are we trying to maximse the number of benefits delivered or focus on certain key benefits?* There were 24 responses.

Further comments and ideas

During the workshop participants were able to post on an electronic comments board if they did not get the change to raise these during the workshop sessions (Figure A2.5).

Figure A2.5 Comments and questions raised by the workshop participants.

Table A2.1 List of Participants.

Participant	Organisation
Alison Holt	NCS
Amanda Best	EA
Angus Hunter	SCC
Anthony Barber-Lomax	Fitzwilliam Wentworth Estates
Anthony Devonport	BMBC
Catherine Nuttgens	SCC
Chris Wilson	SCC
Craig McCrindle	RMBC
Helen Barber	SCC
Helen Markland	DMBC
J Neville	Harworth Estates
Jim Smith	FC
Jo Holden	Peel L&P
Joe Jenkinson	BMBC
Kevin Burke	RMBC
Laurie Heykoopcoup	SYMCA
Liam O'Reilly	NE
Liz Ballard	SRWT
Melissa Massarella	DMBC
Mike Winstandley	YWT
N Biddle	Peel L&P
Nick Selwood	Woodland Trust
Nicky Rivers	SRWT
Pete Tomlin	SRWT
Peter Henchley	RMBC
Rachel Overfield	RMBC
Richard	SYMCA
Simon Pickles	NEYEDC / YEDN
Ted Talbot	National Trust
Tim Newton	DMBC
Timothy Bryant	DMBC
Tom Wild	UoS
Trevor Maine	BMBC