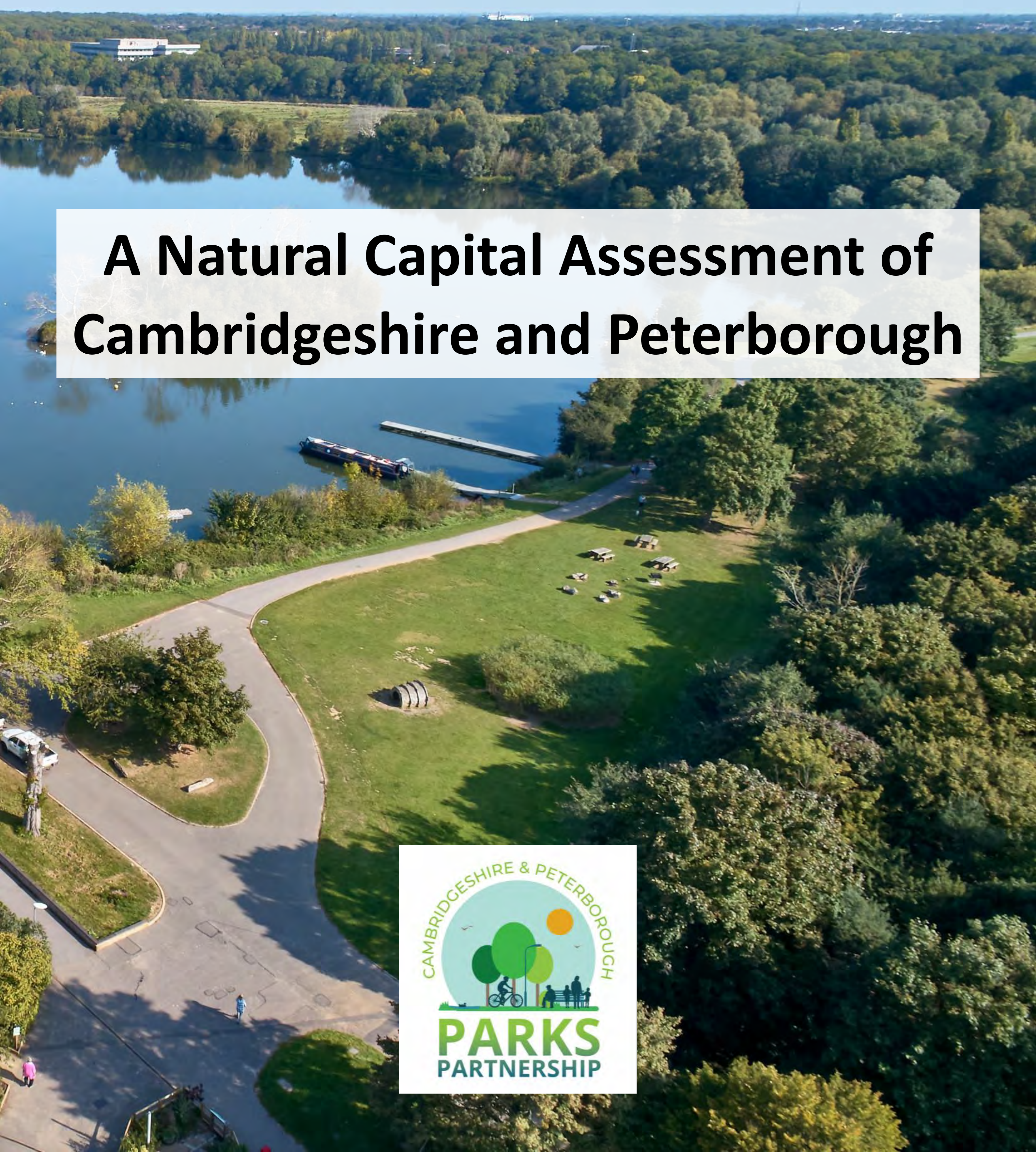
Natural Capital Solutions

A Natural Capital Assessment of Cambridgeshire and Peterborough



Cambridgeshire & Peterborough Parks Partnership

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Report prepared for and funded by:

Cambridgeshire and Peterborough Future Parks project

Version: Final

November 2022

Acknowledgements

We would like to thank all members of the Steering Group who provided invaluable input throughout this project:

- Robert Pearce, Cambridgeshire and Peterborough Future Parks
- Gabriella Yeomans, Cambridgeshire and Peterborough Future Parks
- Darren Sharpe, Peterborough City Council
- Quinton Carroll, Cambridgeshire County Council
- Oliver Burke, Nene Park Trust
- Paul Frainer, Greater Cambridge Shared Planning

We'd also like to thank all participants who attended the four stakeholder workshops in January to April 2022, for really useful discussions and for helping to shape the outputs of the project, especially in the development of the Environmental Justice Index.

Funding

This repot was commissioned by the Cambridgeshire and Peterborough Future Parks (CPFP) Project. The CPFP Project is funded by the National Lottery Heritage Fund and the National Trust, with additional support from the Ministry for Housing, Communities and Local Government. It is a collaboration between the Local Nature Partnership, the Nene Park Trust and eight local authorities including Cambridge City Council, Cambridgeshire County Council, East Cambridgeshire District Council, Fenland District Council, Huntingdonshire District Council, Peterborough City Council, South Cambridgeshire District Council, Cambridgeshire and Peterborough Combined Authority, and other stakeholders.

CAMBRIDGESHIRE & PETERBOROUGH PARKS PARTNERSHIP

Cover image: Nene Park, Peterborough

Executive Summary

The Cambridgeshire and Peterborough Future Parks Project (CPFP) aimed to develop a joined-up response to the threats and opportunities created by the pace and scale of development in Cambridgeshire and Peterborough, to deliver equal access to high-quality, financially sustainable, vibrant green spaces across the whole county. To further this aim, the CPFP Project commissioned Natural Capital Solutions Ltd to produce a natural capital assessment of Cambridgeshire and Peterborough.

The report begins by assessing the baseline situation, by modelling and mapping the natural capital assets present across the whole of Cambridgeshire and Peterborough, the benefits that flow from those assets, and the biodiversity value of habitats across the landscape. This information was then used to determine the benefits and values of each individual park and greenspace across the area. Once the baseline position was understood, the next step was to objectively identify opportunities to enhance natural capital to deliver a range of objectives. A number of applications of the mapping were then developed, including an Environmental Justice Index to focus investment in areas suffering from environmental inequalities, as well as outcomes around growth and development, health and deprivation, biodiversity and the Local Nature Recovery Strategy (LNRS).

The baseline – natural capital assets

This project has produced and updated a detailed habitat basemap using the best available data to assign Phase 1 habitat types to each plot of land and building across the whole of Cambridgeshire and Peterborough (1.61M polygons covering 340,000 ha). The county is dominated by arable land, making up 69.9% of the land (237,000 ha). Woodland, scrub and tree habitats take up just 4.9% of the county (16,600 ha), which is well below the national average. Semi-natural habitats such as fen, marsh and swamp, semi-natural and marshy grasslands together make up 4.5% of the region, while water covers 2.1%. Built up areas, infrastructure and gardens make up a combined 8.8% of the area.

Modelling and mapping ecosystem services (benefits)

In total, 10 ecosystem services were modelled and mapped: carbon storage, carbon sequestration, air purification, noise regulation, local climate (urban heat) regulation, water flow regulation, water quality (soil erosion) regulation, food production, timber production, and accessible nature. Maps showing the demand for air purification, noise regulation, local climate regulation and accessible nature were also produced. Demand was focussed on the urban centres, especially in Peterborough and Cambridge, but smaller towns and the main road network were also hotspots for demand. The capacity to provide these services was highest in woodlands, which is more prevalent in the west and south of the county. Some of the fenland nature reserves are also high scoring. The river corridors are effective at bringing habitats delivering high levels of ecosystem services right into the heart of urban areas, and this is particularly prominent in Peterborough, Huntingdon and St Ives.

Assessment of biodiversity value

The habitats in each polygon of the Cambridgeshire basemap were assigned a distinctiveness and condition score based on Biodiversity Metric 3.1. It was possible to estimate the condition for 94.9% of the region. Much of the area (c.82%) is in poor condition (score 1), primarily due to the predominance of arable and improved grassland habitat, and the extent of domestic gardens and

amenity grasslands. Most of the Ouse Washes is also considered to be in poor condition There were patches of moderate, fairly good and good condition habitats scattered throughout the region, including the Nene Washes, many of the woodlands to the west and many of the fenland nature reserves. The overall biodiversity score was 794,000 units, excluding the 5.1% of land that has not been assigned a score. Arable delivered the most units in total because it is by far the dominant habitat across Cambridgeshire, but broadleaved woodland provided a large number of units (118,000) and fen, marsh and swamp habitats provided the highest average units per hectare (18.4).

Benefits and values of parks and greenspaces

Scores and values were extracted for each park and greenspace across the area, with results available for each individual site on the mapping portal that accompanies this report. This included biodiversity units, scores for each ecosystem service, and the monetary value of public benefits provided by the greenspaces. Greenspaces in Fenland District provided the greatest number of biodiversity units in total and the highest mean biodiversity units per hectare (1.9) of all the local authorities, due almost entirely to the Nene Washes. East Cambridgeshire has the lowest mean score of 1.1 units per ha. Greenspaces in Fenland District are net emitters of carbon, due to the dominance of peat soils in the area, whereas greenspaces in Peterborough were the best at delivering air purification benefits. Patterns across the other ecosystem services were variable.

The monetary value of air purification was calculated and added to values for four other benefits previously calculated by Vivid Economics. The total value of greenspaces varied from a few hundred pounds per annum up to £22.7M for Nene Park in Peterborough. In total, Cambridgeshire's greenspaces provide public benefits with an annual value of £377 million. The value of greenspaces was highest in Peterborough (£115M pa) and South Cambridgeshire (£99.5M) and lowest in Fenland (£18.6M pa). Across all the districts, the total value is driven by the values for mental wellbeing and physical health and is determined more by the number of visitors than the types of habitats present. Access to greenspace is key for delivering health and wellbeing benefits that are valued so highly.

Habitat opportunity mapping

Habitat opportunity mapping is a Geographic Information System (GIS) based approach used to identify potential areas for the expansion of key habitats to meet different objectives, whilst taking constraints into account. Opportunity maps were created for three different broad habitat types and for six different ecosystem services, with opportunities prioritised to indicate three levels of importance in each case.

The opportunity maps for biodiversity highlight 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. Broadleaved and mixed woodland opportunities are numerous across the county, but are less prevalent in the northeast quarter (especially Fenland District) where there is less existing woodland. There is a high density of high priority opportunities to the west of Peterborough. Habitat creation could considerably enlarge and connect woodland networks, which are currently relatively small and fragmented. Semi-natural grasslands are fairly evenly dispersed across Cambridgeshire. However, although a number of these patches are ecologically connected into a network (e.g. along the Great Ouse), many patches remain disconnected, but there is good opportunity to enhance connectivity through habitat creation. Wet grassland and wetland opportunities are almost entirely focused along the Nene Washes, Ouse Washes and Cam downstream of Cambridge.

The opportunity maps for ecosystem services highlight the best areas to create habitats to enhance the delivery of each ecosystem service in turn, based in most cases on where demand is high and capacity is currently low. Opportunities for water flow regulation are present over much of Cambridgeshire, but the higher priority opportunities tend to occur on arable fields on slopes in the west and south. In contrast, the vast majority of opportunities to improve water quality by reducing soil erosion are located adjacent to watercourses and are found predominantly in the north-east. Billing Brook catchment in the north-west is in bad condition and contains the highest priority opportunities after weighting the results by catchment water quality. The best opportunities to ameliorate air pollution were located in Fenland and around Peterborough and a similar pattern was revealed when considering opportunities to reduce noise pollution. Opportunities to regulate local climate (reduce urban heat) tended to fall in and around the larger urban areas. Opportunities for increasing access to the natural environment were concentrated in a ring around the edges of urban areas, mainly Cambridge, but also Peterborough, Huntingdon and Whittlesey. The map was prioritised based on the degree of failure to meet ANGSt standards. The priority remained around Cambridge, but with less emphasis on places which already had good access to natural greenspaces, such as Peterborough and St Ives.

Combined opportunities for new habitats

Opportunity maps were combined to highlight areas where new habitat can be created that provides opportunities to enhance more than one of the services mapped previously. Here we present opportunities that are focused on delivering multifunctionality, but restricted to areas that deliver biodiversity benefits, and also a map that combines all opportunities without restrictions. Combined opportunities for new broadleaved and mixed woodland tend to deliver the highest scores, as woodland is able to deliver all of the opportunities modelled here. The areas that would deliver greatest overall benefits are on the outskirts of Peterborough, between Peterborough and Huntingdon, and there are also high opportunities to the west of Cambridge and around March and Wisbech. Creating semi-natural grassland or wetland habitats would not deliver the same level of multifunctionality, but can still deliver significant additional benefits. When combining all opportunities equally (without restricting to areas that deliver biodiversity opportunities), most areas delivering multiple benefits occur in and around urban areas and adjacent to the road network.

Developing an Environmental Justice Index for Cambridgeshire and Peterborough

Environmental justice is concerned with the equitable distribution of environmental benefits and reducing environmental inequalities. By mapping the distribution of these inequalities, it then becomes possible to prioritise resources in locations that are suffering from environmental injustice. The idea of an Environmental Justice Index was developed by Birmingham City Council, who incorporated five indicators to create a map of city wards in need of prioritised investment. In this study, the framework was expanded to include 10 datasets across 3 categories. The Environmental Justice Index (EJI) was calculated by summing the three indicators together: health and deprivation, environmental risk, and natural green space access and demand

The average index value for each ward was then calculated. The worst performing wards generally centre around urban areas, particularly Wisbech, Huntingdon, Chatteris, parts of Peterborough and North Cambridge. The three wards with the highest average EJI score within each Local Authority were also identified. A case study was then developed for Wisbech (the worst performing town) to demonstrate the application of these indicators at a local scale. An interactive story map has also been produced to present the development and results of the Environmental Justice Index and this is publicly available on the internet.

Further applications and prioritising action

The natural capital assessment provides an extensive evidence base that has a wide range of applications. A small number of these are discussed, focussing on applications around growth and development, health and deprivation, biodiversity, and the use of the maps to inform the development of a Local Nature Recovery Strategy (LNRS).

Contents

1 Introduction

The Cambridgeshire and Peterborough Future Parks Project (CPFP) is one of nine projects across the UK awarded funding to develop innovative solutions to secure and enhance the future of their public parks and greenspaces. The CPFP project aimed to develop a joined-up response to the threats and opportunities created by the pace and scale of development in Cambridgeshire and Peterborough, to deliver equal access to high-quality, financially sustainable, vibrant green spaces across the whole county.

Previous work within the CPFP project has mapped all the open spaces across the area[1], and the connectivity between the open spaces have also been explored through the production of the innovative Greenground map[2]. Another project calculated the monetary value of the public benefits being delivered[3] and how this will change going forward[4]. However, this was limited to four different values (physical health, mental health, amenity value, and carbon sequestration) and it was felt that there was a need to consider a broader range of monetary and non-monetary benefits, such as biodiversity, water quality and flow regulation, and air quality regulation benefits. In addition, it was considered important to determine how the parks and greenspaces in the area fitted within the wider landscape context, to explore opportunities to create new habitats that could deliver a range of benefits (either within or outside existing greenspaces), and to take into account broader socio-economic considerations when making the case for investment in parks and greenspaces.

Natural Capital Solutions were therefore commissioned to produce a natural capital assessment for Cambridgeshire and Peterborough, with the following eight aims:

1. Produce an updated and detailed natural capital (habitat) basemap for the whole area.
2. 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.
3. Assess and map the biodiversity value of habitats across the landscape, based on the Biodiversity Metric.
4. Determine the benefits and values of each individual park and greenspace across the area.
5. Create habitat opportunity maps for biodiversity enhancement and for a range of ecosystem services, showing where new habitats could best be created, for both individual and combined benefits.
6. Develop an Environmental Justice Index, drawing attention to the equitable distribution of environmental benefits and reducing environmental inequalities.
7. Develop ideas for a Strategic Green Network, with a particular focus on outcomes around environmental justice, growth and development, health and deprivation, biodiversity and Local Nature Recovery Strategy (LNRS).
8. Engage with stakeholders throughout the process, and to disseminate results through an interactive web portal, a story map, and a technical report.

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[1] Cambridgeshire Open Space Mapping & Standards (2020). Report for Cambridgeshire County Council, Jon Sheaff and Associates.

[2] Greengound Map (2021). Available from: https://cambsfutureparks.org.uk/wp-content/uploads/2021/12/Cambridgeshire-Greenground-Map-5.pdf

[3] Natural Capital Account (2020). Prepared for Cambridgeshire County District Authorities, Vivid Economics.

[4] Greenkeeper Scenario Analysis for Cambridgeshire County Council and Peterborough District Council (2021). Vivid Economics.

1.1 The natural capital and ecosystem services framework

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[5]).

These benefits (often referred to as ecosystem services) include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities. Different types of ecosystem service are shown in Figure 1.

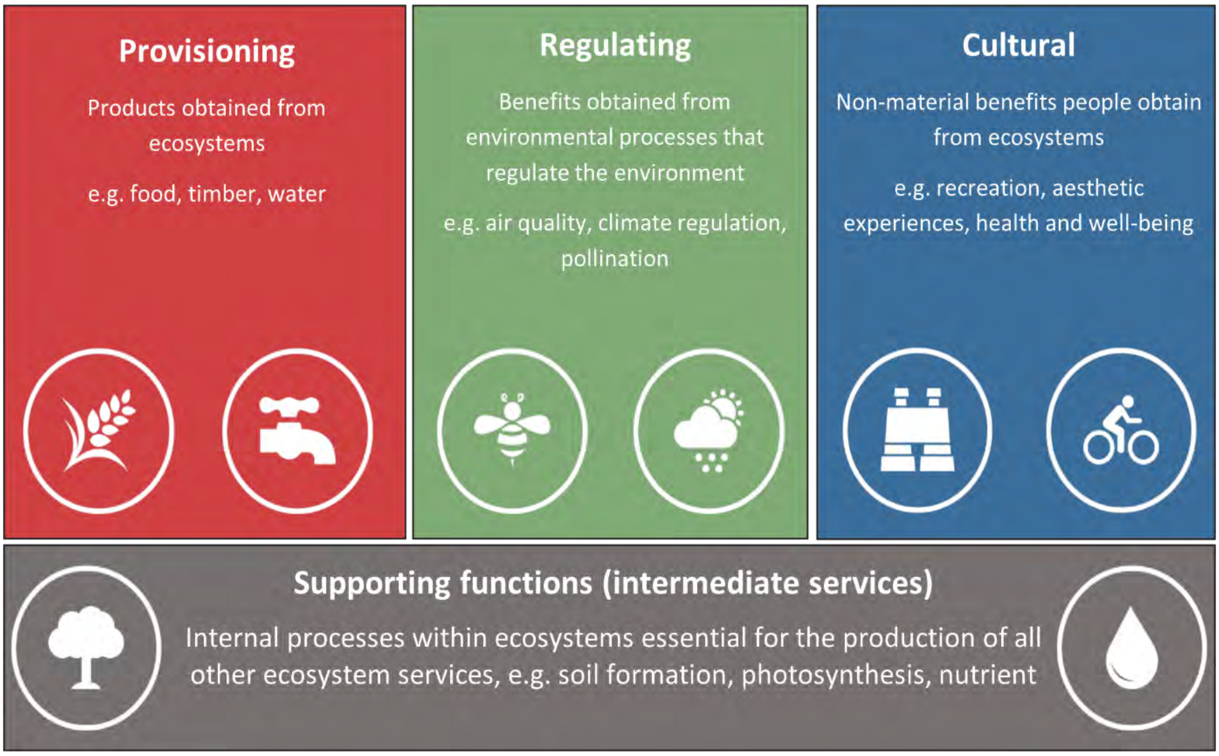


Figure 1: Key types of ecosystem services (based on MA 2005[6]). Note that supporting or intermediate services are now categorised as ecological functions (CICES[7]). They are the underpinning structures and processes that give rise to ecosystem services.

The environment is being increasingly regarded as 'multi-functional', delivering a range of environmental, social and economic benefits to society. Green spaces can sequester carbon, reduce downstream flood risk and water quality problems, as well as providing quality space for recreation and biodiversity gain, demonstrating how multi-functional benefits can be delivered. Locating new greenspaces in optimal locations or changing habitats within existing greenspaces can further enhance the benefits delivered and reduce environmental inequalities.

[5] Natural Capital Committee 2014. Towards a Framework for Defining and Measuring Changes in Natural Capital. Working Paper 1, Natural Capital Committee.

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

[7] 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.

The concepts of natural capital and ecosystem services are widely supported; the challenge, however, is in implementing the approach and embedding it in working practices, so that it becomes an integral component of decision making. Progress is being made on how to deliver the approach on the ground and how to use it to inform and influence management and decision-making.

Methods for quantifying and valuing natural capital benefits are becoming increasingly robust and additional insight can be gained by taking a spatial perspective on the variation in natural capital assets and the benefits that they deliver across the 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. They can also be used to objectively identify areas where natural capital can be created to enhance benefits, often in areas where demand is currently high and supply low, in a process known as opportunity mapping.

There are a large number of applications of a natural capital assessment and a number of these are explored in this project. This includes the development of an Environmental Justice Index to promote investment in wards that are currently suffering form a lack of greenspace access, poor health and deprivation and high rates of environmental risk. Further applications are explored focusing on health and wellbeing priorities, biodiversity and the Local Nature Recovery Strategy process, and opportunities around growth and development.

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, and the baseline natural capital assets of Cambridgeshire are presented in Section 2. This is followed by the assessment of 10 different ecosystem services in Section 3 and the demand for four of these services.

The overall biodiversity value of Cambridgeshire and Peterborough is presented in Section 4, by calculating Biodiversity Units across the county. Section 5 then focuses on the specific value of parks and greenspaces in the county, picking out case studies to highlight this. The report then moves on to the assessment of opportunities for enhancing biodiversity and ecosystem services across Cambridgeshire. Three different broad habitats were assessed in Section 6 – broadleaved and mixed woodland, semi-natural grassland, and wetland and wet grassland – and six different ecosystem services. In Section 7, the individual opportunity maps are then overlain to identify opportunity areas where multiple benefits could be delivered, creating maps that focus on biodiversity, and which focus on all benefits equally.

Section 8 looks at developing an Environmental Justice Index for Cambridgeshire, which helps to highlight areas that should be prioritised for investment. Further applications of the mapping are discussed in Section 9.

One of the key outputs from this project are the numerous GIS maps and layers. A mapping portal has been developed, hosted by Peterborough City Council, to display and query these layers. In addition, a publicly accessible story map has been developed to showcase the Environmental Justice Index described in Section 8.

Please note that the maps presented here are based on existing data and have not been extensively ground-truthed, so will be prone to some error. They do, however, provide the most comprehensive and detailed information that is possible at this time. Note also that the opportunity mapping identifies areas based on landscape-scale ecological principles and ecosystem services models and does not consider local site-based factors that may impact on 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.

Note that when the report refers to *Cambridgeshire*, this is intended to mean the entire ceremonial county, including Peterborough. Note also that the term *greenspace* is used as shorthand for both green and blue space and for all types of greenspace. The term *natural greenspace* is also used in some parts of the report, and that refers to a subset of greenspaces, that contain more natural habitats, as defined by Natural England in their Accessible Natural Greenspace Standard (ANGSt)[8].

[8] Natural England (2010). 'Nature Nearby': Accessible Natural Greenspace Guidance. Natural England

2 Cambridgeshire and Peterborough baseline natural capital assets

2.1 Approach to mapping habitats

The first step of the project was to produce a detailed map of the current habitats present across the area. This is an important component of any assessment of natural capital assets and is required before an assessment of the current benefits and values being delivered by the natural capital, or opportunities for enhancement, can be determined. To do this we used Ordnance Survey MasterMap polygons as the underlying mapping unit and a series of different data sets to classify each polygon to a detailed habitat type. We also added a range of additional data to the polygons across the area. The data used is outlined in Box 1.

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

- OS MasterMap Topography layer
- OS VectorMap District
- OS Open Greenspace data
- Open spaces and parks data for each LA – supplied by Cambridgeshire FPA
- Phase 1 habitat data – supplied by CPERC
- Natural England Priority Habitats Inventory
- County and City Wildlife Sites – supplied by CPERC
- National Forest Inventory data
- Ancient Woodland Inventory data
- Corrine European Habitat data
- Built-up Area Boundaries data
- Digital terrain model

This map was originally produced as part of a previous project[9]. For the current project, we partially updated the map, using a new (2021) version of OS MasterMap, which enabled us to map recently developed areas, alongside new data sets on parks and opens spaces, and woodland. Polygons were classified into Phase 1 habitat types and were also classified into broader habitat groups. The final basemap covered the whole of Cambridgeshire (including Peterborough), and covers an area of 339,700 ha or 3,397 km^2. It contained 1.61M polygons, each of which was classified to an appropriate habitat type.

Note that the basemap provides the best approximation of habitat types that can be achieved based on available data, but has not been ground-truthed and will inevitably contain errors. The Phase 1 habitat data supplied by CPERC dates from the 1990s, so some changes are inevitable and could only be partially checked. 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. Other areas, where there was a mismatch between data sources, or land use is changing rapidly, remained a challenge.

[9] Rouquette, J. (2019) Mapping natural capital and opportunities for habitat creation in Cambridgeshire. Report for Cambridgeshire Biodiversity Partnership, Natural Capital Solutions.

2.2 Asset register for Cambridgeshire and Peterborough

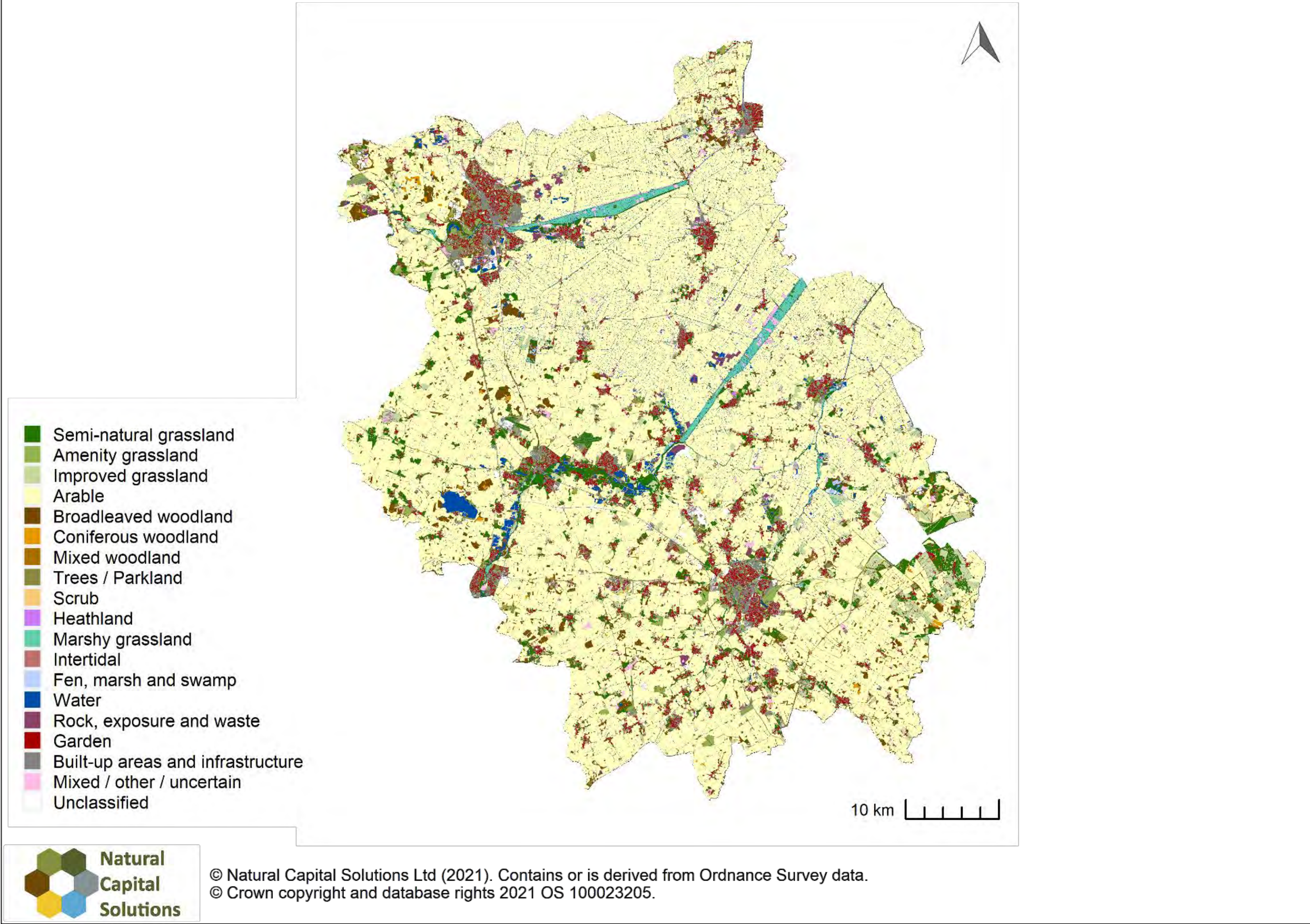
Map 1 shows the distribution of broad habitat types across Cambridgeshire and Peterborough, and the area and percentage cover are shown in Table 1. Cambridgeshire is dominated by arable land, making up 69.9% of the land (237,388 ha), with agricultural improved grasslands making up a further 3.8% (12,860 ha). Semi-natural grassland is the most common non-agricultural/manmade habitat, occupying 3.6% of the county (12,371 ha). This habitat is concentrated in the south of the county, particularly around Newmarket and St Ives.

The combined cover of all woodland, scrub and tree habitat types makes up just 4.9% of the area (16,608 ha), which is considerably lower than the national average. This is distributed across the county but is noticeably lower in the northeast quarter (with the exception of Wisbech). Fresh water and brackish water together cover 2.1% (7,092 ha). There are some significant rivers in the county, for example the Cam, the Great Ouse and the Nene, but much of the freshwater is found in ditches which mark field boundaries. Marshy grassland, and fen, marsh and swamp habitats together cover 0.9% of Cambridgeshire (3,177 ha). These are concentrated around the Cam, the Great Ouse and the Nene, particularly in the Nene and Ouse Washes.

Built-up areas and infrastructure (roads, pavements, paths and railways) cover 5.4% of the county (18,812 ha). Gardens make up a further 3.4% and amenity grassland covers 2.5% (11,664 and 8,542 ha respectively).

Table 1: Asset register for Cambridgeshire and Peterborough showing the area and percentage cover of broad habitat types.

Broad habitat	Area (ha)	% Cover
Cultivated / disturbed land	237,388	69.9
Uncertain agriculture (improved grass or arable)	5,817	1.7
Improved grassland	12,860	3.8
Amenity grassland	8,542	2.5
Semi-natural grassland	12,371	3.6
Marshy grassland	2,868	0.8
Fen, marsh and swamp	308	0.1
Scrub	442	0.1
Trees / Parkland	2,812	0.8
Broadleaved Woodland	11,668	3.4
Coniferous woodland	1,166	0.3
Mixed woodland	520	0.2
Water	7,092	2.1
Built up areas	10,351	3.0
Infrastructure	8,461	2.4
Gardens	11,664	3.4
Rock, exposure and waste	1,005	0.3
Mixed / other / uncertain	2,825	0.8
Unclassified (under development)	1,583	0.5
TOTAL	339,745	100.0



Map 1: Cambridgeshire and Peterborough baseline natural capital asset map

3 Modelling and mapping ecosystem services (physical flows)

Once a detailed habitat basemap had been created for Cambridgeshire, 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
- Carbon sequestration
- Air purification
- Noise regulation
- Local climate regulation
- Water flow regulation
- Water quality regulation
- Food production
- Timber production
- Accessible nature

The list of services assessed was considered to capture all of the most important services provided by the natural capital assets within Cambridgeshire.

A variety of methods were used, and these are described for each individual ecosystem service in the sections below. In all cases, the models were applied at a 10m-by-10m 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, noise regulation, local climate regulation and accessible nature it was also possible to map the local demand (the beneficiaries) for these services. The importance and value of ecosystem services can often be dependent upon its location in relation to the demand for that service, hence capturing this information provides useful additional insight. Mapping demand is not possible for some services as either there is no obvious method to apply (water flow and quality regulation), or local demand is not relevant (food and timber production).

3.1 Carbon storage capacity

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 are 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 significant changes in carbon storage, as can the restoration of degraded habitats. Note that carbon storage measures the stock of carbon in the natural environment, whereas carbon sequestration (Section 3.2) measures its annual flow.

How is it measured?

This model estimates the amount of carbon stored in each habitat type. It applies average values (tC/ha) for each habitat type taken from Natural England (2019) [10]. A multiplier [11] is then applied to habitat carbon storage values depending on which soil type the habitat occurs on. As such, it does not take into account habitat condition or management, which can cause variation in amounts of carbon stored. It is calculated for every 10m by 10m cell across the study area. Scores are scaled on a 0 to 100 scale relative to values present within the mapped area.

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 Cambridgeshire and Peterborough

Map 2 shows the baseline carbon storage values across Cambridgeshire. The highest values are found in coniferous and broadleaved woodland planted on deep peat soils, pockets of which are found in the northwest of the map (in red, 400-520 tC/ha). Woodland on mineral soil has the next highest capacity (in cream, 200-250 tC/ha). The majority of the county has relatively low values of 73 tC/ha (shown in blue), which are from agricultural areas on mineral soil. Agricultural land on peat soil in the northwest of the county has a slightly higher carbon storage value of 109.5 tC/ha (in light blue). Storage is lowest in built surfaces (buildings, roads), which have no capacity, as well as bodies of water (dark blue).

[10] 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.
[11] Lagas and Sweep (2020) Ecosystem service – carbon storage and sequestration.

Map 2: Carbon storage capacity for Cambridgeshire

3.2 Carbon sequestration capacity

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 a year as the sequestered carbon is immediately released. However, there are emissions associated with the management of the agricultural land (e.g. machinery use 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 relatively low.

How is it measured?

This model estimates the amount of carbon sequestered by each habitat type. It applies average values (tCO2e/ha/year) for each habitat type taken from Natural England (2019)[12] and the RSPB's Accounting for Nature report[13], 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)[14], Smart et al. (2020)[15] and Gregg et al. (2021)[16]. It is calculated for every 10m by 10m cell across the study area. Scores are given in tonnes of CO_2 equivalent per ha per year.

Results for Cambridgeshire and Peterborough

The baseline carbon sequestration map (Map 3) shows that the greatest areas of carbon sequestration (in dark red, typically 9 tco2e/ha/year) are broadleaved woodland habitats on mineral soil across the northwest, west and south of Cambridgeshire. Other woodland, including coniferous woodland and scrub, has a slightly lower capacity. Grassland and gardens on mineral soil have a low carbon sequestration capacity (shown in light red, 1.6 tco2e/ha/year). Agricultural land on mineral soil is a slight net emitter of carbon due to emissions associated with agricultural practices, and this covers the bulk of the map (in orange, -1.5 tco2e/ha/year) except for the northeast quarter. The northeast quarter of the county, as well as some patches in the south, have shallow peat soil. These soils are almost entirely covered with agricultural habitats, and as a result these areas have higher emissions (light blue, -18.3 tco2e/ha/year). There are a few patches of deep peat soil across the county. Where these coincide with land managed for agriculture, there are high emissions associated with it (dark blue, -39.0 tco2e/ha/year). However, these emissions from deep peat soil are much lower along the Nene and Ouse Washes, where marshy grasslands are present (-2.08 tco2e/ha/year).

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12 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.

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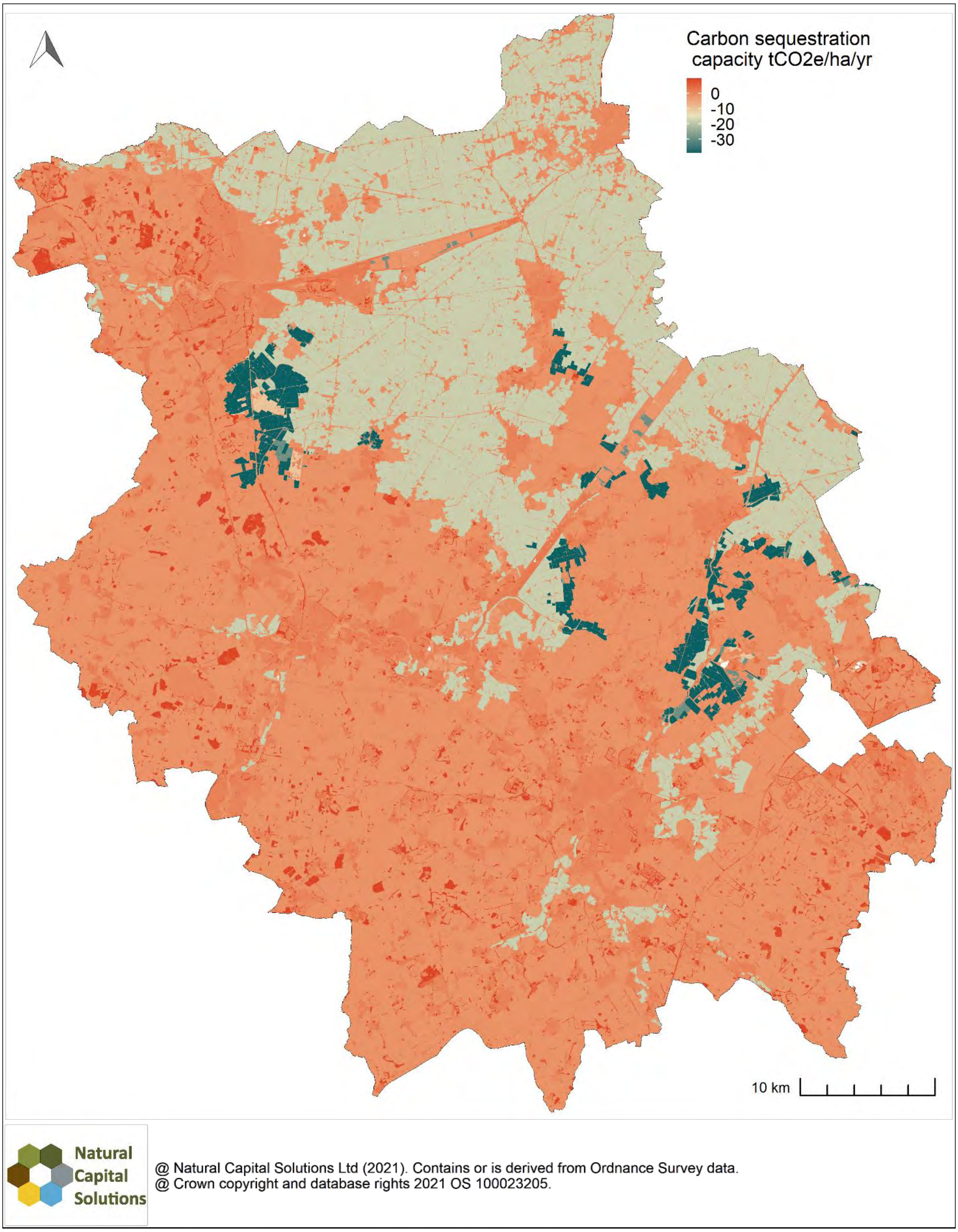


Map 3: Carbon sequestration capacity for Cambridgeshire

3.3 Air purification capacity

What is it and why is it important?

According to the Public Health England, air pollution is the biggest environmental threat to health in the UK, with between 28,000 and 36,000 deaths a year attributed to long-term exposure, with the greatest threats from particulate matter ($PM_{2.5}$) and nitrous oxides (NO_x). Even small changes can make a big difference, just a 1µg/m^3 reduction in $PM_{2.5}$ concentrations could prevent 50,000 new cases of coronary heart disease and 9,000 new cases of asthma by 2035[17]. Air pollution also contributes to climate change, reduces crop yields, and damages habitats and 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?

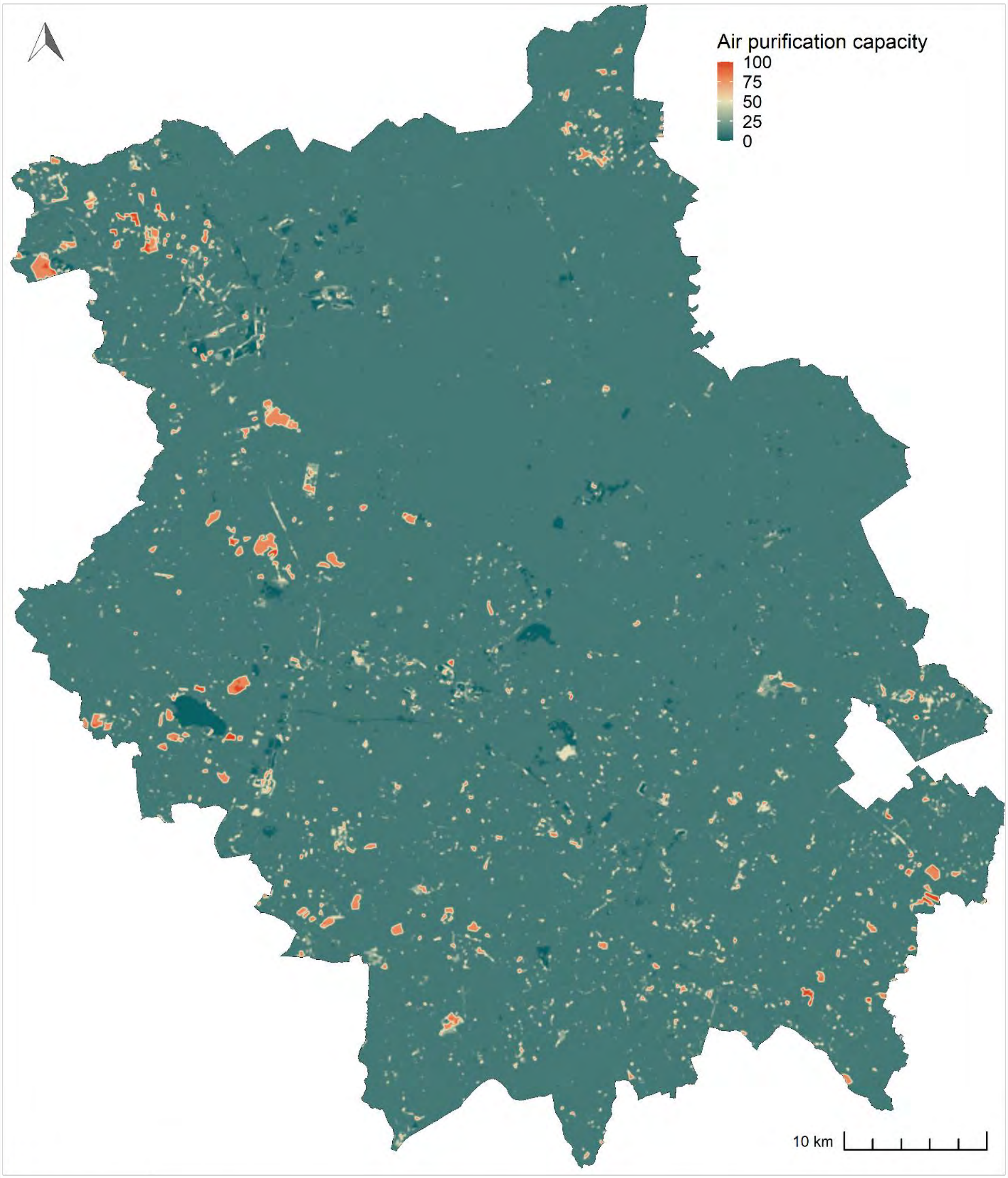
Air purification capacity was mapped using an EcoServ R model. The model assigns a score to each habitat type, representing the relative capacity of each habitat to ameliorate air pollution. The cumulative score in a 20m and 100m radius around every 10m-by-10m pixel was then calculated and combined. 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 Cambridgeshire and Peterborough

Woodland is by far the best habitat at intercepting and absorbing air pollution, with the very highest scores from the coniferous woodland within Cambridgeshire (Map 4 below, in red). Broadleaved, coniferous and mixed woodland provide a high level of this service in blocks throughout the county. These areas are concentrated somewhat around the borders of the county, with a noticeable absence of capacity in the northeast quarter (with the exception of Wisbech). Scrub and trees/parkland provide a medium level of air purification capacity (shown in cream), again found mainly in the south and northwest of the county. Semi-natural grassland has a low capacity (shown in light blue). Much of the map is covered by agricultural land which very little capacity. The lowest scores are from man-made sealed surfaces and areas of water, which have no ability to ameliorate air pollution (dark blue).

[17] Public Health England (2018) Estimation of costs to the NHS and social care due to the health impacts of air pollution. Crown Copyright.



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Map 4: Air purification capacity for Cambridgeshire

3.4 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 EcoServ R. 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).

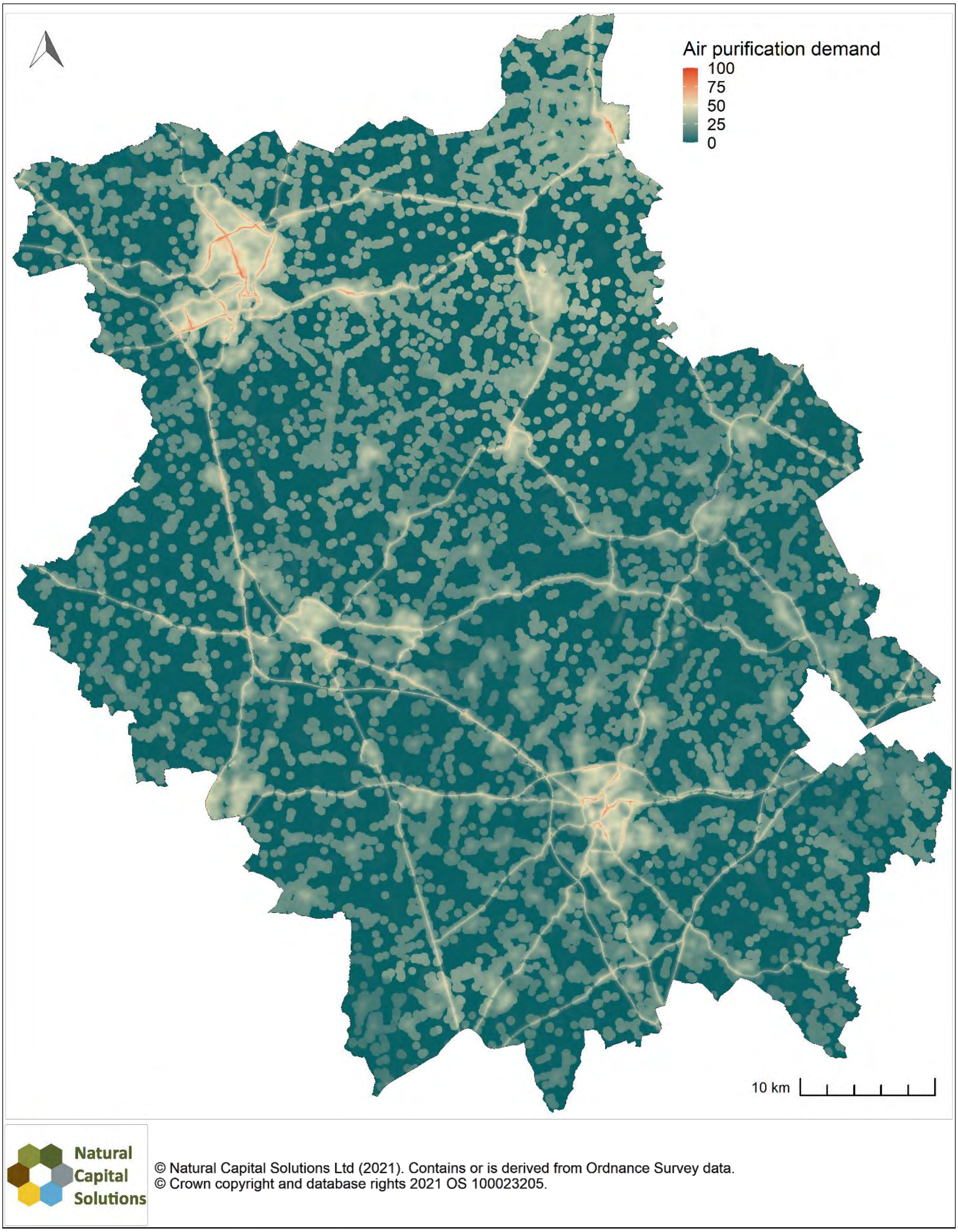
The scores for each indicator were normalised and combined with equal weighting. The final score was then projected on a 0 to 100 scale relative to values present within the study area. High values (red) denote areas with the greatest demand for air purification as a service.

Results for Cambridgeshire and Peterborough

Air purification demand is highest in urban centres (Map 5), particularly Peterborough and to a slightly lesser extent Cambridge, 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. There is high demand on the A-roads passing through the centres of Peterborough, Cambridge, Huntingdon and Wisbech, as well as moderate to high demand along the A14 and A1(M) which run along the west side of the county, particularly where these are close to settlements.

Balancing supply and demand

Comparing the supply and demand maps, there is a spatial disparity between the provision of and need for air pollution amelioration, as areas of woodland are relatively sparse in Cambridgeshire and are largely concentrated outside of urban areas. 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 urban areas of Cambridgeshire. 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 Cambridgeshire. 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 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. There is potential opportunity for urban parks and greenspaces to play a greater role in delivering this service through tree planting, particularly when close to roads.



Map 5: Air purification demand for Cambridgeshire

3.5 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 [18]). 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.

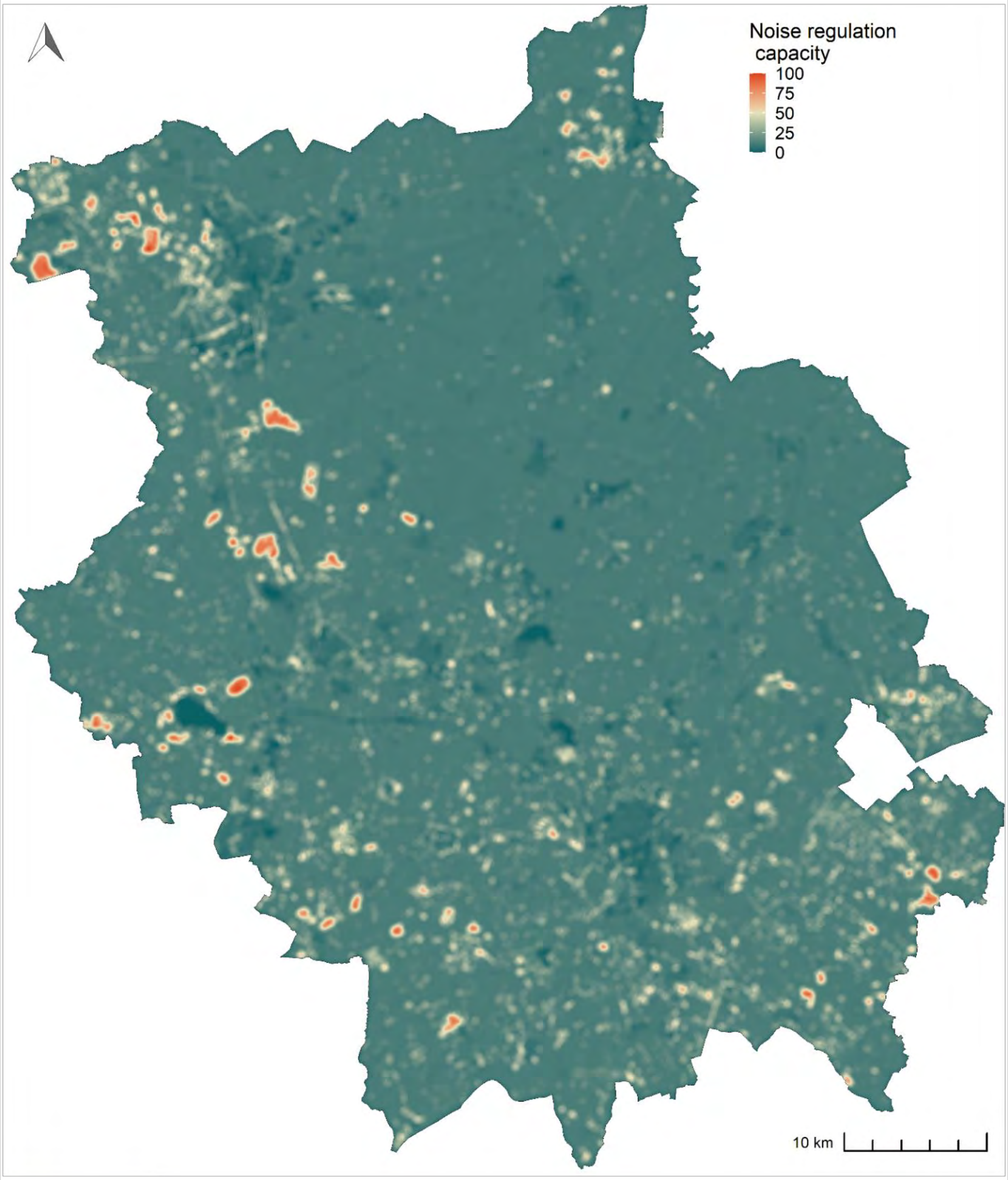
How is it measured?

The EcoServ R 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 10m 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 Cambridgeshire and Peterborough

The woodland in Cambridgeshire is by far the most effective habitat at absorbing noise (Map 6). The larger wider blocks of woodland have the highest provision of this service, for example the nature reserves in the west of the county (for example, Holme Fen NNR, Bedford Purlieus NNR and Monks Wood NNR) and blocks of broadleaved and coniferous woodland in the southeast. However, the effects can be modest, with reductions of 2-4 dB typically recorded across dense tree belts.

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



Map 6: Noise regulation capacity for Cambridgeshire

3.6 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 is mapped using a modified version on an EcoServ R 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.

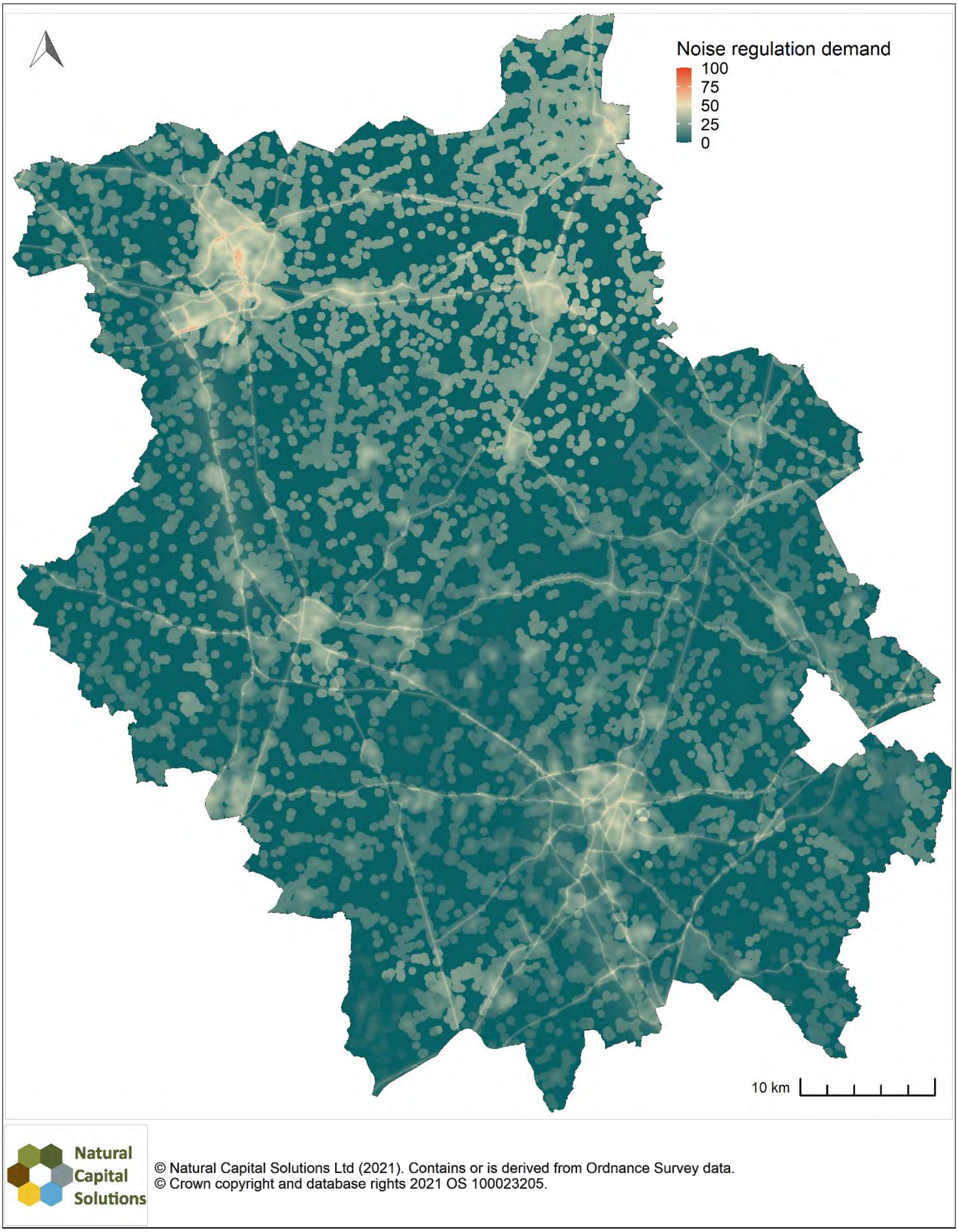
Results for Cambridgeshire and Peterborough

Demand for noise regulation (Map 7) 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 is moderate demand for noise regulation across the urban centres of Cambridgeshire. The highest demand is found in the centre of Peterborough.

Balancing supply and demand

Similar to air purification, the supply and demand maps show a spatial disparity between capacity and need for noise regulation. There is very little capacity in urban areas, as most of the woodland is found in rural areas. Planting of new woodland or tree belts in urban areas next to roads would be the most effective way to meet demand.

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.



Map 7: Noise regulation demand for Cambridgeshire

3.7 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 waterbodies, 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.

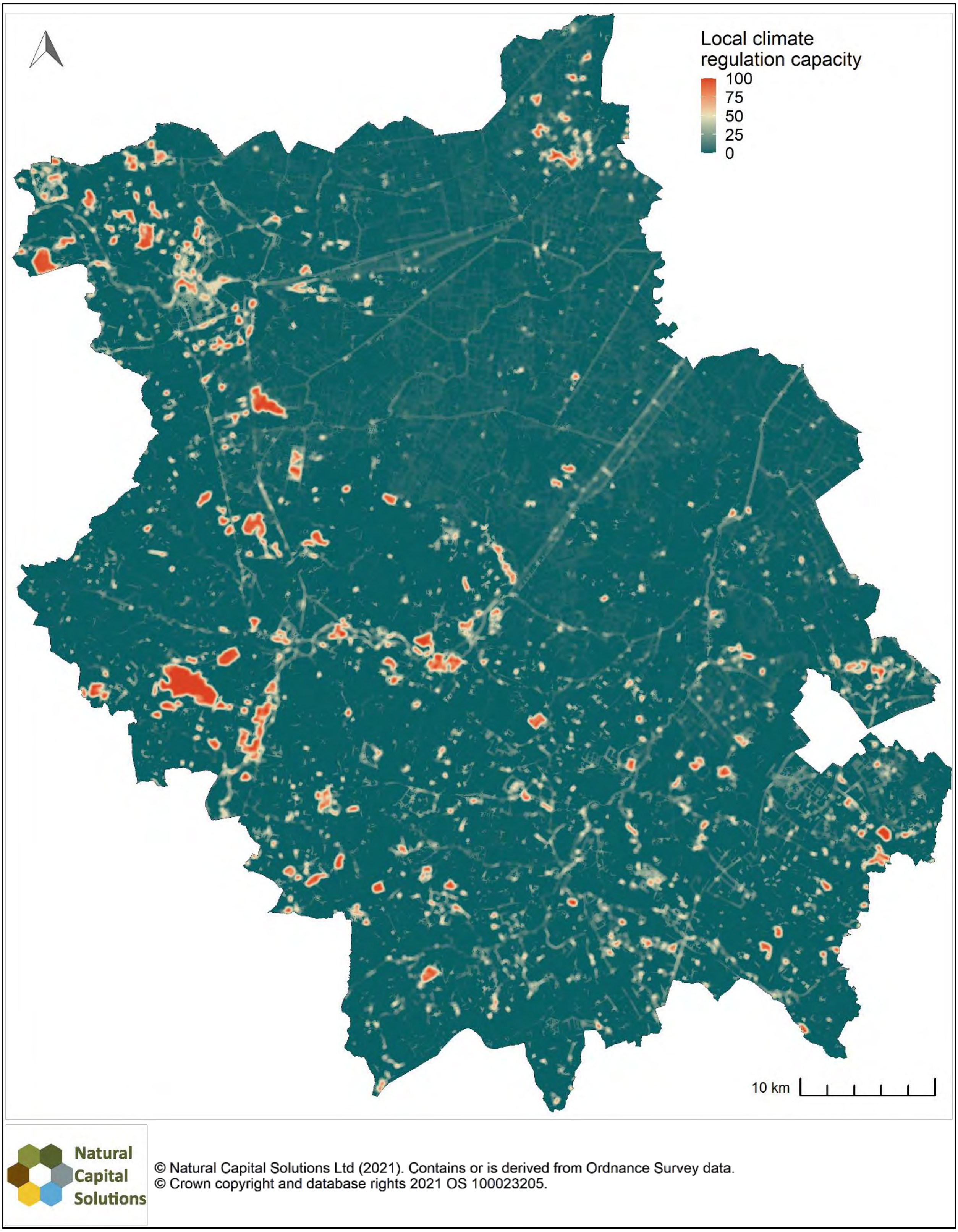
How is it measured?

Local climate regulation capacity was mapped using an EcoServ R 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 includes 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 Cambridgeshire and Peterborough

Woodland and water bodies deliver the highest provision of the local climate regulation service with larger patches shown as red areas (Map 8). The largest patches are to the west of the county surrounding Peterborough and Huntingdon, including Grafham Water and Holme Fen Nature Reserve. There are also some patches of woodland with a high climate regulation capacity to the south around Cambridge. The northeast of Cambridgeshire has a notably low capacity as it is almost entirely agricultural land.



Map 8: Local climate regulation capacity for Cambridgeshire

3.8 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 EcoServ R 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 Cambridgeshire and Peterborough

Demand for local climate regulation is greatest in the following urban centres in Cambridgeshire: Cambridge, Peterborough, Huntingdon, March, Ramsey and Wisbech (Map 9). The highest level of demand is found in the centre of Cambridge, whereas Peterborough has the most extensive demand. Lower demand is also present across a number of the smaller urban areas across the county. Demand is centred in urban areas due to the urban heat island effect.

Balancing supply and demand

Large water bodies, and large areas of woodland in or adjacent to towns are particularly beneficial to local climate regulating services as they can bring moderating conditions into the heart of these urban areas. A prime example of this is Peterborough, where the River Nene and associated lakes and woodlands within the river corridor extend right into the heart of the city.

In other parts of Cambridgeshire there is a small amount of overlap where there are woodland areas or waterbodies in urban fringes, but for the most part, woodland and water habitats are found outside of urban centres where demand is highest. 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 water features within or adjacent to the urban centres would help to decrease urban temperatures. Urban parks and greenspaces are important at delivering urban cooling in areas of high need and can be ideal locations to further enhance delivery though planting additional woodland or creating water features (or by creating new parks). The opportunity mapping in Sections 6 and 7 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.

Map 9: Local climate regulation demand for Cambridgeshire

3.9 Water flow regulation capacity

What is it and why is it important?

Water flow regulation 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 EcoServ R 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 three 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.

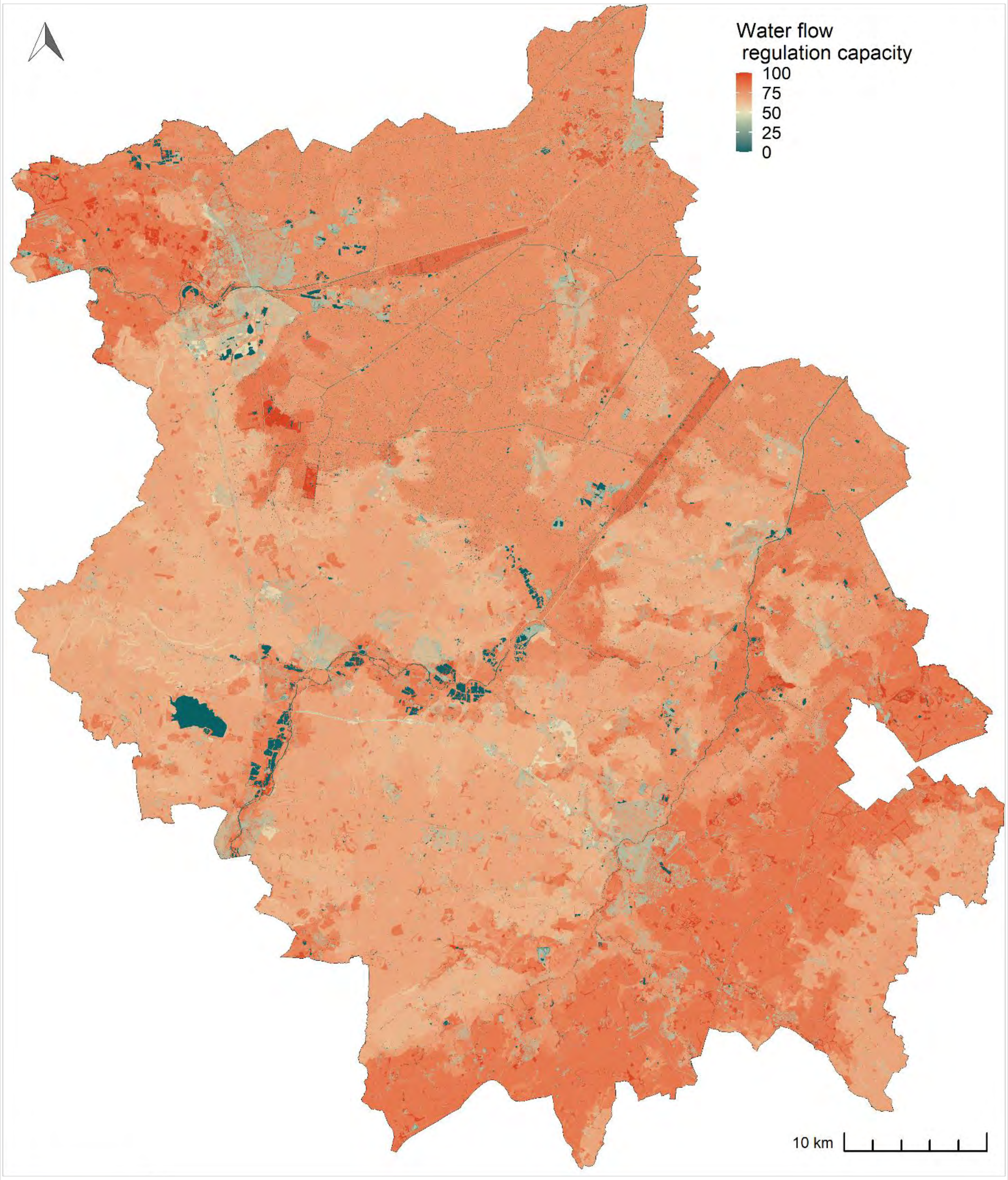
Slope score - based on a detailed digital terrain model, slope was re-classified into several classes based on the British Land Capability Classification and others.

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 Cambridgeshire and Peterborough

The best locations for slowing water runoff are areas which have woodland vegetation (providing the highest roughness of any habitat) and are flat. The worst areas are sealed surfaces and slopes. Water flow capacity is highest in patches of broadleaved woodland around Peterborough and to the west of Cambridge (in red, Map 10). As most of Cambridgeshire is flat, this improves flow regulation. There is also high capacity in the northwest corner and the south, where habitats are on flat ground and freely draining soils. Lower capacity in the centre west of the map is due to the presence of soils with impeded drainage. The lowest water flow regulation capacity is found in urban areas with sealed surfaces (in light blue) and bodies of water (dark blue).



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Map 10: Water flow regulation capacity for Cambridgeshire

3.10 Water quality regulation 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. Sedimentation causes direct impacts on river substrates, fish and aquatic invertebrates, and on flood risk, but also causes indirect impacts though pollutants that are adsorbed onto sediment, and then washed into watercourses. Note that although diffuse urban pollution is partially captured in the model at the catchment scale, the focus is on sedimentation risk from agricultural land.

How is it measured?

A modified version of an EcoServ R 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 particularly 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.

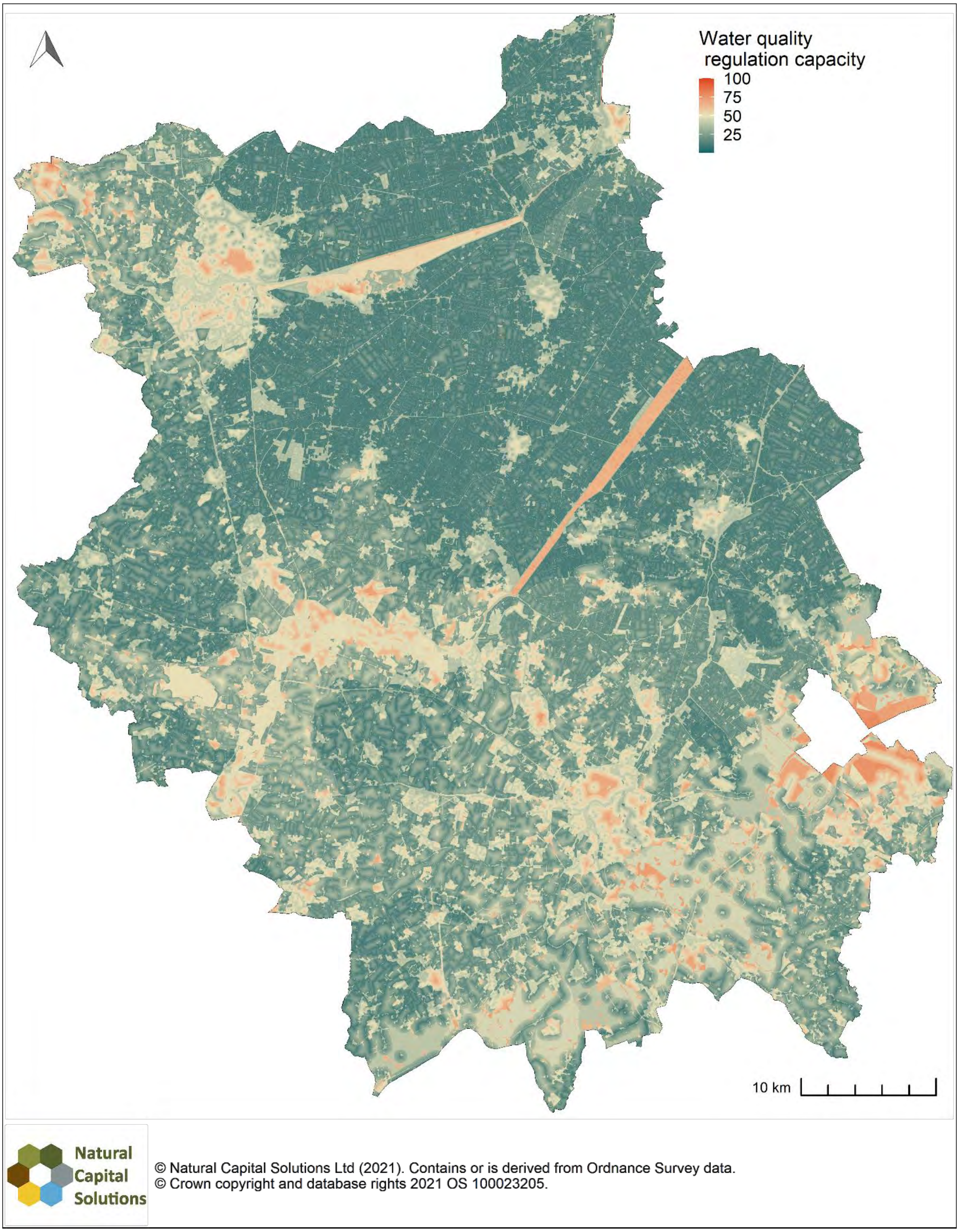
• **Slope length** - using a flow accumulation grid and equations from the scientific literature. Longer slopes lead to greater amounts of runoff.

• **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 Cambridgeshire and Peterborough

Much of Cambridgeshire has a low capacity to deliver the water quality regulation service (blue areas in Map 11). This is due to the dominance of agriculture, particularly arable farming which causes increased erosion, in areas that are close to watercourses. Arable fields are a particular feature across the north of the county where an extensive network of ditches form the boundaries between most fields. There is therefore a high risk of sedimentation, and thus a lowering of water quality. There are patches of grassland with relatively high provision in the southeast of the map around Newmarket and Cambridge, as well as along the Ouse Washes. Urban areas have higher provision than arable fields as the model focuses on sedimentation risks.



Map 11: Water quality regulation capacity for Cambridgeshire

3.11 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 Cambridgeshire, 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?

An EcoServ R model was developed using a methodology outlined in Smith (2020)[19] that was developed for the Eco-metric tool. Broad habitats in Cambridgeshire 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 agricultural land uses 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

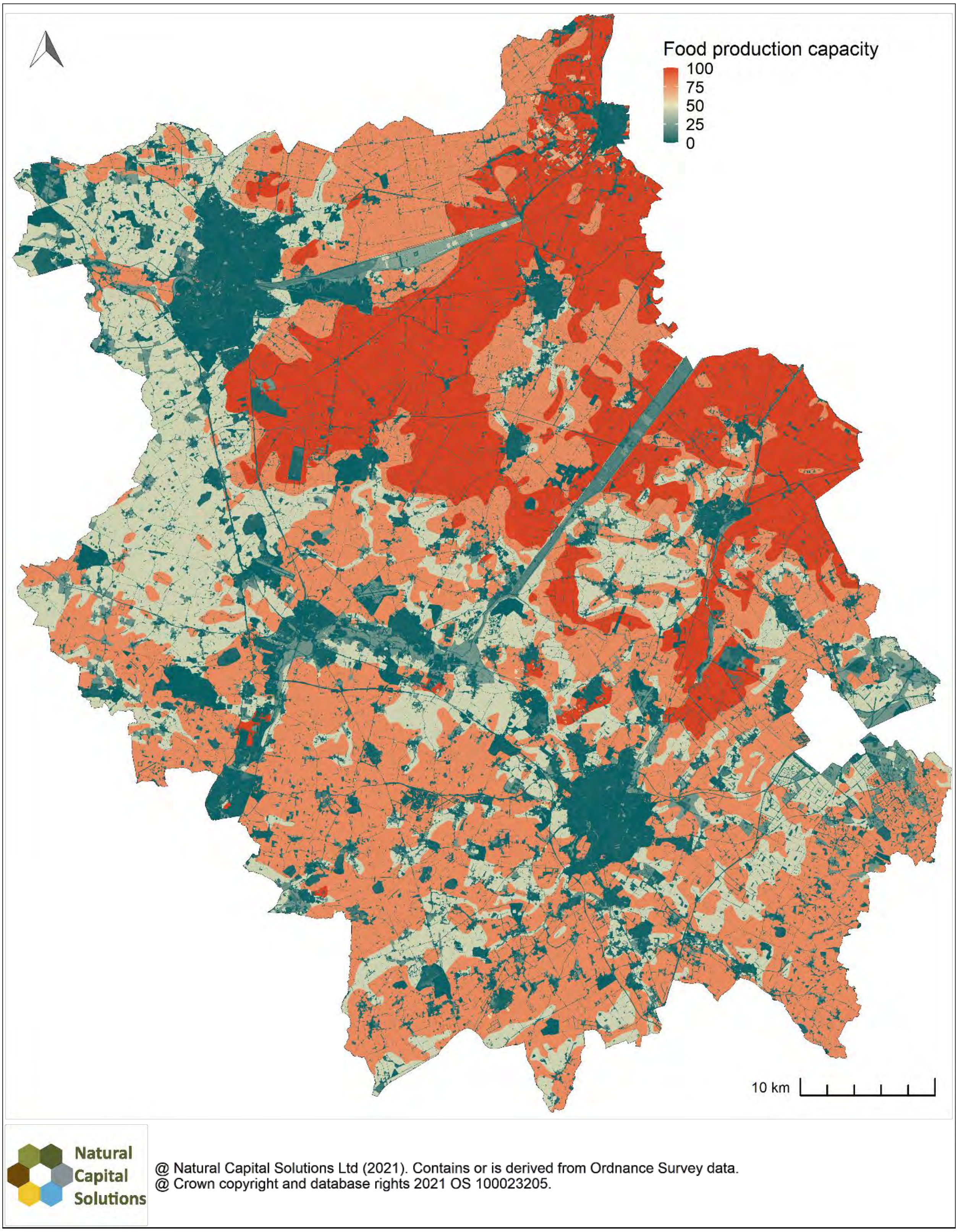
Grade 5 - 0.50

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 Cambridgeshire and Peterborough

Food production capacity is moderate to high across most of Cambridgeshire. The highest capacity is found in the east of the county, where agricultural land is managed on Grade 1 shallow peat soil (shown in red, Map 12). Agricultural land on Grade 2 shallow peat and mineral soils also have high food production capacity (shown in orange). Grade 3 land on mineral soil is found towards the west of the county as well as distributed across the south (shown in cream). This has a moderate food production capacity. Areas of semi-natural grassland and allotments have fairly low capacity (shown in light blue), and urban areas (apart from allotments) have very low food production capacity (shown in dark blue).

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



Map 12: Food production capacity for Cambridgeshire

3.12 Timber production 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.

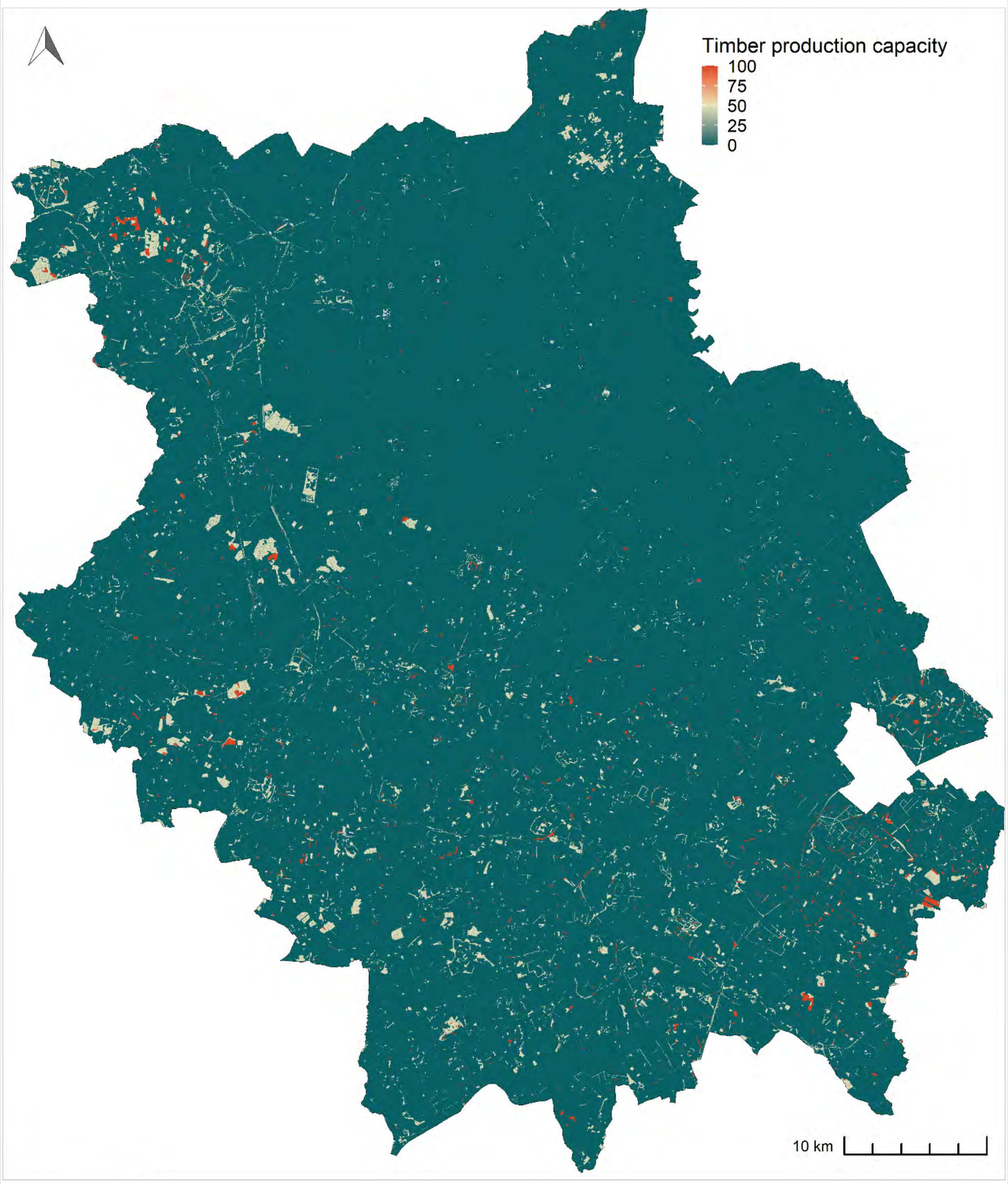
How is it measured?

The model uses information on the species mix and yield class obtained from the Forestry Commission's National Inventory of Woodland and Trees County Report for Cambridgeshire (2002), and Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). This was used to determine the average yield of timber (m^3) per hectare per year.

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 Cambridgeshire and Peterborough

Timber/woodfuel capacity is low across most of the county. There are some small patches of mixed and coniferous woodland which have high capacity (shown in red; Map 13). Moderate capacity is found in patches of broadleaved woodland. The rest of the area has no capacity (in dark blue).



Map 13: Timber production capacity for Cambridgeshire

3.13 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 EcoServ R 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 and blue infrastructure marked as accessible, including streams, reservoirs, canals, parks, playgrounds, and other amenity greenspaces.

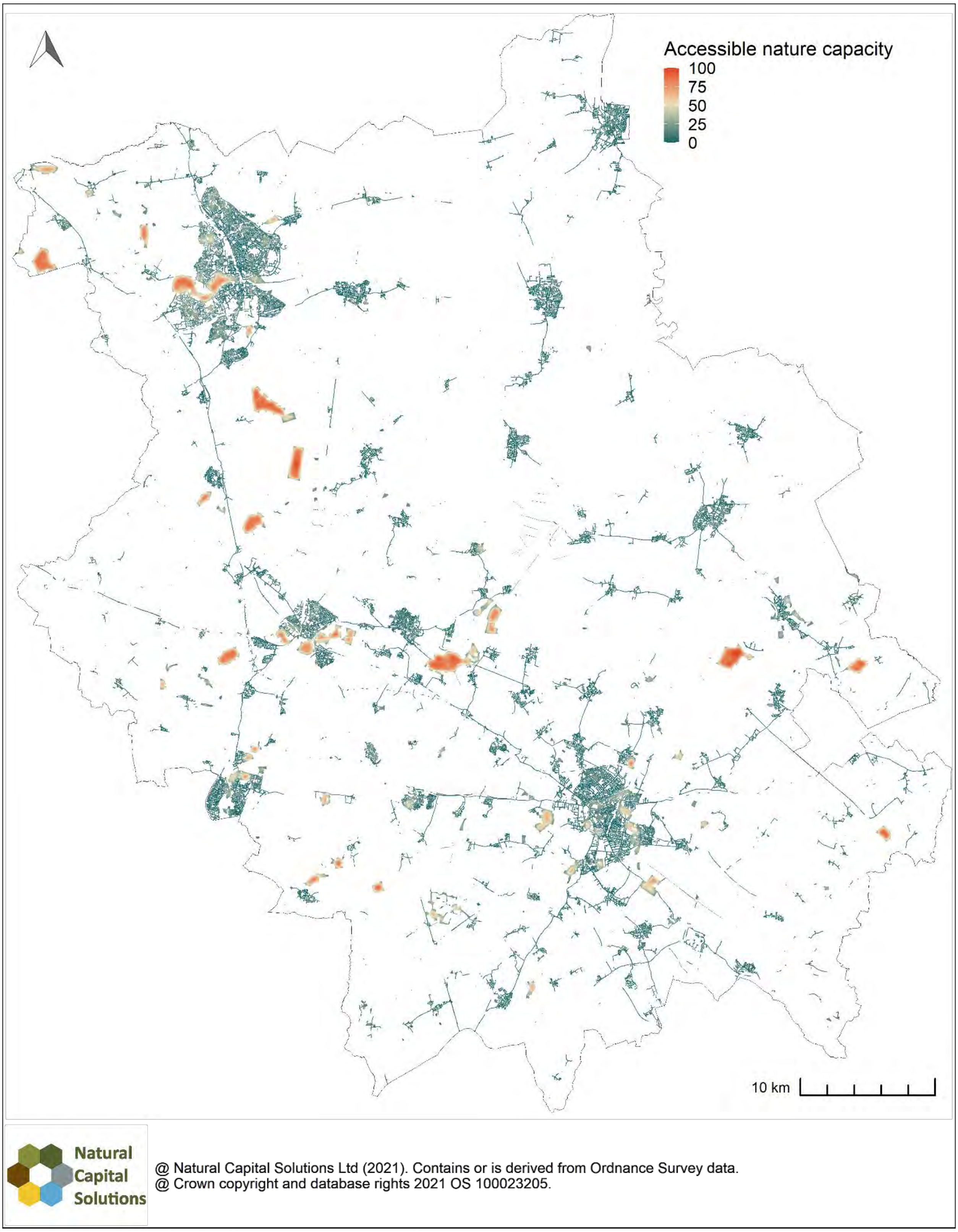
These areas were then scored for their perceived level of naturalness, with scores taken from the scientific literature. Naturalness was scored in a 300m radius around each point, representing the visitors' experience within a short walk of each point.

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 land with no other access will not score highly.

Results for Cambridgeshire and Peterborough

Map 14 shows accessible nature capacity across Cambridgeshire. Red areas indicate highest provision. These are mainly correlated with nature reserves, including Bedford Purlieus National Nature Reserve in the northwest, Woodwalton National Nature Reserve and Holme Fen National Nature Reserve between Peterborough and Huntingdon, and Fen Drayton and Wicken Fen Nature Reserves towards the south of the county. Nene Park and adjacent areas on the edge of Peterborough are also providing good levels of this service and there are numerous sites with lower provision close to other urban centres, particularly around Cambridge, Huntingdon and St Neots.



Map 14: Accessible nature capacity for Cambridgeshire

3.14 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. MENE surveys in Cambridgeshire and Peterborough have also shown that most people engage with nature in parks and greenspaces.

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 Cambridgeshire and Peterborough

Demand for accessible nature (Map 15) is concentrated in the centre of Cambridge and Peterborough (shown in red). There are lower areas of demand in smaller settlements and surrounding villages.

Balancing supply and demand

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.

Map 15: Accessible nature demand for Cambridgeshire

3.15 Combined ecosystem service capacity

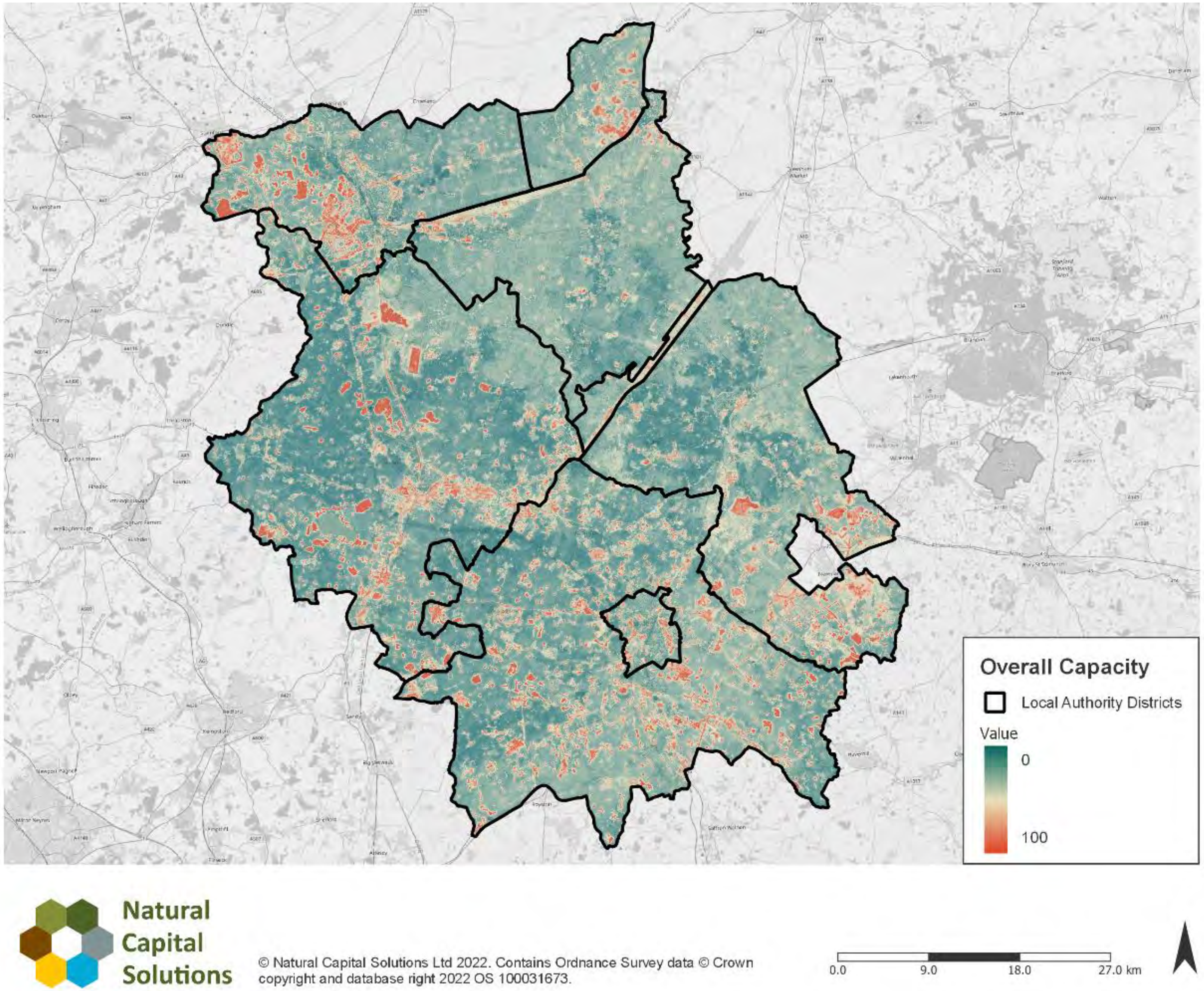
The combined provision across the ten ecosystem services modelled in this project is shown in Map 16. The ecosystem services are the capacity to supply carbon storage, carbon sequestration, air purification, noise regulation, local climate regulation, water flow regulation, water quality regulation, food production, timber production, and accessible nature.

The map highlights the importance of woodlands in delivering multiple ecosystem services, with the woodlands to the west of Peterborough, the west of Huntingdon and scattered in the south of the county delivering the greatest amounts of high-scoring patches. Some of the fenland nature reserves are also high scoring, such as Woodwalton Fen, Wicken Fen and Holme Fen (the latter is predominantly woodland). The River Nene and Ouse corridors are also distinguishable as supplying medium to high levels of ecosystem services throughout their length. The river corridors are also effective at bringing habitats delivering high levels of ecosystem services right into the heart of urban areas, and this is particularly prominent in Peterborough, Huntingdon and St Ives. The river corridor is acting as an effective green (and blue) corridor, providing continuous habitats that deliver moderate to high levels of ecosystem services throughout much of their course. The woodlands and fenland reserves, on the other hand, tend to be more isolated, delivering very high levels of ecosystem services, but surrounded by habitats that are less good at delivering multiple benefits.

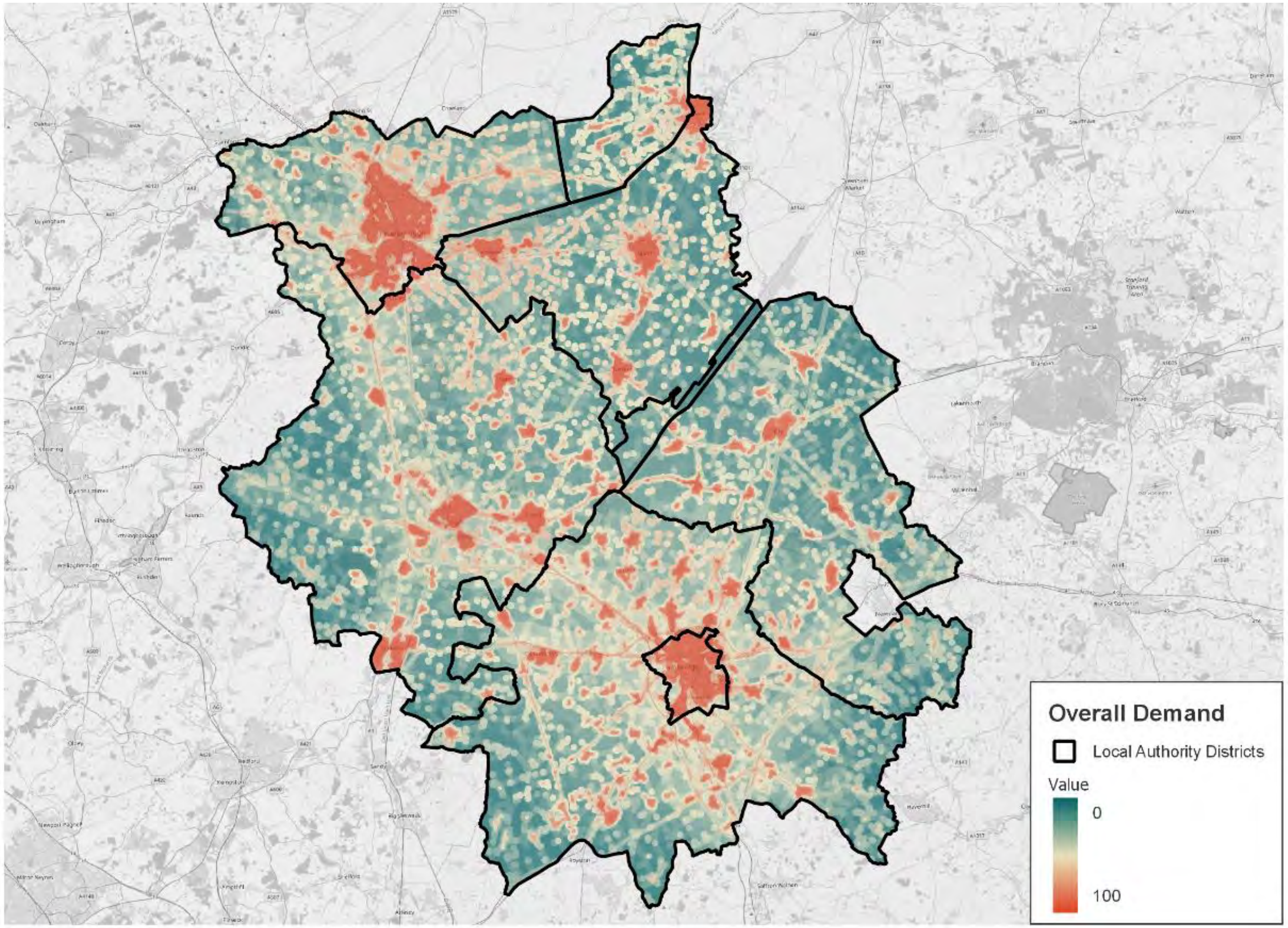
Farmland is less multi-functional, with the dominant service being that of agricultural production, and there is often a trade-off between agricultural production and the other ecosystem services. The areas delivering the lowest levels of ecosystem service provision are, unsurprisingly, the urban areas, but in these areas, parks and greenspaces (especially urban woodlands) can be seen to be really important in delivering multiple benefits.

3.16 Combined ecosystem service demand

The combined demand for four ecosystem services modelled in this project is shown in Map 17. These are demand for air purification, noise regulation, local climate regulation, and accessible nature. The combined map clearly highlights the importance of the urban areas in driving demand, with the very highest demand from parts of Peterborough and Cambridge. Demand is also apparent from the smaller towns and across the road network. The lowest demand areas overall are generally in the middle of the countryside.



Map 16: Combined ecosystem services capacity for Cambridgeshire



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0.0 9.0 18.0 27.0 km

Map 17: Combined ecosystem services demand for Cambridgeshire

4 Assessment of biodiversity value

4.1 Approach

An important aim of this project was to set a biodiversity baseline for Cambridgeshire and Peterborough. The Biodiversity Metric 3.1, a relatively simple metric developed by Natural England (2022)[20], has been used to calculate 'biodiversity units' for each polygon in the Cambridgeshire basemap. The biodiversity unit score is based on the area of the habitat, its distinctiveness, and its 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. Since the Environment Act has been passed, a net gain in biodiversity (BNG) of 10% is compulsory for new developments, and South Cambridgeshire District Council and Cambridge City Council are proposing a 20% target. Using the metric at a landscape scale is useful (i) to predict how changes in habitats or in habitat management within parks and greenspaces, or across the wider area, will impact biodiversity, (ii) to assess progress towards the target of doubling nature, which has been set as a policy objective for Cambridgeshire, (iii) to provide a baseline score from which to work out the BNG of any developments in the region, and (iv) to identify parcels of land to be managed as biodiversity off-sets purchased by a developer so they can achieve BNG on their development.

Note, however, that an accurate assessment of condition (and hence biodiversity units) requires a site visit and a detailed assessment, based on set criteria for each habitat type. This is not practical at a landscape scale, but it is possible to use existing data and inferences to give a good indication of condition for much of the area. A method to do this was developed and agreed in a previous project, with expert consultation[20]. But it is important to bear in mind that the results are indicative of the likely condition and biodiversity units, and would require ground truthing at specific sites of interest, or for use in calculating offsetting for a proposed development.

The first step was to assign the distinctiveness scores to each natural surface polygon in the Cambridgeshire basemap. These are set scores in the Biodiversity Metric 3.1, and range from low (given a score of 2) for improved habitats such as arable and improved grassland, up to very high (scoring 8) for irreplaceable habitats such as ancient woodland and intact fens. Built habitats score 0.

The second step was to assign a habitat condition to each of the habitat polygons. 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 existing data and inferences, we were able to assign condition to 94.9% Cambridgeshire 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 20,395 ha (6.0%) of Cambridgeshire fell into the N/A-other category, and so received a score of 0. The arable land cover, amenity grasslands and gardens scored 1 and covered 277,220 ha (81.5%) of the county.

[20] Stephen Panks, Nick White, Amanda Newsome, Mungo Nash, Jack Potter, Matt Heydon, Edward Mayhew, Maria Alvarez, Trudy Russell, Clare Cashon, Finn Goddard, Sarah J. Scott, Max Heaver, Sarah H. Scott, Jo Treweek, Bill Butcher and Dave Stone (2022). Biodiversity metric 3.1: Auditing and accounting for biodiversity – User Guide. Natural England.

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[21]). County Wildlife Site (CWS) assessments were supplied by Cambridgeshire and Peterborough Environmental Records Centre (CPERC) and were also translated into Biodiversity Metric condition categories. Condition data was not available for all existing CWS. SSSI and CWS data combined gave us condition data for approximately 12,700 ha (3.7%) of Cambridge.

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[22] 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 3.1 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 approximately a further 10,100 ha (3.0%) of the county, although there was some overlap with the category above.

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 6,968 ha (2.0%) of the county using this approach.

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. Also, any habitat that we could not fully classify in the basemapping process was not assigned a score. This left 17,255 ha (5.1%) of Cambridgeshire without a condition score.

Table 2 Biodiversity Metric 3.1 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

[21] Rouquette, J. (2020) Testing approaches to mapping habitat quality and ecosystem condition. Natural Capital Solutions.
[22] Forestry Commission (2020). NFI woodland ecological condition in England. National Forest Inventory.

4.2 Results and discussion

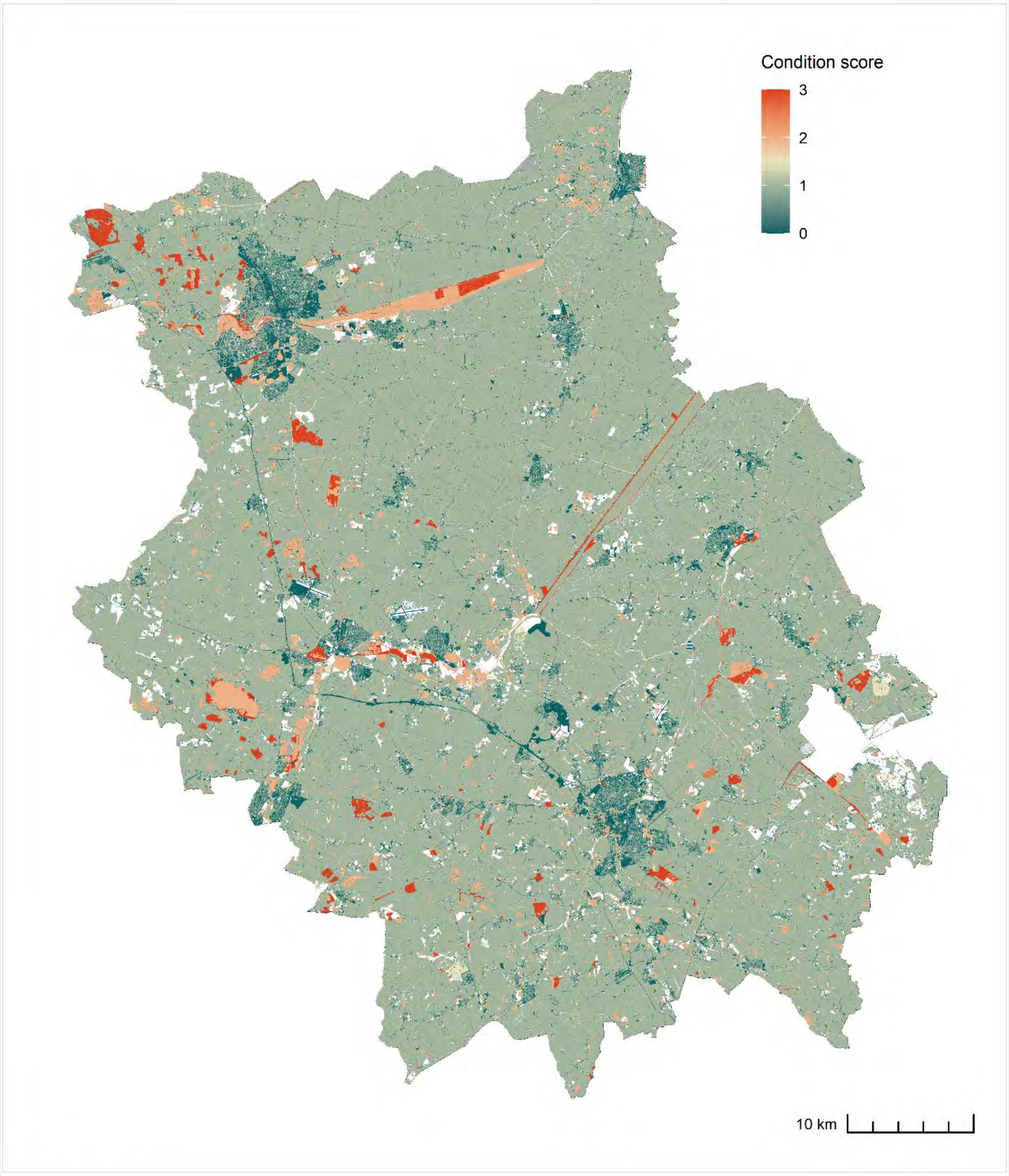
A large proportion (81.7%) of the habitats of Cambridgeshire (Map 18) are in poor condition (a score of 1, blue areas), and a further 6.0% of built and artificial surfaces score 0. In the main this is due to the dominance of agricultural habitats in the region (see Map 1), although most of the Ouse Washes is also considered to be in poor condition. However, there are a number of areas of moderate condition (5.4% of the region) scattered throughout the county (score 2, light brown), for example Grafham Water and surrounding areas, much of the Nene Washes, and Bedford Purlieus National Nature Reserve. Habitat in good condition is relatively rare, taking up 1.4% (score 3, red) and is scattered across the region. These include Holme Fen Nature Reserve and RSPB Fowlmere Nature Reserve, sections of the Nene Washes and small parts of the Ouse Washes, several patches to the west of Cambridge and some surrounding Wicken Fen.

Once condition had been assigned, biodiversity units were calculated based on condition, distinctiveness and area. Most of Cambridgeshire has a low biodiversity unit score (blue areas, Map 19). Habitats with higher scores are scattered across the county, with the exception of the northeast quarter which is almost all agricultural land, away from the Nene Washes. The Nene and Ouse Washes have higher biodiversity unit scores. There are high (red) biodiversity units around Huntingdon, Newmarket and to the west of Peterborough, many of which are areas of ancient woodland. There are also several areas of high biodiversity value around nature reserves such as Wicken Fen, Chippenham Fen and Holme Fen.

It is important, when interpreting the map, to note that the habitat units have been assigned to polygons, rather than sites. If a habitat, or site, consists of numerous polygons in the basemap, they may display multiple different unit scores. To reflect the unit value of a whole site, the units will have to be summed over the polygons that make up the site.

Table 3: Total biodiversity units scored for each broad habitat type.

Habitat Type	Biodiversity units
Cultivated land (arable)	474,268
Uncertain agriculture	13,308
Improved grassland	25,721
Amenity grassland	18,518
Semi-natural grassland	16,914
Marshy grassland	29,389
Fen, marsh and swamp	4,581
Broadleaved woodland	118,367
Coniferous woodland	3,556
Mixed woodland	500
Scrub	877
Trees / Parkland	6,144
Water	53,910
Rock, exposure and waste	0
Built-up areas and infrastructure	0
Garden	23,328
Mixed / other / uncertain	3,214
Unclassified	0
All habitats	**793,518**



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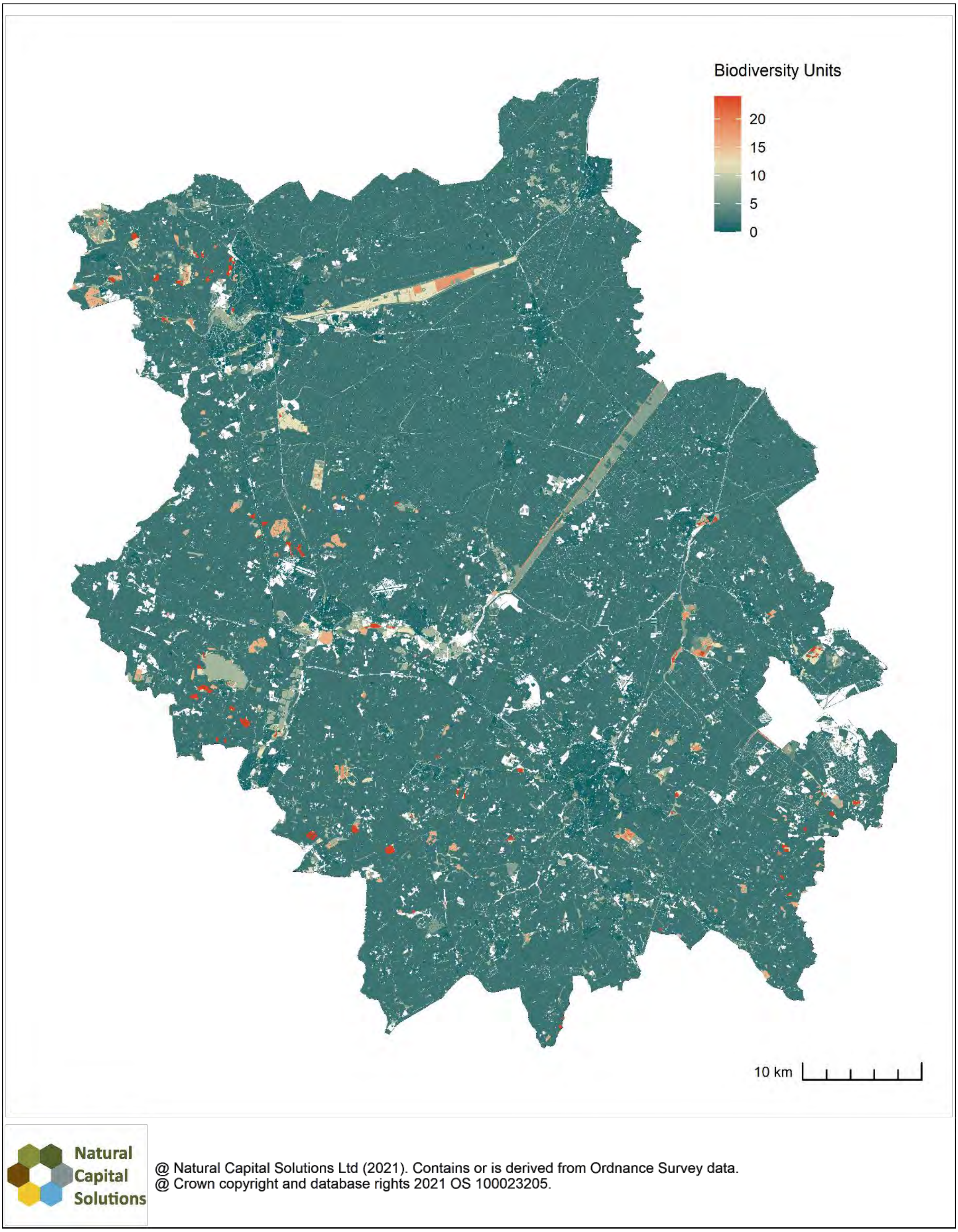
Map 18: Habitat condition across Cambridgeshire. The white areas are habitats where no data existed on which to base a condition estimate.



Map 19: Biodiversity units across Cambridgeshire.

Overall, the habitats of Cambridgeshire provide a total of approximately 794,000 biodiversity units. Note, however, that this is an underestimate, as it does not include the habitats for which we were unable to assign a condition. The total unit value can be recalculated when condition data is available for these areas, or if completeness is important in the meantime, a precautionary "moderate" condition can be assigned to all these unassigned habitats[23]. It is estimated that applying a moderate condition to the remaining habitats would increase the total biodiversity units by about 15%.

The total biodiversity units supplied by each broad habitat type is shown in Table 3 (above) and the average biodiversity units per habitat is shown in Figure 2 (below). Although arable land only scores 2 biodiversity units per hectare, because it is by far the dominant habitat across Cambridgeshire, it delivers 474,000 biodiversity units in total. The habitat providing the second most biodiversity units in total is broadleaved woodland (118,000 units), with an average of 10.2 units per hectare.

Fen, marsh and swamp provides the highest average units per hectare at 18.4, but only contributes 4,600 units across Cambridgeshire, as it is a relatively rare habitat type. Parkland and scattered trees also score a high 16.8 units per ha, but note that we were only able to assign a condition score to 13% of the area of this habitat. The polygons that we did assign tended to be in areas of historic parkland which is considered to be a very high distinctiveness habitat. It is likely that if more area of scattered trees were assessed outside of these historic sites, then the average score would reduce considerably. The most frequent unassigned habitat was semi-natural grassland where 10,100 ha (82%) of this habitat was not assigned a score. If a more complete biodiversity score was required, condition assessment fieldwork should be focussed on areas of this habitat (or a moderate condition applied by default). By contrast, 96% of marshy grassland and 92% of fen, marsh and swamp were assigned a condition and biodiversity unit score.

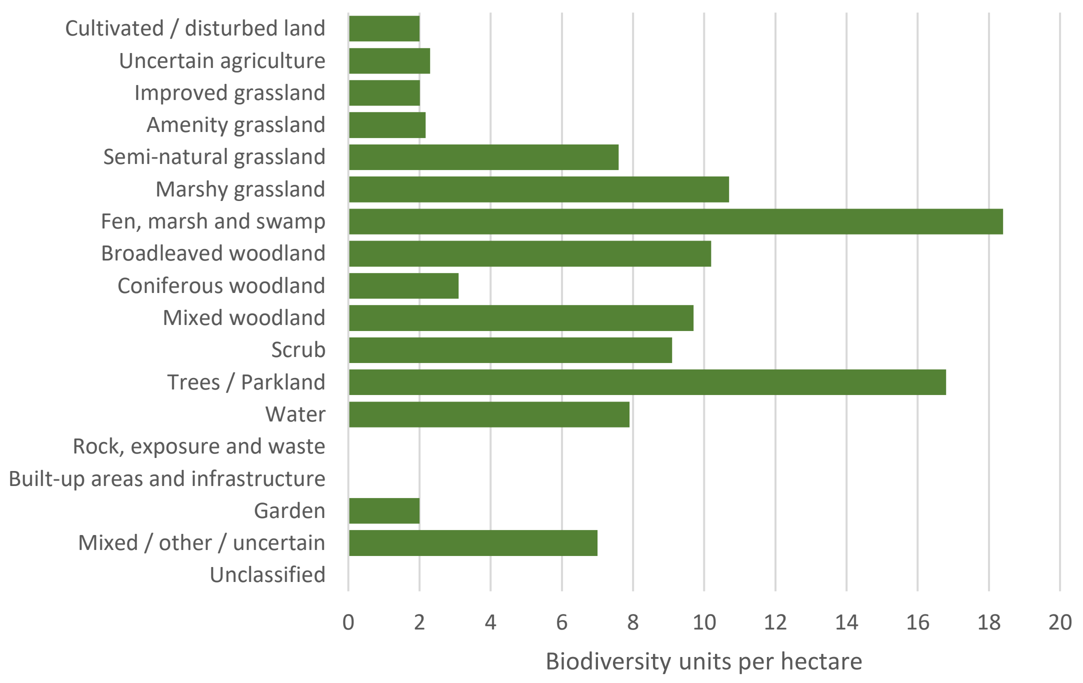


Figure 2: Average biodiversity units per hectare for each broad habitat type.

[23] In a previous study, stakeholders decided that it was better to produce a condition (and biodiversity units) map with gaps, but where there was reasonable confidence in the categories assigned, rather than one that was complete but relied on a significant number of assumptions, that was felt outweighed the usefulness of the product. Hence we have applied that approach here, but this can be changed subject to stakeholder discussion.

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 sites, 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. This is particularly relevant where there are sites of conservation interest that fall below good condition, such as the floodplain grazing marshes in the Ouse Washes and other areas, enhancing management of woodland (see Biodiversity Metric 3.1 guidance[24] for what constitutes a woodland in good condition), creating field margins and riparian buffer strips in agricultural areas, or indeed through creating new habitats of high distinctiveness where the ecological opportunities lie, e.g. within the nature recovery network 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 3.1 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 Cambridgeshire. 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.

[24] Stephen Panks, Nick White, Amanda Newsome, Mungo Nash, Jack Potter, Matt Heydon, Edward Mayhew, Maria Alvarez, Trudy Russell, Clare Cashon, Finn Goddard, Sarah J. Scott, Max Heaver, Sarah H. Scott, Jo Treweek, Bill Butcher and Dave Stone (2022). Biodiversity metric 3.1: Auditing and accounting for biodiversity – technical supplement. Natural England.

5 Benefits and value of parks and greenspaces in Cambridgeshire and Peterborough

The analyses in Sections 2-4 have been conducted across Cambridgeshire as a whole. Here we extract data, scores and values from the results presented in the previous sections for each park and greenspace across the area. Results for each individual site are available on the mapping portal that accompanies this report. Here we outline the information available and summarise the results for each Local Authority area.

5.1 Approach

Biodiversity
Biodiversity units for the greenspaces in Cambridgeshire were extracted from the figures outlined in Section 4. The mean values per ha and total biodiversity units were calculated for each Local Authority and are presented in Table 4.

Ecosystem services
Ecosystem services scores for all greenspaces in Cambridgeshire were extracted from the models outlined in Section 3. The mean scores for greenspaces in each Local Authority were calculated and are presented in Table 5, alongside a mean score for each service for the whole county.

Valuation
Values for mental wellbeing, physical health, amenity value and carbon sequestration were produced for each greenspace in Cambridgeshire by Vivid Economics, as part of an earlier Future Parks project[25]. We added to this by calculating the annual monetary value of air quality regulation at each site. The methods used are described in more detail at the end of the report (Annex C). The total value of each greenspace (including the four benefits calculated by Vivid economics) are presented in Map 20 and are broken down by Local Authority in Table 6. All five individual values, along with total value, are available for each park and greenspace on the accompanying portal.

5.2 Biodiversity

Table 4 presents the biodiversity units estimated across greenspaces in Cambridgeshire, as described in the previous section. The total biodiversity units vary significantly. These can be influenced by large, high-quality greenspaces; for example, 13,678 of Fenland's 14,418 biodiversity units come from the Nene Washes. Similarly, the vast majority of East Cambridgeshire's score comes from the Ouse Washes. While the Ouse Washes also have a moderate mean biodiversity unit per ha (5.8), the district as a whole has the lowest mean of 1.1 units/ha. This implies that the other greenspaces present have a very low biodiversity value. Cambridge City has a far lower total than the other districts due to its far smaller overall area, but its average score is very close to the county average. South Cambridgeshire has the second-highest mean score but the second-lowest total units, suggesting it has fewer greenspaces, but the existing ones are higher quality. Peterborough and Huntingdonshire both have relatively high total biodiversity units, which is due in part to the high number of green spaces in both of these districts. Fenland has the highest mean biodiversity score of 1.89 units per ha, indicating the relatively high biodiversity value of the Nene Washes, whereas East Cambridgeshire has the lowest mean score of 1.1 units per ha.

[25] Vivid Economics (2020). Natural Capital Account – Cambridgeshire. Prepared for Cambridgeshire County District Authorities.

Table 4: Biodiversity units across greenspaces in Cambridgeshire, grouped by Local Authority.

	Mean Biodiversity Units / ha	Total Biodiversity Units
Cambridge City	1.47	1,770
South Cambridgeshire	1.82	6,753
East Cambridgeshire	1.10	9,948
Fenland	1.89	14,418
Peterborough	1.44	9,592
Huntingdonshire	1.17	9,065
All	**1.48**	**51,541**

5.3 Ecosystem services

Ecosystem service scores across the greenspaces in Cambridgeshire are detailed in Table 5.

Carbon storage is highest in Fenland District, as peat soils are predominant across the area, providing very high carbon storage capacity. On mineral soils, sites containing woodland have the highest carbon storage values. East Cambridgeshire is the local authority area with the lowest average carbon storage capacity in its greenspaces as it contains few woodlands and predominantly mineral soils.

Carbon sequestration in greenspaces varies between districts but is generally low. The highest score is South Cambridgeshire (1.0 tCO2e/ha/year) and the lowest is Fenland, which is a net emitter (-0.3 tCO2e/ha/year). This is predominantly due to soil types – South Cambridgeshire is mostly mineral soil whereas Fenland is mostly peat soil, so any planting on greenspaces in South Cambridgeshire will act as a carbon sink whereas planting in greenspaces in Fenland may act as a carbon source. Note therefore, that Fenland sites generally have high carbon storage capacity, but this is gradually being lost (emitted) each year. Over Cambridgeshire as a whole, the relative amount of woodland also causes significant differences, with sites with considerable woodland achieving higher carbon sequestration.

Air purification capacity is generally high in greenspaces in Peterborough and Cambridge City and lowest in South and East Cambridgeshire. **Noise regulation capacity** has broadly similar scores across the districts, although again with slightly higher scores for greenspaces in Peterborough and slightly lower for greenspaces in East Cambridgeshire. High scores in both services are related to higher woodland cover.

Local climate regulation capacity also varies considerably between districts. It is highest in the greenspaces of Cambridge City and Peterborough because these greenspaces contain more woodland on average than most other districts, and they also contain water bodies, such as the River Nene in Nene Park in Peterborough. Local climate regulation capacity is lowest in South and East Cambridgeshire, which scored 1 and 0 respectively, due to having fewer wooded areas and bodies of water.

The lowest scores for **water flow regulation** are in East Cambridgeshire and Huntingdonshire. These districts have more slopes compared to the flatter areas to the north-east, and also do not have much tree planting within their greenspaces. Fenland has the lowest **water quality regulation** score, which is at least partially due to the fact that it contains a lot of watercourses which are at greater risk. Planting woodland or wetland habitats, especially as riparian buffer strips, would enhance these scores.

Food production capacity is generally low as most of the greenspaces are not farmed, but varies considerably between the greenspaces in different districts. It is lowest in Cambridge City as many of these greenspaces are predominantly amenity grassland. The highest score is for South Cambridgeshire, because a lot of the greenspaces are based partially on arable or improved grassland. The other districts have broadly similar scores.

Timber production is low across all of the districts, and is particularly low in Huntingdonshire. This may be because there are not many trees in the greenspaces in the county, and in particular coniferous trees which score highest.

Accessible nature capacity varies between districts. It is broadly similar across South Cambridgeshire, East Cambridgeshire, Fenland and Huntingdonshire, and higher in Cambridge City and Peterborough. These higher values are because these more urban districts have a higher density of greenspace.

Table 5: Ecosystem service capacity scores for greenspaces across Cambridgeshire, grouped by Local Authority.

	Cambridge City	South Cambridgeshire	East Cambridgeshire	Fenland	Peterborough	Huntingdon shire	All
Carbon storage (tC/ha)	18.0	19.1	15.4	21.0	18.8	16.3	**17.5**
Carbon sequestration (tCO2e/ha /yr)	0.7	1.0	0.4	-0.3	0.5	0.4	**0.5**
Air purification	39.3	22.8	29.0	36.5	41.8	33.7	**34.0**
Noise regulation	10.4	14.0	9.2	10.1	13.0	9.9	**11.0**
Local climate	34.2	1.0	0	15.1	27.6	11.1	**13.6**
Water flow	71.3	71.7	63.7	69.1	69.4	64.3	**66.9**
Water quality	51.0	45.2	46.0	43.2	48.0	51.6	**48.8**
Food production	0.9	15.9	6.1	5.22	3.0	3.8	**5.3**
Timber production	3.5	5.4	1.2	1.2	3.0	0.8	**2.0**
Accessible nature	64.4	33.6	29.2	28.0	49.6	37.3	**39.1**

* Scores are scaled from 0-100 with the exception of carbon storage and carbon sequestration.

5.4 Valuation

Map 20 shows the value of greenspaces across Cambridgeshire. Greenspaces tend to be clustered around urban centres, in particular Peterborough and Cambridge, as well as Huntingdon, St Neots, Ely, Wisbech and March to a lesser extent. There are three greenspaces in the highest category: Milton Country Park, providing benefits valued at £12.3 million/year; Fen Drayton Nature Reserve, valued at £18.7 million/year; and Nene Park, valued at £22.7 million/year. The first two of these are in South Cambridgeshire, and the final one is in Peterborough. There are several in the next bracket, including in Peterborough, Cambridge City, the centre of Huntingdon and the Ouse Washes. Fenland is the only district without a greenspace valued in the top two brackets. This is reflected in the total greenspace values for each district in Table 6, where Fenland has the lowest value of £18.5 million. Fenland also has the lowest annual visit rate. The highest value is in Peterborough and the second highest is South Cambridgeshire. This matches with the placement of the highest valued individual greenspaces. However, Peterborough has far more small greenspaces, most of which are centred around the city. Cambridge City has the next highest value.

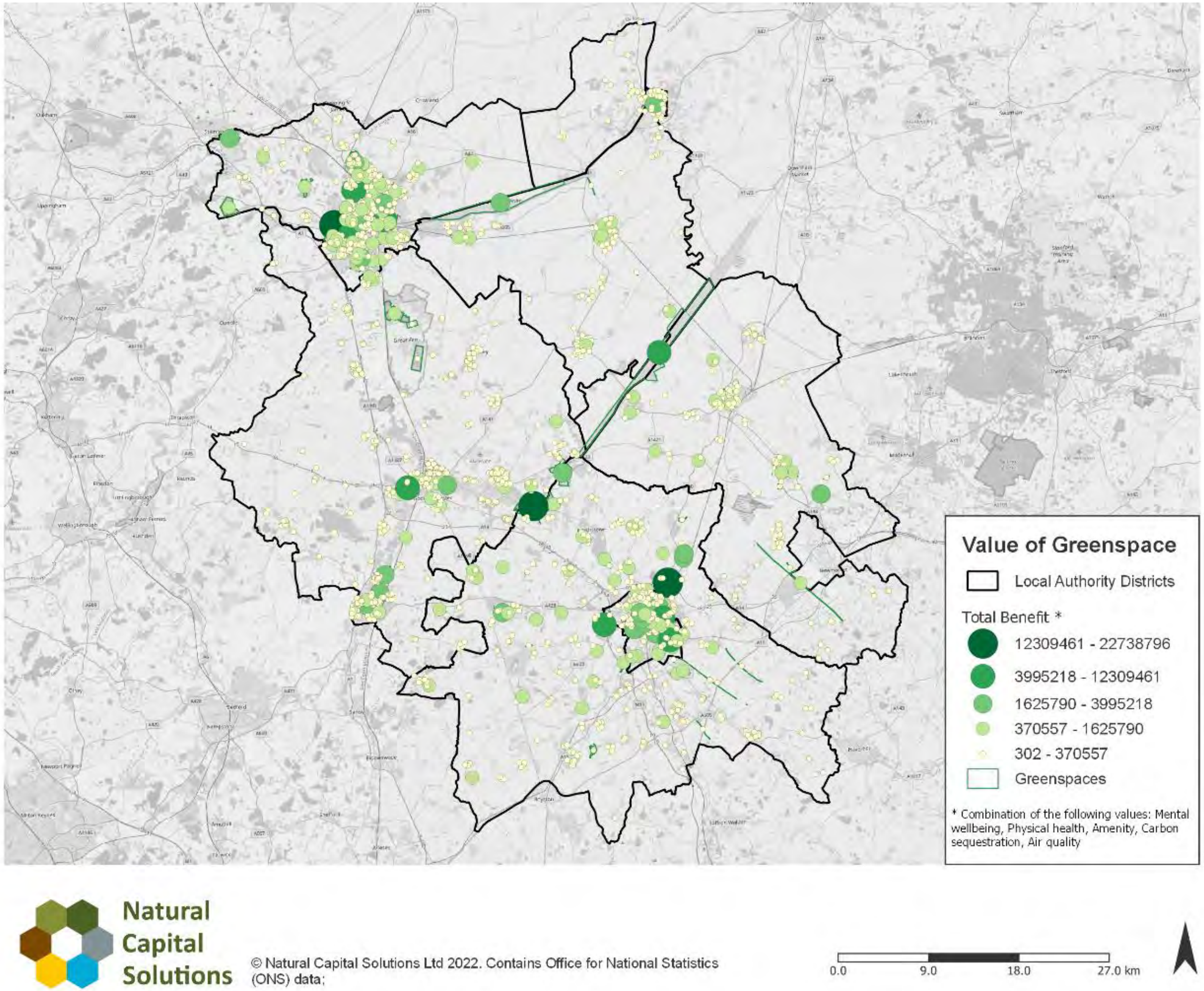
Table 6: Valuation of greenspaces in Cambridgeshire, grouped by Local Authority.

	Cambridge City	South Cambs	East Cambs	Fenland	Peterborough	Huntingdonshire	All
Annual visits (M)	2.44	3.93	1.16	0.78	4.76	2.10	**15.2**
Annual value (£M pa)							
Mental wellbeing	32.03	54.34	15.72	10.18	65.15	28.01	**205.4**
Physical health	17.60	29.33	8.50	5.51	35.22	15.04	**111.2**
Amenity value	12.77	9.13	4.79	2.75	13.37	14.44	**57.3**
Carbon sequestration	0.02	0.08	0.05	0.03	0.27	0.21	**0.66**
Air quality	0.23	0.54	0.16	0.12	1.18	0.61	**2.84**
Total	**62.65**	**99.42**	**29.22**	**18.59**	**115.19**	**58.31**	**377.4**

NB. Annual visit numbers and all valuations apart from air quality are from Vivid Economics.

Across all the districts, the total value is driven by the values for mental wellbeing and physical health. Cambridge City has the lowest carbon sequestration value of all the districts. This is likely because the greenspaces will be mostly urban parks and amenity space, so may not have as much vegetation as more rural greenspaces in other areas. Huntingdonshire has a middling total value, although it has the highest amenity value. For further information on the methods and results of the valuation (excluding air quality regulation), please refer to the Vivid Economics report.

In total, Cambridgeshire's greenspaces provide public benefits with an annual value of **£377.4 million**. The majority of this comes from mental and physical health value estimates. As such, the value of individual parks and greenspaces is driven more by the number of visitors, than the types of habitats present (although the latter may influence the former). Studies elsewhere have shown that facilities, such as toilets and car parking, are strongly linked to increased visitor numbers, which in turn means that these sites provide greater public benefits. Although enhancing habitats at sites can increase the range of benefits provided and its biodiversity value. The value of individual greenspaces can vary by several orders of magnitude, as can be seen on Map 20 and explored in more detail in the mapping portal.



Map 20: Value of greenspaces across Cambridgeshire.

6 Habitat opportunity mapping

6.1 Introduction

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 identify 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. In this project, opportunities for new habitats across a range of different benefits have been mapped. This has included mapping opportunities for the following:

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

The approach taken and results obtained for each of these potential services are described in turn below. Maps have also been combined to show areas that could deliver multiple benefits, and this is described in Section 7.

Please note that the mapping identifies areas based on landscape-scale ecological principles or indicative ecosystem services models 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.

6.2 Opportunity mapping for biodiversity enhancement

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 three key habitat groupings, incorporating the main semi-natural habitats across Cambridgeshire. The broad habitats and their constituent types are shown in the table overleaf.

Broad habitats	Specific habitats included
Semi-natural grassland	Acid, neutral, calcareous, rough and semi-improved grasslands.
Woodland	Broadleaved and mixed woodland types (excludes coniferous woodland, parkland or individual trees).
Wet grasslands and wetlands	Marshy grassland, floodplain grazing marsh, lowland fen and swamp (reedbed)

Biodiversity opportunity mapping followed a four-step process, as explained below, and was based on the approach developed by Catchpole (2006) [26] and Watts et al. (2010) [27]. Note that opportunity areas for the three broad habitats may overlap, and no attempt has been made to ascertain the most suitable habitat at a particular location.

Method

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, with adjustments made by Natural Capital Solutions to make them locally relevant and to cover all habitat types. 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:

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

[27] 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.

Dispersal distance in optimal habitat	
Semi-natural grassland	2.0 km
Woodland	3.0 km
Wet grassland and 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 mapped and are shown in Annex A:

- 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.
- High quality habitats – all 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.
- Historic sites – data were obtained from Historic England on the location of Scheduled Monuments and Registered Parks and Gardens, and Registered Battlefields across the study area and a 30m buffer was applied around each individual site, as recommended by Historic England. This constraint was not applied for semi-natural grassland opportunity areas, which should be feasible at historic sites.
- 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.
- For wet grassland and wetland habitats it was assumed that hydrology (wetness) would be a limiting factor. Therefore, habitat opportunity areas were restricted to areas within the indicative floodplain, as indicated by the Environment Agency's Flood Zone 2 map.

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.
- **Steppingstone 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.

As the above process identifies portions of land in relation to the ecological network for each habitat, it often results in thin slivers of land being identified adjacent to existing habitats, which bear no relationship to existing fields and boundaries. As habitat creation or restoration projects usually operate on whole fields, an additional step was taken to identify those fields that present buffer opportunities. To do this, the layer was overlaid on to the basemap to identify whole fields that are immediately adjacent to existing habitat patches and are not constrained by the factors described in Step 3. Parts of these fields fall within the previously identified ecological network and creating new habitat will extend the network.

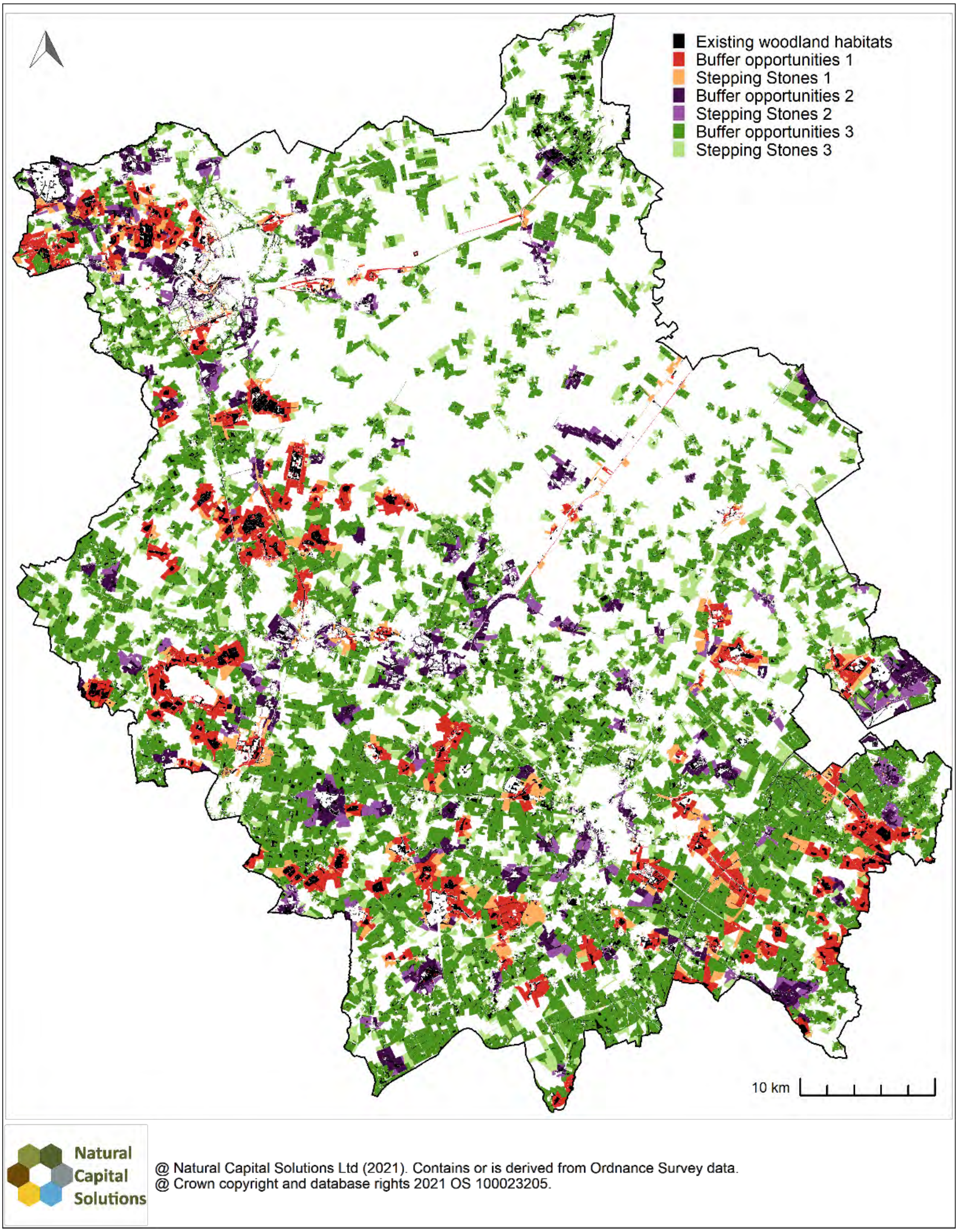
To remove spurious results where only a tiny fraction of a field fell within a buffer zone, fields where less than 10% of the whole field overlapped with the buffer zone were removed. In the same way, the steppingstone layer was also overlain to identify whole fields that fall outside of the ecological network but are immediately adjacent to it.

The maps presented below combine the buffer and stepping-stone opportunities and prioritise them into three groups: (1 – high priority) opportunities to buffer and connect up areas of habitat with national designations (e.g. SSSI) and ancient woodland, (2 – medium priority) opportunities to buffer and connect up areas of habitat of local importance (e.g. local nature reserves and wildlife sites), and (3- low priority) all other opportunities. The opportunities are presented at the field scale in the sections below, with the non-field maps presented in Annex A.

The permeability of the landscape for typical species of each main habitat type are shown in Annex A. For semi-natural grassland, woodland and wetland species, arable fields and urban centres are the most significant barrier to movement.

Broadleaved and semi-natural woodland

The habitat network map of the buffer and stepping-stone opportunities for woodland is shown below (Map 21), with the existing woodlands shown in black. Opportunities are numerous across the county, but are less prevalent in the northeast quarter (especially Fenland District) where there is less existing woodland. There is a high density of high priority opportunities to the west of Peterborough, particularly around National Nature Reserves including Castor Hanglands, Bedford Purlieus, Hills and Holes, and Easton Hornstocks which lies just outside the county border. Opportunities are densest in the south of the county and could considerably enlarge and connect woodland networks, which are currently small and fragmented.



Map 21: Woodland buffer and stepping-stone field opportunities across Cambridgeshire.

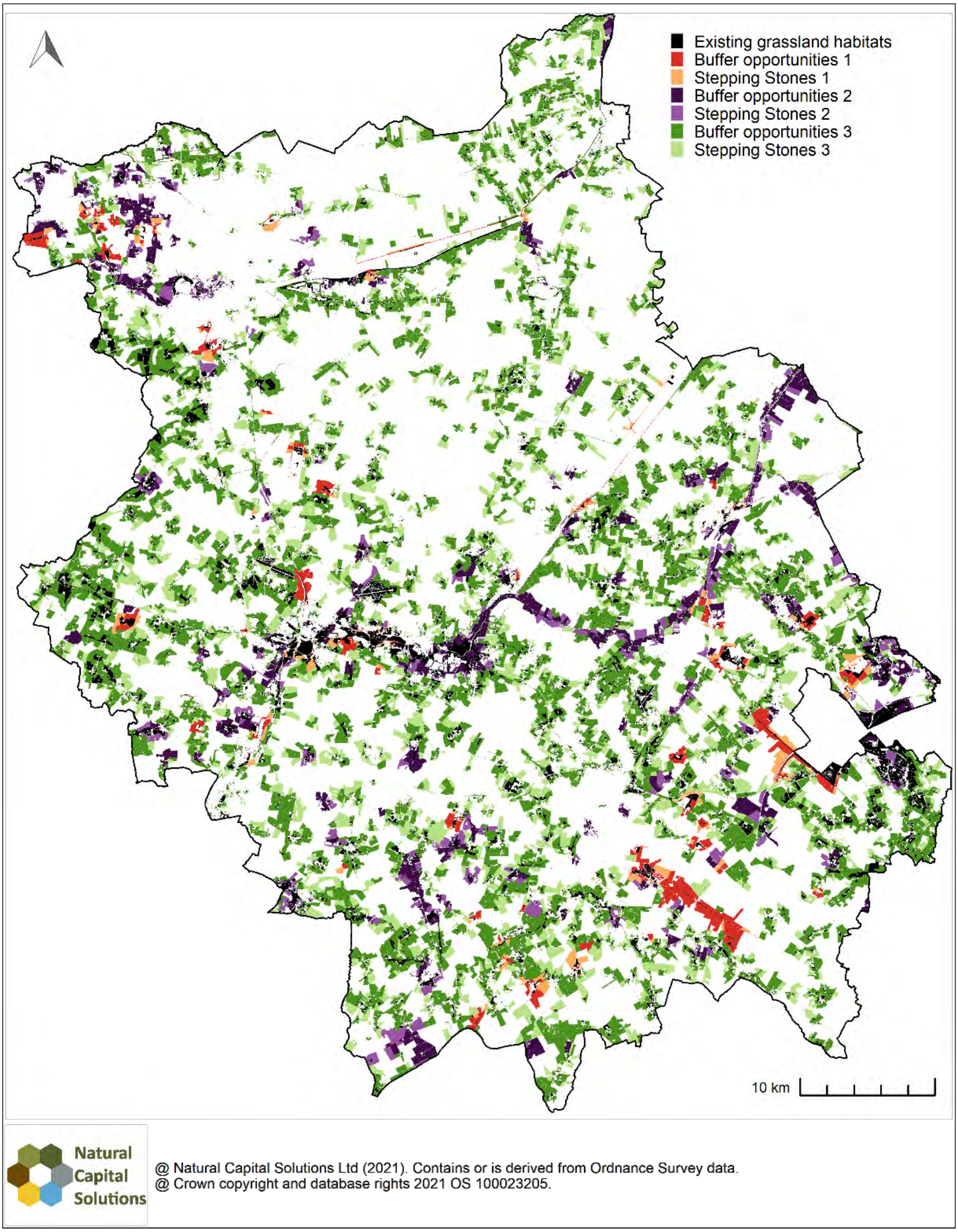
1 = highest priority opportunities – around nationally important sites (SSSIs) and ancient woodlands
2 = medium priority opportunities – around locally important sites (County Wildlife Sites and Local Nature Reserves)
3 = lower priority opportunities – all other opportunities

Semi-natural grassland

The habitat network map of the buffer and stepping-stone opportunities for grassland is shown in Map 22, with the existing grassland shown in black. High priority areas are scattered across the county, with the exception of the northeast quarter as this has little existing semi-natural grassland. There is a corridor of high priority opportunities to the south bordering on Wandlebury Country Park and Gog Magog Golf Course, which is a SSSI. There are also high priority opportunities around National Nature Reserves, including Bedford Purlieus, Castor Hanglands, Woodwalton and Upwood Meadows. There is a corridor of high, medium and low priority opportunities along the entirety of the Great Ouse which runs across the middle of the county. While most of the opportunities are in rural areas, there are a few within urban areas, such as Sheep's Green and Midsummer Common in Cambridge, Portholme Meadow in Huntingdon and Thorpe Park in Peterborough.

Wet grassland and wetlands

The habitat network map of the buffer and stepping-stone opportunities for wet grassland and wetlands is also shown below (Map 23). The existing wet grassland and wetlands are shown in black. The high priority opportunities mostly are focused around the Nene Washes and Ouse Washes SSSIs. There are also smaller patches of high priority opportunity around National Nature Reserves like Woodwalton, Holme Fen and Wicken Fen. These also have some lower priority opportunities surrounding them, helping to create a network. There are fewer opportunities to the west of the county where wetland is less currently prevalent, though there are some around Grafham Water such as a buffer opportunity around Grafham Lagoon, which is an SSSI. There are also some in St Neots and Huntingdon, centred around the Great Ouse.

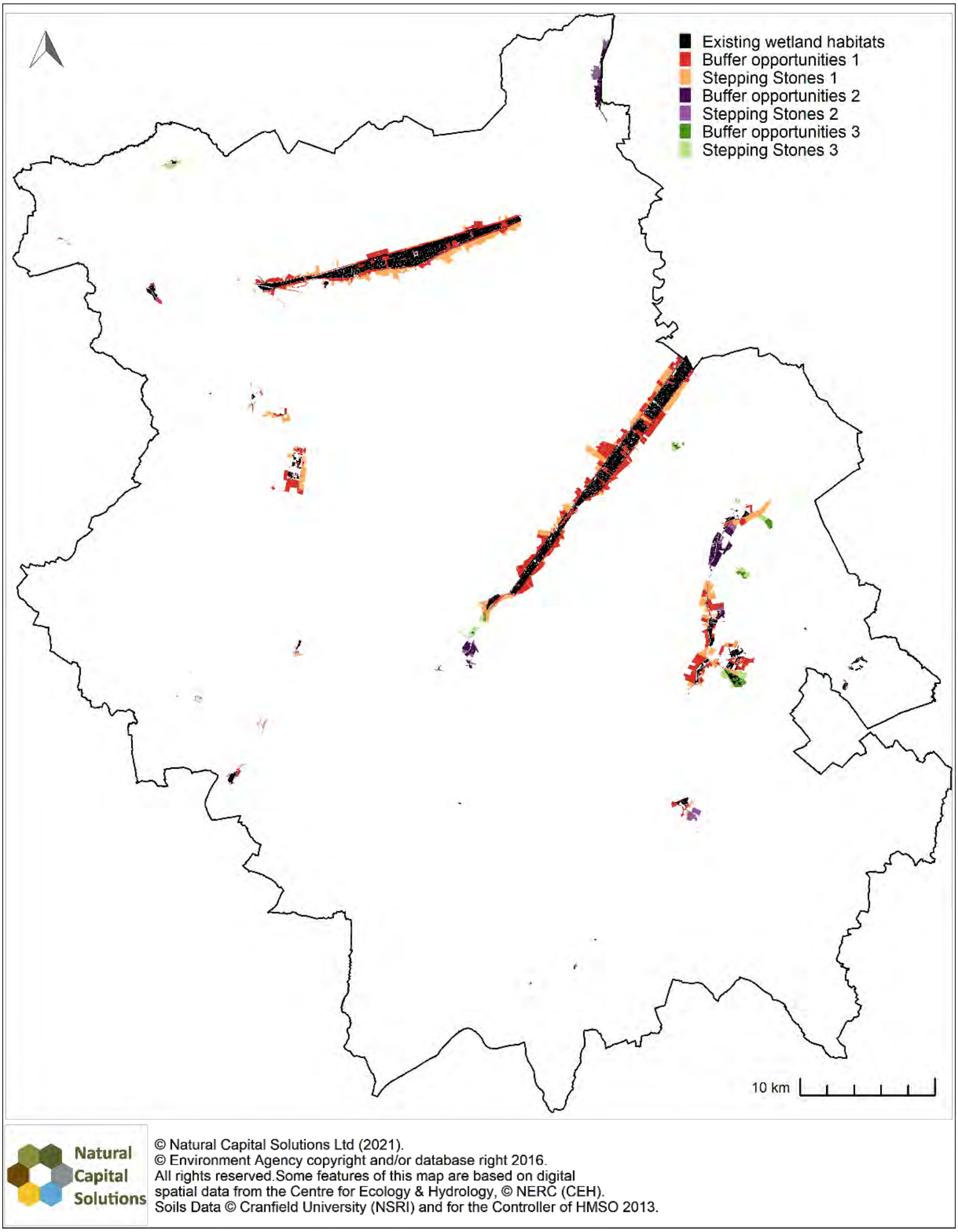


Map 22: Semi-natural grassland buffer and stepping-stone field opportunities across Cambridgeshire.

1 = highest priority opportunities – around nationally important sites (SSSIs) and ancient woodlands

2 = medium priority opportunities – around locally important sites (County Wildlife Sites and Local Nature Reserves)

3 = lower priority opportunities – all other opportunities



Map 23: Wet grassland and wetland buffer and stepping-stone field opportunities across Cambridgeshire.

1 = highest priority opportunities – around nationally important sites (SSSIs) and ancient woodlands

2 = medium priority opportunities – around locally important sites (County Wildlife Sites and Local Nature Reserves)

3 = lower priority opportunities – all other opportunities

6.3 Opportunity mapping to reduce surface runoff

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. Planting woodland is an effective way to achieve this aim, 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 capacity model described in Section 3.9 and highlights areas across the whole catchment where changing land-use would have the greatest impact on reducing runoff.

Method

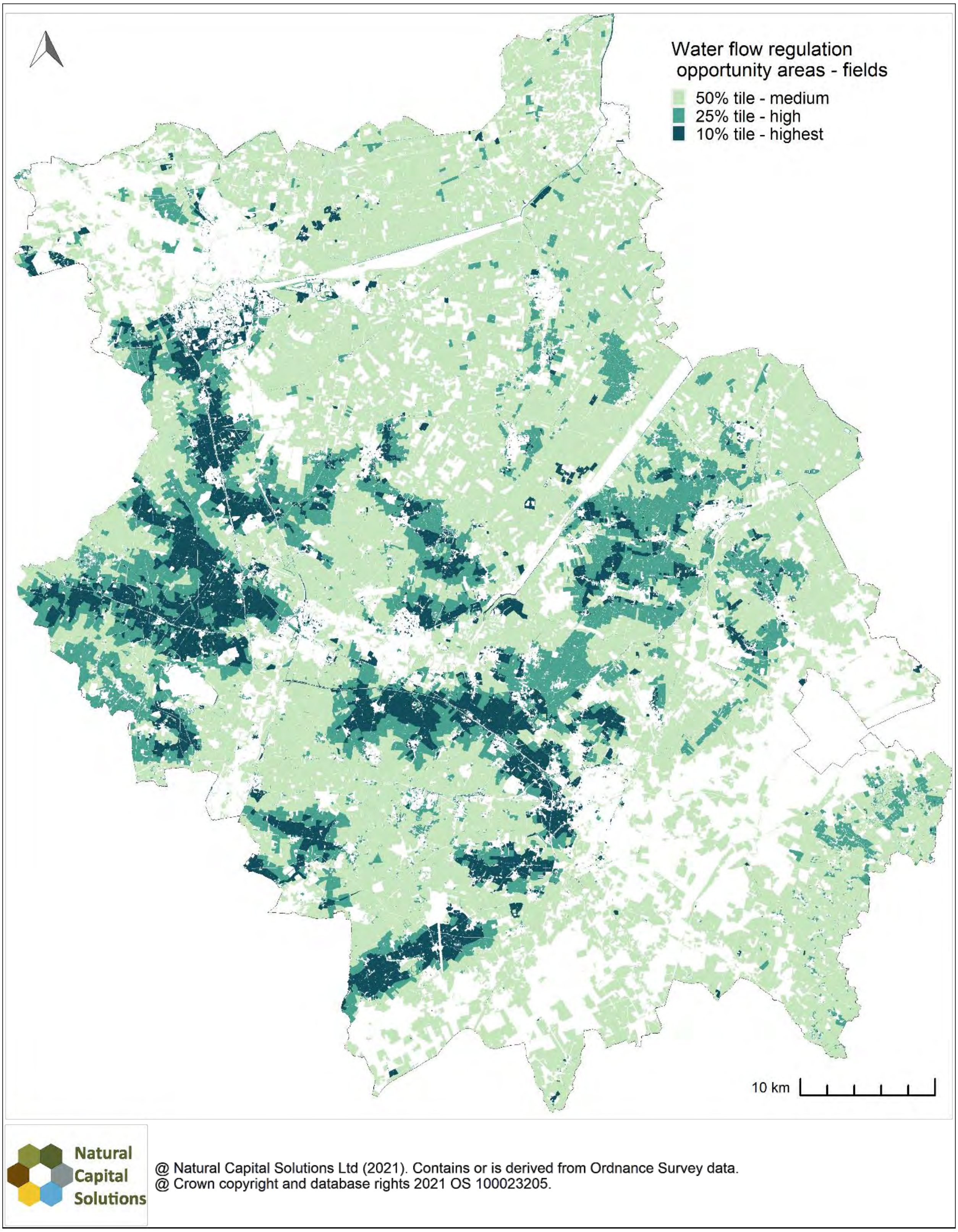
Constraints were identified and mapped in the same way as described for biodiversity opportunities. These locations were then erased from the water flow regulation map developed in Section 3.9 to leave a map showing water flow regulation in all unconstrained locations. This was then classified into percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance. These show areas of land across the study area where surface water runoff is currently high and where there are no constraints on potentially altering land use.

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. Note that the final field-based maps are presented here, and for the other ecosystem services, with the non-field versions of the maps in Annex A.

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 24. Opportunities are present throughout much of Cambridgeshire, but the top two categories (more important opportunity areas) tend to occur on arable fields on slopes in the west and south. There are also some spots with high opportunity within urban areas, such as in the centre of Cambridge.

Note that some of the worst areas for water flow regulation highlighted in Map 10 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 24: Water flow regulation opportunity fields across Cambridgeshire.

10% tile = highest priority opportunities (top 10%)

25% tile = high priority opportunities (10-25% best opportunities)

50% tile = medium priority opportunities (25-50% best opportunities)

6.4 Opportunity mapping to reduce soil erosion and improve water quality

Soil erosion from agricultural areas has a major impact on water quality in the UK and there is growing interest in working with natural processes to tackle this issue. Woodland planting, especially in floodplains and riparian buffer strips, can be particularly beneficial in this regard. Opportunity mapping focussed on identifying areas at highest risk of sedimentation and soil erosion, highlighting areas where planting woodland would have the greatest impact on reducing soil erosion and hence improving water quality. To further prioritise the best locations, we also took into account the overall water quality of each waterbody (sub-catchment) across the study area. Note that the focus is on sedimentation risk from agricultural diffuse pollution, rather than urban diffuse pollution.

Method

Constraints were identified and mapped in the same way as described earlier. These locations were then erased from the soil erosion regulation map, to leave a map showing water quality regulation in all unconstrained locations. This was then classified into percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance, and were given a score of 3, 2 and 1 respectively. As for water flow, 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.

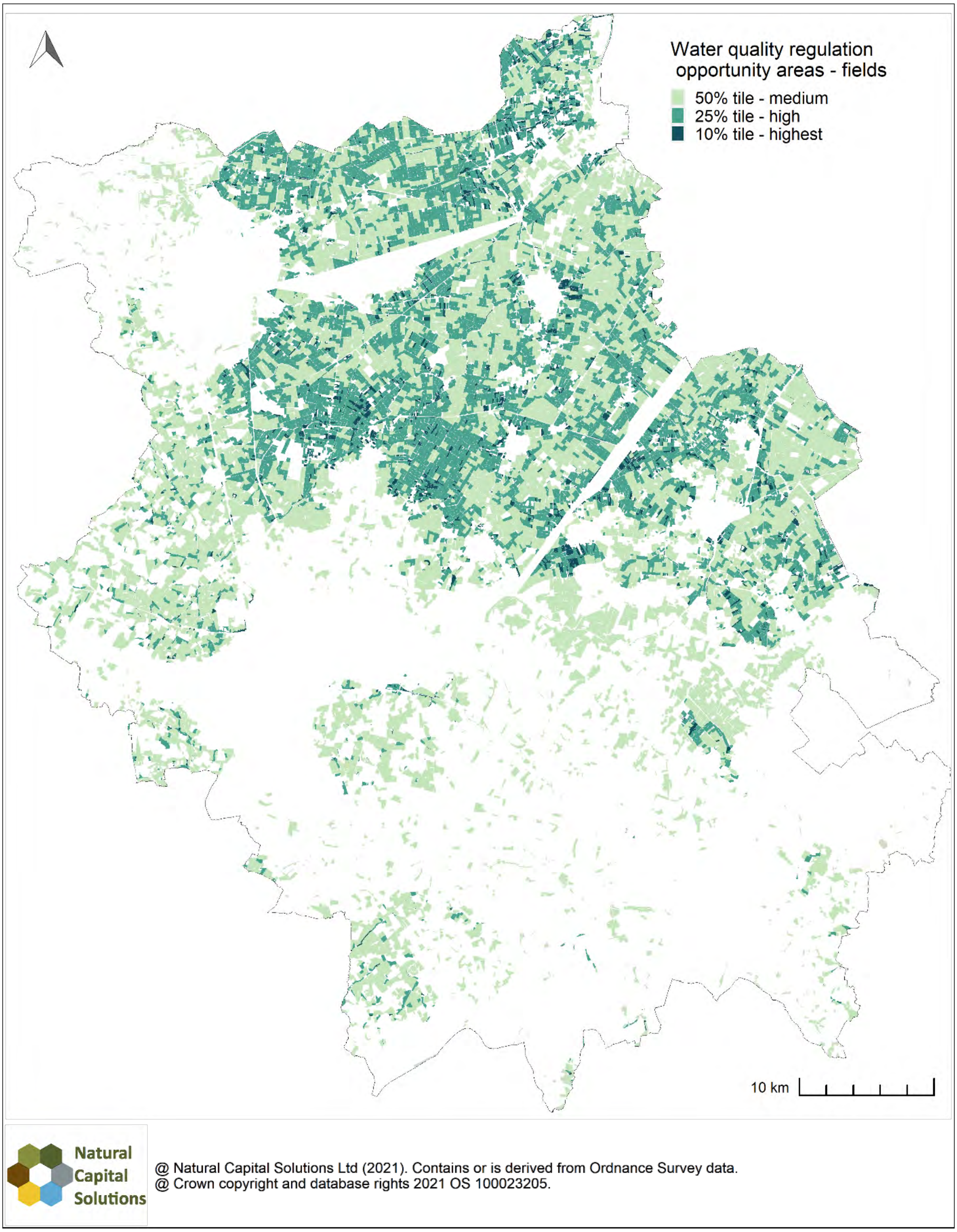
To further prioritise the opportunity areas identified, we gathered information on the overall waterbody status from the Water Framework Directive, for each river waterbody catchment[28]. This water quality data was used to weight the opportunity map. Fields in moderate condition catchments were given a weighting of 1, those in poor condition catchments were given a weighting of 2, those in bad condition given a weighting of 3. These weightings were multiplied by the opportunity scores and the weighted opportunity scores were then rescaled back to a 1-3 scale to match the other opportunity maps.

Results

Once land use constraints were removed, many areas that are currently poor for reducing soil erosion and improving water quality remained and these were identified as opportunity areas (Map 25). Note that 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. Opportunities are focussed in the north-east of Cambridgeshire, particularly in Fenland, an area dominated by arable fields adjacent to numerous watercourses.

Overall waterbody status is shown in Map 26 and shows that the majority of water bodies across the study area are in moderate condition, but the Cam (Audley End to Stapleford), Swavesey Drain, Mill River, Brook Drain, and Folly River waterbodies are in poor condition, and Billing Brook in the north-west, near Peterborough, is in bad condition. The final weighted water quality regulation opportunity map is shown in Map 27. Fields in the Billing Brook waterbody now contain the highest scoring opportunities, with some moderate scoring opportunities now identified in some of the poor quality catchments.

[28] This combines ecological status with chemical status to form an overall assessment of the quality of the waterbody. There are five classes (high, good, moderate, poor, or bad).

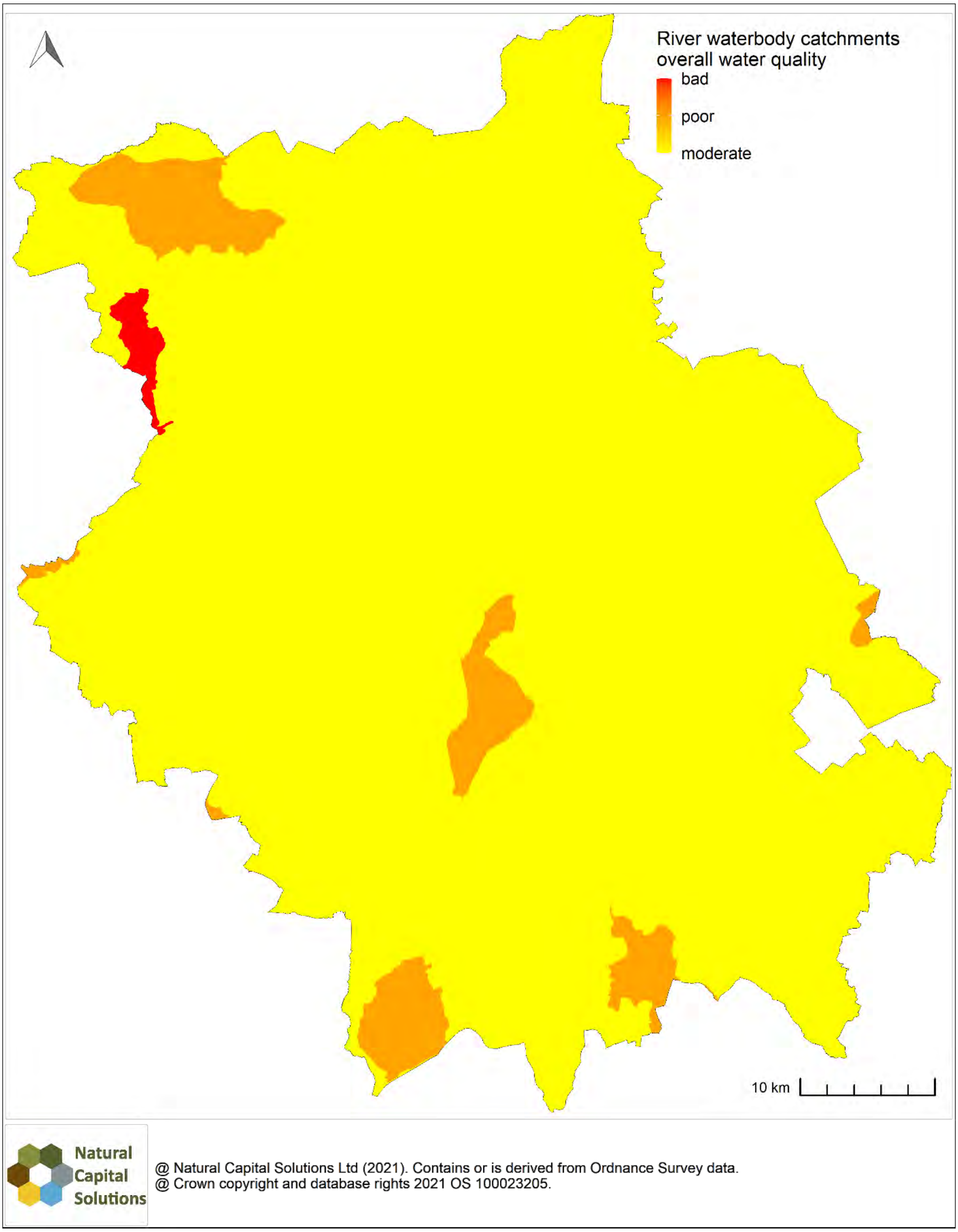


Map 25: Water quality regulation opportunity fields across Cambridgeshire.

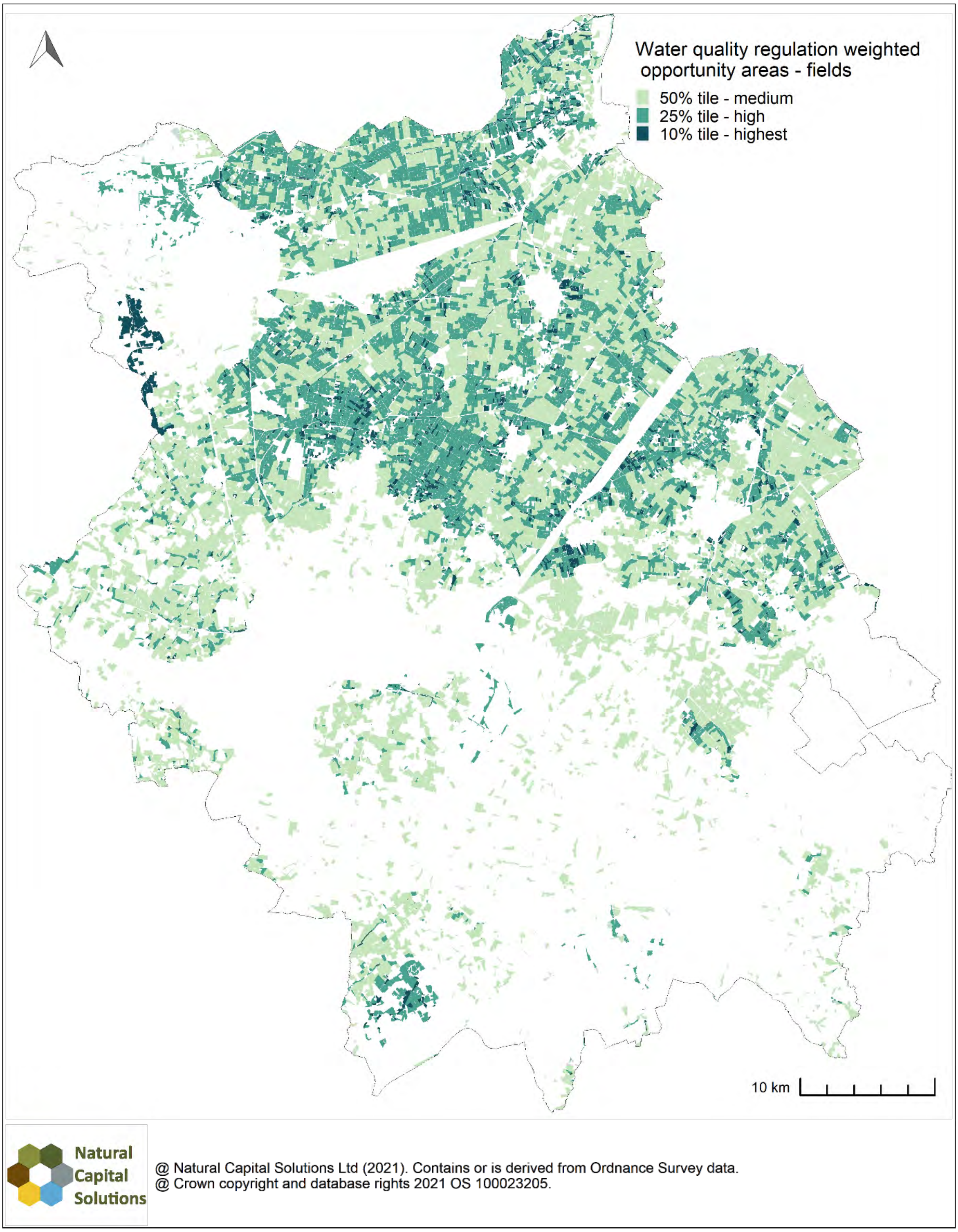
10% tile = highest priority opportunities (top 10%)

25% tile = high priority opportunities (10-25% best opportunities)

50% tile = medium priority opportunities (25-50% best opportunities)



Map 26: Overall water body class of WFD River Waterbody Catchments across the study area (data from Environment Agency).



Map 27: Water quality regulation opportunity fields across Cambridgeshire, weighted by catchment water quality.

10% tile = highest priority opportunities (top 10%)
25% tile = high priority opportunities (10-25% best opportunities)
50% tile = medium priority opportunities (25-50% best opportunities)

6.5 Opportunity mapping to ameliorate air pollution

To map opportunities to use the natural environment to ameliorate air pollution, 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 greatest demand. 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.

Method

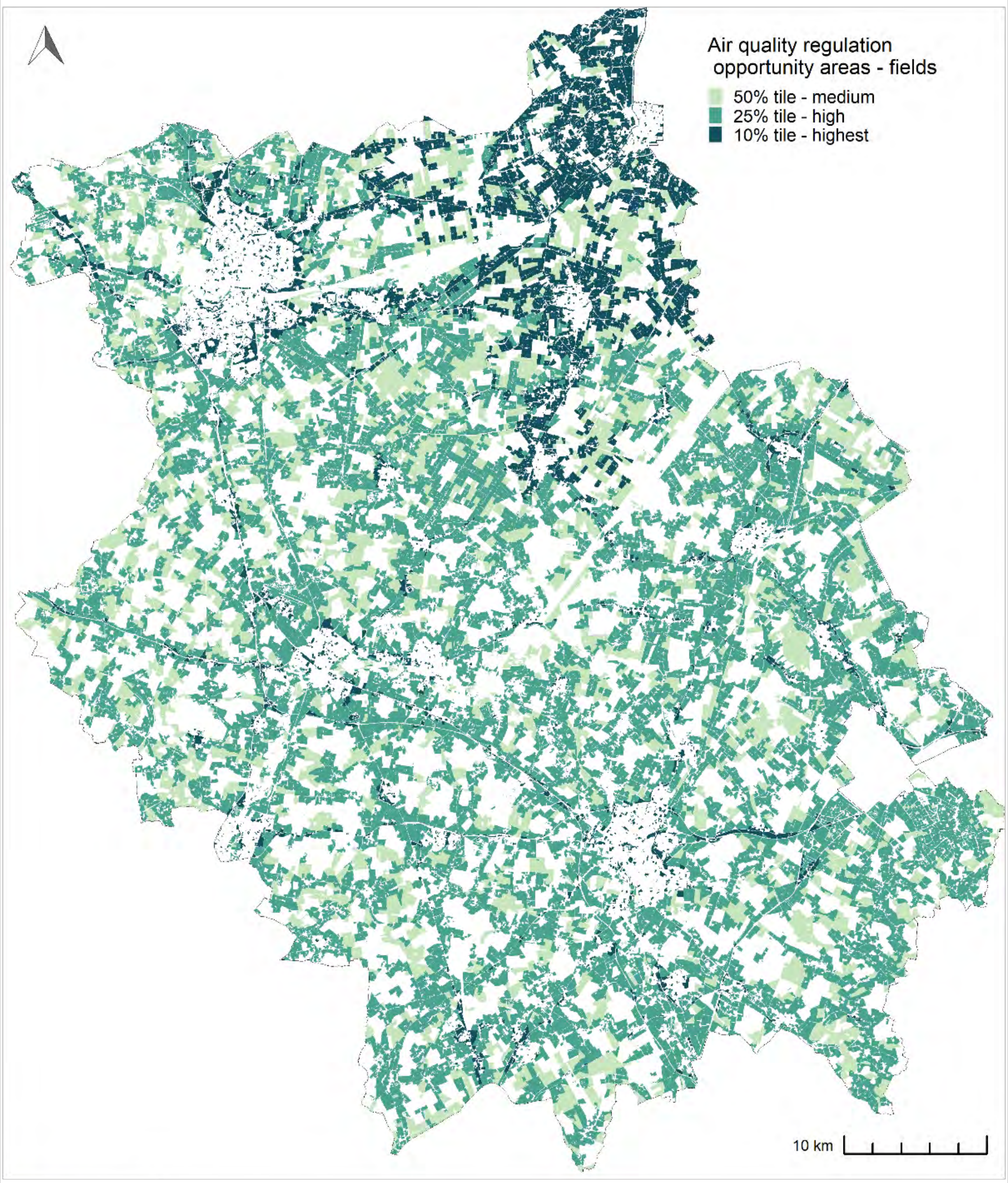
The constraints identified previously were erased from the air quality regulation demand map to leave a map showing demand in all unconstrained locations. This was then classified into percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance, and were given a score of 3, 2 and 1 respectively. Therefore, these showed the areas of land across the study area where demand for air quality amelioration is moderate to high and where there are no constraints on potentially altering land use.

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 urban tree in very small plots of land.

Results

Demand for air quality regulation 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. These are the areas identified as opportunity areas in the map (Map 28), although opportunities are identified across the study area. The highest priority opportunity areas occur predominantly in Fenland and around Peterborough as these are the areas with greatest health deprivation in the county.

Opportunity areas along the main roads were also highlighted, for example on the main trunk roads e.g. the A1(M), A14 and A10, as well as some opportunities along the Ely to Peterborough railway line. 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.



Natural Capital Solutions

Map 28: Air quality regulation opportunity fields across Cambridgeshire.

10% tile = highest priority opportunities (top 10%)
25% tile = high priority opportunities (10-25% best opportunities)
50% tile = medium priority opportunities (25-50% best opportunities)

6.6 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. 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.

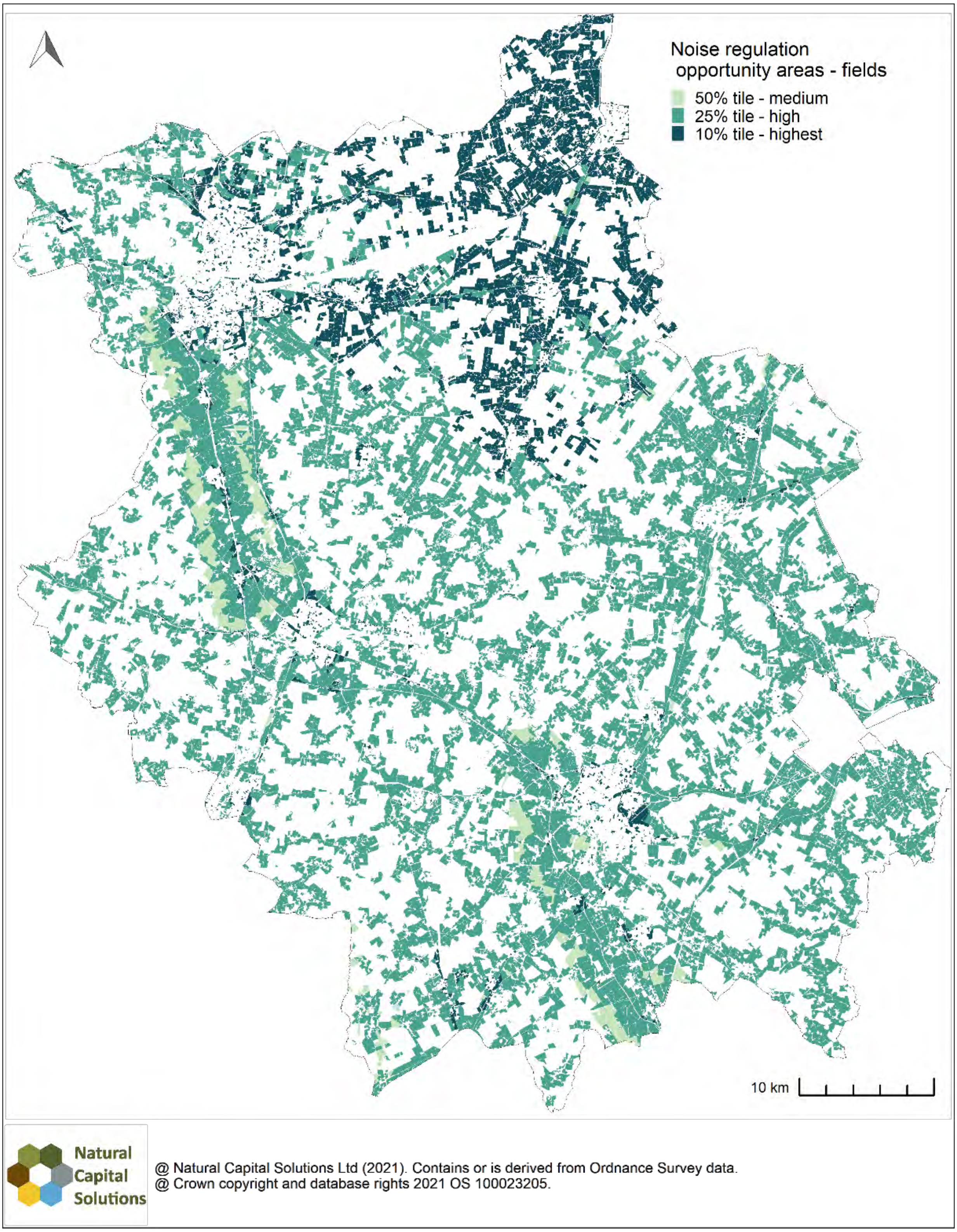
Method

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 percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance, and given a score of 3, 2 and 1 respectively. Therefore, this shows the 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.

Results

Similarly to air quality regulation, demand for noise regulation 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 (Map 29). The highest priority opportunities have been identified in Fenland, due to the higher levels of deprivation in this area. There are also opportunities surrounding the urban fringes of Peterborough, Huntingdon and Cambridge, as well as along the edges of the A1(M) to the west of the county. These locations potentially provide the opportunity to plant trees and scrub belts that could help to block and screen noise pollution.



Map 29: Noise regulation opportunity fields across Cambridgeshire.

10% tile = highest priority opportunities (top 10%)
25% tile = high priority opportunities (10-25% best opportunities)
50% tile = medium priority opportunities (25-50% best opportunities)

6.7 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.

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. As before, this was then classified into percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance, and these were scored as 3, 2 and 1 respectively. Therefore, this shows the 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.

Results

Demand for local climate regulation is highest in the main urban centres of Peterborough, Cambridge, Huntingdon, Wisbech, March and Ramsey, 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 30). 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 30: Local climate regulation opportunity fields across Cambridgeshire.

10% tile = highest priority opportunities (top 10%)
25% tile = high priority opportunities (10-25% best opportunities)
50% tile = medium priority opportunities (25-50% best opportunities)

6.8 Opportunity mapping for accessible natural greenspace

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, based on creating new sites in areas with the highest demand for access to greenspaces. To further prioritise the best locations, we also took into account current access to natural greenspaces, based on Natural England's Accessible Natural Greenspace Standards (ANGSt), giving more weight to opportunities identified in areas that did not meet these standards.

Method

Constrained areas were erased from the map, along with 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 percentiles and three classes of percentile were identified. The top 10%, 10-25% and 25-50% percentiles were extracted, indicating three levels of importance, and these were scored as 3, 2 and 1 respectively. Therefore, this shows the areas of land across the study area where demand for access to 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%.

Natural England's ANGSt stipulates that everyone should have an accessible natural greenspace:

- Of at least 2 ha in size, no more than 300 m from home.
- At least one accessible 20 ha site within 2 km of home.
- One accessible 100 ha site within 5 km of home.
- One accessible 500 ha site within 10 km of home.

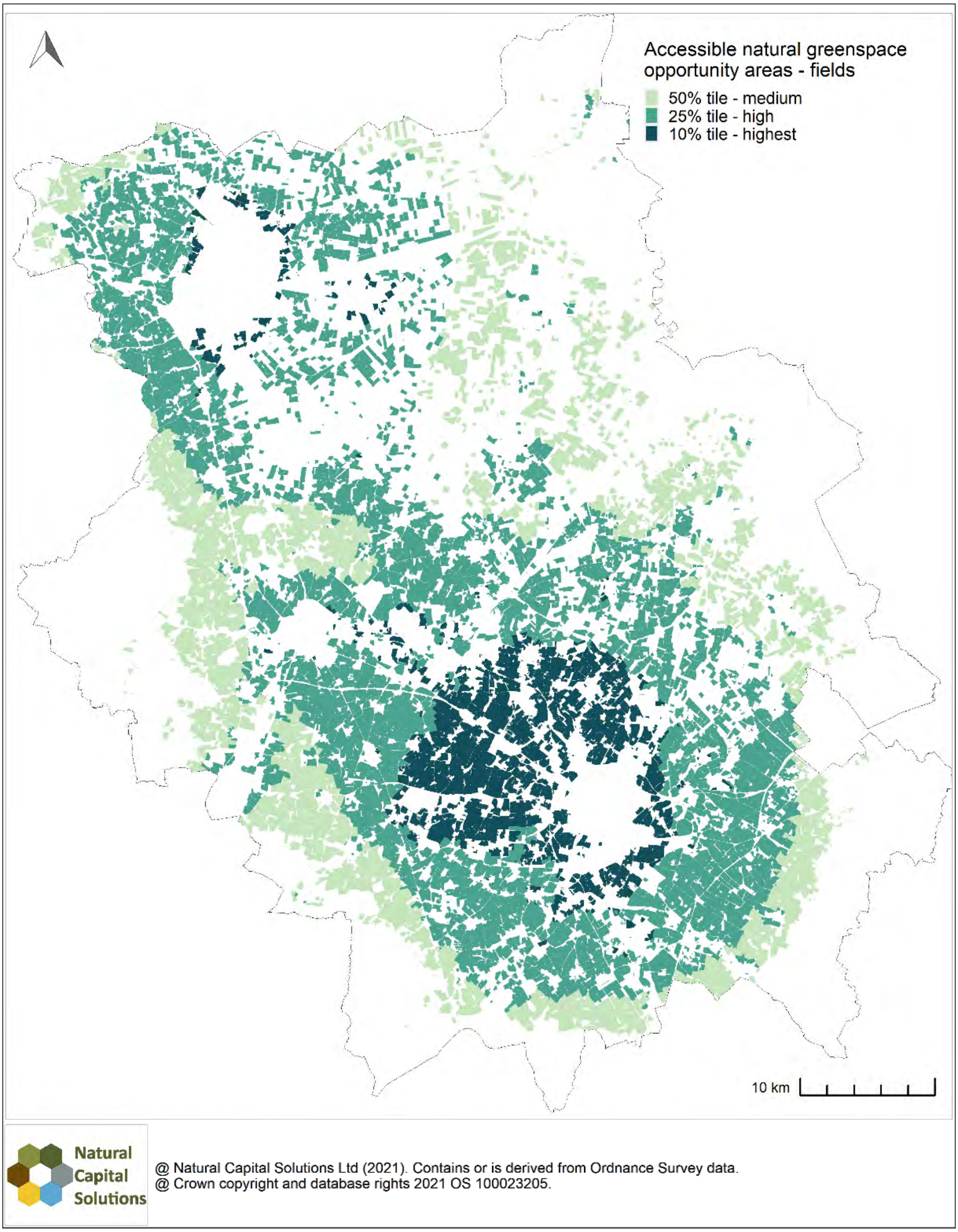
We therefore created a GIS layer identifying all natural greenspaces that were publicly accessible across the study area and then created buffers based on the criteria above.

This ANGSt data was used to weight the opportunity map. Locations that failed to meet any of the criteria were given a weighting of 4, those that failed to meet 3 criteria were given a weighting of 3 and so on. These weightings were multiplied by the opportunity scores and the weighted opportunity scores were then rescaled back to a 1-3 scale to match the other opportunity maps.

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 (Map 31) are centred around the major towns across Cambridgeshire, mainly Cambridge, but also Peterborough, Huntingdon and Whittlesey. It should be noted that as population data from outside the county was not available, there is likely to be more opportunity near the borders than is shown on the map.

Map 32 shows the ANGSt weighting for the study area and shows that large areas did not meet more than one of these standards, particularly away from the larger towns. The final weighted accessible nature opportunity map is shown in Map 33. The priority for opportunities remains around Cambridge and the other urban areas, but there is now more refinement regarding the exact location of the top priority locations and areas where opportunities are less important (e.g. around Peterborough and St Ives) as existing accessible natural greenspaces already occur nearby.

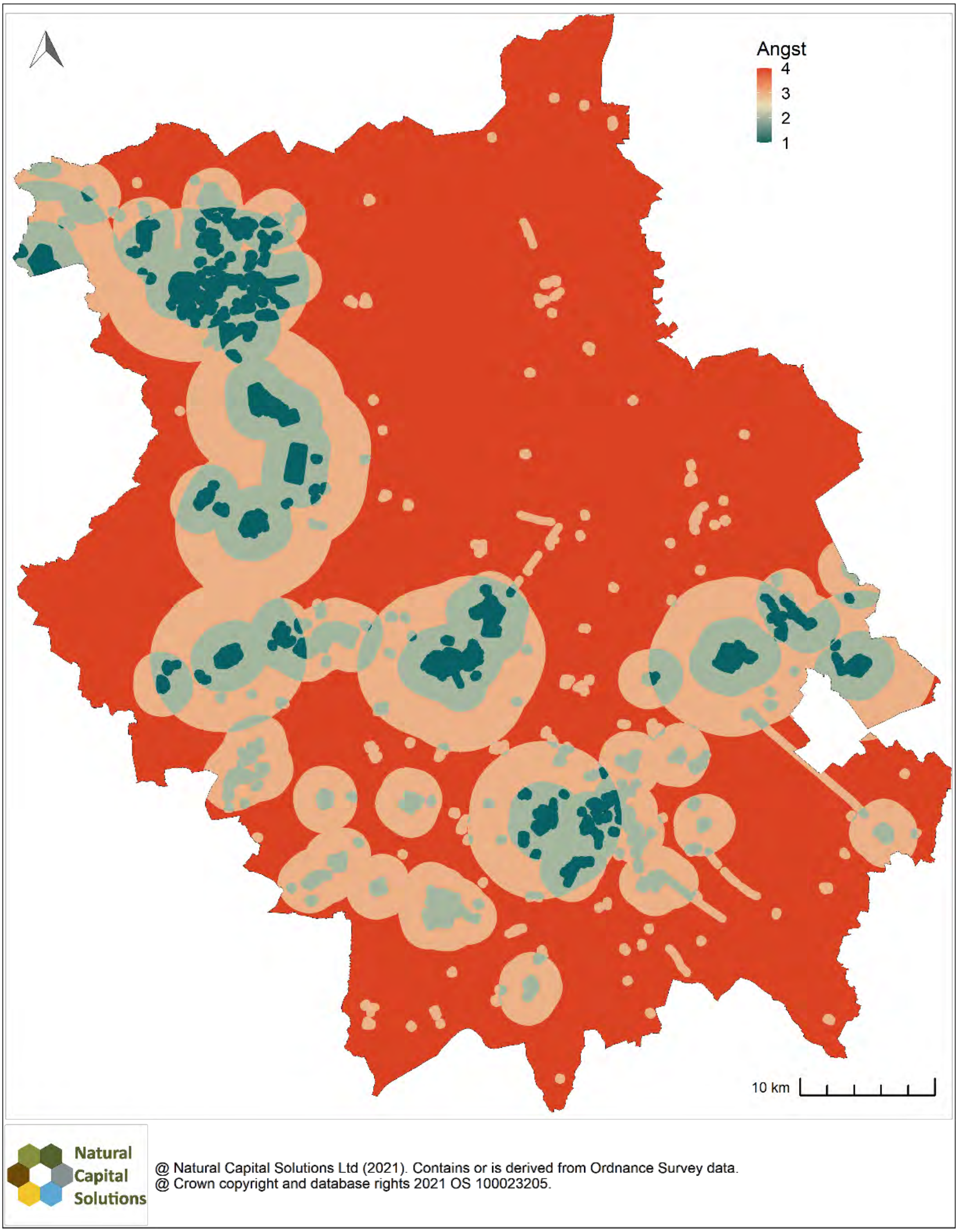


Map 31: Accessible natural greenspace opportunity fields across Cambridgeshire.

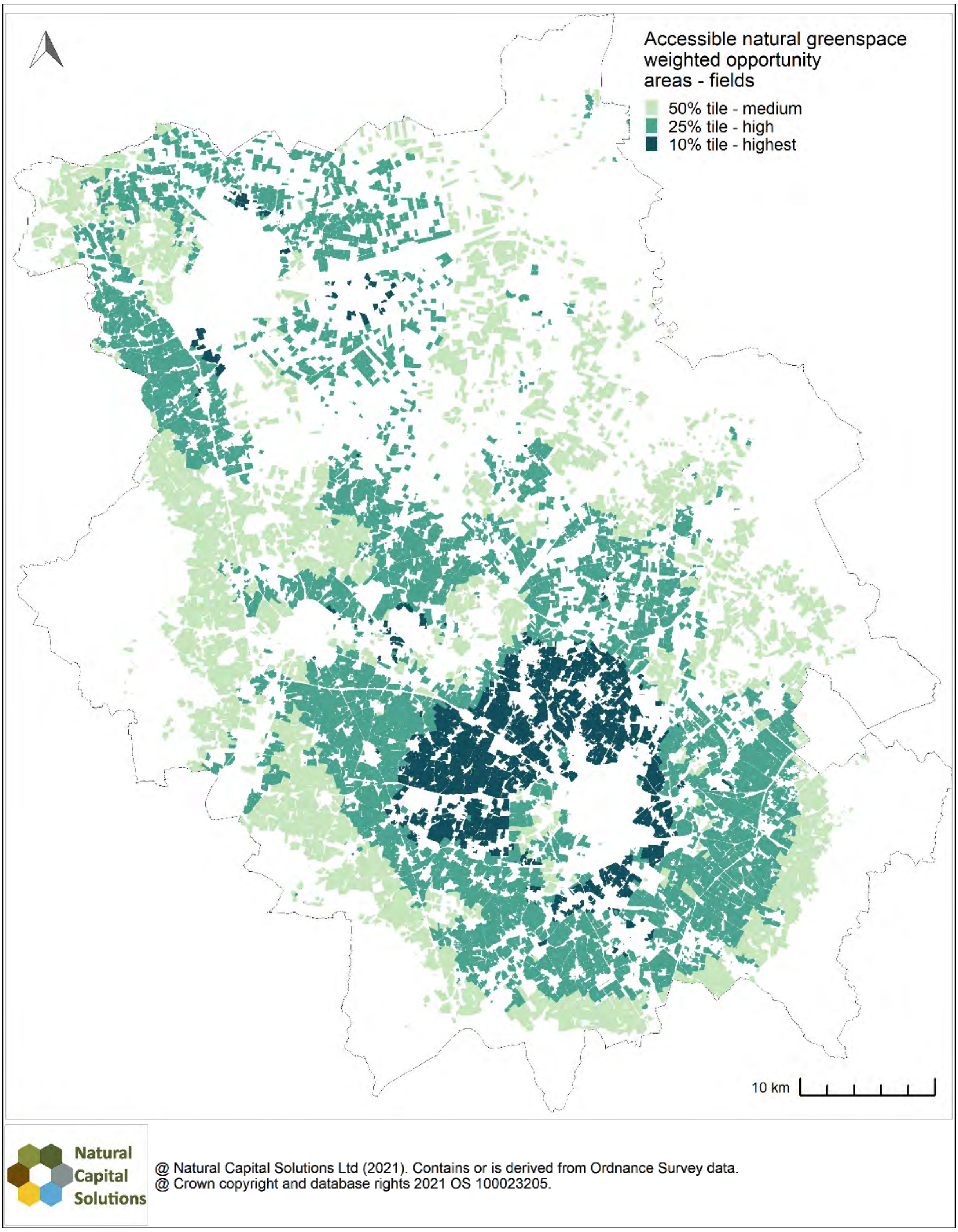
10% tile = highest priority opportunities (top 10%)

25% tile = high priority opportunities (10-25% best opportunities)

50% tile = medium priority opportunities (25-50% best opportunities)



Map 32: Weighting based on Accessible Natural Greenspace Standards (ANGSt) assessment. A higher score indicates an area that fails to meet more of the ANGSt standards.



Map 33: Accessible natural greenspace opportunity fields across Cambridgeshire, weighted by ANGSt.

10% tile = highest priority opportunities (top 10%)
25% tile = high priority opportunities (10-25% best opportunities)
50% tile = medium priority opportunities (25-50% best opportunities)

7 Combined opportunities for new habitats

In addition to mapping the individual opportunities presented above, it is also possible to examine multiple opportunities, which are areas where new habitat can be created that provides opportunities to enhance biodiversity and 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. Here, if an opportunity falls within the top 10% (highest) opportunity it is given a score of 3, an opportunity in the 10-25% (high) zone is given a score of 2, and an opportunity in the 25-50% (medium) zone is given a score of 1. Biodiversity opportunities can score between 1 and 3, with the highest priority score taking precedence where there is more than one opportunity in the same location.

The maps can be combined in a number of different ways, depending on the objective. Here we present opportunities that are focused on delivering multifunctionality, but always in areas that deliver biodiversity benefits, and also a map that combines all opportunities. We have combined maps by treating biodiversity opportunities and all ecosystem service opportunities equally. It would also be possible to weight the different ecosystem services according to stakeholder priorities.

The combined opportunities maps in Figures 36 to 40 show that there are a number of locations where broadleaved woodland, semi-natural grassland and wetland could be planted that would be ecologically connected to existing habitats and deliver multiple additional benefits. Red areas show the combined opportunities that have the highest number of benefits associated with them.

7.1 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 6.3-6.7), 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 6.8). 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 21). 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.

Woodland opportunities across the county are plentiful (Map 34) and extend across most areas, except for the northeast quarter. The map shows the degree of multi-functionality that could be delivered by creating new woodland in each field if all benefits are treated equally, and is a potential way of targeting woodland creation. The areas that would deliver greatest overall benefits are on the outskirts of Peterborough, between Peterborough and Huntingdon, and there are also high opportunities to the west of Cambridge and around March and Wisbech. Planting woodland in the higher scoring locations would deliver higher biodiversity and ecosystem service benefits.

7.2 Combined opportunities for new semi-natural grassland

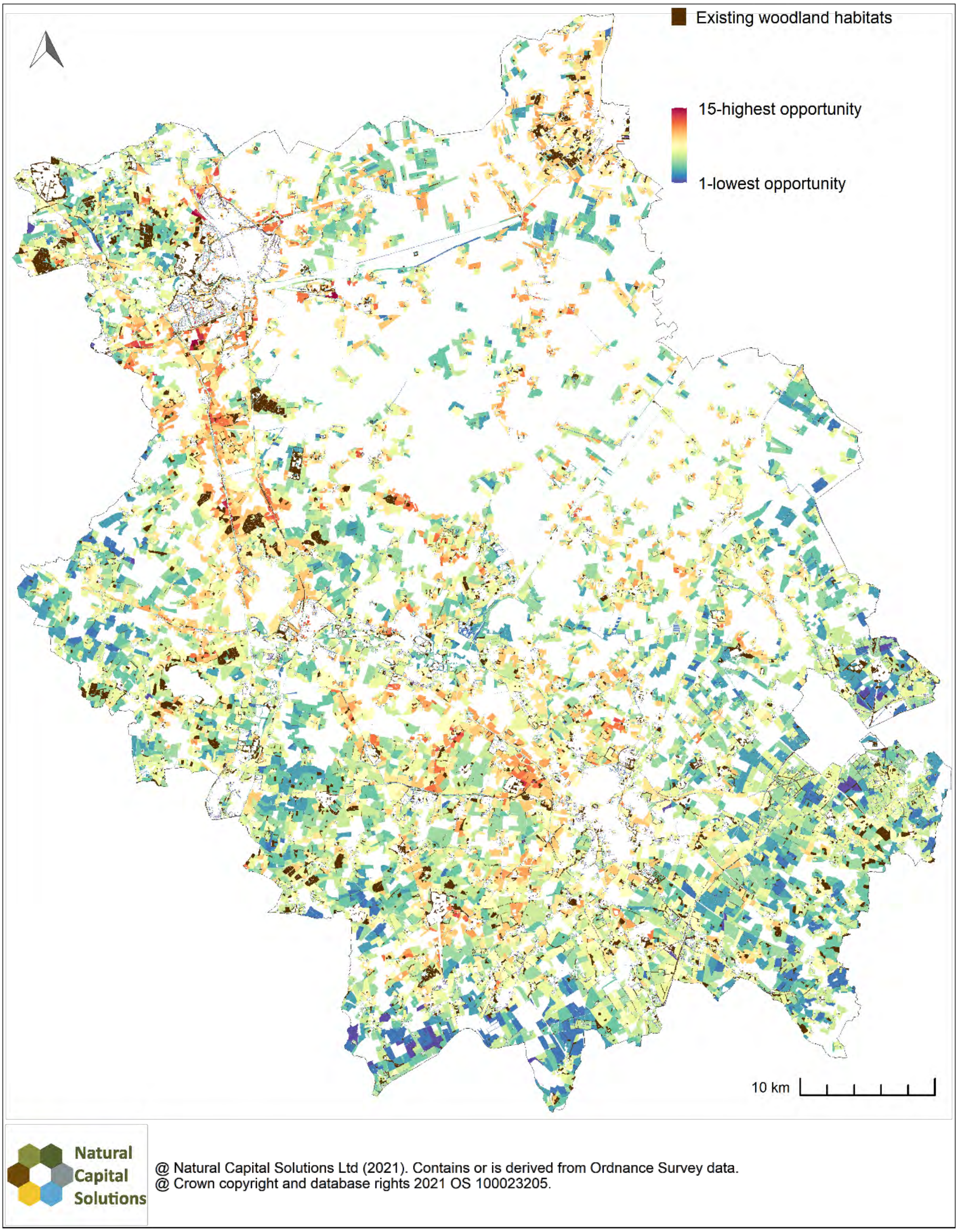
Creating semi-natural grassland will not be as effective at reducing water flow or enhancing water quality as planting woodland, but it is likely to be significantly better than arable and is likely to enhance the provision of these services. It will not, however, be effective at ameliorating air pollution, 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.

For semi-natural grassland, opportunities are present throughout much of the county. The highest opportunities are scattered, but the largest concentration of them is southwest of Peterborough near the A605 (red; Map 35). There are also several areas of high opportunity to the west of Cambridge. There are fewer opportunities to the northeast of the county.

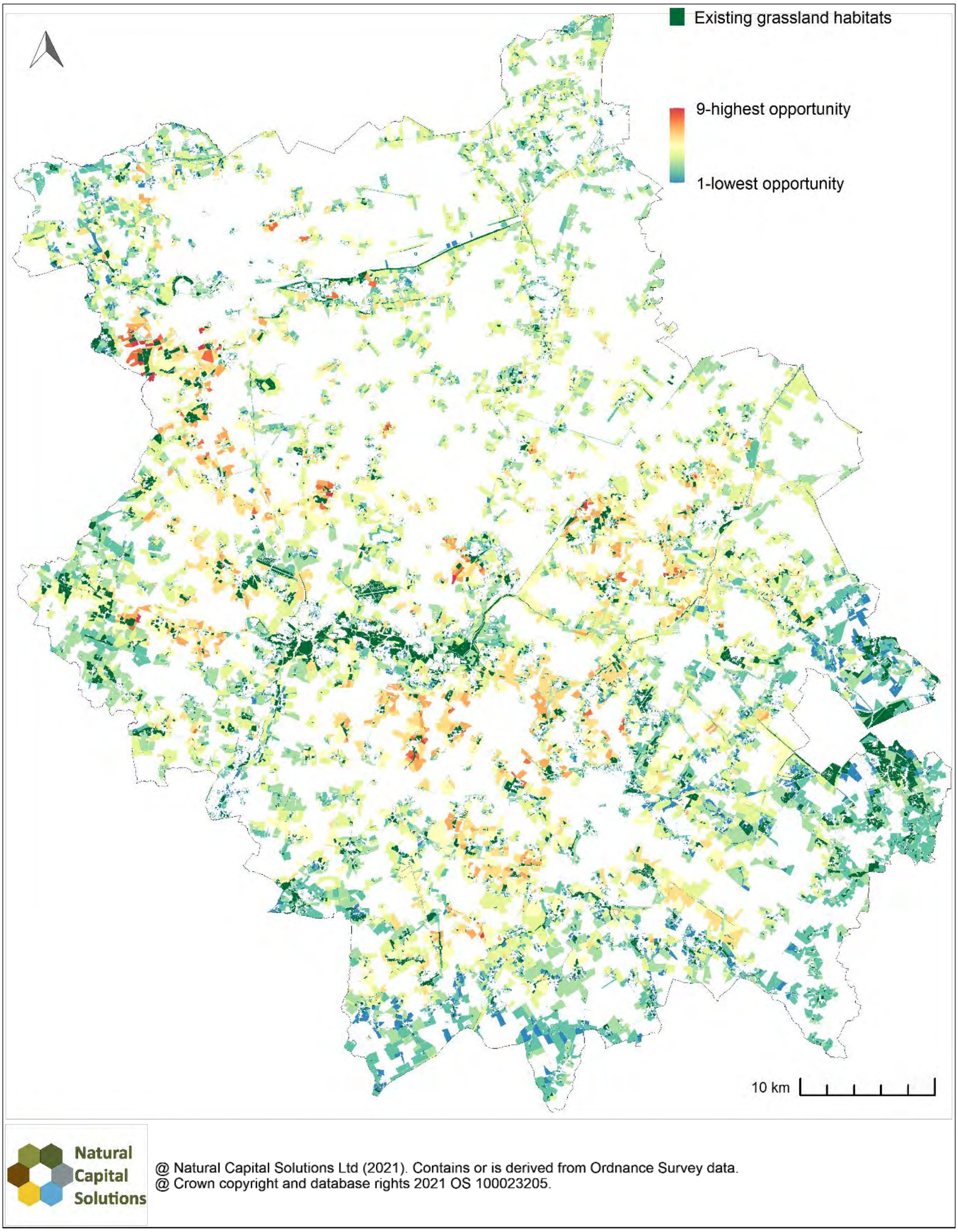
7.3 Combined opportunities for new wet grassland and wetlands

Wetland habitats can be effective at reducing water flow and enhancing water quality. Combined opportunities for new wet grassland and wetlands therefore included four out of the seven services (water flow, water quality, accessible natural greenspace, and biodiversity enhancement), with air quality, noise, and local climate excluded. In addition, the opportunities were restricted to areas within the indicative floodplain.

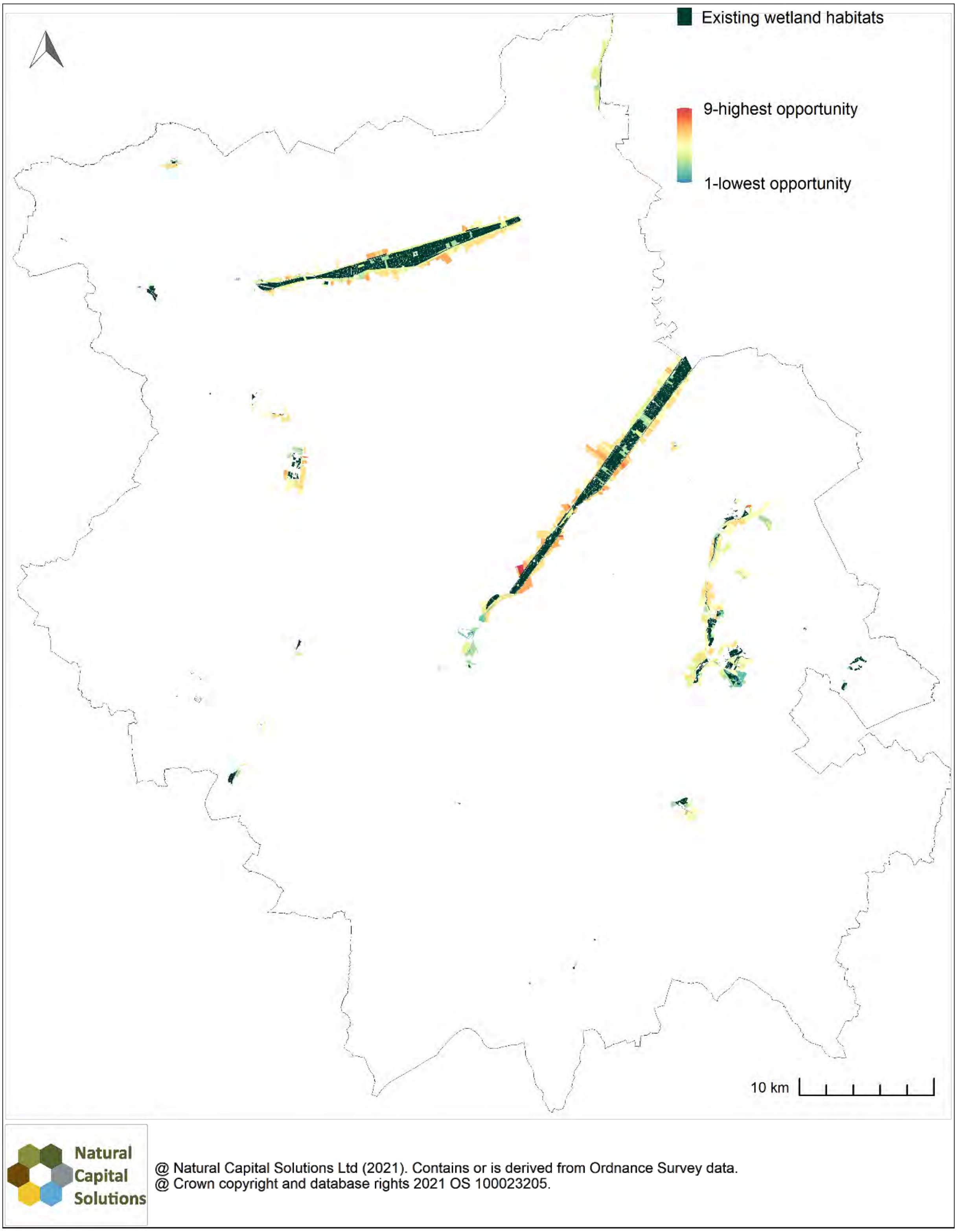
There are few opportunities for wetland habitats to be created (Map 36). Opportunities are primarily located adjacent to the Nene and Ouse Washes. There are also a few opportunities around existing wetland nature reserves, including RSPB Fowlmere, Woodwalton Fen and Holme Fen.



Map 34: Combined opportunities for woodland across Cambridgeshire, restricted to areas that are ecologically connected to existing woodlands.



Map 35: Combined opportunities for semi-natural grassland across Cambridgeshire, restricted to areas that are ecologically connected to existing grasslands.

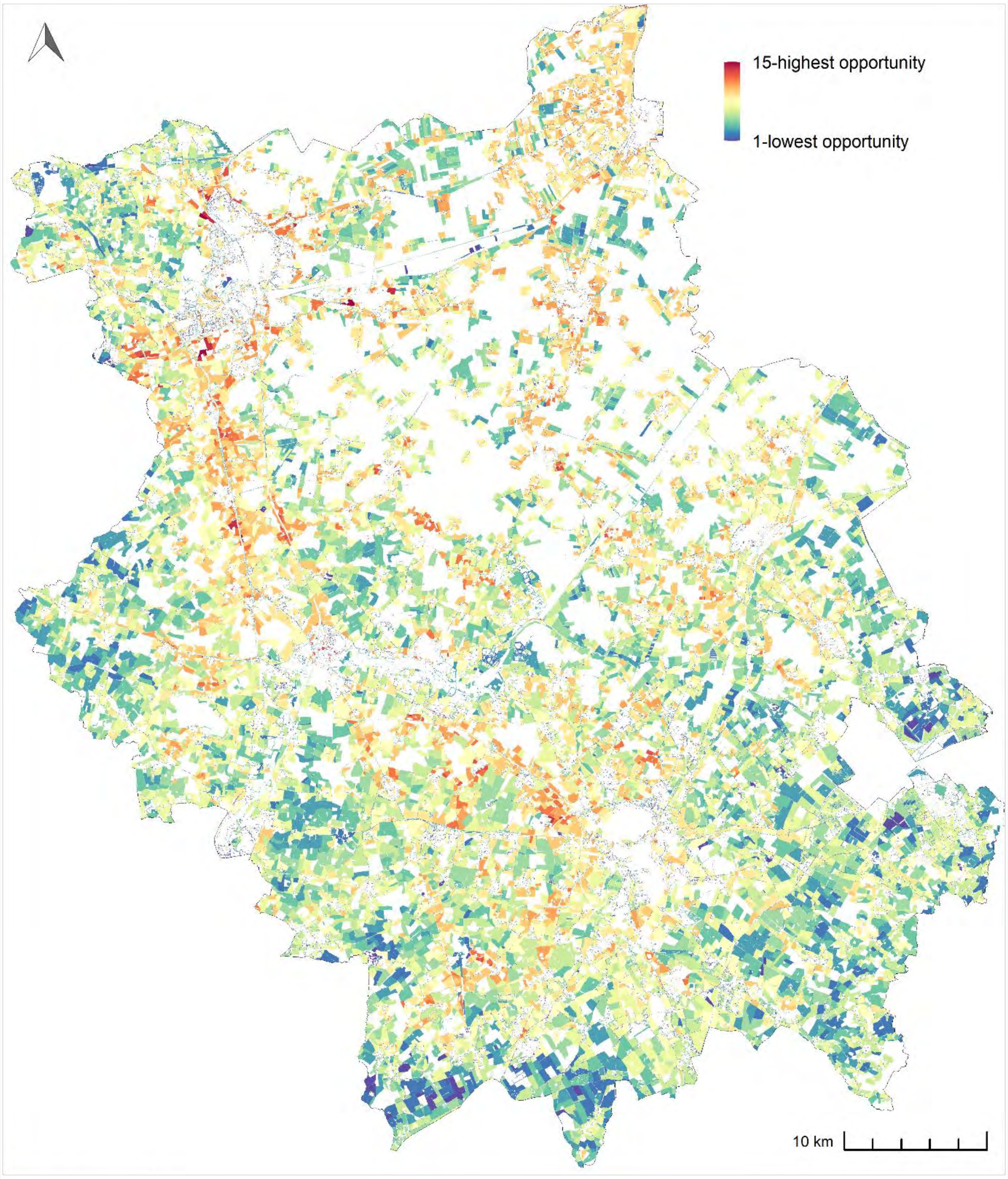


Map 36: Combined opportunities for new wet grasslands and wetlands across Cambridgeshire, restricted to areas that are ecologically connected to existing wetlands.

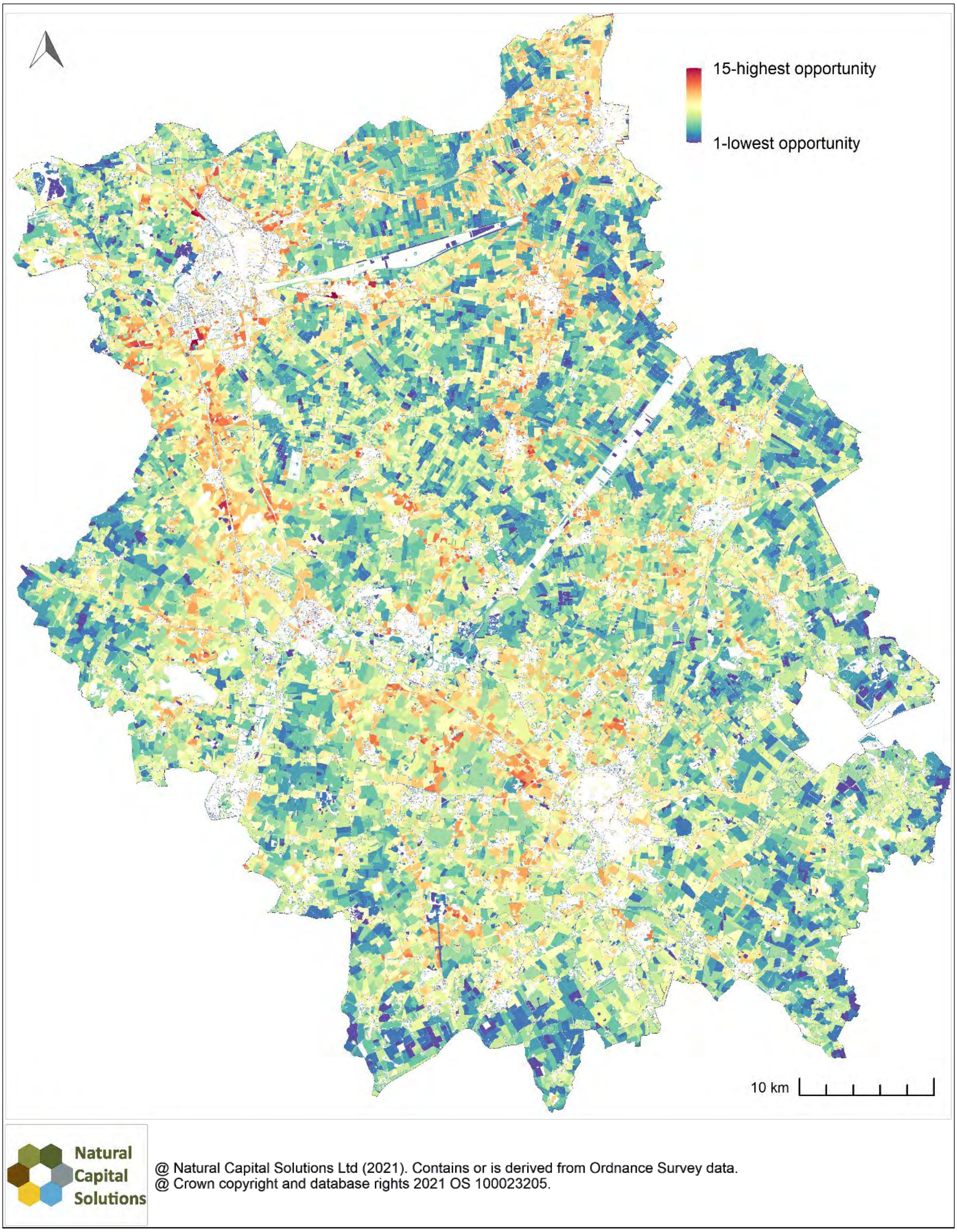
7.4 All combined opportunities

Whilst the figures above have illustrated the combined opportunities by each broad habitat, Map 37 shows all the ecosystem services and biodiversity opportunities in one map. These are displayed at field scale, showing all the benefits that can be delivered, restricted to areas that can also deliver the identified biodiversity opportunities. Note that there are sites where opportunities for the broad habitats overlap, that is, there are fields where more than one habitat could potentially be created. No attempt has been made at this stage to determine the most suitable habitat to create in each location.

The second combined opportunities map (Map 38) shows all opportunities combined equally and is not restricted to areas delivering biodiversity opportunities. Results show that once constrained areas are excluded (the white areas on the map), almost all remaining parts of the map present at least some opportunity for enhancing ecosystem services. However, most areas delivering multiple benefits occur in and around urban areas and adjacent to the road network.



Map 37: Combined opportunities for new habitats across Cambridgeshire, restricted to areas offering biodiversity (woodland, semi-natural grassland and wetland) buffer and stepping-stone opportunities.



Map 38: Combined opportunities for new habitats across Cambridgeshire.

8 Developing an Environmental Justice Index for Cambridgeshire

There is growing evidence that greenspaces in urban and rural areas not only deliver multiple ecosystem services, but also enhance the health and wellbeing of local residents and visitors. Greenspaces are also important components of 'place-making' providing local landscape identities to residents and businesses. Quality green spaces deliver a range of benefits that have real value to society, create community well-being, and enhance liveability and sense of place. They are also able to help mitigate against environmental risks such as air and noise pollution and flood risk, and are key to enhancing resilience to climate change.

However, environmental risks, poor health and deprivation, and (lack of) access to greenspace are not distributed evenly and are often linked. Many poorer communities face significantly poorer environmental conditions and may also have less access to greenspaces. Environmental justice is concerned with the equitable distribution of environmental benefits and reducing environmental inequalities. By mapping the distribution of these inequalities, it then becomes possible to prioritise resources in locations that are suffering from environmental injustice.

The idea of an Environmental Justice Index was developed by Birmingham City Council (BCC), who incorporated five indicators (Index of Multiple Deprivation, access to green space, flood risk, urban heat island effect, and excess years of life lost) to create a map of city wards, indicating which areas should be prioritised for investment[29]. BCC see greenspace as a vehicle to deliver ambitions around 'levelling up', climate adaptation, health outcomes and biodiversity net gain. Here, we have taken that framework and expanded it to include 10 indicators across three categories (Figure 3), detailed below. These were chosen with input from stakeholders via an online workshop held in February 2022.

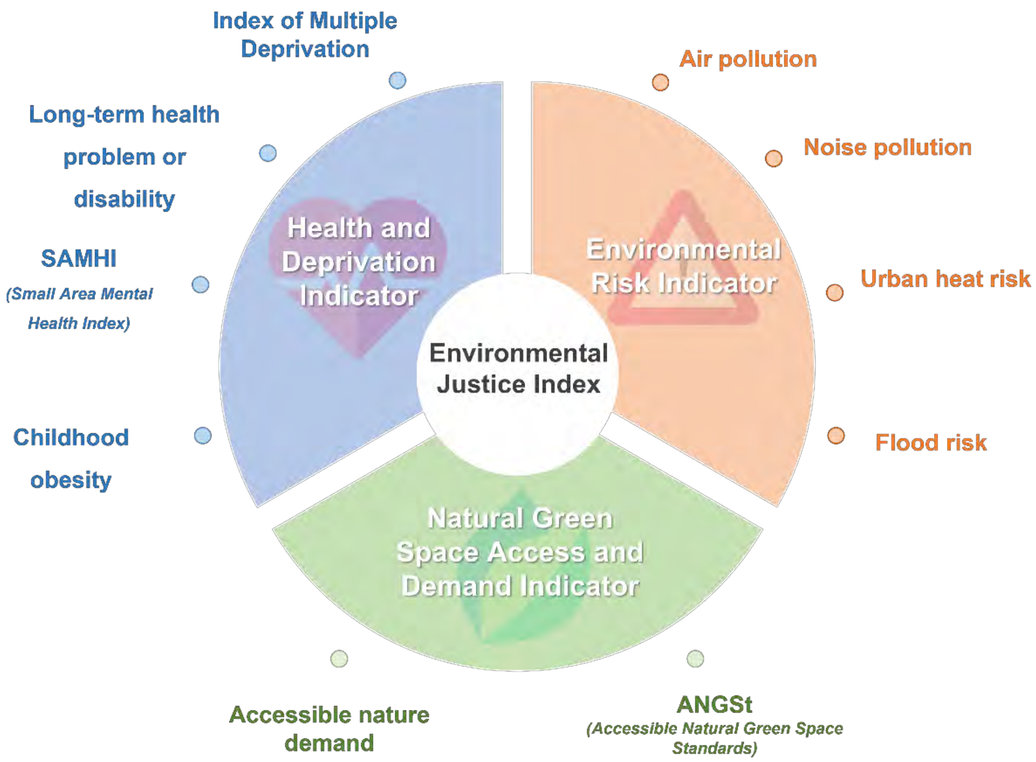


Figure 3: The 10 datasets used to create the Environmental Justice Index.

[29] Birmingham City Council. Future Parks Accelerator. Environmental Justice in Birmingham.

8.1 Health and deprivation indicator

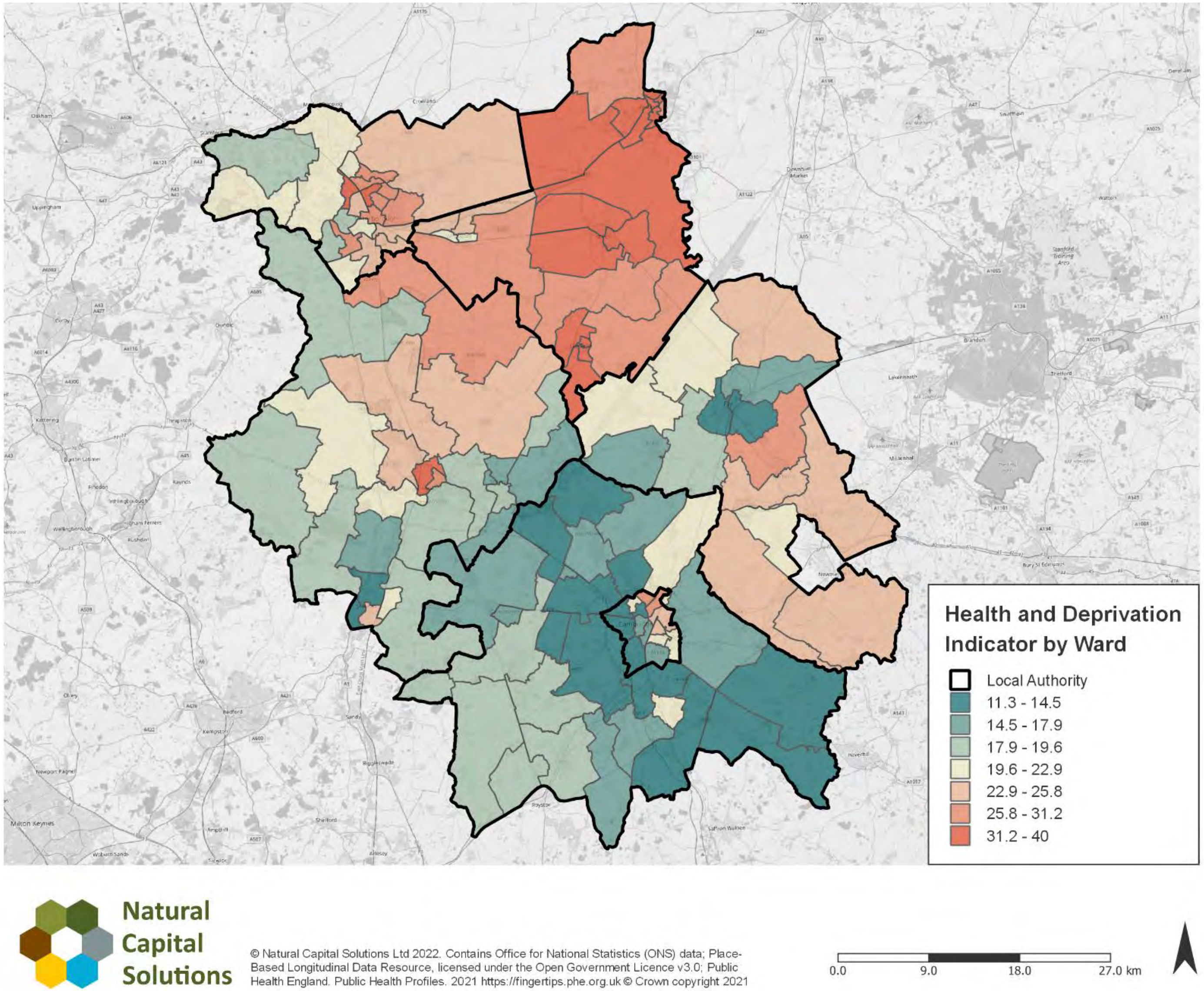
A health and deprivation indicator was developed, comprising the following four datasets: Index of Multiple Deprivation (IMD), long-term health problem or disability, Small Area Mental Health Indicator (SAMHI), and childhood obesity data. Each of the datasets were converted to deciles (1-10) and summed together. The resulting output had a range of 4-40 with higher scores indicating worse areas for health and deprivation. Finally, for each LSOA and Ward, the average index value was calculated and assigned. The datasets used are detailed in Annex B, along with maps of each individual indicator.

Map 39 shows the health and deprivation indicator across Cambridgeshire. There is a fairly distinct north-south split, with health and deprivation much higher in the north of the county. Fenland District has the highest level of deprivation with all of its worst performing wards in or around Wisbech. Peterborough Unitary Authority has some higher levels of poor health and deprivation, and the worst performing wards are all within central Peterborough. The wards to the west of the district have lower levels of deprivation. Huntingdon and East Cambridgeshire have generally lower levels of deprivation but there are some wards that are higher; these are found within central Huntingdon and towards the Suffolk border. In contrast, South Cambridgeshire and Cambridge City have generally low levels of deprivation and better levels of health.

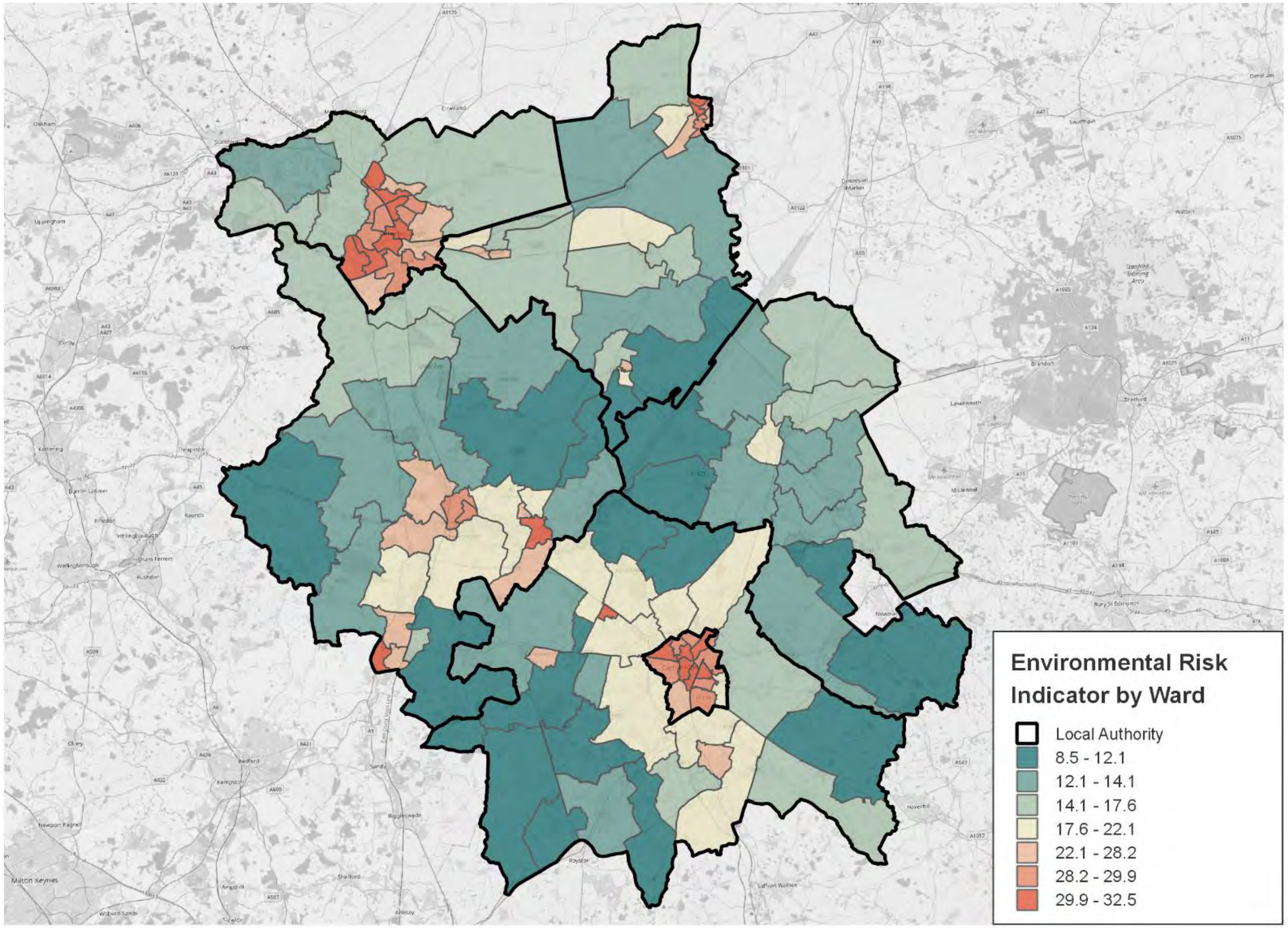
8.2 Environmental risk indicator

An environmental risk indicator was created from the following four indicators: air pollution risk, noise pollution risk, areas at risk from the urban heat island effect (local climate risk), and flood risk. The datasets were converted to deciles (1-10) and summed together. The resulting output had a range of 4-40 with higher scores indicating higher levels of environmental risk. As before, for each Ward, the average index value was calculated and assigned. The datasets used are detailed in Annex B, along with detailed maps of each individual indicator.

Map 40 shows the average environmental risk score for each ward across Cambridgeshire. The worst performing wards are mainly around urban centres, which have a high density of roads. This is particularly prevalent in Peterborough, Cambridge, Huntingdon and Wisbech. There is a medium environmental risk score in the wards that have the M11 and A14 running through them. The southwest corner of the county has very low environmental risk.



Map 39: Health and deprivation indicator for Cambridgeshire.



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Map 40: Environmental risk indicator for Cambridgeshire.

8.3 Natural greenspace access and demand indicator

A natural greenspace access and demand indicator was calculated from the accessible nature demand ecosystem service model (Section 3.14) and Natural England's Accessible Natural Green Space Standards (ANGSt) model. This indicator highlights areas where there is high demand for access to natural greenspace, but that do not currently have good access. The accessible nature demand dataset was converted to deciles (1-10) and multiplied by the ANGSt model output (1-4) showing where standards are not being met, to create a final output ranging from 4-40. Finally, within each Ward, the average index value was calculated and assigned. The datasets used are detailed in Annex B, along with detailed maps of both individual indicators.

The areas in red, which have the lowest greenspace access compared to demand, are around the outskirts of Cambridge, with smaller hotspots around Whittlesey, March and Wisbech in the north (Map 41). South Cambridgeshire generally has quite low natural greenspace access compared to the more northern local authorities, and the worst performing areas are all to the northwest of Cambridge. Cambridge City, interestingly, has better natural greenspace access than some of the surrounding wards in South Cambridgeshire, which may be due to large urban parks like Midsummer Common. The centre of Peterborough also does very well compared to areas immediately outside of it. A number of more rural wards on the eastern and western edges of the county perform well for this indictor, due to the relatively low demand for greenspace in these areas. In contract, smaller urban centres tend to perform the worst across Cambridgeshire.

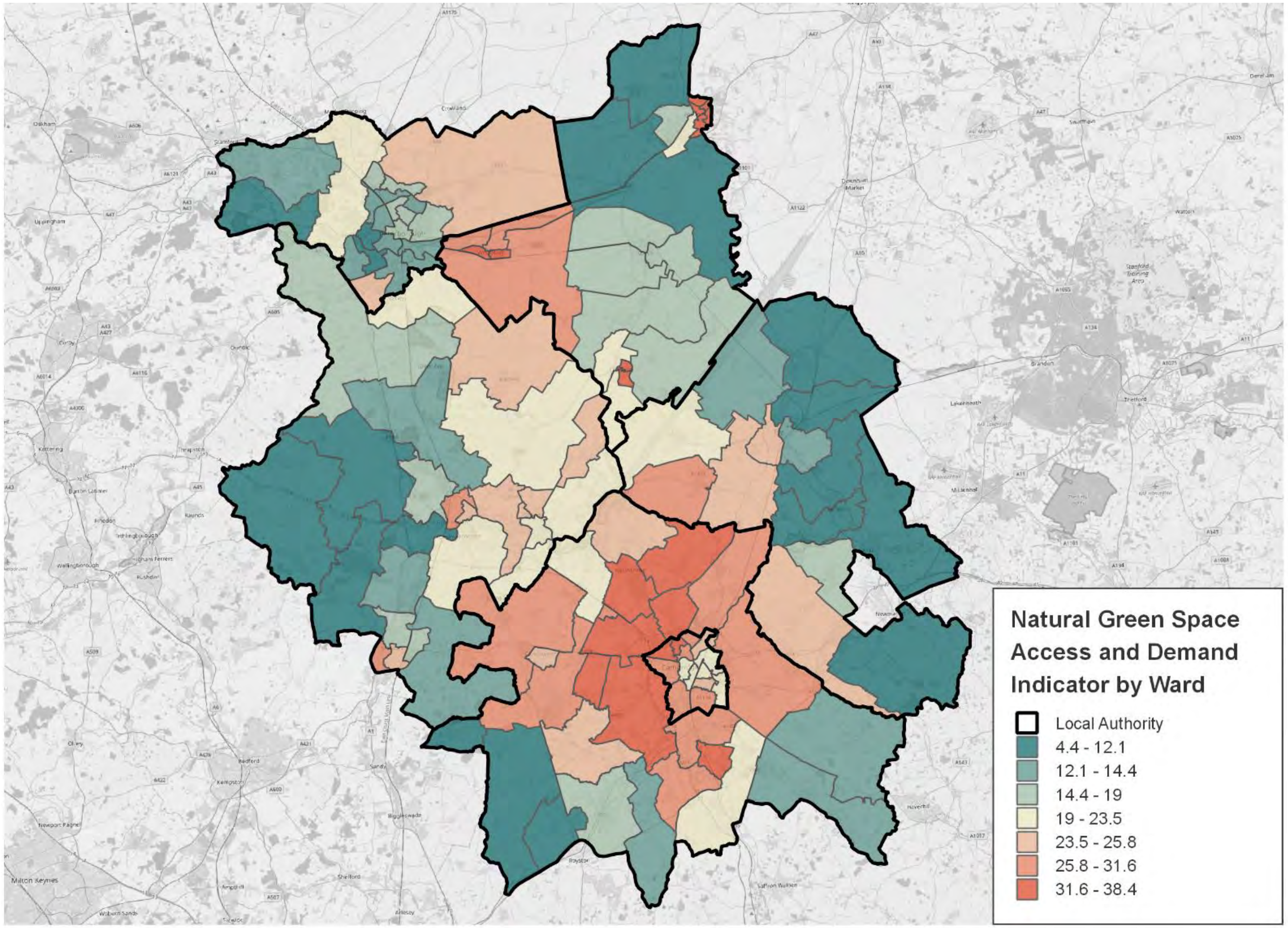
8.4 Environmental Justice Index

The Environmental Justice Index was calculated by summing the following indictors: health and deprivation indicator + environmental risk indicator + natural greenspace access and demand indicator. This was based on the raw indicators, rather than the ward-averaged indicators, to produce a detailed, spatially accurate index. To create the final ward-based Environmental Justice Index, the average index value for each ward was then calculated.

In Map 42, the three wards with the highest average Environmental Justice Index score within each Local Authority are shown in white and are listed in the box on the top right of the map. These wards represent locations for prioritised investment to deliver environmental justice. The worst performing wards in each local authority are generally centred around urban areas; three in Peterborough, two in Huntingdon, three in Wisbech and four in Cambridge. There are also several in the smaller towns in the county; one each in St Neots, Sawston and Ely. There is not much north/south divide between scores, as northern wards tended to have high deprivation scores, but southern wards had less greenspace access. Wards that score lowest (best) tend to be on the borders of the county. Note that all of the wards in East Cambridgeshire perform relatively well. Haddenham, Bottisham and Ely West are identified as the three worst performing wards within that LA, but in the context of the county as a whole are above average.

Map B11 in Annex B shows the top 10 (worst performing) wards across the county as a whole and shows that the top four wards are all in Wisbech. Wards in Chatteris, Cambridge, Huntingdon and another in Wisbech make up the rest of the top 10.

An interactive story map has also been produced to present the development and results of the Environmental Justice Index and this is publicly available on the internet.



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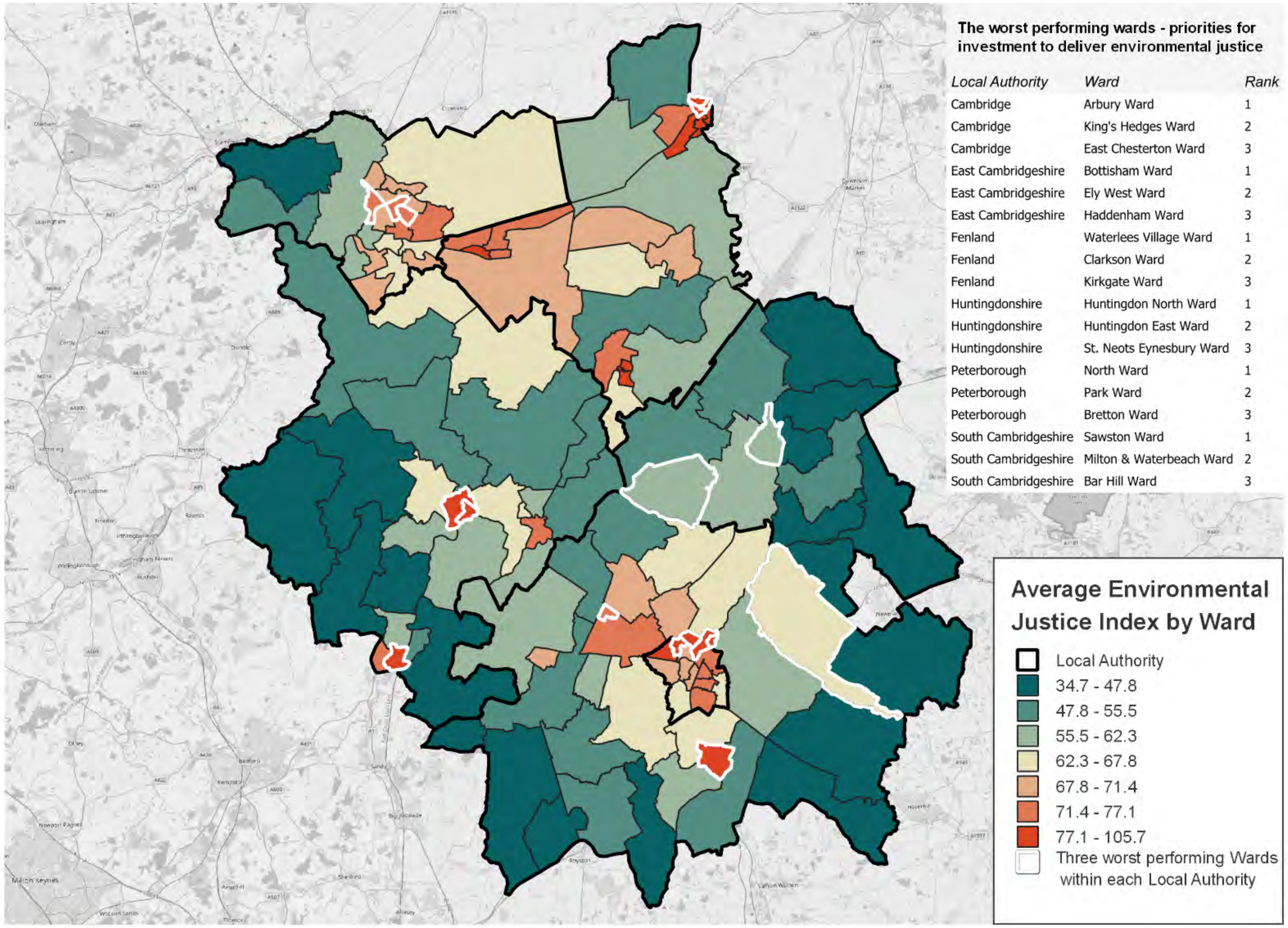
Map 41: Natural greenspace access and demand index for Cambridgeshire.



The worst performing wards - priorities for investment to deliver environmental justice

Local Authority	*Ward*	*Rank*
Cambridge	Arbury Ward	1
Cambridge	King's Hedges Ward	2
Cambridge	East Chesterton Ward	3
East Cambridgeshire	Bottisham Ward	1
East Cambridgeshire	Ely West Ward	2
East Cambridgeshire	Haddenham Ward	3
Fenland	Waterlees Village Ward	1
Fenland	Clarkson Ward	2
Fenland	Kirkgate Ward	3
Huntingdonshire	Huntingdon North Ward	1
Huntingdonshire	Huntingdon East Ward	2
Huntingdonshire	St. Neots Eynesbury Ward	3
Peterborough	North Ward	1
Peterborough	Park Ward	2
Peterborough	Bretton Ward	3
South Cambridgeshire	Sawston Ward	1
South Cambridgeshire	Milton & Waterbeach Ward	2
South Cambridgeshire	Bar Hill Ward	3

Natural Capital Solutions

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Map 42: Environmental Justice index for Cambridgeshire, detailing the three worst performing wards for each Local Authority.

8.5 Case study: Wisbech

Wisbech is a town in the northeast of Cambridgeshire within Fenland District, near the border with Lincolnshire. It has shown high scores in the Environmental Justice Index at county level, so has been chosen as a case study to demonstrate the application of these indicators at a local scale.

Map 43 shows the overall Environmental Justice Index (EJI) for Wisbech in two forms. The top panel shows it averaged by ward (as Map 42), and the bottom panel shows the non-averaged version based on the raw data. The ward version is useful at highlighting broad areas on which to focus effort, although all of the wards fall into the highest category. Waterlees Village Ward is the highest scoring (worst) ward, with a score of 105.7, with almost identical scores for neighbouring Clarkson Ward (105.4) and Kirkgate Ward (103.7), highlighting these wards as areas for potential investment. The remaining wards to the south and west are slightly lower scoring, although still high.

For a more detailed picture, the non-averaged version of the EJI (Map 43, bottom panel) shows specific locations, including levels along roads and within the urban centre. The slightly lower values apparent in the centre of Wisbech occur due to Wisbech Park, which is the most significant public greenspace within the town and provides a number of public benefits.

Health and wellbeing

Map 44 shows the four health and wellbeing indicators for Wisbech. Three of these indicators are available at the level of Lower Super Output Areas (LSOA), which provides greater detail than ward level, and all are shown in raw data form, before converting to deciles for use in the EJI. Most of the indicators show high values within the centre of Wisbech (or low in the case of IMD), in particular childhood obesity and SAMHI (Small Area Mental Health Indicator). The long-term health problem or disability indicator, and IMD show more variation. Long-term health problem or disability values are generally higher in the north of Wisbech and get slightly lower in the south. IMD values show highest levels of deprivation (low scores) immediately to the east of the Nene and in the town centre. These indicators can be used to create a much more fine-scale picture of health and wellbeing across Wisbech. Clarkson, Waterlees Village and Peckover wards all show poor performance across the indicators.

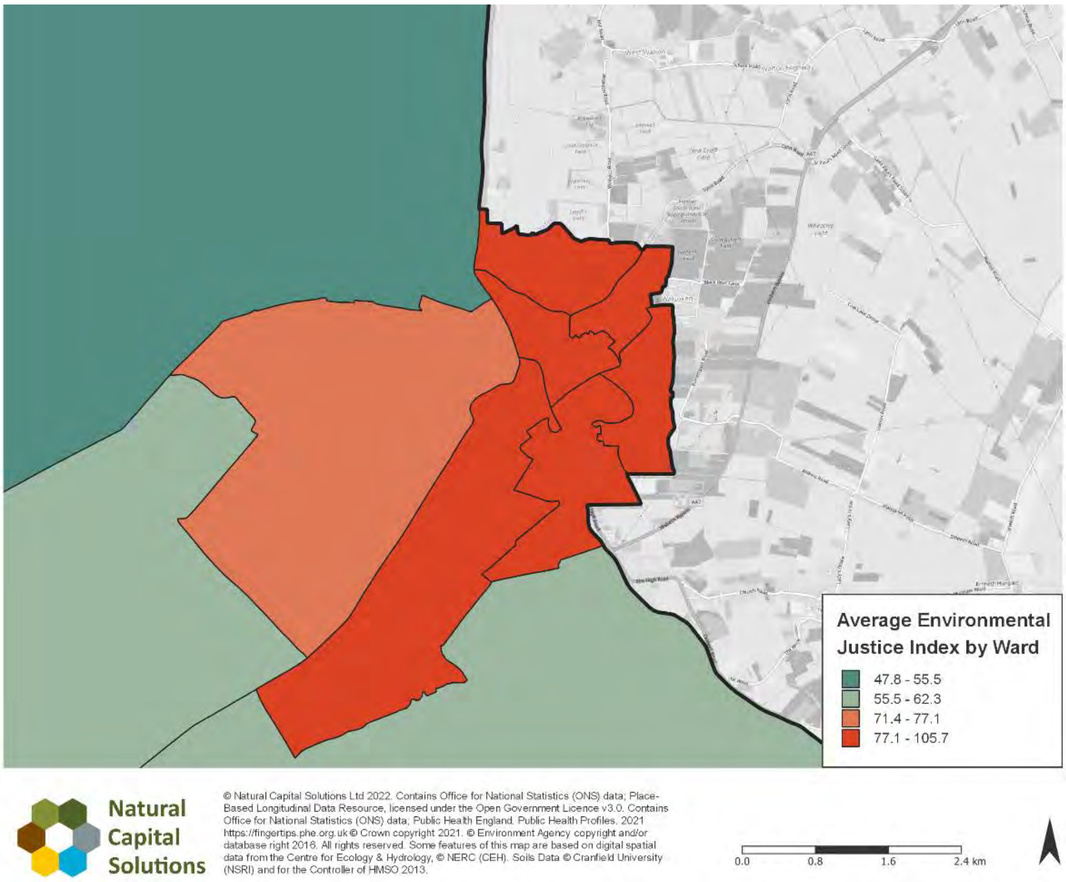
Environmental risk

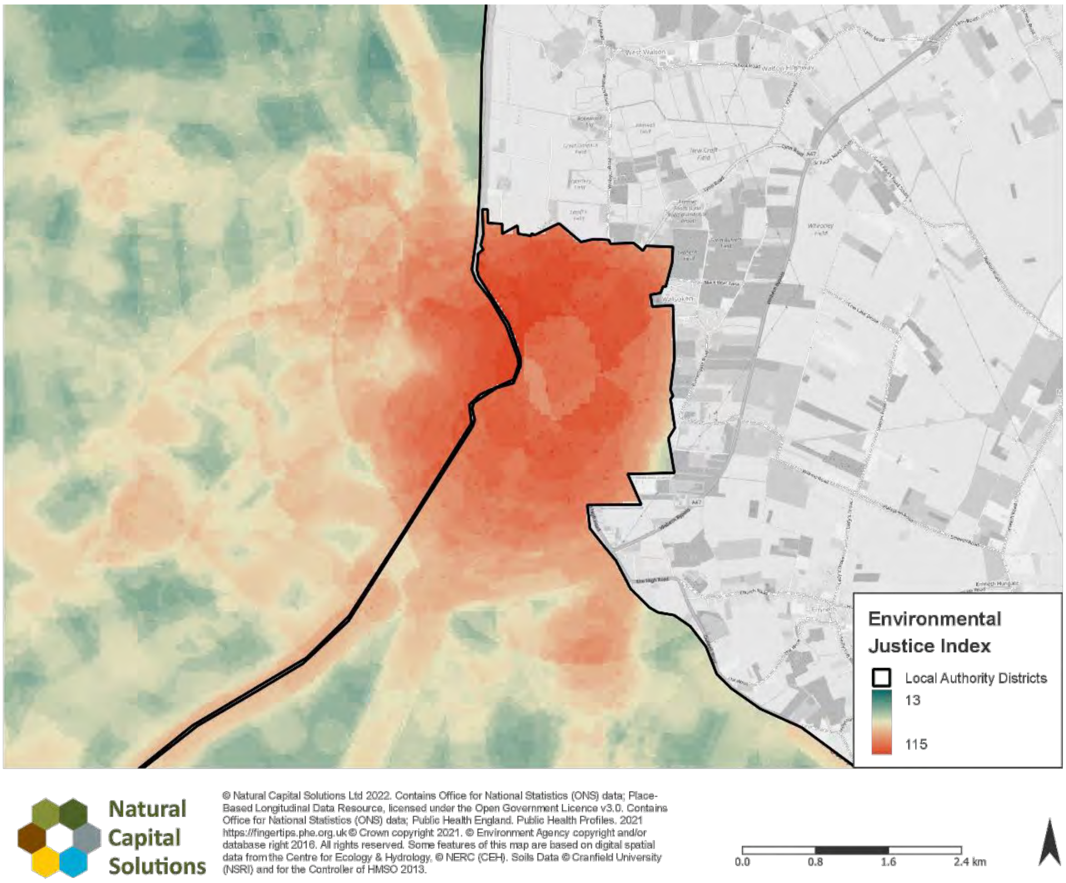
Map 45 shows the four environmental risk indicators for Wisbech in their raw data versions. Both the air pollution and noise pollution indicators are centred quite strongly along the main roads in the area, the A47 and A1101, with a larger buffer where the A1101 goes through the town centre. The air pollution indicator has a generally high value throughout the town centre. The local climate (urban heat island risk) indicator is also centred in the town, with a few pockets of risk further out in areas such as Elm and Leverington. Flood risk is higher immediately surrounding the River Nene, and continues to be medium risk across most of the area west of the river. Risk is mostly very low in the town centre. The areas at high risk are dotted along the west bank of the Nene.

Natural greenspace access and demand

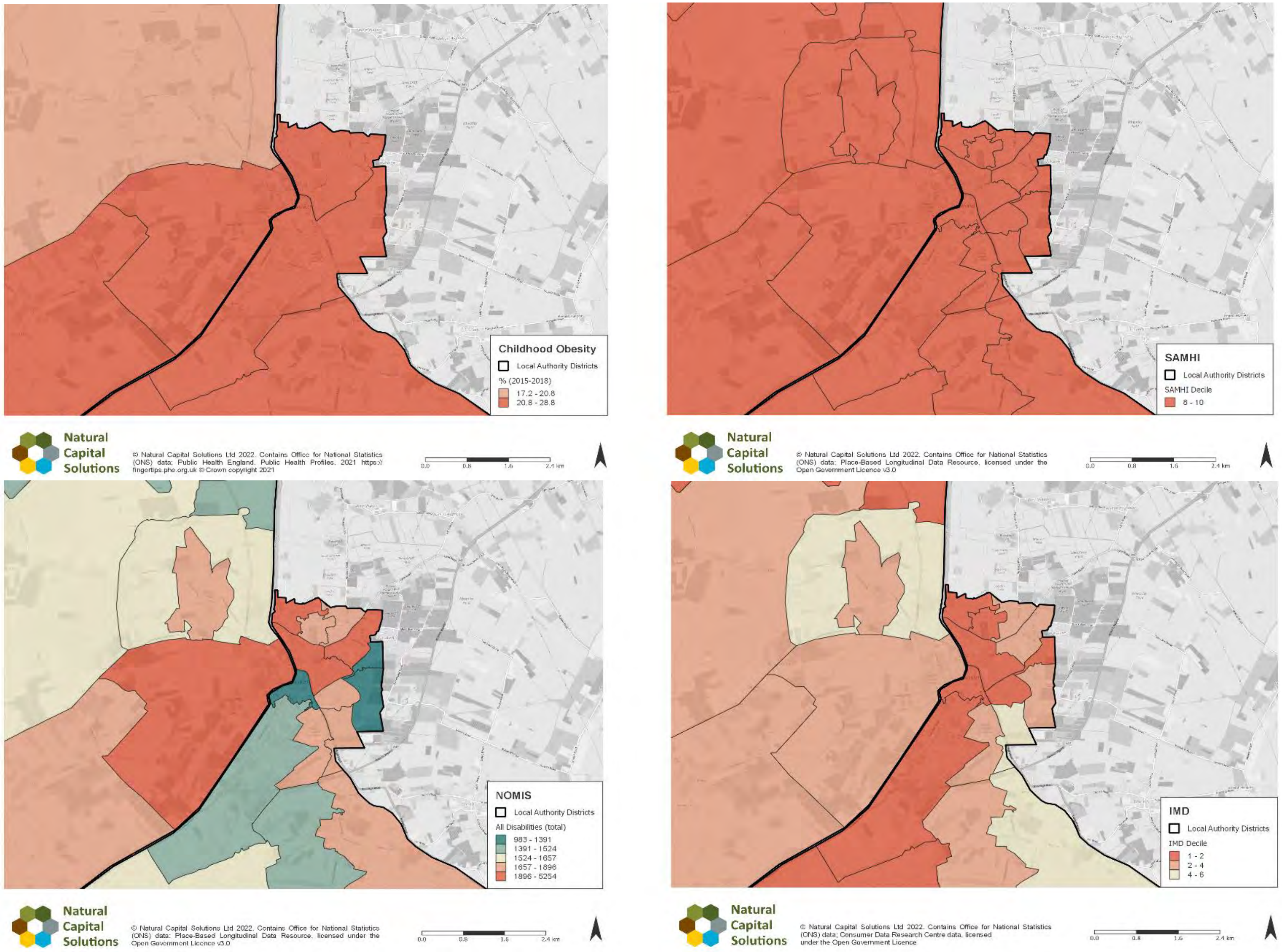
Map 46 shows the natural greenspace access and demand indicators for Wisbech. This consists of the accessible nature demand and ANGSt indicators. The accessible nature demand model shows that demand is highest in the centre of town, and there are some areas of high demand in outlying villages.

In the ANGSt indicator map, almost all of the area shown scores 4, which means that it does not meet any of the ANGSt criteria. There are buffers around the three largest green spaces which have a score of 3, meaning that they meet one of the criteria. There are currently no larger greenspaces in or around Wisbech, which would help to fulfil more ANGSt criteria. Combining the two indicators shows that current greenspace capacity is not meeting demand, and can highlight the best areas to target for investment in new greenspaces.

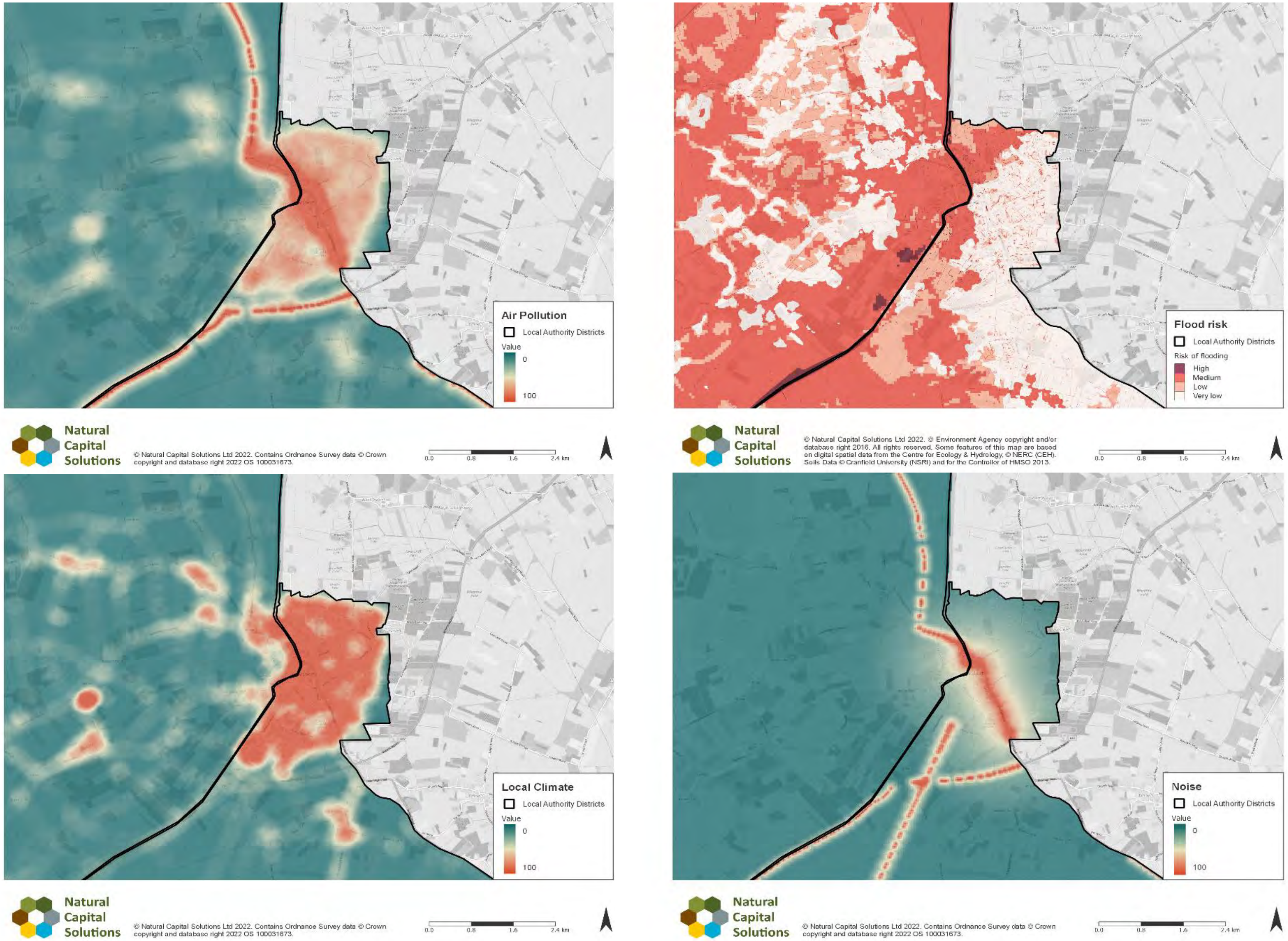




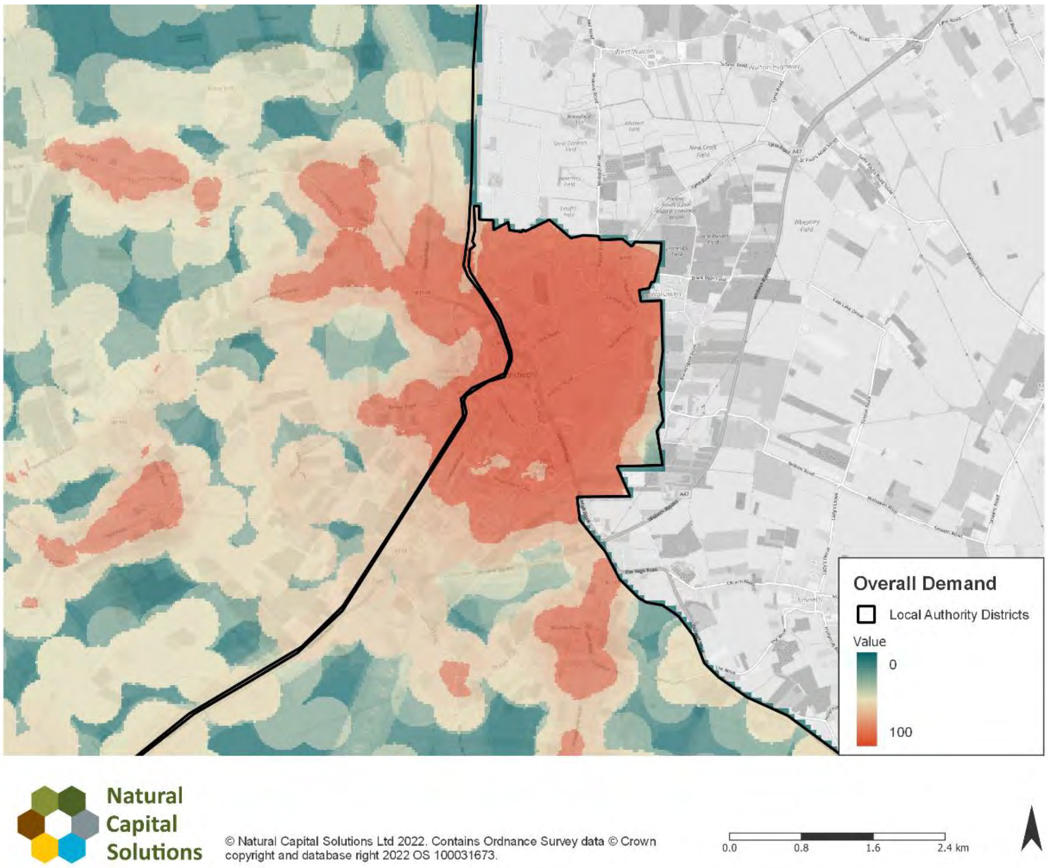
Map 43: Environmental Justice Index for Wisbech, shown as an average for each ward (top) and in full detail (bottom).

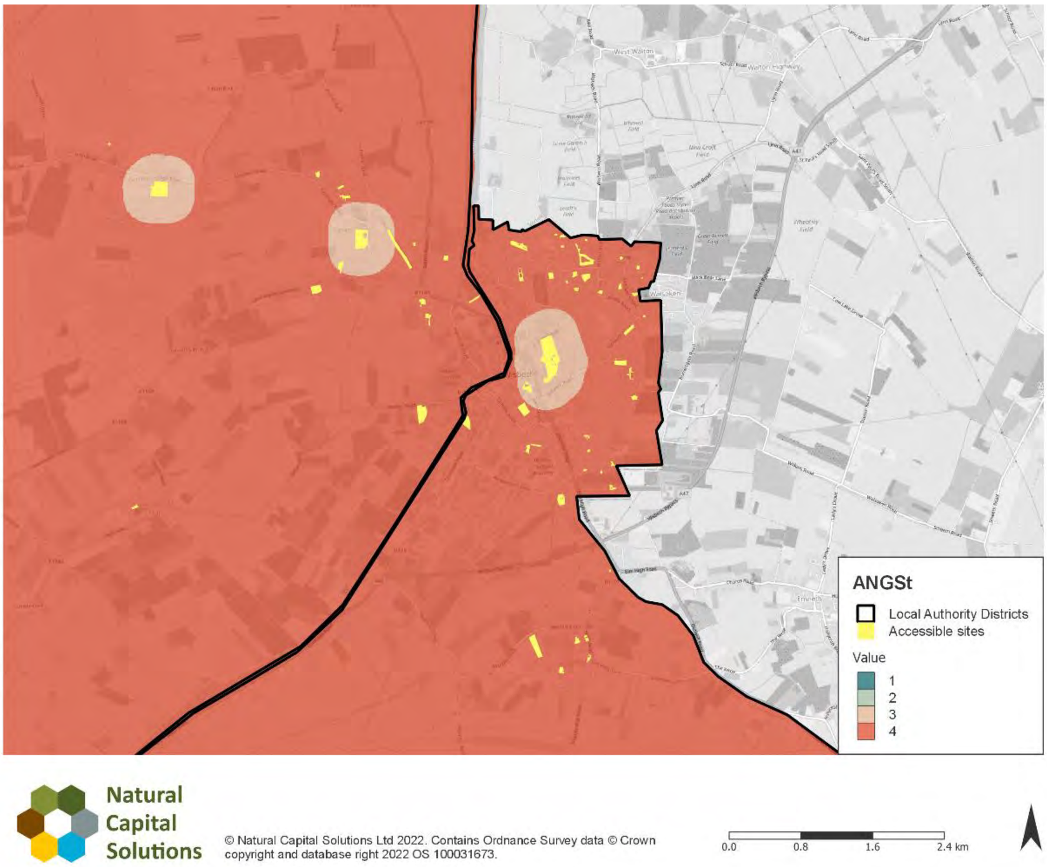


Map 44: Health and wellbeing indicators for Wisbech.



Map 45: Environmental risk indicators for Wisbech





Map 46: Natural greenspace access and demand indicators for Wisbech, showing accessible greenspace demand (top) and the ANGSt indicator (bottom).

9 Further applications and prioritising action

The natural capital assessment provides an extensive evidence base that has a wide range of applications. A small number of these are discussed below, focussing on applications directly related to enhancing greenspace provision, although many more uses are possible.

9.1 Growth and development

A key topic identified during the mapping process has been around the current provision of natural greenspace in relation to need. It would be ideal if these maps could be used to guide the creation of new greenspaces, and locating these in areas identified in the opportunity mapping would enable them to be situated in sites that delivered multiple additional benefits. However, often the best opportunities for the creation of entirely new greenspaces occurs through the development process, so it is important that planners and developers take into account the existing situation, alongside the immediate need for greenspace provision for the new development itself.

In Map 47, the top 3 Wards, within each Local Authority (shown in white), with the highest mean value for natural greenspace access and demand were selected and ranked from 1 to 3[30]. These are areas where there is currently high demand for access to natural greenspace and it is not currently being met by existing greenspace provision. The average natural greenspace access and demand value for each ward is shown with allocations overlaid. Note that these are the worst performing wards within each local authority, rather than across the whole of Cambridgeshire and Peterborough, hence in some LAs the identified wards are performing better than in others.

The worst performing areas are mostly centred around urban areas, and are particularly found around the outskirts of Cambridge. In Fenland District, the worst performing wards are around Wisbech, Chatteris and Whittlesey. Interestingly, in the Peterborough District the three worst performing wards are not within the centre of Peterborough as might be expected, and instead are more suburban or rural, but on the edge of the city. The centre of Peterborough actually performs very well in terms of greenspace access. In Huntingdonshire, the worst performing wards are around the settlements of St Neots, St Ives and Huntingdon. However, wards to the west of Huntingdon have very low demand for greenspace access. In East Cambridgeshire, two of the three wards are bordering South Cambridgeshire and are in closer proximity to Cambridge. The other one is within Ely. South Cambridgeshire has quite low greenspace access compared to other districts, and the worst performing ones are all to the northwest of Cambridge. In Cambridge City, the three worst performing wards are Arbury and Castle to the north, which border with the worst performing wards in South Cambridgeshire, and Queen Edith's to the south of the city.

This map can be used as a guide for development on existing allocations. Planners and developers working on allocations occurring in identified wards, or in other wards that are performing badly (shown in orange/red), should be advised that the area already has a deficit of natural greenspace, and its provision should therefore be a priority within new development plans. The detailed opportunity maps (Sections 6 and 7) can then be consulted to identify which parts of the allocation present the best opportunities to deliver multiple public benefits. The map could also be used to direct the placement of future allocations to best meet the natural greenspace needs of the population.

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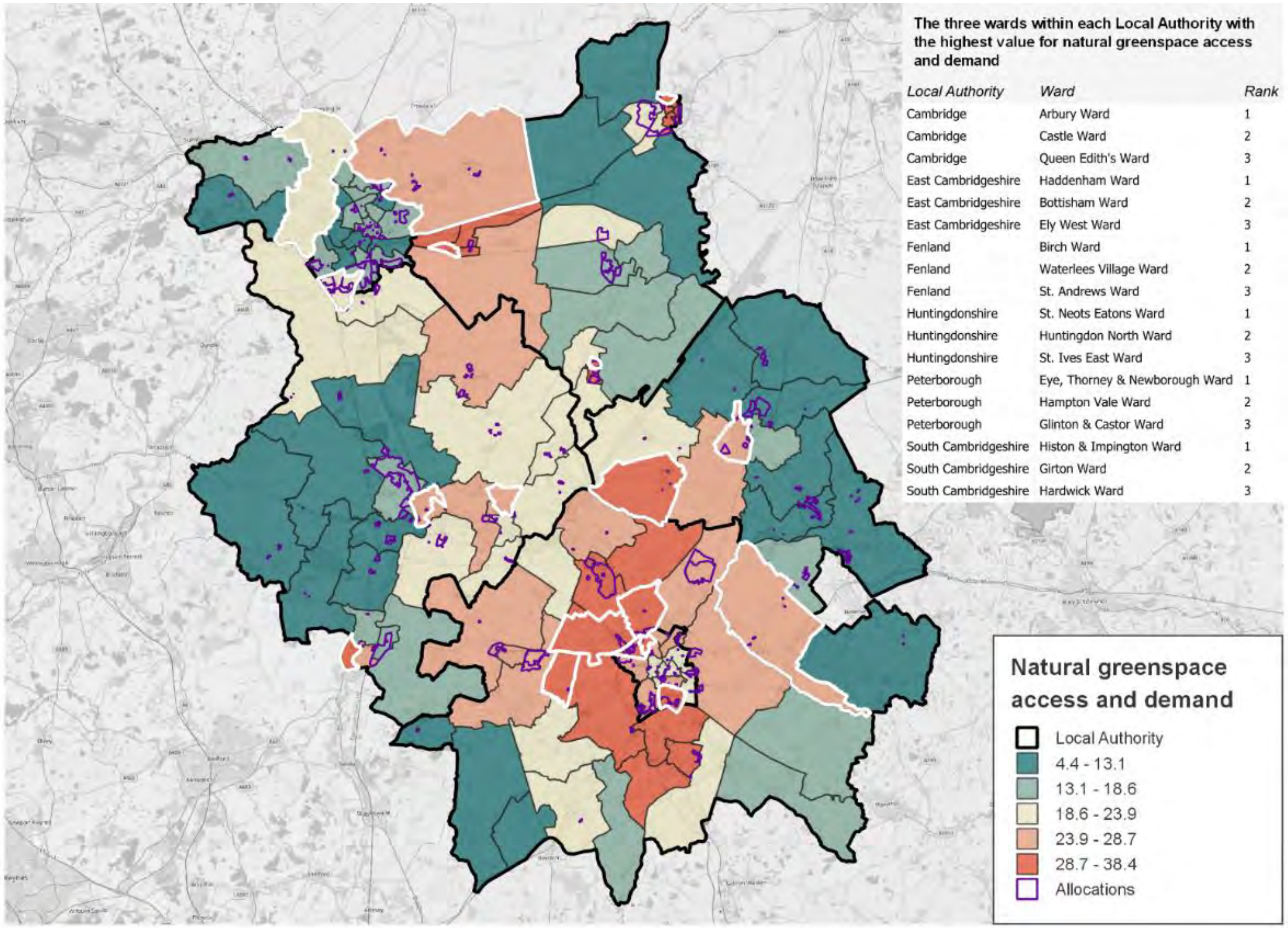
[30] Note that the underlying data presented here is the same as Map 41, but here we are presenting it with a specific application in mind, focussing on its application for the development process.



Local Authority	Ward	Rank
Cambridge	Arbury Ward	1
Cambridge	Castle Ward	2
Cambridge	Queen Edith's Ward	3
East Cambridgeshire	Haddenham Ward	1
East Cambridgeshire	Bottisham Ward	2
East Cambridgeshire	Ely West Ward	3
Fenland	Birch Ward	1
Fenland	Waterlees Village Ward	2
Fenland	St. Andrews Ward	3
Huntingdonshire	St. Neots Eatons Ward	1
Huntingdonshire	Huntingdon North Ward	2
Huntingdonshire	St. Ives East Ward	3
Peterborough	Eye, Thorney & Newborough Ward	1
Peterborough	Hampton Vale Ward	2
Peterborough	Glinton & Castor Ward	3
South Cambridgeshire	Histon & Impington Ward	1
South Cambridgeshire	Girton Ward	2
South Cambridgeshire	Hardwick Ward	3

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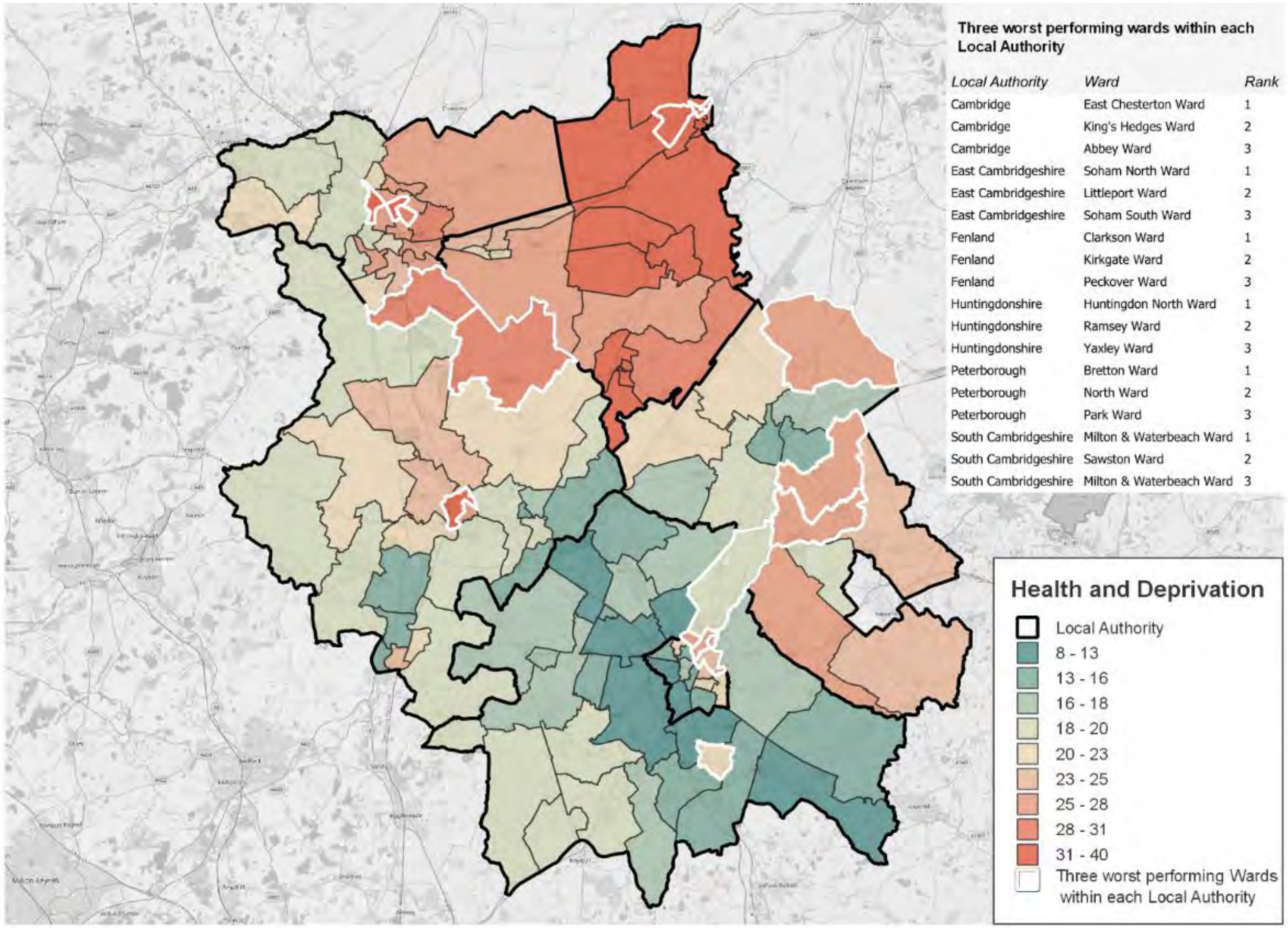
Map 47: Natural greenspace access and demand in Cambridgeshire. The three worst performing wards in each district are highlighted in white.



Natural Capital Solutions

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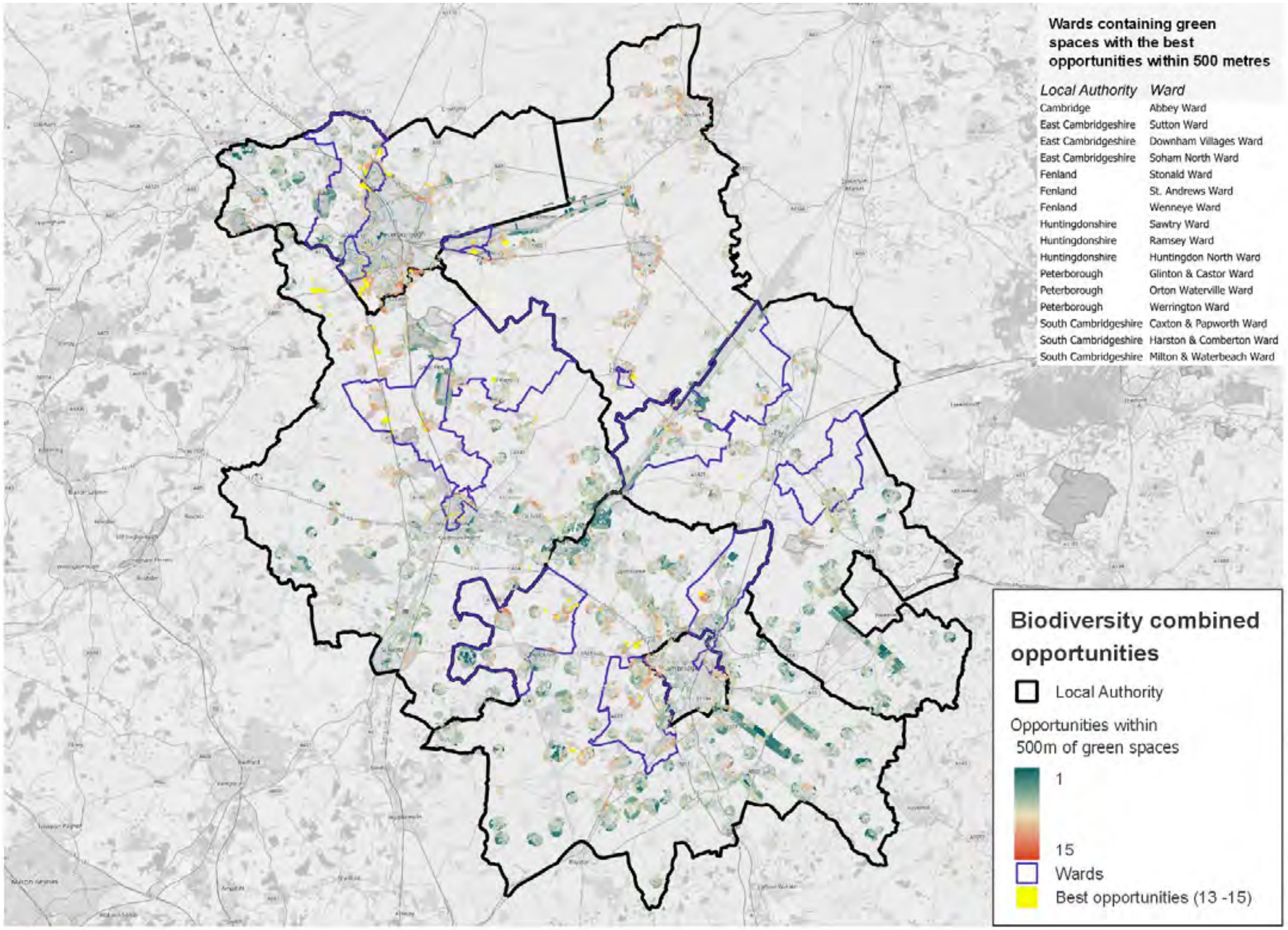
Map 48: Health and deprivation index for Cambridgeshire. The three worst performing wards in each Local Authority are highlighted in white.



Natural Capital Solutions

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Map 49: Combined biodiversity opportunities across Cambridgeshire. The best opportunities within local wards are highlighted in yellow.

9.2 Health and deprivation

Health and deprivation is another important driver in terms of planning investment in parks and greenspaces across the area. A health and deprivation indicator was developed as part of the Environmental Justice Index described in Section 8 and is further explored here. The average health and deprivation indicator value was calculated for each ward, as described in Section 8.1, and the three wards with the highest index score within each Local Authority were selected (shown in white and listed in the top right panel on Map 48). As before, these are the worst performing wards within each LA, so includes some wards (especially in South Cambridgeshire) that do not have particularly poor health and deprivation compared to the county as a whole, but are still the worst performing in that particular LA, so warrant attention. The worst performing wards in each district tend to be centred around the urban areas, in particular Peterborough, Wisbech, Ramsey, and Huntingdon. In East Cambridgeshire the worst performing wards are around Soham and Littleport, which are relatively small towns. The highlighted wards in Cambridge City and South Cambridgeshire are almost all to the northeast of central Cambridge, with the exception of Sawston.

The map highlights those wards that suffer from the highest rates of health and deprivation relative to their area, so can be used to target wards for interventions. Interventions related to parks and greenspaces could focus on increasing the quality of the greenspaces so that they deliver greater benefits and attract more users, running programmes that encourage greater use of greenspaces and active health campaigns, along with green social prescribing.

9.3 Biodiversity and the greenspace network

Enhancing biodiversity through the greenspace network is another key area of interest. The opportunity mapping presented in Sections 6 and 7, particularly the combined opportunity maps, can be used to highlight the best locations to create new habitats that will deliver biodiversity benefits, alongside a range of further benefits. This can be achieved either through the creation of new greenspaces or through habitat enhancement at existing sites. To allow further targeting of where this effort should be focussed, we have created a new map based on the combined opportunity mapping, but concentrating on opportunities that are in or close to existing parks. Opportunities in Map 49 are therefore restricted to the existing greenspace network, or within 500m of the edge. We also highlight in yellow the best combined opportunities, which are those with a score of 13-15, hence capable of delivering multi-functional benefits. As before, the three wards offering the greatest amount (m^2) of these high performing opportunity areas within each Local Authority are highlighted on the map and listed in the top right panel.

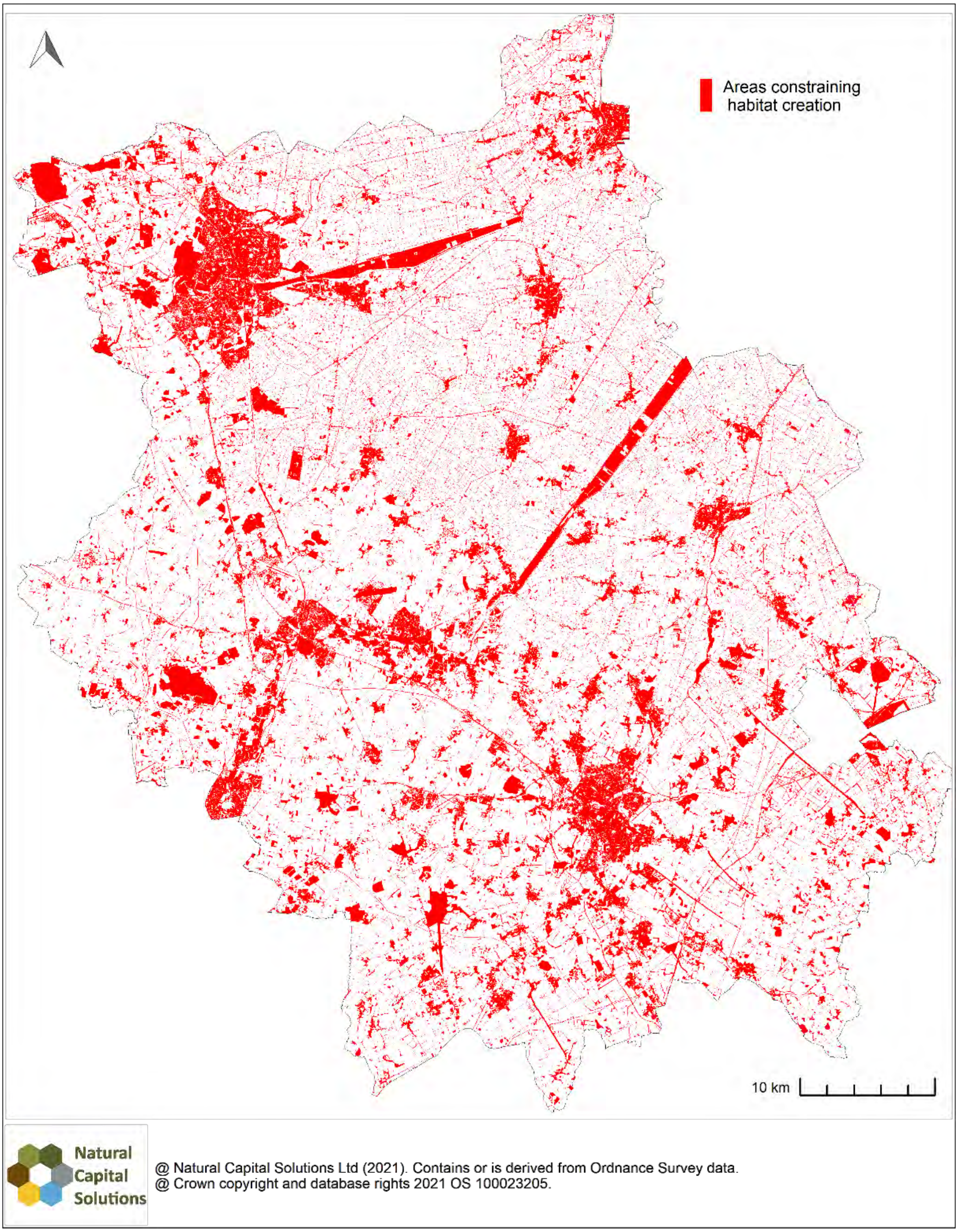
The largest areas of high opportunity are in the northwest of the county (Map 49), with several surrounding the city of Peterborough, especially to the west, and also close to Whittlesey and the Nene Washes (in Fenland District). High scoring opportunity areas are also present in all the other LAs, although tend to be scattered in a number of different locations. Likewise, the wards with the best opportunities are also spread around the LAs.

9.4 Towards a Local Nature Recovery Strategy (LNRS)

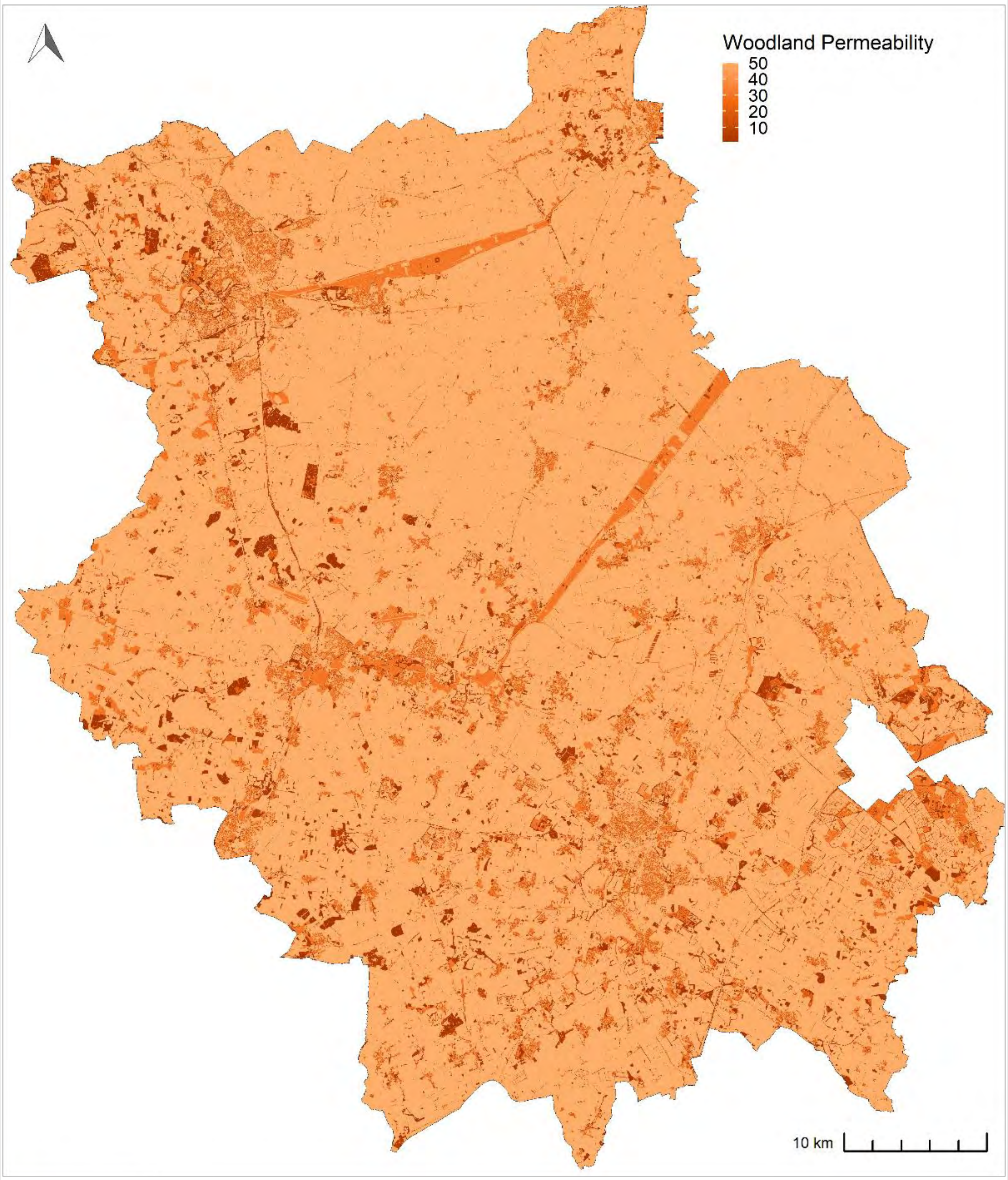
The habitat opportunity mapping completed for Cambridgeshire provides a sound and scientifically robust approach to identifying a Nature Recovery Network for the region, a key component of an LNRS. We have presented an extensive range of potential opportunities to create new habitat to extend existing semi-natural habitat networks in Cambridgeshire. These maps provide the basis from which to begin to explore what a Nature Recovery Network in Cambridgeshire might look like. It is not a blueprint but a guide to explore real opportunities. It is based on the biodiversity network mapping (Section 6.2) 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 Cambridgeshire, 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, hence any areas suggested for habitat creation will require ground-truthing before implementation.

The process of creating a Local Nature Recovery Strategy (LNRS) for nature recovery necessarily needs to involve multiple stakeholders. Each stakeholder will have their own interests and priorities, so a process needs to guide all involved towards a shared vision for the region. A series of workshops will be required to build a vision for the area, along with specific objectives and actions, based on existing policies, initiatives, projects and challenges, and using the mapped evidence base developed here. These objectives and actions can then be used as a methodology that guides the prioritisation of the opportunities for habitat creation and restoration to enhance biodiversity and deliver multiple benefits, creating both a Nature Recovery Network map and a strategy to deliver it.

Annex A: Additional opportunity maps

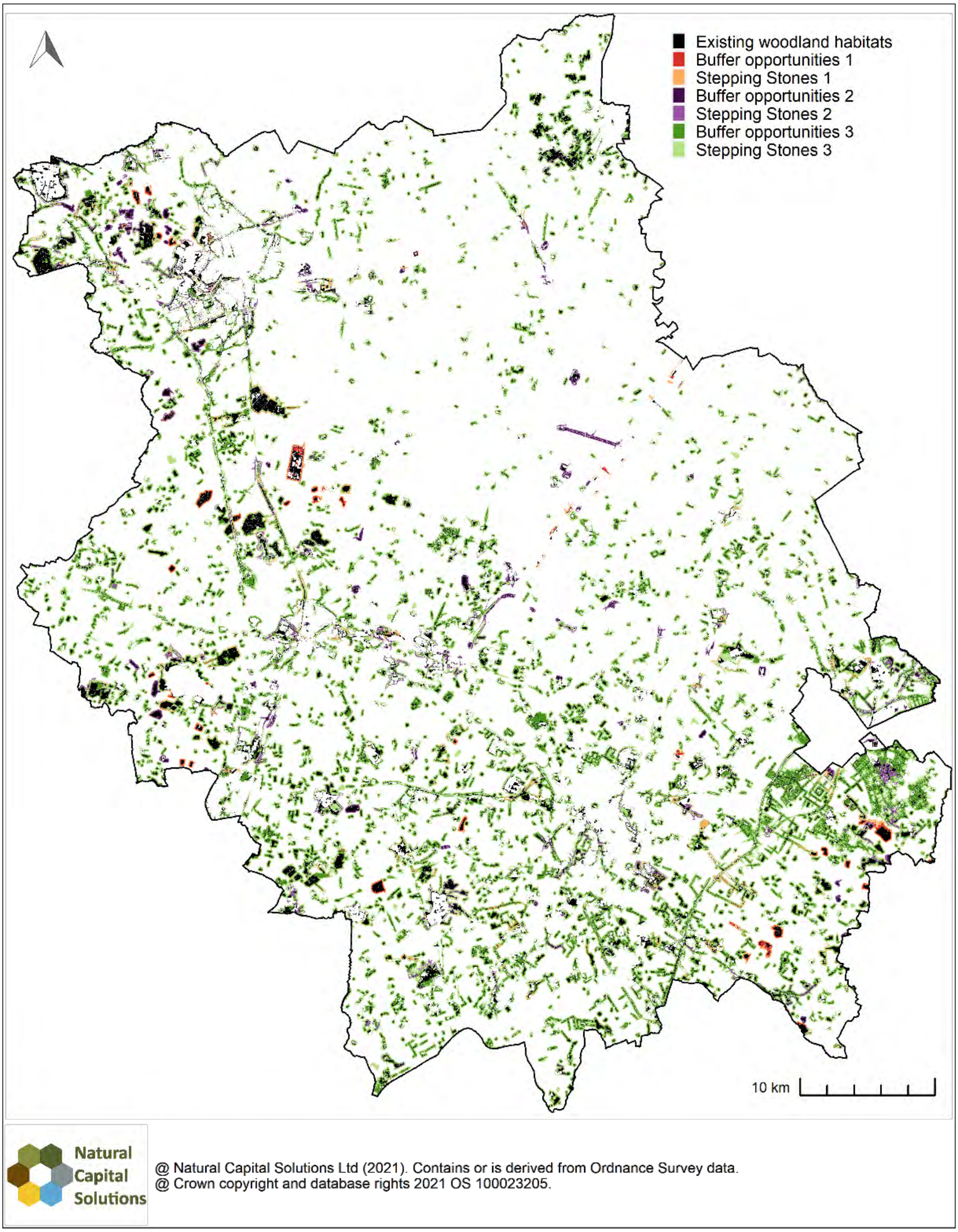


Map A1: The constrained areas taken into account during habitat opportunity mapping across Cambridgeshire.

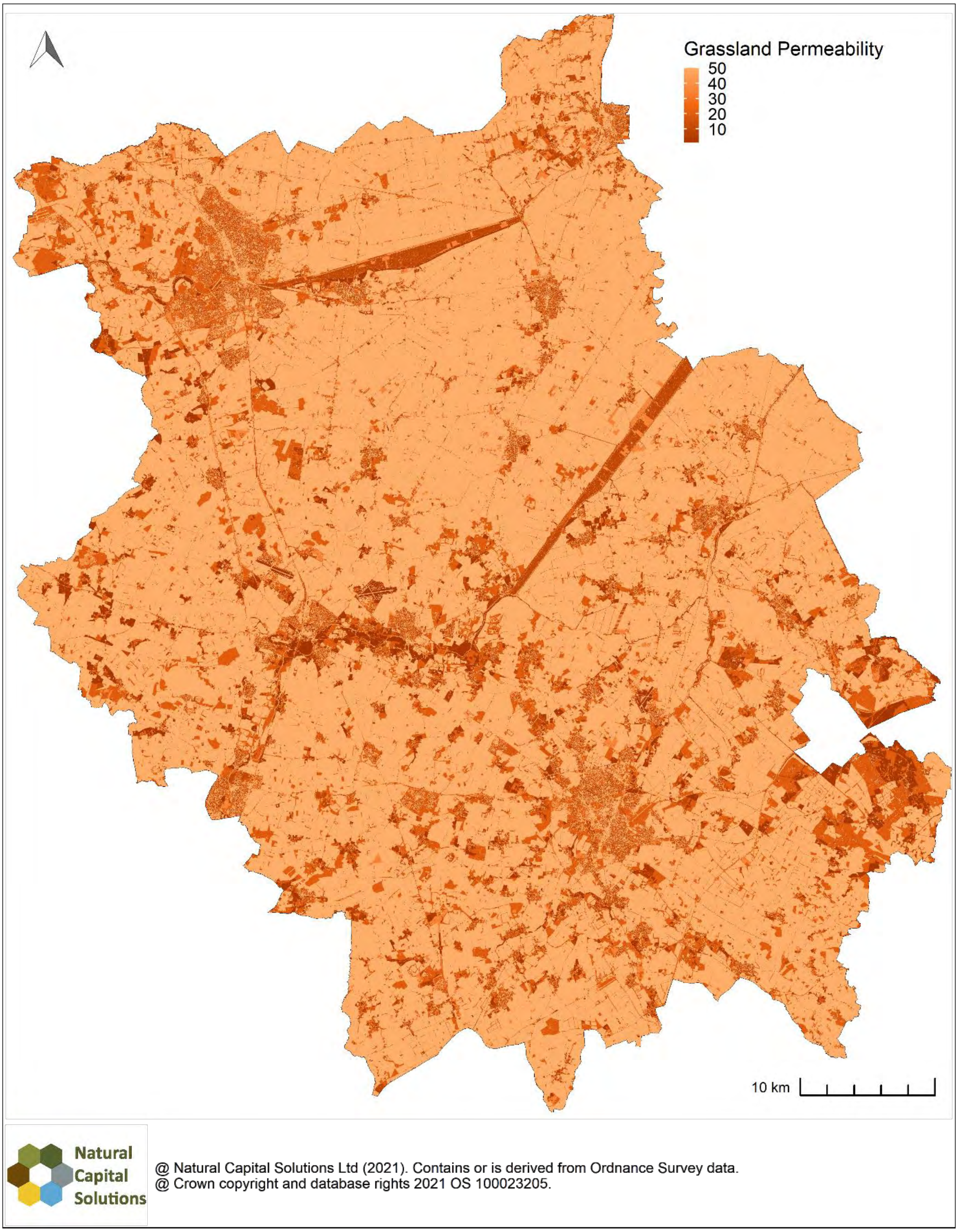


Natural Capital Solutions

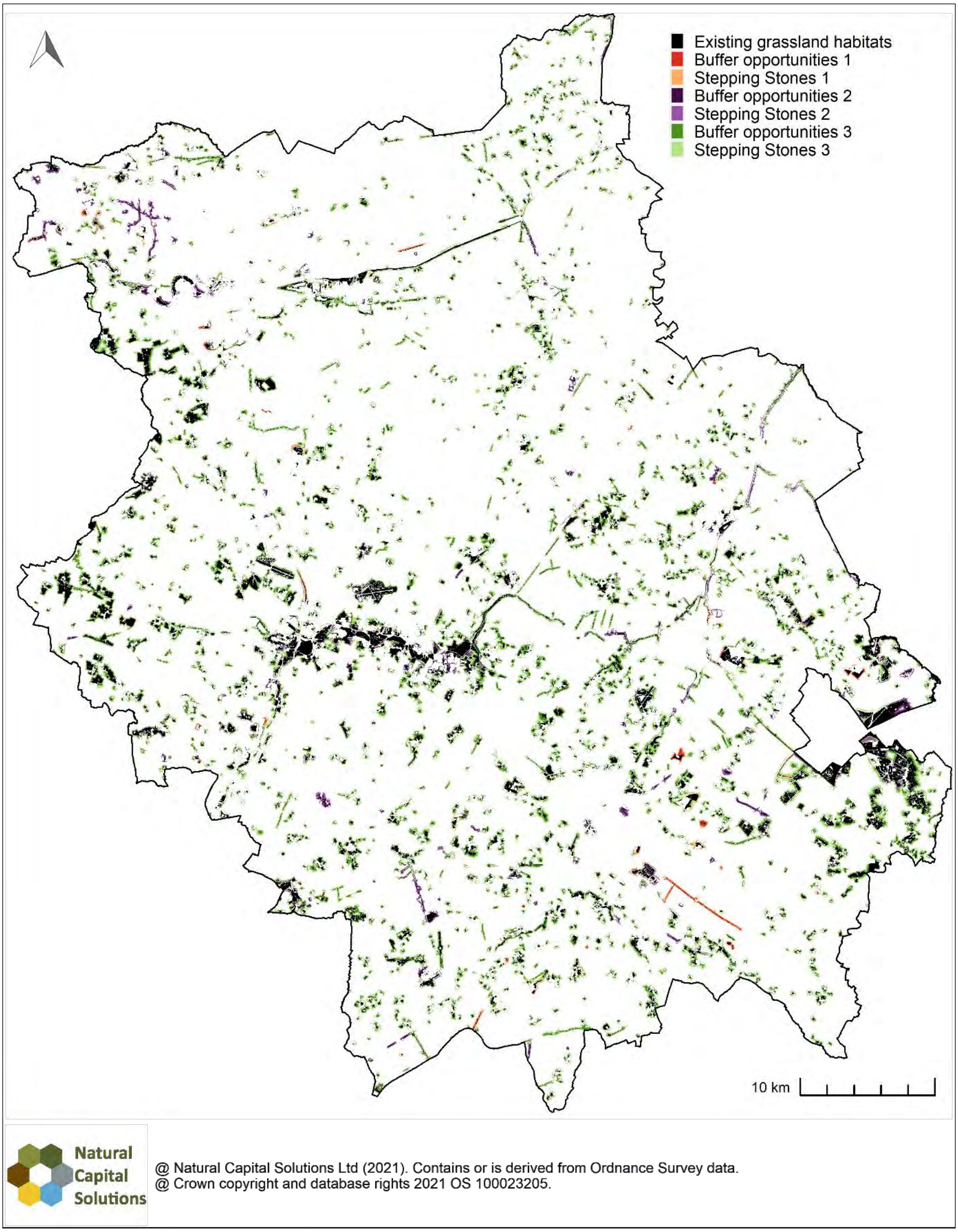
Map A2: Landscape permeability for typical broadleaved and mixed woodland species across Cambridgeshire.



Map A3: Broadleaved and mixed woodland opportunity zones across the study area (not field based).

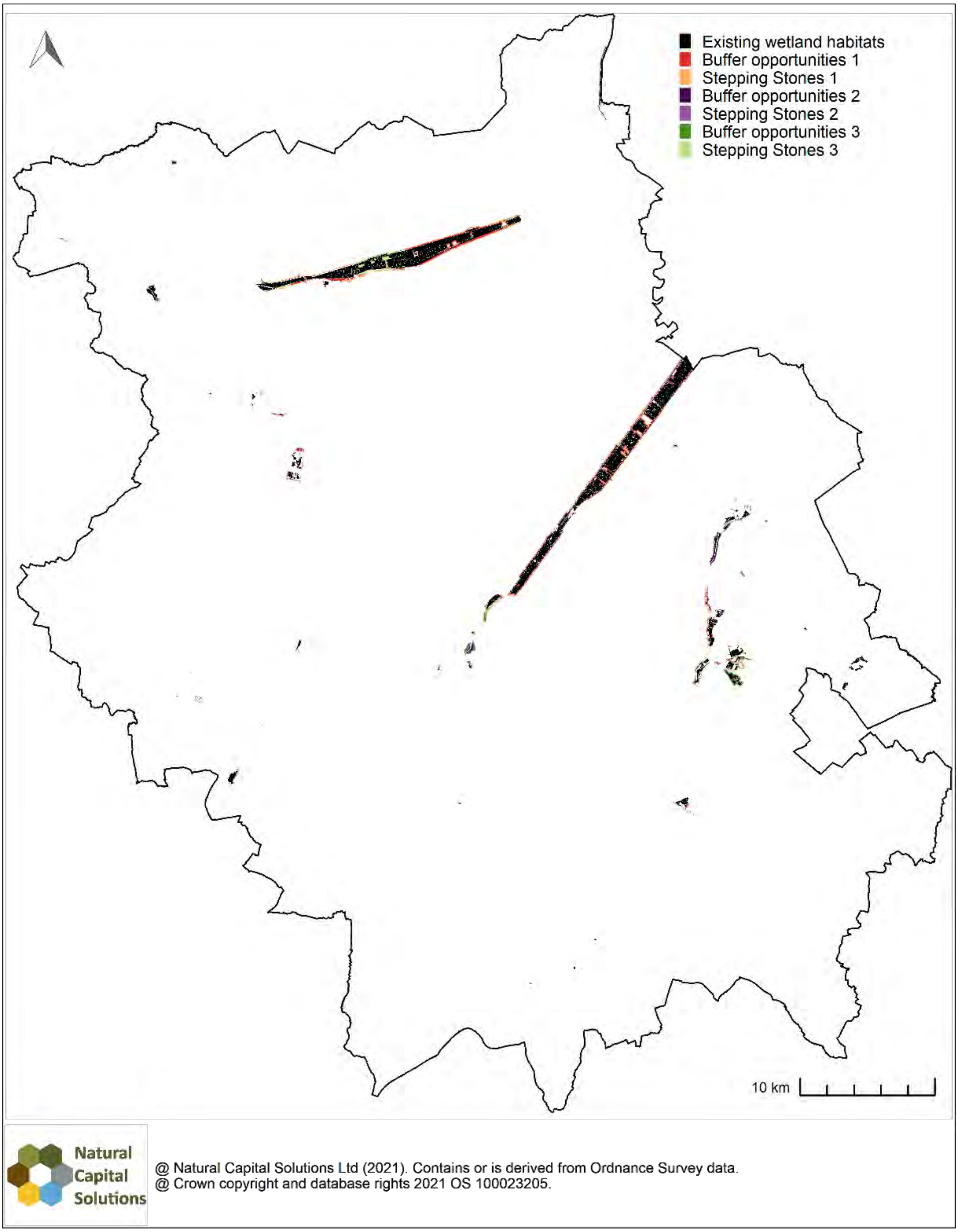


Map A4: Landscape permeability for typical semi-natural grassland species across Cambridgeshire.

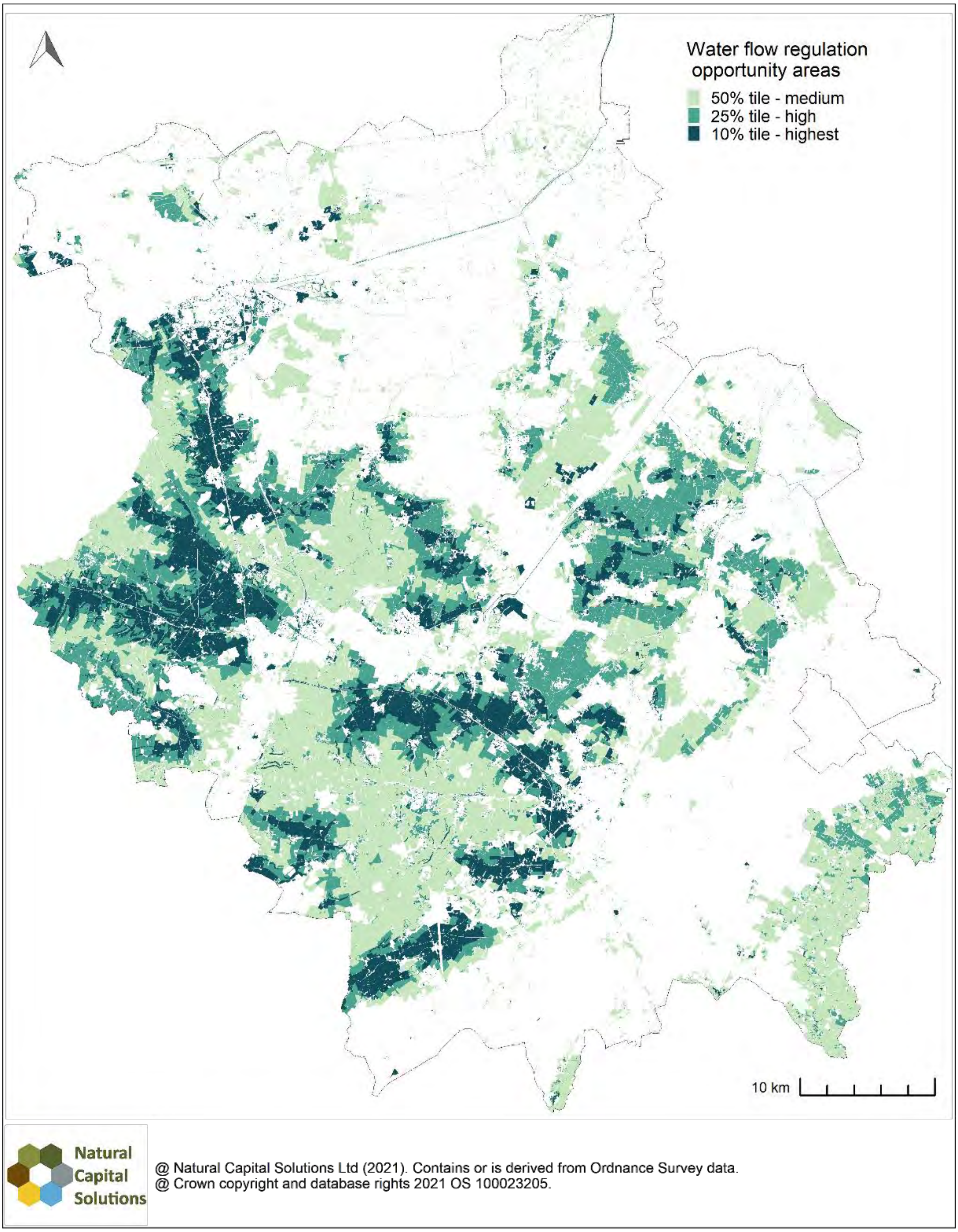


Map A5: Semi-natural grassland opportunity zones across the study area (not field based).

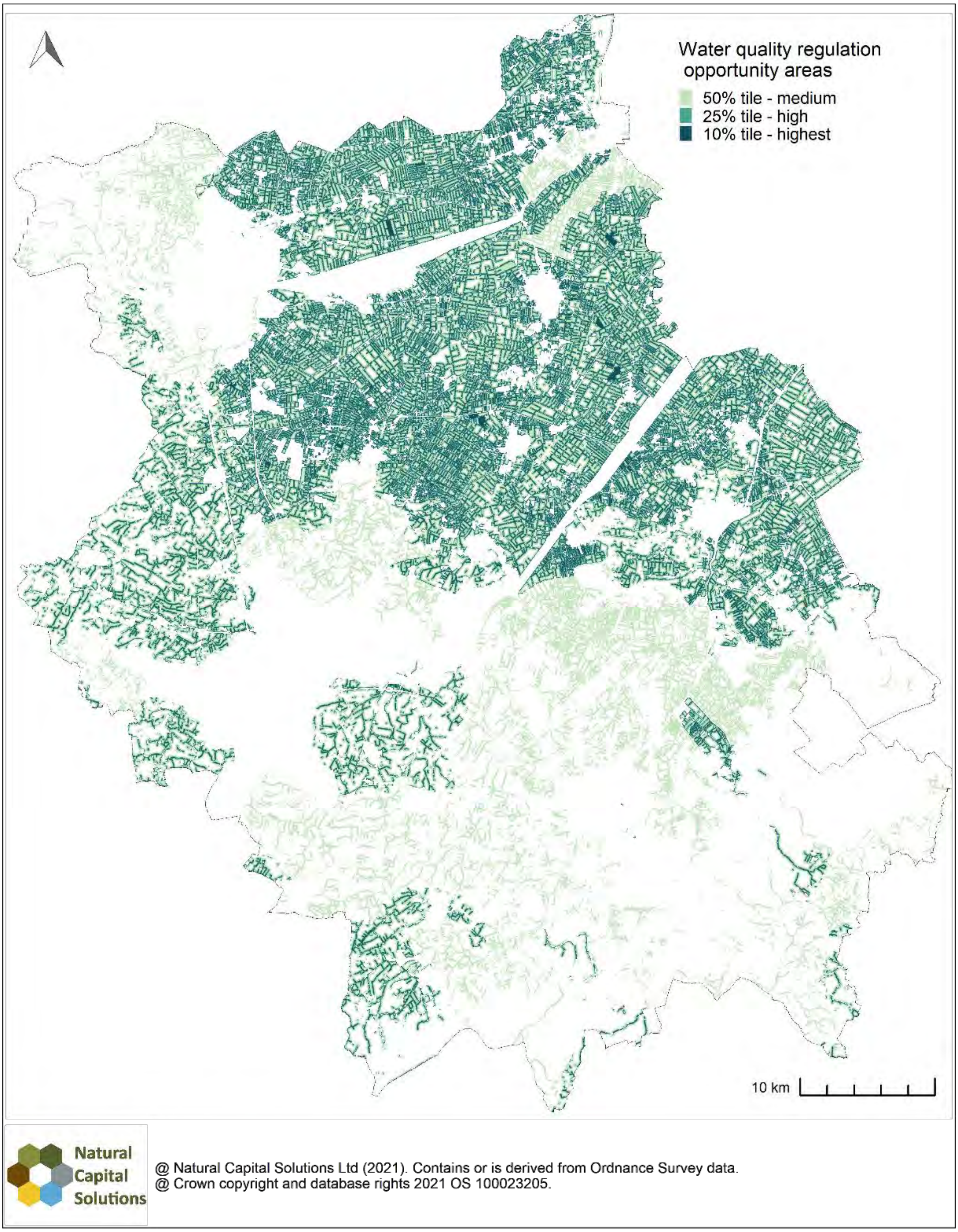
Map A6: Landscape permeability for typical lowland wetland and wet grassland species across Cambridgeshire.



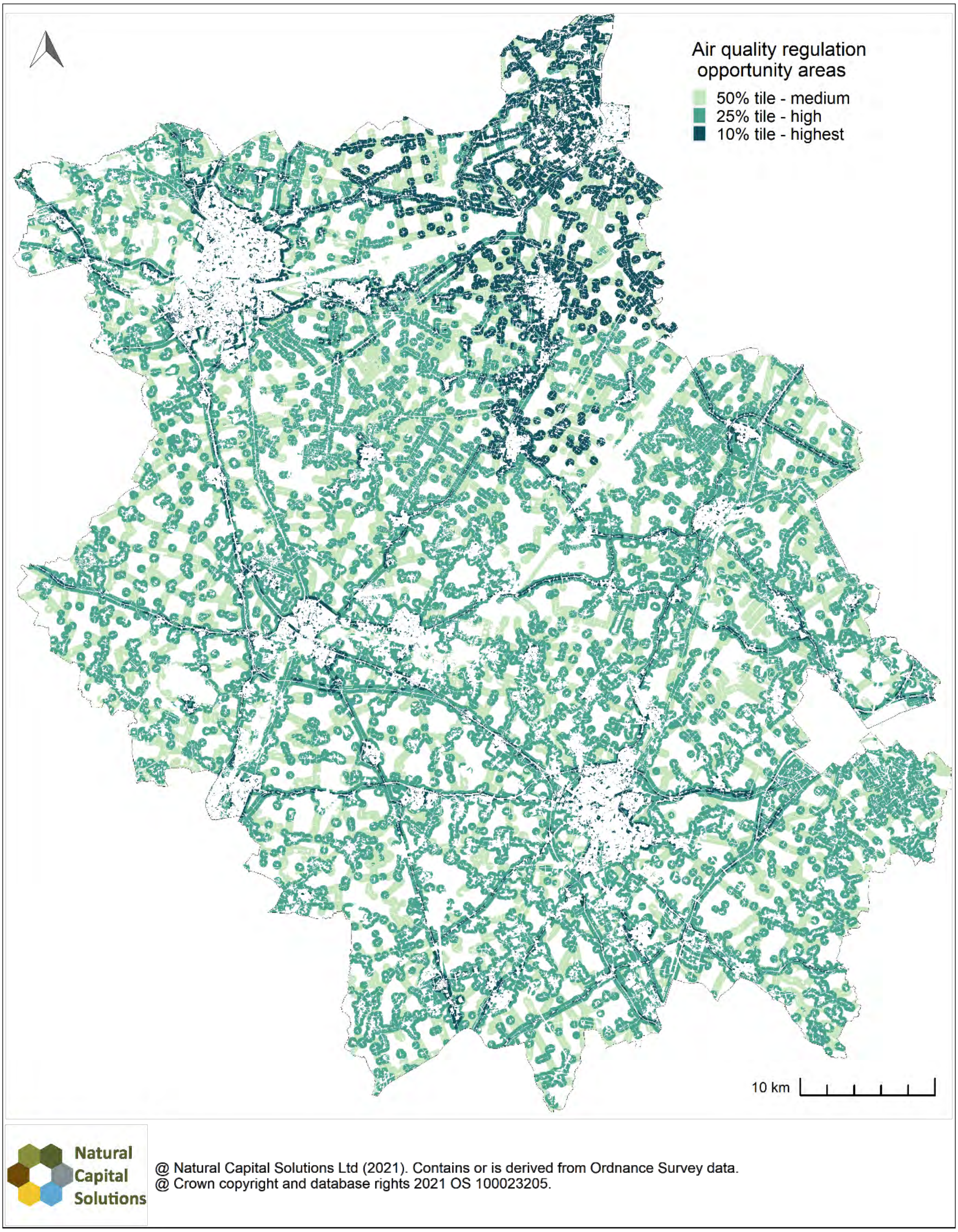
Map A7: Lowland wetland and wet grassland opportunity zones across the study area (not field based).



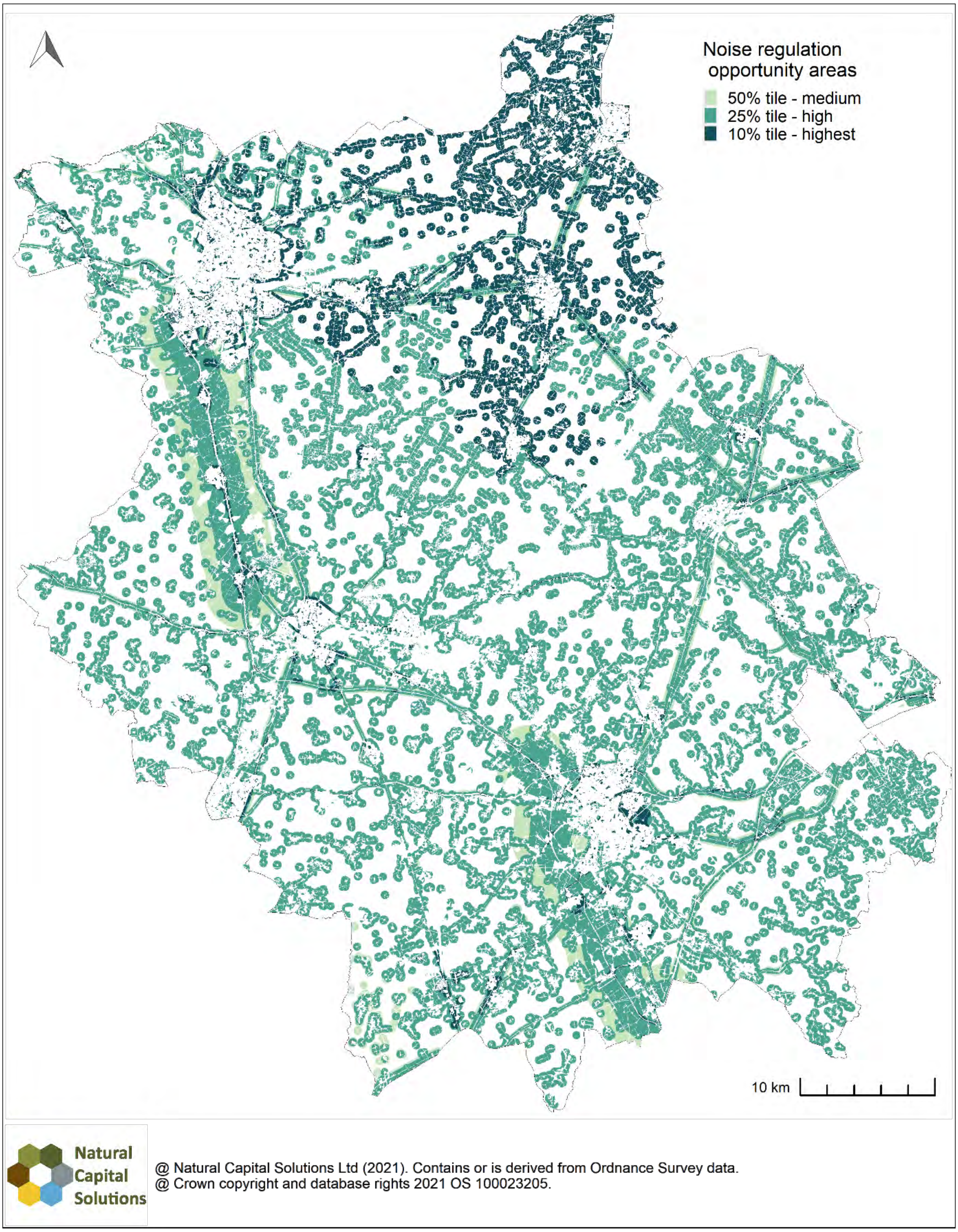
Map A8: Water flow regulation opportunity areas across the study area.



Map A9: Water quality regulation opportunity areas (unweighted) across the study area.

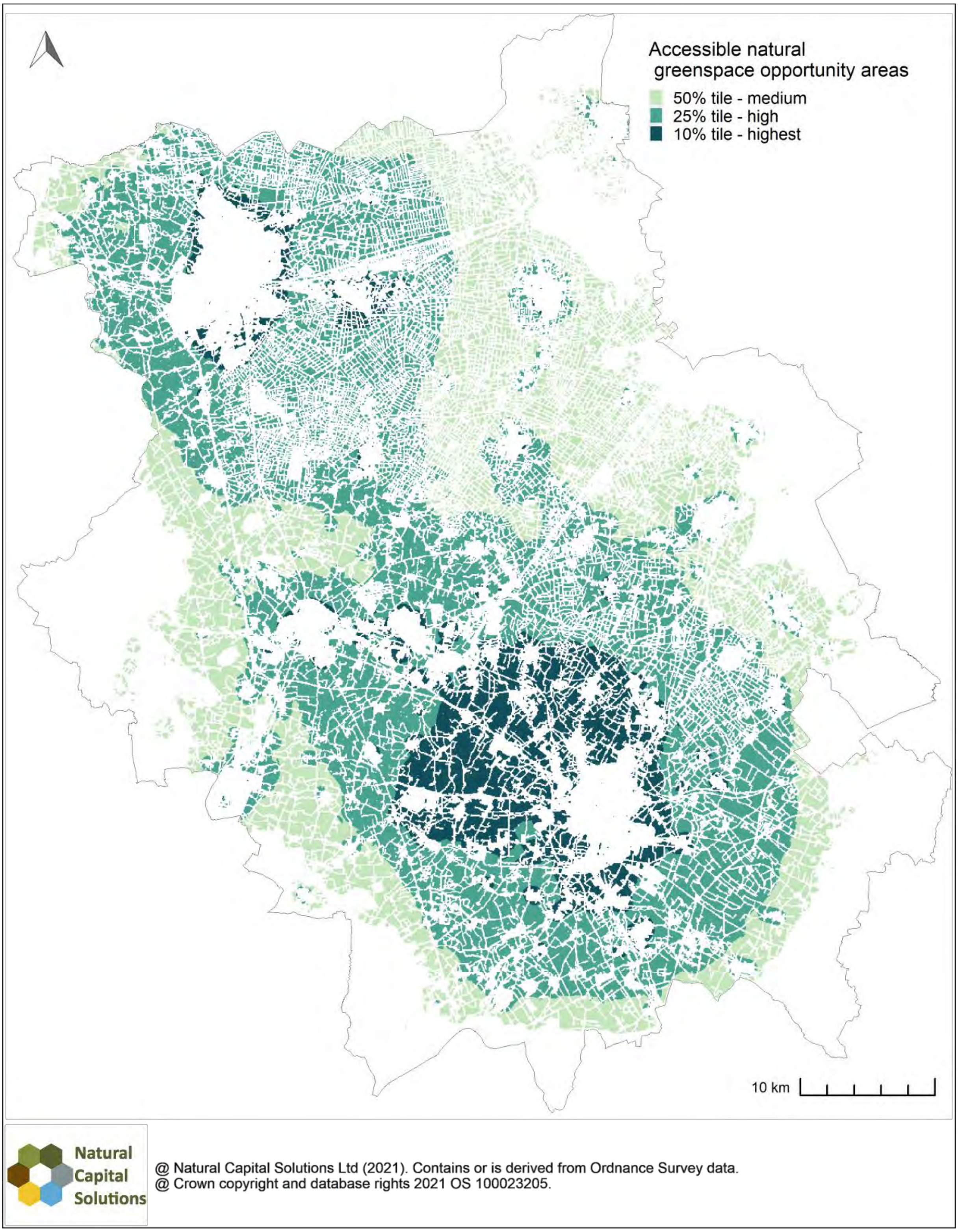


Map A10: Air quality regulation opportunity areas across the study area.



Map A11: Noise regulation opportunity areas across the study area.

Map A12: Local climate regulation opportunity areas across the study area.



Map A13: Accessible natural greenspace opportunity areas (unweighted) across the study area.

Annex B: Environmental Justice index – datasets and maps

Health and deprivation indicator datasets

Childhood obesity

Childhood obesity data was obtained from the NHS National Child Measurement Programme website: https://digital.nhs.uk/services/national-child-measurement-programme/. The percentage of childhood obesity (from 2015-2018), amongst the child population, for each Middle Super Output Area (MSOA) was converted to deciles (1-10). Higher percentages of childhood obesity were allocated to higher deciles.

Index of Multiple Deprivation

The most recent IMD data (2019) was downloaded from the gov.uk website: https://www.gov.uk/guidance/english-indices-of-deprivation-2019-mapping-resources. The dataset is at Lower Super Output Area (LSOA) scale, and those within the Cambridgeshire and Peterborough areas were selected. The 'IMD Decile' attribute, which scales areas from most deprived (1) to least deprived (10), was selected. This attribute was inverted to ensure the highest values were associated with the most deprived LSOAs.

Long-term health problem or disability

The long-term health problem or disability dataset (2011) was accessed from the nomis website: https://www.nomisweb.co.uk/census/2011/qs303ew. Data for Cambridgeshire and Peterborough were downloaded, and the 'All disabilities' attribute was converted to deciles (1-10). The highest deciles indicate the LSOAs with the highest number of long-term health problems or disabilities amongst the population.

Small Area Mental Health Indicator (SAMHI)

The SAMHI data set was accessed from the Place-based Longitudinal Data Resource website: https://pldr.org/dataset/2noyv/small-area-mental-health-index-samhi. The 2019 SAMHI index values, for the LSOAs within Cambridgeshire and Peterborough, were converted to deciles (1-10). The highest deciles indicate the LSOAs with the highest values of the SAMHI combined data on mental health, which includes: NHS-Mental health-related hospital attendances, Prescribing data – Antidepressants, QOF - depression, and DWP - Incapacity benefit and Employment support allowance for mental illness.

Environmental risk indicator datasets

Air pollution risk

Air pollution risk is modelled based on two indicators of air pollution sources: log distance to roads and percentage cover of sealed surfaces. The scores for both indicators were normalised and combined with equal weighting, and then projected on a 0 to 100 scale relative to values present within the study area (map for Cambridgeshire shown below). To create the environmental risk indictor, the dataset was first converted to deciles (1-10) before combining with the other environmental risk indicators, with higher deciles representing higher risk.

Urban heat island (local climate) risk

There is a strong correlation between the strength of the urban heat island effect and the proportion of sealed surfaces. Risk was therefore modelled based on this measure, and scaled on a 0-100 scale. For use in the environmental risk indicator, the dataset was converted to deciles (1-10) with the higher deciles representing higher risk (greater temperatures).

Noise pollution risk

Transport networks are a primary source of noise pollution and the distances over which noise pollution occurs increases with increasing road traffic volume. The area within which noise pollution may be experienced was mapped by calculating the inverse logarithm for the distance to different classes of roads and railways. Maximum search distances were used, based on Defra noise modelling for Cambridgeshire. The dataset was converted to deciles (1-10) with the higher deciles representing higher noise risk.

Flood risk

The flood risk data was obtained from the Environment Agency via the Defra Data Services Platform https://environment.data.gov.uk/. The dataset classifies flood risk to high, medium, low, and very low. These categories were reclassified to allow compatibility with the deciles of the air pollution, noise pollution and local climate demand. High flood risk areas were assigned a decile value of 10, medium flood risk areas a value of 5, low flood risk areas a value of 2, and very low flood risk areas a value of 0.

Natural greenspace access and demand indicator

Accessible nature demand

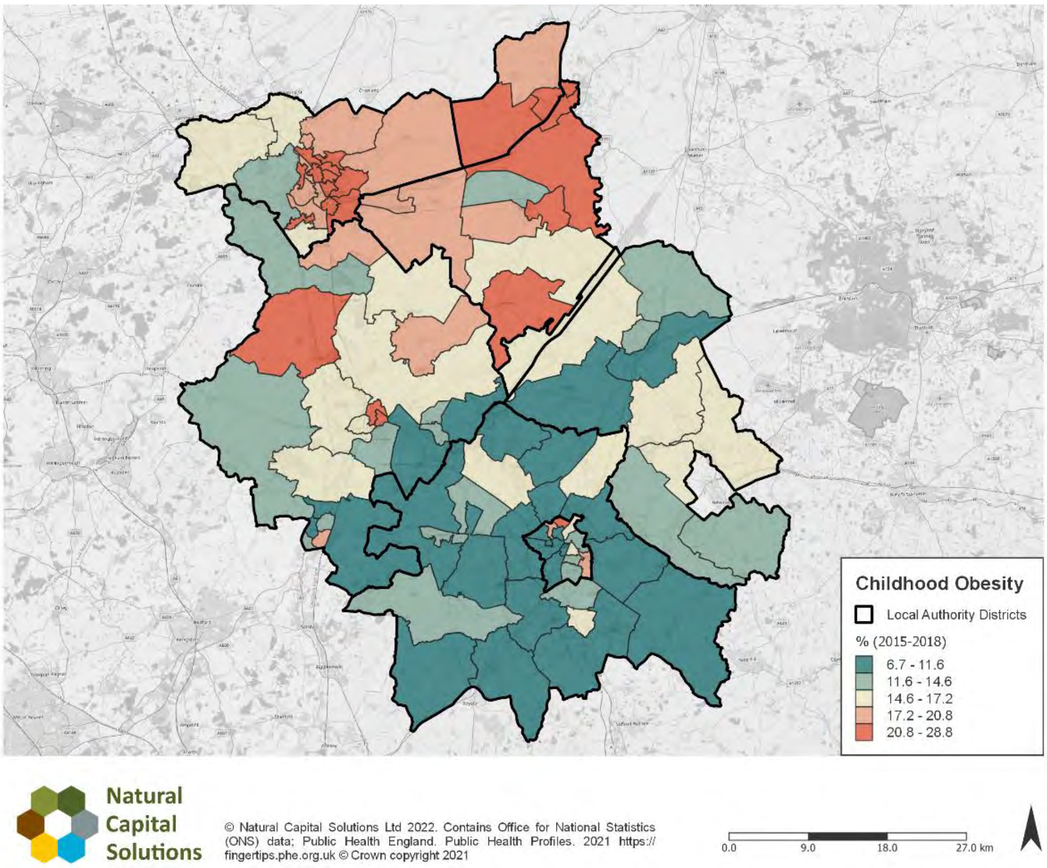
The accessible nature demand dataset was generated from the accessible nature demand ecosystem service methodology (see Section 3.14 for further details). The dataset was converted to deciles (1-10) with the higher deciles representing higher demand.

Accessible Natural Greenspace Standards (ANGSt)

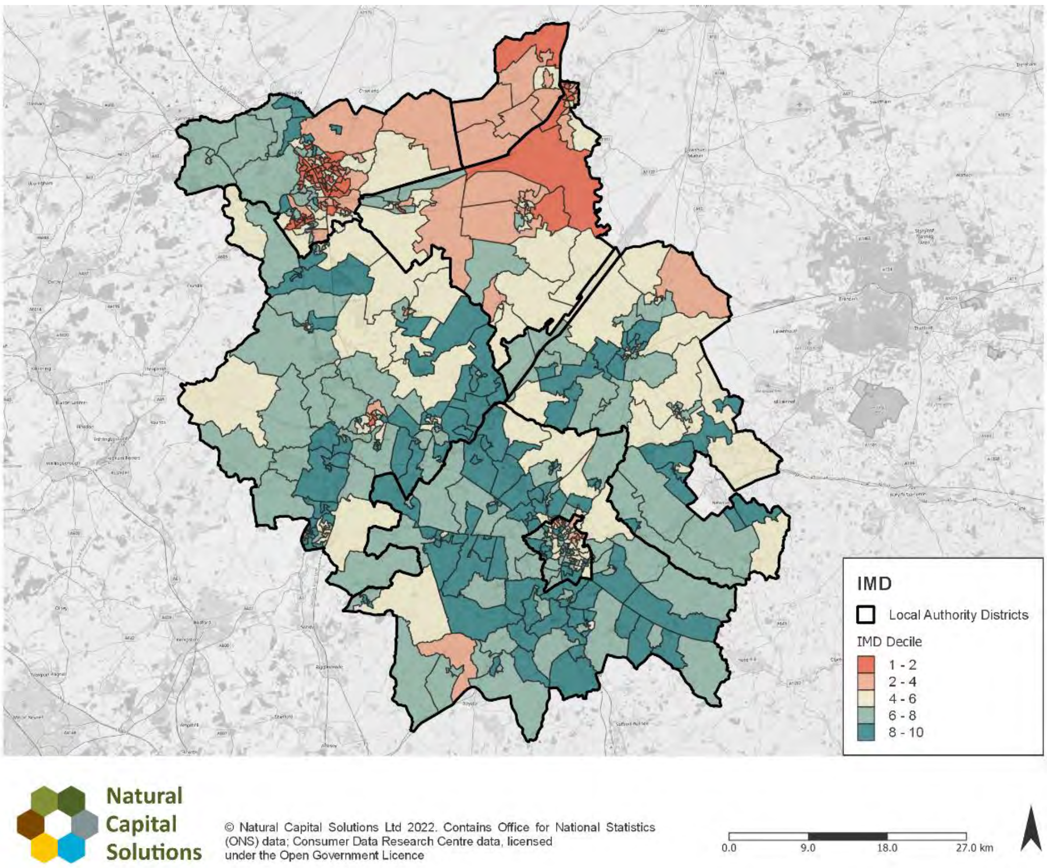
Natural England's Accessible Natural Greenspace Standards (ANGSt) stipulate that everyone should have accessible natural greenspaces of different sizes within stipulated distances from their home. Details are provided in: http://publications.naturalengland.org.uk/publication/65021. An indicator showing failure to meet ANGSt targets was created, as described in Section 6.8. The ANGSt output was classified from 1-4, with locations that failed to meet any of the criteria given a weighting of 4, those that failed to meet 3 criteria given a weighting of 3 and so on.

Maps for Cambridgeshire

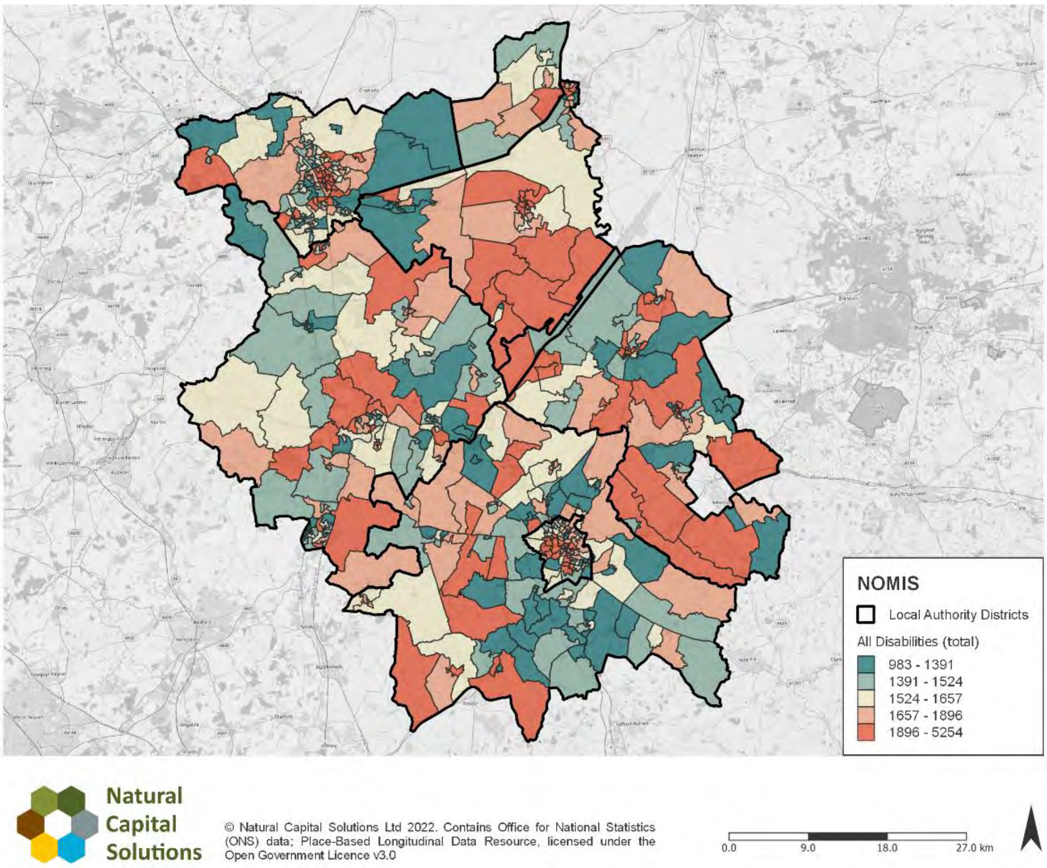
The maps that follow (Maps B1-B10) show each dataset described above, mapped across Cambridgeshire. In most cases, these show the raw datasets, before they are converted to deciles.



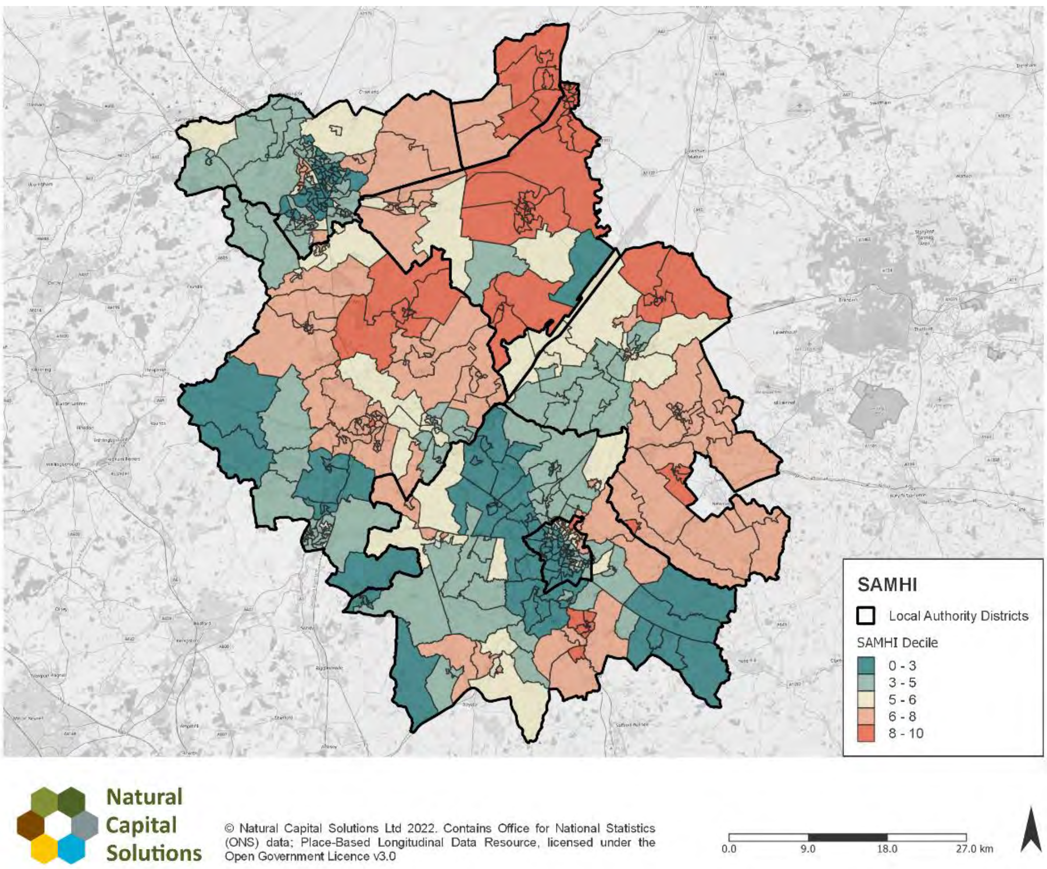
Map B1: Childhood obesity indicator for Cambridgeshire (health and wellbeing indicator).



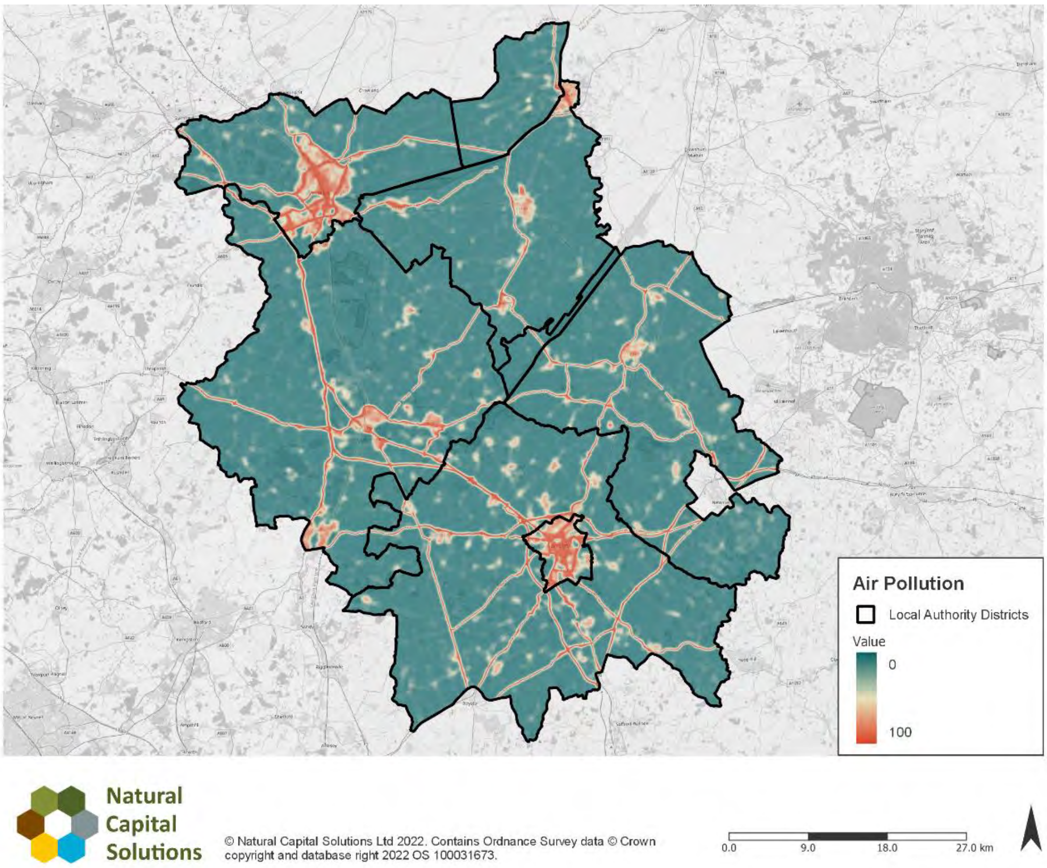
Map B2: Index of Multiple Deprivation (IMD) indicator for Cambridgeshire (health and wellbeing).



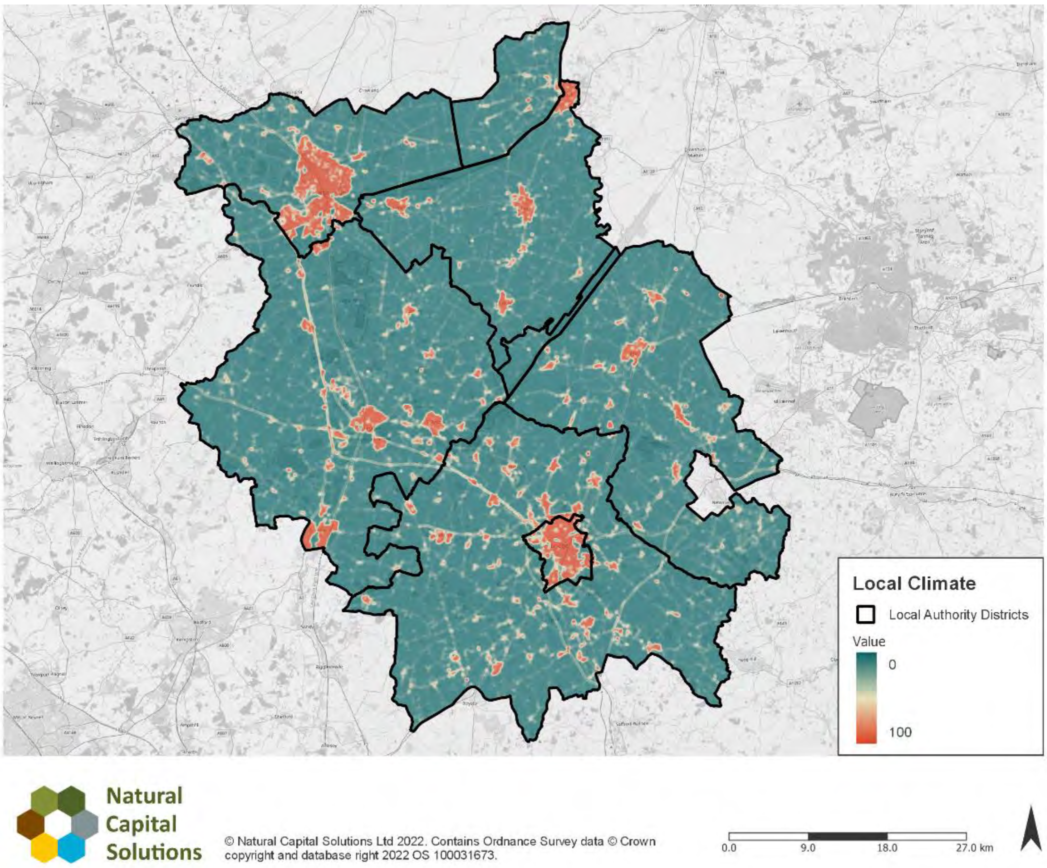
Map B3: Long-term health problem or disability indicator for Cambridgeshire (health and wellbeing).



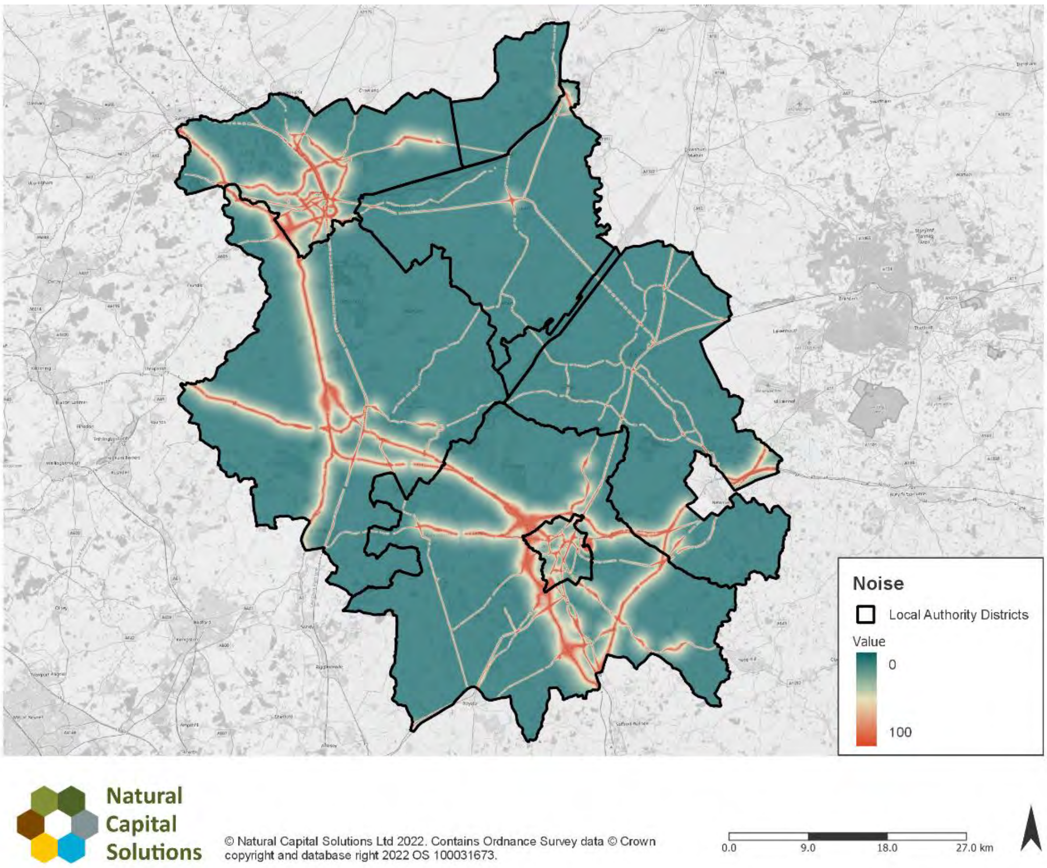
Map B4: Small Area Mental Health Indicator (SAMHI) for Cambridgeshire (health and wellbeing).



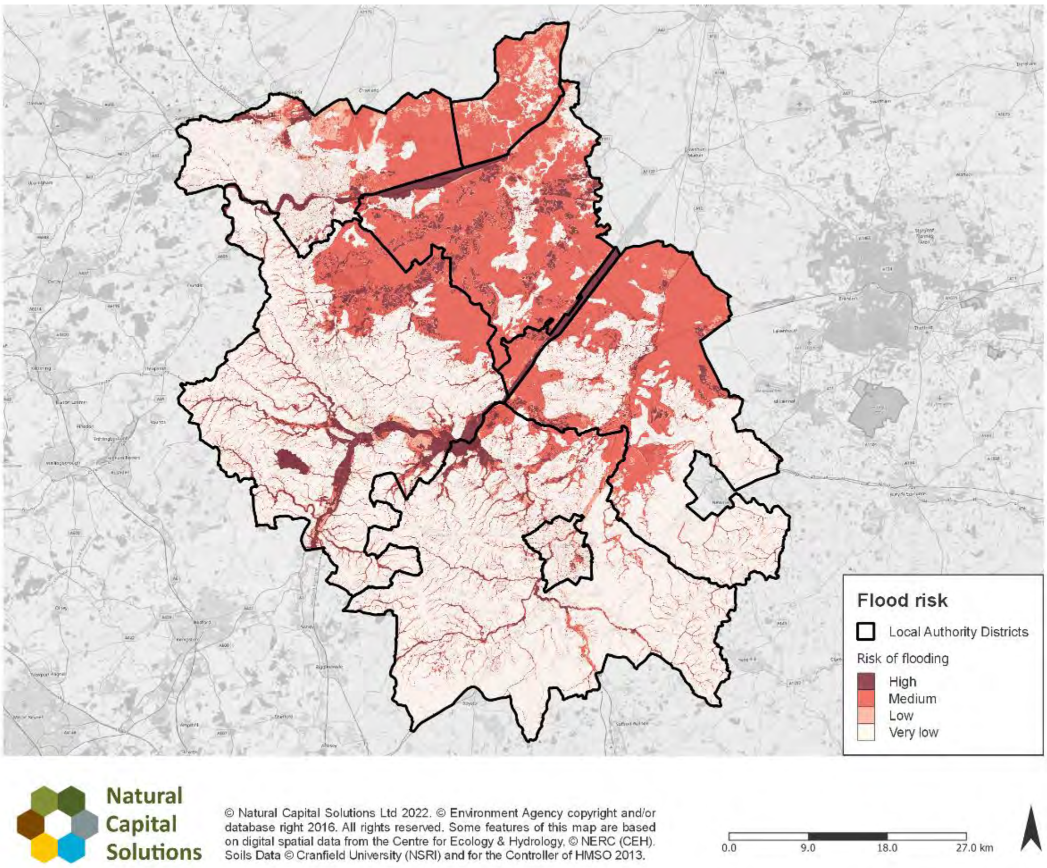
Map B5: Air pollution indicator for Cambridgeshire (environmental risk indicator).



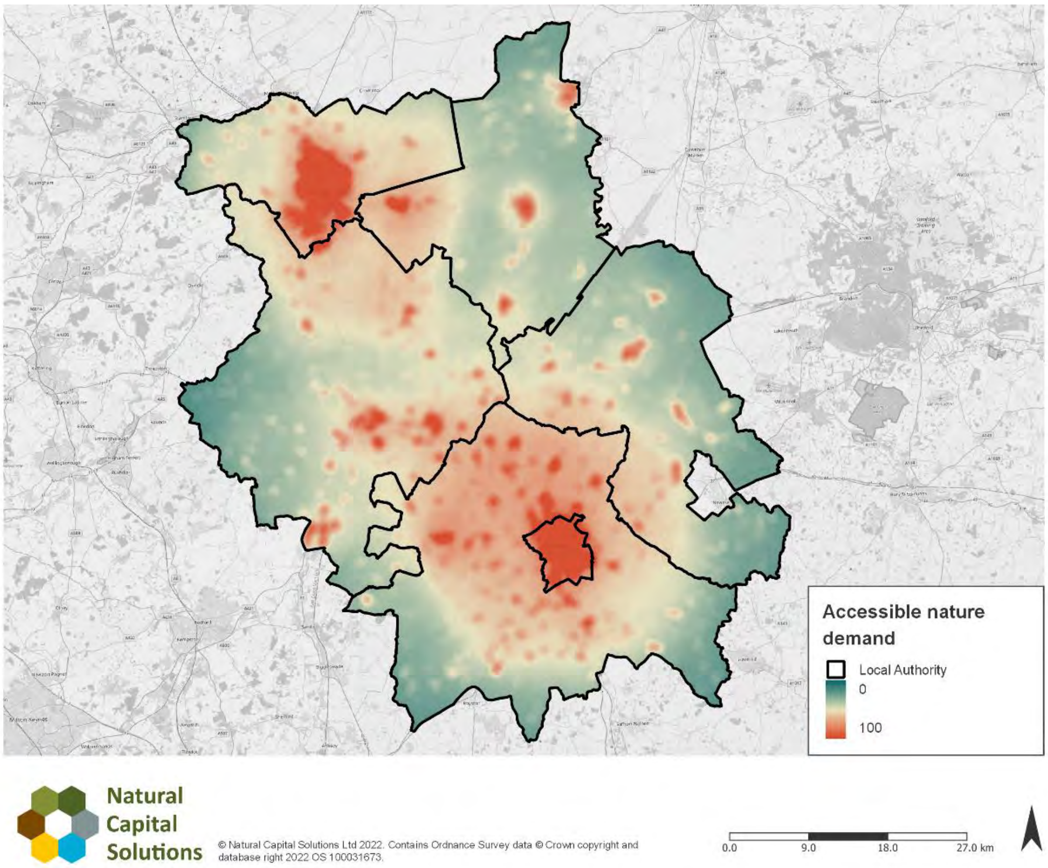
Map B6: Urban heat island (local climate) risk indicator for Cambridgeshire (environmental risk).



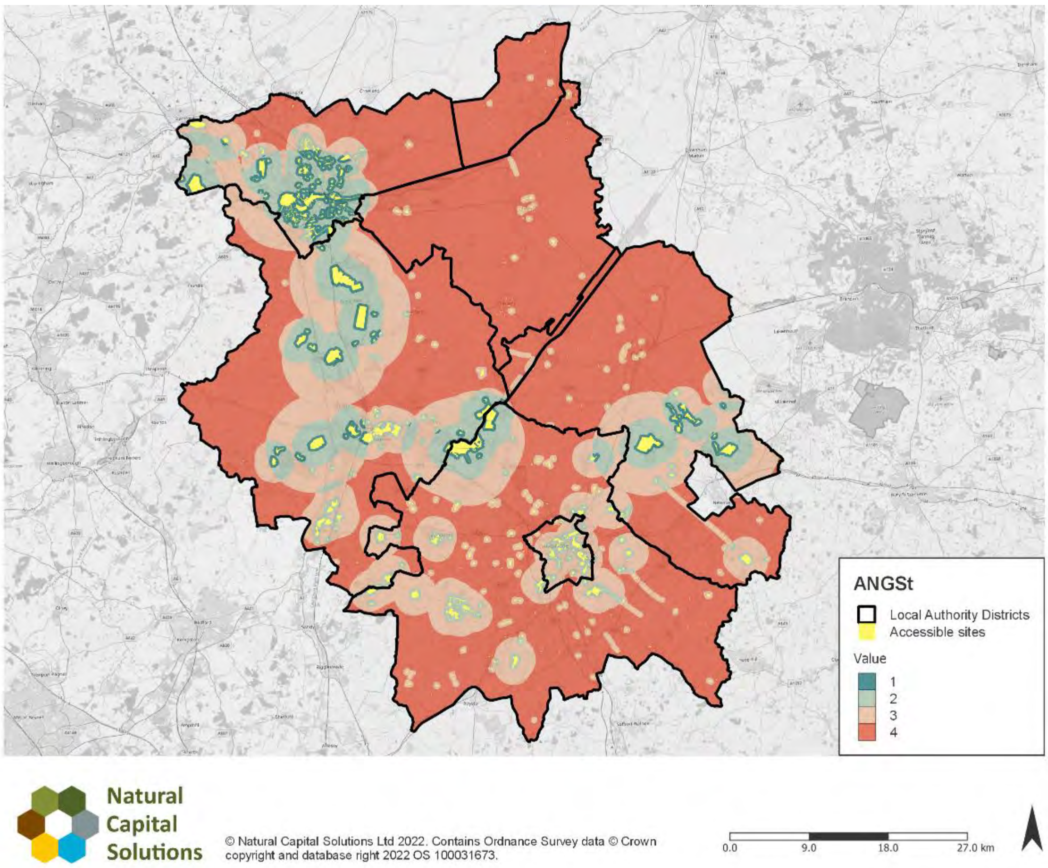
Map B7: Noise pollution indicator for Cambridgeshire (environmental risk indicator).



Map B8: Flood risk indicator for Cambridgeshire (environmental risk indicator).

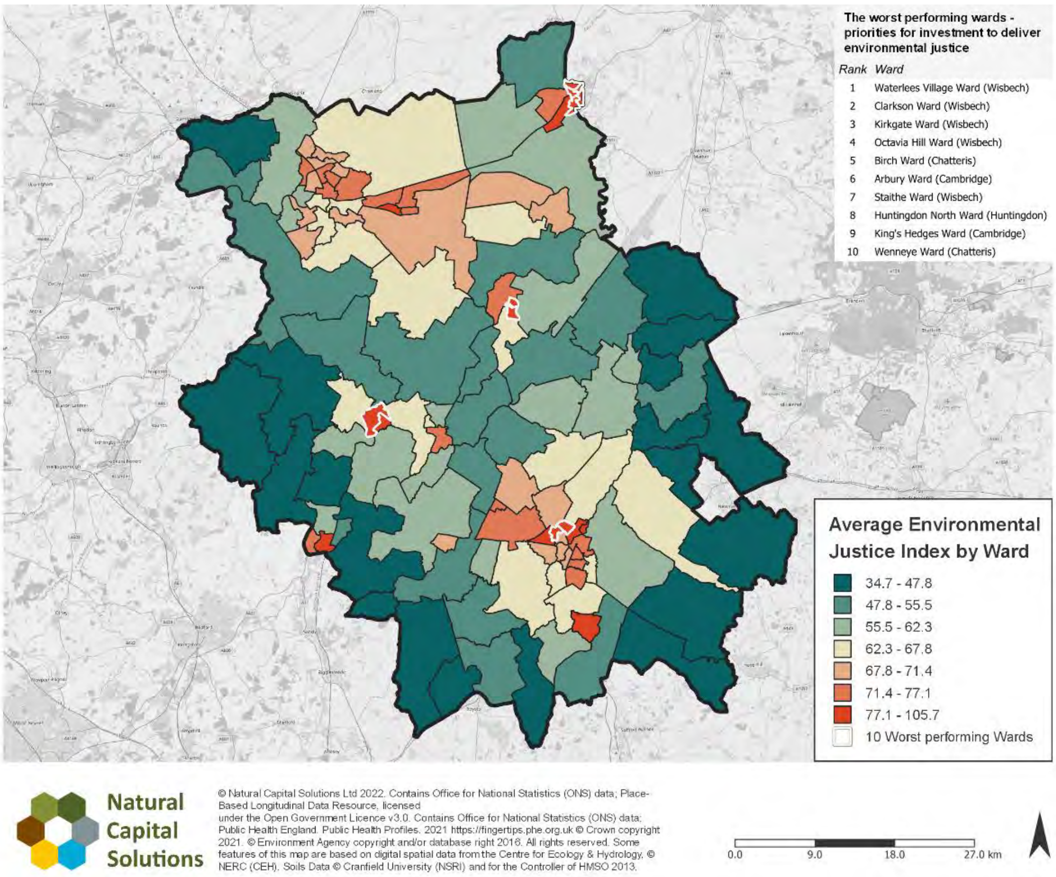


Map B9: Accessible nature demand indicator (natural greenspace access and demand indicator).



Map B10: ANGSt indicator for Cambridgeshire (natural greenspace access and demand indicator).

Combined Environmental Justice index



Map B11: Environmental Justice Index for Cambridgeshire, highlighting the 10 worst performing wards overall.

Annex C: Valuation of air quality regulation – method statement

Air quality regulation

The ability of the woodland, hedges, scrub, and grassland vegetation across Cambridgeshire to absorb particulate matter =<2.5µm in diameter ($PM_{2.5}$) was calculated. Quantifying the physical flow of the air quality regulation service was based on the absorption calculation in Powe & Willis (2004)[31] and the method in ONS (2016)[32]. 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 2022 (rainfall <1mm) for Cambridgeshire was estimated using MET office regional value data for East Anglia (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)[33]. These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of adsorbed 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. 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 2022. 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.

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[31] 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.
[32] ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts.
[33] Defra (2019) Air quality damage costs guidance. Crown Copyright.