Natural Capital Solutions

# Baseline natural capital assessment of the City of London Corporation's open spaces


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## Executive Summary


*Context and aims*

This project has involved a fine-scale and detailed mapping of the natural capital assets, biodiversity and ecosystem services baselines for the open spaces and green infrastructure owned by the City of London Corporation (CoLC). Natural capital accounts were also set up for these 13 groups of sites in the CoLC portfolio, estimating the value of the ecosystem service benefits provided by the green and blue assets, the costs of maintaining them, and, therefore, enabling their net natural capital value to be estimated. The CoLC portfolio consists of a diverse array of sites ranging from school grounds, church yards and pocket parks, formal parkland and Victorian gardens, through to expansive commons and large woodlands, covering an area of 4,459.6 ha in the City of London and Greater London. The majority of the larger sites are important for biodiversity and hold conservation designations at the local, national and/or European level. The aim of this project was to reveal the broader suite of benefits that are provided by these natural capital assets, and to estimate their monetary value.

As there are a large number of sites this report presents a full set of results and maps for the Hampstead Heath and the Epping Forest and Buffer Land sites. The results for the remaining 11 groups of sites are summarised. Recommendations for enhancing ecosystem service provision and biodiversity have been outlined for all sites, taking into consideration their current and future management objectives.

*Hampstead Heath baseline natural capital assessment*

The natural capital map and asset register for Hampstead Heath shows that woodland covers a large proportion of the site (41.1%). Consequently, the maps show that the site delivers a high provision across a range of ecosystem services. The woodland delivers 86% of the sequestration ability of the site and is a significant store of carbon. It also has a high capacity for air pollution, noise, climate and water flow regulation. In addition, the woodland delivers a high accessible nature provision. These services are particularly important given the high demand for them immediately outside of the site in the surrounding urban areas. Whilst woodland is always an important habitat for delivering a wide range of services, the assessment demonstrates that semi-natural grasslands, heathlands and water all provide important ecosystem service benefits. Most notably pollination, particularly in the summer, local climate regulation and natural habitats for recreation and health benefits.

The biodiversity baseline assessment shows that the majority of the habitats are in moderate or fairly poor condition. Consequently, there is room for improvement in the baseline biodiversity unit score (1,673). A focus on increasing the condition of the woodland from moderate to good, and the semi-natural grassland and some of the water bodies from fairly poor to moderate would increase the biodiversity units. The activities outlined in the management plan for the site should go a long way to achieving this.

The overall net natural capital value of the site is £1.3 billion over 50 years, and for every £1 spent on maintaining the natural capital at the site there is a £8.4 return in benefits. This high value is driven by the cultural services, recreation and health (£34.8 million and £13.5 million annually), air pollution regulation (£2.1 million annually), the amenity value (accessibility to green space and views provided by the site (£420,000 annually)), and the ability of the site to sequester carbon (£280,000 annually).

*Recommendations:* If the aim of the site management is to continue to maintain the habitats present as they are for the foreseeable future, then substantial increases in ecosystem service provision at this site will not be possible. However, modest gains can be made by planting some additional trees on the

edges of the site where possible, and also incorporating more hedgerows and scrub to create ecotones between habitats. This will increase carbon sequestration, storage, help regulate climate and air pollution closest to where people live, whilst increasing the water quality and flow services. The natural capital value of the site can also be increased by enhancing the number of recreational visitors and the exposure to nature that visitors receive. This could be achieved by increasing access to footpaths through diverse habitats, or through supporting particular recreational activities that will attract people in the surrounding urban areas to visit the site (e.g. walks as part of green prescribing from local GPs, conservation activities etc). Clearly this is already a well visited site so it will be important to maintain footpaths and manage use carefully to ensure that the natural capital assets are not degraded, which is likely to impact negatively on other services and biodiversity.

*Epping Forest and Buffer Land baseline natural capital assessment*

The natural capital map and asset register shows that broadleaved woodland is the dominant habitat at Epping Forest and Buffer Land (63.5%). There are small pockets of mixed and coniferous woodlands across the sites (0.5%). Consequently, ecosystem services maps for the site show a high provision of a wide range of ecosystem services (carbon sequestration, air purification, noise regulation, local climate regulation, water flow and quality regulation, access to nature). The woodland delivers 97% of the sequestration capacity of the site and is a significant store of carbon. It also has a high accessible nature capacity, which is particularly important in the southern end of the site, where the demand for this service is high because of the surrounding urban settlements. Whilst woodland is always an important habitat for delivering a wide range of services, the assessment demonstrates that the semi-natural grasslands, the dominant habitat type across the Buffer Lands, heathland and scrub also provide important ecosystem service benefits. These include carbon sequestration and storage, water flow and quality regulation, albeit to a lesser extent than the woodland, but are particularly important for pollinators, especially in the summer, and access to nature.

The biodiversity baseline assessment shows that the majority of habitats are in good to moderate condition. The biodiversity baseline score for the combined site is high (the highest of all of the CoLC sites, which is driven largely by the size of the site) at 27,896. A focus on improving the areas of semi-natural grassland and woodland from moderate to good condition throughout Epping Forest, and the poor condition grassland habitats in the Buffer Lands. The activities outlined in the management plan should help achieve this.

The overall net natural capital value of both sites combined is £1.9 billion over 50 years. For every £1 spent on maintaining the natural capital at the Epping Forest site there is a £20.2 return in benefits, and a lower £4 return in benefits in the Buffer Land area. This high natural capital value is driven by the recreation and health services across the sites (£35.7 million and £17.4 million annually), the ability of the site to sequester carbon (£4.5 million annually) and air pollution regulation (£6.0 million annually) across the sites. The sites provide important and valuable services in the context of a densely urban environment.

*Recommendations:* The planned management activity at the sites is extensive (focused on improving the condition of woodland, heathland, grassland, scrub, hedgerows, creating wood pasture and ponds) and will be very beneficial to a range of ecosystem services such as carbon storage, sequestration, water flow and quality regulation and pollination. It will also increase attractiveness to visitors. The removal of trees and scrub on heathland, and opening up woodland to create wood pasture, will impact on a range of ecosystem service benefits as they are key habitats for delivering carbon sequestration, storage, local climate regulation, water flow and quality regulation. However, this trade-off in favour of biodiversity may be acceptable given the extent of woodland at the site, and the need to maintain the heathland habitats.

Where trees and scrub are removed in the Epping Forest site, it would be beneficial to introduce new trees and scrub in other more appropriate areas of the site (woodland edges, amenity grassland areas) to maintain service provision, or perhaps offset their loss in the Buffer Land area. Hedgerows and wildflower / pollinator field margins could be introduced around arable fields in the Buffer Land if they are not already present, which would enhance both ecosystem services and biodiversity. When managing woodlands at the sites it is important to manage for a diverse species and age structure to build ecological resilience and ensure carbon sequestration can be maintained into the future.

The Epping Forest site is clearly a highly visited site and supports a great deal of recreational activity. Access to the Buffer Land area could be improved, especially as the highest demand for accessible nature lies just outside of the sites in the south. The recreation and health services are the most valuable and further value can be added by increasing visitors through participation in organised activities such as walking groups, conservation volunteering, ensuring access for active travel. The sites could host green social prescribing activities which would increase health and wellbeing of those taking part. It is important that visitor pressure is managed carefully to avoid degrading other ecosystem service benefits at the site.

*Conclusions and recommendations at the portfolio level*

The natural capital mapping has created a valuable evidence base for the green and open spaces of the City of London Corporation. A baseline for the natural capital assets has been set, along with the baseline provision eleven different ecosystem services, showing how the level of provision of each of these services varies across the sites. The demand for a set of important public benefits around the sites has also been mapped. The biodiversity baseline assessment has mapped the variation in condition of habitats and biodiversity units across the sites, quantifying the total biodiversity units for each site category. The monetary value of a suite of ecosystem services has also been estimated, demonstrating which services are providing the most value. Using information on the high level costs of maintaining the sites we have calculated the net natural capital value of each set of sites and have demonstrated the value of natural capital benefits delivered for every pound invested.

Clearly, the majority of the 13 groups of sites are important for biodiversity. The management strategies for these sites are largely to maintain, and in some cases restore valuable habitats, and enhance their condition over the next decade. The biodiversity assessment shows the variation in biodiversity unit scores (a quantification of the level of habitat biodiversity) across the groups of sites. Some sites (e.g. Epping Forest and Buffer Lands, Burnham Beeches and Ashtead Common) score very highly as they have distinctive habitats (relatively rare), are in moderate or good ecological condition, and occur over a large area. Other sites, such as the City Gardens, Cemetery and Crematorium score much lower due to their small size and lack of semi-natural habitat. The scores are interesting to compare across sites, but crucially have been set up so that the CoLC can track the impacts of management on the level of biodiversity in the future, using the resource to predict what the outcomes of management might be in advance.

However, the location of these sites in London and the Greater London region makes them crucial areas of green and blue infrastructure that are vital for the provision of natural capital benefits to a densely populated and highly urbanised city. The natural capital assessment shows that they provide a vast area of woodland, semi-natural grassland and heathland assets. The woodland particularly is important for providing a wide range of public benefits to the local urban inhabitants e.g. carbon sequestration, air pollution regulation, noise regulation, local climate regulation, water flow and quality regulation, although other natural habitats can provide these, albeit to a lesser extent, but additional services such as pollination. Although the accessibility of these sites varies slightly (all but the City of London School site are publicly accessible), they are providing good quality natural spaces to the inhabitants of London, and are used for a wide range of recreational activities. The health and wellbeing benefits from these visits are important, and the site management plans do recognise this.

The natural capital accounting demonstrates the high monetary value of these sites. The estimated value of the benefits delivered by the natural capital assets quantified across the whole portfolio is £282.6 million annually, with a present value of £8.1 billion over 50 years. The ecosystem services that provide the largest value are recreation (PV £4.5 billion) and health benefits (PV £2.8 billion), followed by air quality regulation (PV £389.7 million) and carbon sequestration (£200.8 million). Even accounting for the maintenance costs, that is the costs associated with managing the natural capital assets at each of the site groups, the net natural capital asset value of all sites combined is high (£7.6 billion over 50 years). While the benefit to cost ratios vary considerably at the sites level, at the portfolio level there is a benefit to cost ratio of 16.4, which means that every £1 spent on maintenance delivers £16.4 in natural capital benefits. This suggests that while maintenance costs can be considerable, the investment is delivering a good return in public natural capital benefits.

*Recommendations:* Overall, there are no opportunities for substantive increases in ecosystem service benefits, largely because it is not possible to create sizable areas of new habitat at the sites. However, if managing for natural capital benefits is considered along with biodiversity within the management plans at the sites, it will be possible to make some significant increases. For example, extending woodland at the sites where this is possible (e.g. Queen's Park) incorporating more hedgerows, scrub and trees at the edges of the sites, particularly where sites are adjacent to residential areas that have a high demand for air pollution, noise and climate regulation, and to create ecotones (transitions between habitat types). Where trees and scrub are being removed to maintain habitats, consider offsetting the losses elsewhere at the site.

The biggest increases in natural capital value will be made by focusing on increasing recreational opportunities that will also increase health and wellbeing. The open spaces business plan and the management strategies for the sites all demonstrate that the CoLC already recognise the importance of people having access to ecologically diverse spaces with heritage value, and the natural capital assessment shows these areas are well used. However, there will be room for improvement. Groups of people that are not able to access these sites so easily should be considered. A particular focus on events such as walking groups, green gyms, wild/outdoor swimming, conservation programmes, and gardening, will increase the health and wellbeing of those who take part. This could be part of a formal social green prescribing programme linked with local health organisations.

There may be sites where new footpaths can be created. These need to be well maintained and where there is high visitor pressure this needs to be carefully managed, to ensure that the natural capital assets are not degraded, which in turn can negatively impact on the provision of other benefits. Creating areas for active travel to work (cycle paths), areas where people can sit, as well as areas of other activities will increase the provision of the recreation service. This is likely not necessary at every site, but certain activities may be prioritised at particular sites, depending on the demand.

Generally natural capital benefits should be recognised and considered more in the management of the sites alongside biodiversity, and in business plans and performance measures for the open spaces. This assessment provides an evidence base on which to justify the current maintenance costs of these sites, and potentially for expanding management activities. It also demonstrates the value of these spaces that may be under pressure from urban development. In the face of biodiversity and climate crises these are important areas to maintain and enhance, particularly because of their role in providing important public benefits such as reducing air pollution, reducing the heat island effect, reducing run off, and supporting recreation and increases in health and wellbeing.

*Next steps*

The GIS layers produced for this project provide an extensive evidence base for the CoLC. The layers can be combined in a wide variety of ways to explore different issues and key priorities. The natural capital concept is embedded across multiple policy areas that will impact how the sites are managed. For example, developing the Local Nature Recovery Strategy (LNRS), achieving Net Carbon Zero by 2040, the need for Biodiversity Net Gain for development and more generally contributing to solutions for the climate and environmental emergencies that have been declared in the Greater London region. The assessment will also be useful should the CoLC want to consider natural capital financing, e.g. gaining revenue from their assets through payments for carbon credits, biodiversity net gain or nutrient neutrality.

## Contents

# 1. Introduction

## 1.1 Context and aims

The City of London Corporation (CoLC) commissioned Natural Capital Solutions to create a detailed natural capital assessment of its open spaces and green infrastructure. CoLC manages 4,459.6 ha of land in and around London, much of this falling under local and national, and in some cases international statutory designations for biodiversity (see Figure 1 and Table 1). Due to previous work, there is an understanding of the contribution that these natural assets provide in terms of carbon sequestration. However, the aim of this project was to reveal the broader suite of benefits that are provided by these natural capital assets, and to estimate their monetary value.

The project involves a fine-scale and detailed mapping of the natural capital assets, biodiversity and ecosystem services baselines for all the sites within the CoLC portfolio. Natural capital accounts were also set up for the 13 groups of sites in the CoLC portfolio, estimating the value of the ecosystem service benefits provided by the green and blue assets, the costs of maintaining them, and, therefore, enabling their net natural capital value to be estimated.

## 1.2 Natural capital and ecosystem services

The natural environment underpins our wellbeing and economic prosperity, providing multiple benefits to society, yet is consistently undervalued in decision-making. Natural Capital is defined as "..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions" (Natural Capital Committee 2014[1]). It is the stock of natural assets (e.g. soils, water, biodiversity) that produces a wide range of ecosystem services that benefit people. These benefits include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities (Figure 2).

Work is progressing on how to deliver the natural capital and ecosystem services approach on the ground, and how to use it to inform and influence management and decision-making. One of the most important steps is to recognise and quantify ecosystem service delivery (the physical flow of services derived from natural capital). Additional insight can be gained by taking a spatial perspective on the variation in ecosystem service supply and demand across a study area using a Geographic Information System (GIS). Maps are able to highlight hotspots and coldspots of ecosystem service delivery, highlight important spatial patterns that provide much additional detail, and are inherently more user friendly than non-spatial approaches.

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

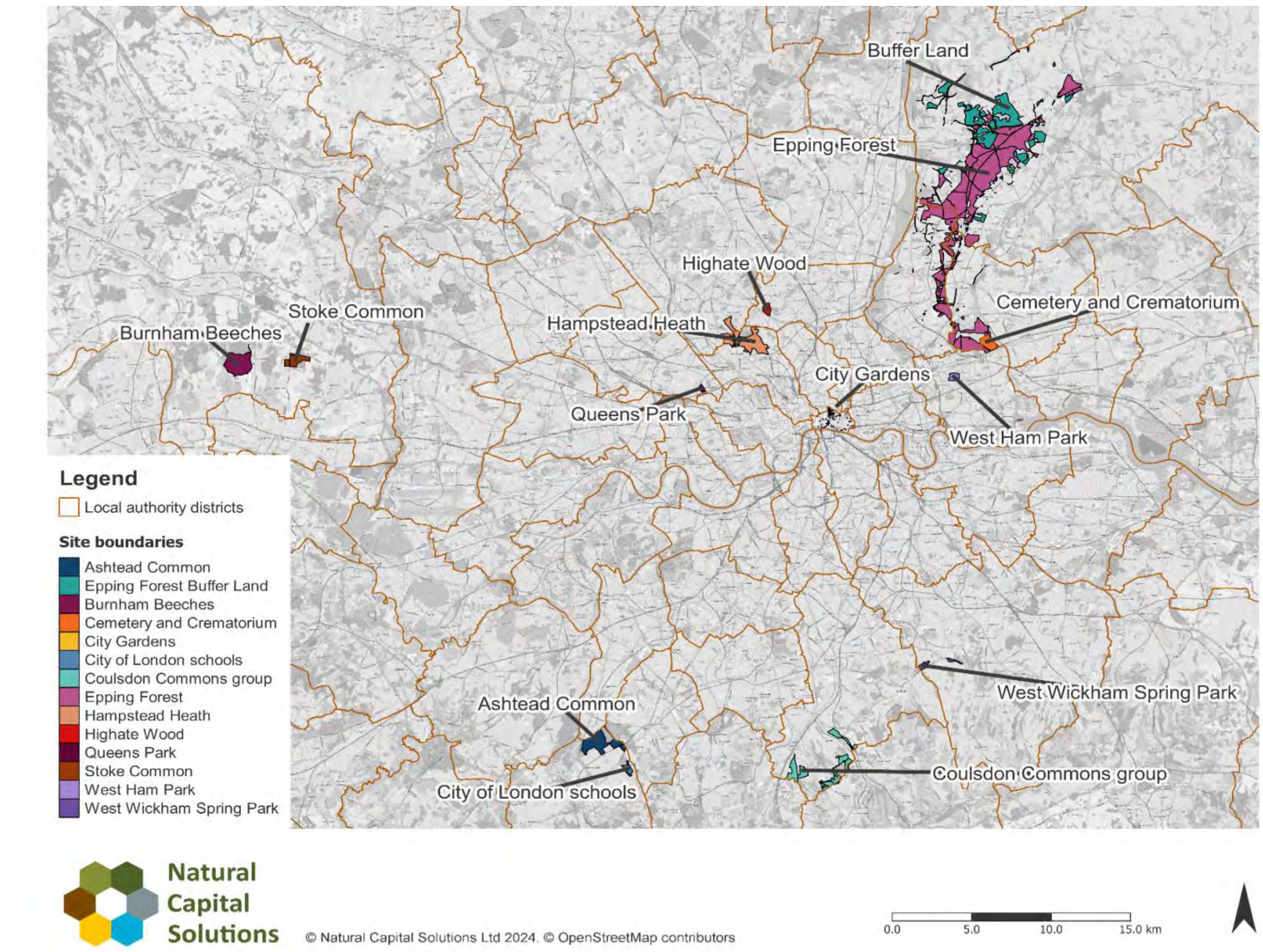


**Figure 1.** Overview map of the City of London Corporation open spaces assessed as part of this project.

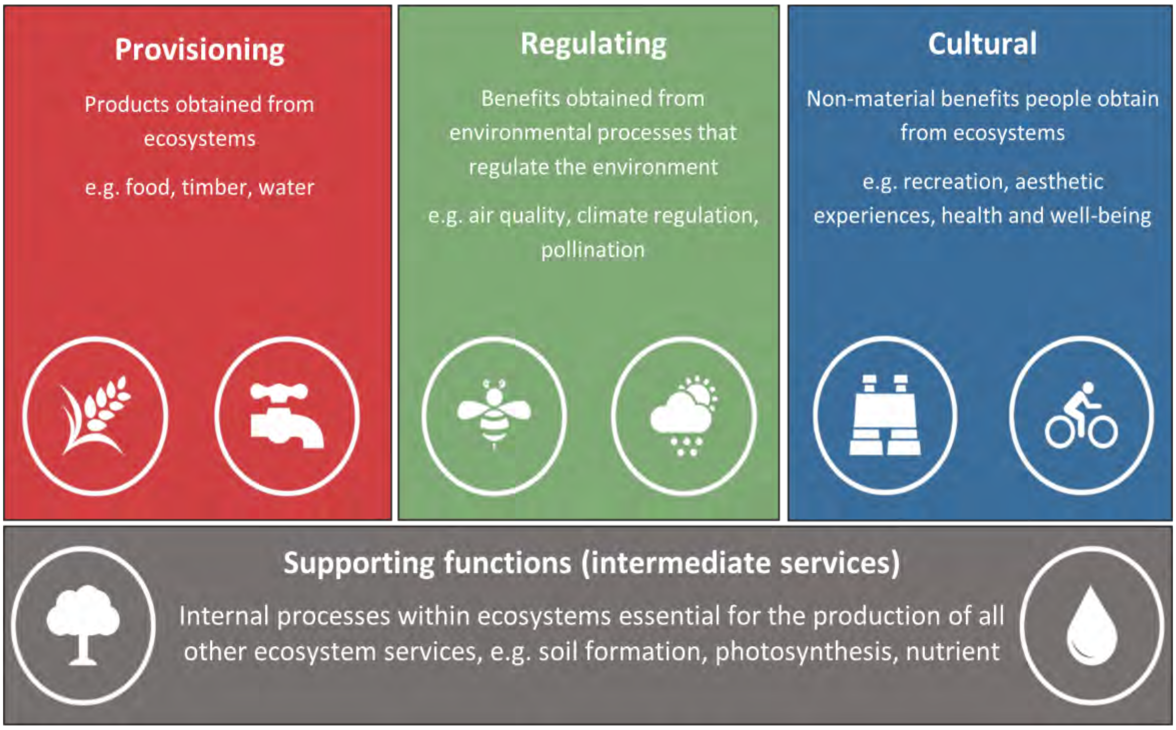


**Figure 2**. Key types of ecosystem services (based on MA 2005[2]). Note that supporting or intermediate services are now categorised as ecological functions (CICES[3]). They are the underpinning structures and processes that give rise to ecosystem services.

### 1.3 The City of London Corporation sites

In order to conduct a natural capital assessment across the portfolio and produce meaningful analyses and recommendations that could be used at the site scale to inform management, but also for strategic decision-making, we mapped and valued the ecosystem service benefits across 13 categories of sites (Table 1). The CoLC portfolio consists of a diverse array of sites from school grounds, church yards and pocket parks, formal parkland and Victorian gardens, through to expansive commons and large woodlands (Figure 1). Many of these sites have national designations for the conservation of biodiversity, e.g. Site of Special Scientific Interest (SSSI) and National Nature Reserve (NNR), along with local designations such as Metropolitan Importance for Nature Conservation (SMINC) and Sites of Nature Conservation Importance (SNCIs), and a two of the sites have been designated as European level Special Area of Conservation (SAC). As a consequence, the management at these sites aims to maintain or enhance biodiversity, and at present is not also focused on increasing ecosystem service benefits. These sites are important areas of green and blue infrastructure in a densely urbanised city and are, therefore, vital for the delivery of important public benefits.

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

[3] 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.

**Table 1.** City of London site categories with a summarised site description (designations and main habitat types) and management strategy.

| Site category name and area | Description | Management strategy |
|---|---|---|
| Ashtead Common<br>199.9 ha | This site is an NNR and SSSI. It comprises of ancient woodland, lowland wood pasture, secondary woodland and grassland. It has 2,237 Veteran trees. | The vision is to manage the habitat to favourable condition and achieve conservation gains through restoring wood pasture, careful woodland management, bracken control, grazing and management of pond riparian zones.<br>Source: Ashtead Common Management Plan 2021-2031. City of London. |
| Burnham Beeches<br>208.7 ha | This site is designated an SAC, SSSI and NNR). It consists of ancient woodland, historical wood pasture, heathland, mire, and secondary woodland. It also has 460 veteran trees. | In the most recent management plan the aim is for Burnham Beeches to be conserved and protected at the same time as be available as a sustainable public open space. This will be achieved through grazing and cutting, habitat maintenance for rare and threatened species, increasing connectivity with the wider natural landscape, managing visitor numbers and improving the information and interpretation at the site.<br>Source: Burnham Beeches Management Plan 2020-2030. |
| Cemetery and Crematorium in Newham,<br>68.0 ha | These sites are formal parkland, old trees, hedgerows, 3 ponds and amenity grassland. | The plan here is to hold the line, so to maintain the listed Grade I landscape as it is.<br>Source: Management plans outlined by the site manager. |
| City Gardens<br>8.5 ha | 200 small sites across the Square Mile comprising churchyards, plazas, pocket parks, and highways plantings. | The aim at these sites is to increase shrub cover and berry bearing plants, including in hedges, providing nesting cover from ground to canopy, planting nectar and pollen rich species, retaining and increasing dead wood.<br>Source: City of London Biodiversity Action Plan 2021-2026. |

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| City of London schools (Freemen's School)<br>29.3 ha | CoLC has one substantial school site (Freemen's School) included in this study. This is made up of mainly amenity grassland, with a small proportion of parkland and improved grassland. | It is not clear what the strategy is for this site going forward. The management of the site is likely to be for sports rather than biodiversity.<br>Source: Current management outlined by the site manager. |
| Coulsdon Commons group: Farthing Downs, Couldson Common, Kenley Common, and Riddlesdown Common<br>245.2 ha | Farthing Downs is designated an NNR and SSSI, Couldson Common is an NNR and an SNCI, Kenley Common is an NNR and an SNCI and Riddlesdown Common is an NNR, SSSI, and SNCI. These sites comprise mainly of grassland (chalk, acidic and neutral), secondary woodland, and formal parkland. | The promotion of wildlife, heritage and landscape is a key priority in the vision for these sites. The management revolves around maintenance through grazing, restoring chalk and lowland grasslands, creating ponds, managing woodlands, scrub and hedgerows and improving access for visitors.<br>Source: Couldon Common, Riddlesdown and Farthing Downs management plans 2021-2031. City of London. |
| Epping Forest and the Buffer Land<br><br>Epping Forest: 2,505.0 ha<br>Buffer Lands: 734.5 ha<br>Total area: 3,239.5 ha | Epping Forest is designated a SSSI and SAC. The site consists of ancient woodland and wood pasture, secondary woodland, grassland, wet and dry heathlands, scrub, ponds, bogs, streams. There are 55,000 veteran trees across the site.<br><br>The surrounding Buffer Lands are a mixture of ancient and $20^{th}$ century woodlands and current and former agricultural land. | The priorities for the **Epping Forest site** is, through specific management activities e.g. to increase the condition of the beech woodland (SAC habitat), wet and dry heath, wood pasture. The SSSI features of lowland meadow and acid grassland, scrub, ponds, lakes, streams and bogs, and veteran/ancient trees also require ongoing maintenance and management. This will maintain priority and notable invertebrates, reptiles and amphibians, dragonflies, breeding bird populations, bats and flora.<br><br>The plan for the **Buffer Land** is to manage deer in the ancient woodland, cut and graze the semi-natural grassland and meadow , maintain hedgerows and open up ponds and ditches. This will benefit skylark and other farmland birds, bats and pollinators. |

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| | | Source: Management plans outlined by the site manager. |
| Hampstead Heath<br>277.0 ha | Hampstead Heath is a SMINC and SSSI and consists of grassland, secondary woodland, and hedgerows with 450 veteran trees and 32 ponds. | The long term aim at this site is to actively manage the balance between woodland and grassland and to hold the line in terms of the relative proportions of each. There is a focus on retaining and protecting existing habitats through coppicing, scrub removal, grass cutting and silt removal. This will protect the priority species (e.g. reptiles, hedgehogs, bats and orchids).<br>Source: Management plans outlined by the site manager. |
| Highgate Wood<br>30.2 ha | This site is an ancient woodland purchased in 1886. | The plan for this site is to ensure the continuity of the wood as a managed ancient woodland site. This requires thinning, encouraging natural regeneration and wildflower meadow, and habitat improvements for bat species across the wood.<br>Source: Management plans outlined by the site manager. |
| Queen's Park<br>12.1 ha | This site consists of formal parkland and Victorian gardens. Purchased 1886, having been the site of 1879 Royal Agricultural Exhibition. | There are plans for an expansion of the woodland at this site and of pond creation. The strategy also includes reducing intensively mown grass where possible and cutting and laying hedgerows. These will increase the attractiveness to butterflies and other important species. This also includes management of a woodland walk.<br>Source: Management plans outlined by the site manager. |
| Stoke Common<br>80.1 ha | This site has SSSI status and consists of heathland, woodland, scrub and ponds. | The aim is for the site to reach Natural England’s favourable condition status, creating a place for the notable bird, insect, reptile, plant and fungi to thrive. The site will form a heathland mosaic with mature trees and a variety of plants |

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| | | with wet and dry areas. Woodland on the edges will add to the diversity of the site.<br>Source: Burnham Beeches and Stoke Common Management Plan 2020-2030 |
| West Ham Park<br>26.3 ha | This site has formal parkland and Victorian gardens. It was purchased 1874. | The planned management activities here revolve around rejuvenating wildflower meadows, increasing areas of long grass, planting of native trees and hedgerows, rejuvenating the orchard, and looking into the creation of a forest school.<br>Source: Management plans outlined by the site manager. |
| West Wickham Spring Park and West Wickham Common<br>30.83 ha | West Wickham Spring Park and Common are SNCIs and are part of City Commons. They consist of ancient woodland, woodland and scrub, hedgerows, grassland and ponds. | The aim is to manage the habitats in the Common to favourable condition through the maintenance of ancient trees, create a mosaic of varied habitats throughout from grassland, heathland to scrub. This involves the active management of woodland, clearing invasive species including bracken on heaths, establishing new heath, and hay cutting on grasslands.<br>Source: West Wickham Commons Management Plan 2021-2031. City of London. |

## 1.4 Report structure and scope

The report contains the results of the natural capital assessment for all of the CoLC owned sites. We present the full range of results and maps from the baseline natural capital and biodiversity assessment for two of the site categories, Hampstead Heath (Section 2) and Epping Forest and Buffer Land (Section 3), with recommendations for these sites included at the end of each of these sections.

Section 4 summarises the mapping and natural capital accounting results for the remaining 11 sites. Section 5 provides conclusions and recommendations for how ecosystem services and biodiversity may be enhanced across the portfolio, recognising where current and future management for conservation objectives align with management for enhancing public benefits (e.g. carbon sequestration, air pollution regulation and recreation).

# 2. Hampstead Heath baseline natural capital assessment

## 2.1 Natural capital assets

The first step of the natural capital assessment of Hampstead Heath was to establish a natural capital asset map and register for the baseline (See Technical Appendix A1.1 for methodological details). Located between Hampstead and Highgate in London, Hampstead Heath is known for being London's largest ancient parkland (277 ha). Figure 3 shows a map of the broad habitat types across the parkland, the area and percentage cover of the habitats is shown in Table 2 below.

The majority of habitat in this parkland is dominated by broadleaved woodland, covering 41% of the site. Grasslands are also prominent across the parkland, with semi-natural grassland comprising about 29%, and modified (amenity) grassland covering 15.5%. Standing water comprises 4.3% of the parkland, with fen, marsh and swamp habitat covering 0.2%. Other semi-natural habitats and built-up areas make up the remaining 10% of the parkland.

**Table 2:** Baseline habitats at Hampstead Heath.

| Habitat | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 113.5 | 41 |
| Semi-natural grassland | 80.4 | 29 |
| Modified (amenity) grassland | 42.9 | 15.5 |
| Built-up areas and infrastructure | 15.4 | 5.6 |
| Water | 11.9 | 4.3 |
| Mixed / other / uncertain | 5.3 | 1.9 |
| Scrub | 4.5 | 1.6 |
| Garden | 1.8 | 0.6 |
| Fen, marsh and swamp | 0.5 | 0.2 |
| Coniferous woodland | 0.4 | 0.1 |
| Heathland | 0.3 | 0.1 |
| Hedgerows | 0.3 | 0.1 |
| **Total** | **277.2** | **100** |

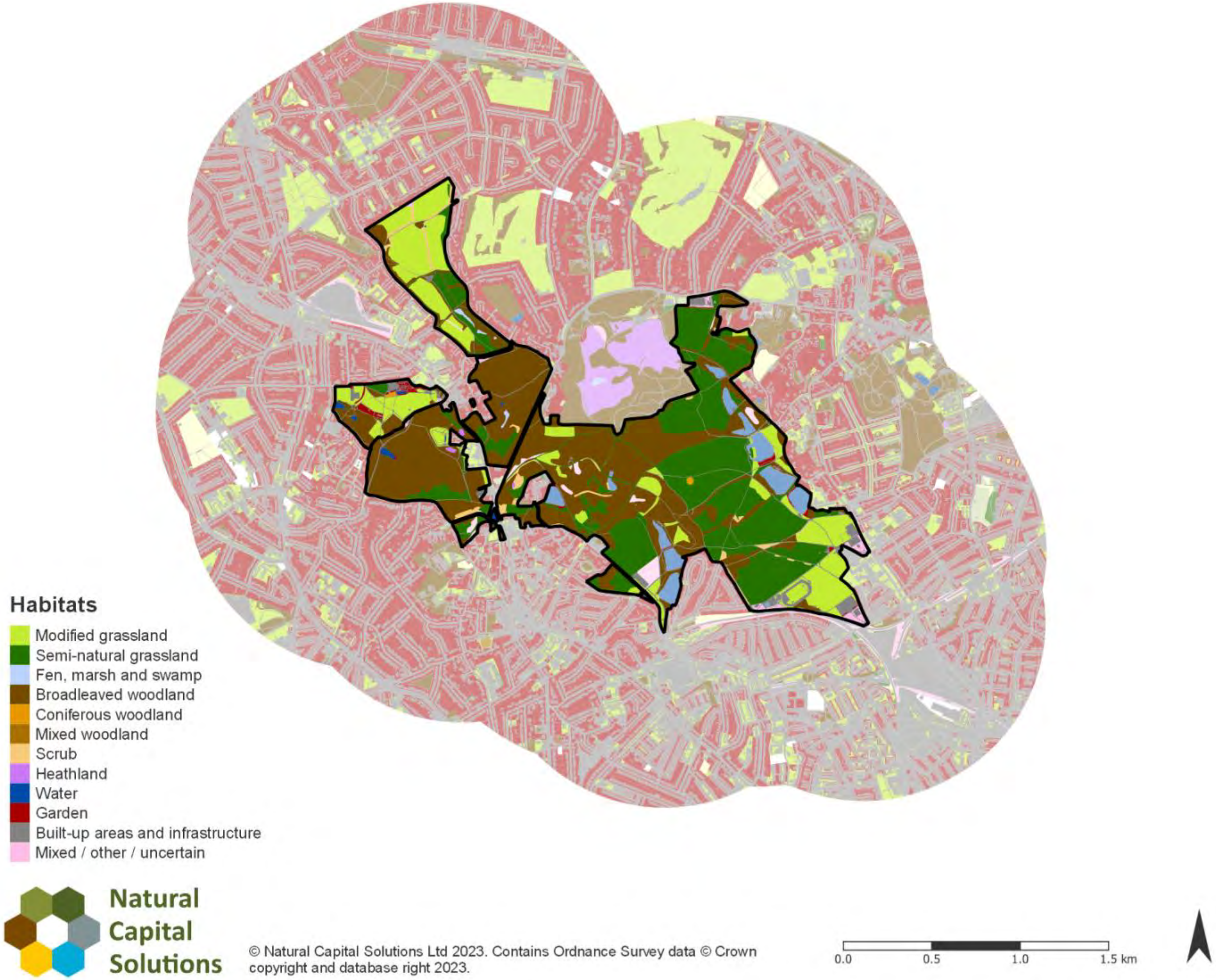


**Figure 3.** Baseline habitats at Hampstead Heath.

## 2.2 Biodiversity baseline

The Statutory Biodiversity Metric[4] is a relatively simple metric developed by Natural England for use when assessing whether a development has achieved 10% Biodiversity Net Gain in England. We use this metric here to set a 'biodiversity unit' baseline for Hampstead Heath so that the CoLC are able to quantify and monitor the impacts on biodiversity from future changes in habitats, or in habitat management at the site. We have very slightly adapted this metric for its use in this circumstance[*].

The biodiversity unit score is based on a number of factors that influence the level of biodiversity: the area of the habitat, its distinctiveness and condition (area (ha) x distinctiveness score x condition score). 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, lower distinctiveness and condition scores.

The first step was to assign the distinctiveness scores to each natural surface/habitat polygon within the basemap. These are set scores in the Statutory Biodiversity Metric. The second step was to assign a habitat condition to each of the habitat polygons according to the Statutory Biodiversity Metric. This assigns categories from 'good' to 'poor' including two N/A categories for agriculture and other (non-natural) habitats (Table 3). When used in the metric, these categories are also given a score from 0-3 (Table 3). It is important to note that areas of ancient woodland are considered irreplaceable habitat, and not a distinct habitat type, and are now exempt from this version of the metric when used under development conditions. However, for the purposes of this project (setting a biodiversity baseline) ancient woodland has been included in the calculation, and given a distinctiveness score of six, like the other woodland categories.

It was possible to assign condition categories to a number of low quality land covers without the need for any further information. This included all built-up habitats such as buildings and infrastructure (N/A – other). Hampstead Heath comprises a mosaic of habitats, dominated by woodland, semi-natural grasslands and improved grasslands. The condition of the habitats of the rest of the site was estimated by the site manager. As a consequence, a condition was assigned to 98.4% of Hampstead Heath, leaving only 1.6% of the site without a condition score (some small water bodies and hedgerow habitats).

The condition map for the site (Figure 4) shows that most of the site is in either or moderate (2) condition (44.4% of the site area), or fairly poor (1.5) condition (31.4% of the site area). It is the broadleaved woodland at the site that is in moderate condition (pink areas, Figure 4), and the semi-natural grasslands that are in fairly poor (cream areas, Figure 4). The areas in poor condition (16.3% of the site area) tend to be areas of improved (amenity) grassland (blue areas, Figure 4). Built-up and infrastructure areas receive a condition score of zero (6.3% of the site area) (dark blue, Figure 4).

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[4] Defra (2023) The Statutory Biodiversity Metric. User Guide. Crown Copyright. https://assets.publishing.service.gov.uk/media/65673fee750074000d1dee31/The_Statutory_Biodiversity_Metric_-_Draft_User_Guide.pdf

[*] The adaptations made to the metric as used here are simply that the weightings for difficulty of habitat creation, strategic significance and spatial risk are not included. It is simply area x distinctiveness x condition. In addition, we have included the ancient woodland in the calculation as outlined above. The results of this baseline assessment could also be adapted for use in the context of a formal Biodiversity Net Gain (BNG) assessment at Hampstead Heath to ensure any future development on the sites meets the mandatory 10% net gain, or to work out which parcels of land at the site could be managed as biodiversity off-sets purchased by a developer so they can achieve BNG on their development. If the results are to be used for these purposes, we advise that a condition assessment is carried out by an ecologist and the spreadsheet tool supplied by Defra is used to revise the estimate.

Figure 5 shows the pattern of biodiversity unit scores across Hamstead Heath. Some areas of broadleaved woodland in the west of the site have the highest scores (> 100 units shown in red). However, there are some areas of woodland that have slightly lower unit scores (60-100 units in orange/pink and 30-46 units in cream), along with some of the semi-natural grasslands. The diversity of scores for woodland of uniform condition is due to the size of the blocks of woodland. Bigger blocks of woodland will have a higher biodiversity unit score because size is part of the metric calculation. The modified (amenity) grassland areas show the lowest scores (0-15 units in dark blue). The total biodiversity unit score for Hampstead Heath is 1,673.

**Table 3:** Biodiversity Metric 4.0 condition categories and associated scores.

| Condition Category | Condition score applied in the metric |
|---|---|
| Good | 3 |
| Fairly Good | 2.5 |
| Moderate | 2 |
| Fairly Poor | 1.5 |
| Poor | 1 |
| Condition assessment N/A (agriculture) | 1 |
| N/A - Other | 0 |

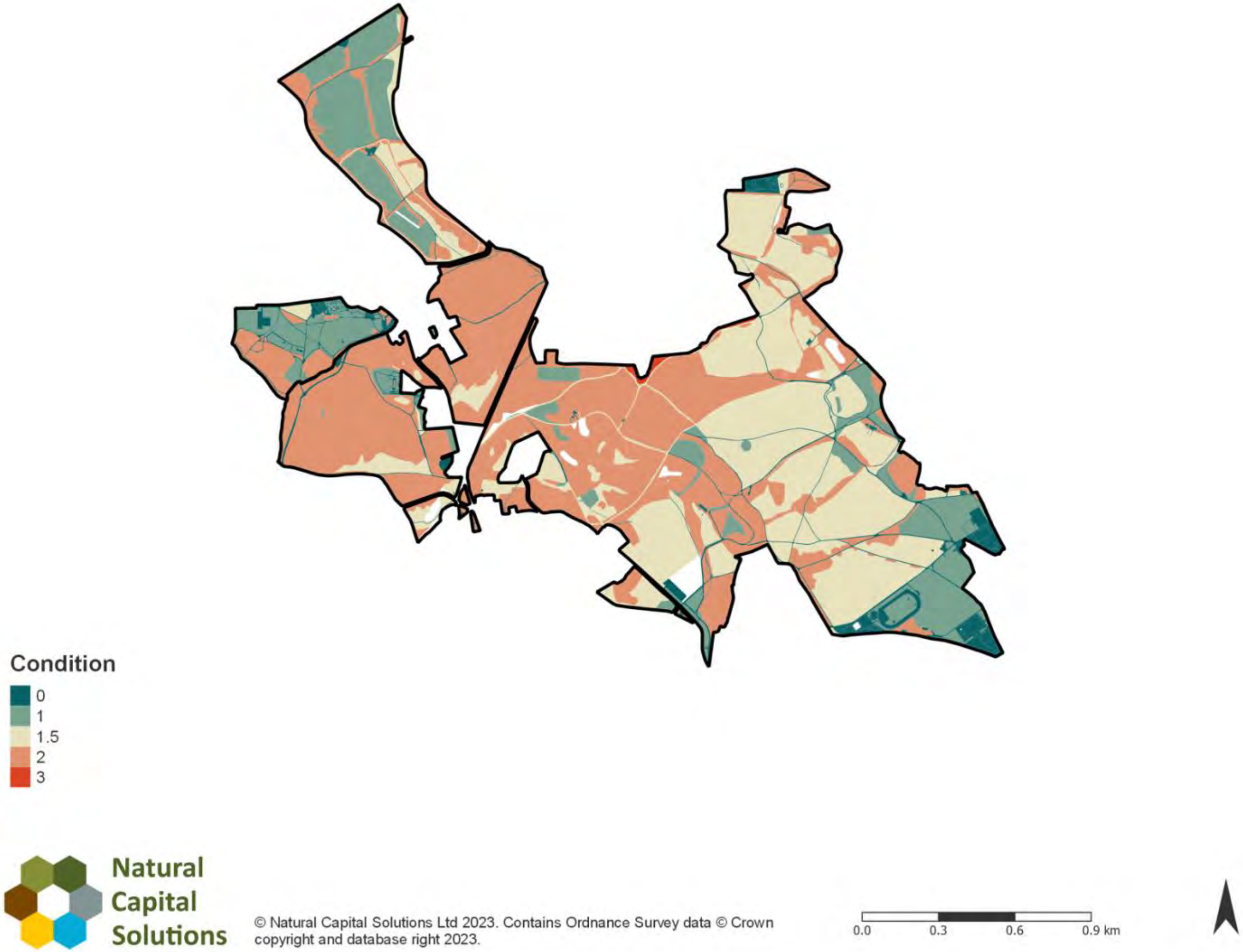


**Figure 4:** Habitat condition across Hampstead Heath (areas in white are where it was not possible to assign a condition score).

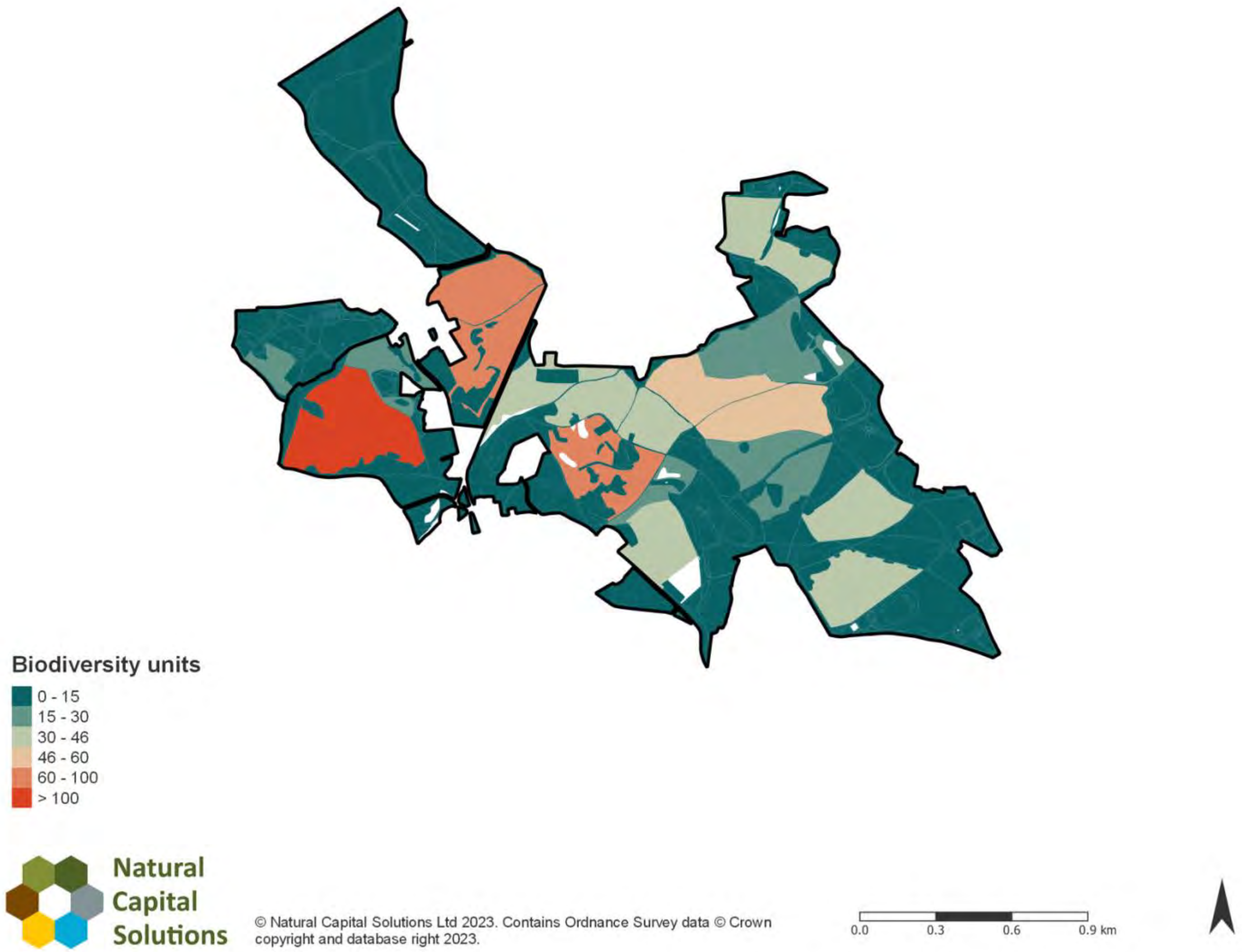


**Figure 5:** Biodiversity units across Hampstead Heath.

## 2.3 Ecosystem service provision (physical flows)

Once a detailed natural capital (habitat) map had been created for Hampstead Heath, it was then possible to quantify and map the benefits that the natural capital provides. A variety of methods were used (see Technical Appendix A1.2). In all cases the models were applied at a 5m-by-5m resolution to provide fine scale mapping across the area. The models are based on the detailed habitat information determined in the basemap (Section 2.1), together with a variety of other external data sets (e.g. digital terrain model data). Note, however, that most of the models are indicative (showing that certain areas have higher capacity than other areas) and are not process-based mathematical models (e.g. hydrological models). For every ecosystem service the capacity of the natural environment to deliver that service, or 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[†]. Both the capacity and demand of the services were mapped relative to the values present across the study site and buffer, and were normalised on a 0-100 scale (apart from carbon sequestration and storage for which the biophysical units were mapped). The resulting maps are shown in Figures 6 to 21. A brief description of each ecosystem service and the outcomes are provided below, detailed methodology is presented in Technical Appendix A1.

### Carbon sequestration capacity

Carbon is sequestered (captured) by growing plants. This model applies average values ($tCO_2$/ha/year) for each habitat type taken from various sources including Natural England (2021)[5] and the RSPB's Accounting for Nature report[6]. Woodland dominates the site and happens to be the best habitat at sequestering carbon (between 8 and 10 $tCO_2$/ha/year, red areas Figure 6), along with areas of scrub (between 6 and 8 $tCO_2$/ha/year, lighter red areas on the map). Semi-natural grassland is also widespread throughout the site but is not as efficient at sequestering carbon as woodland, and so has a lower rate (between 2 and 4 t $CO_2$/ha/year, pink areas). The other semi-natural habitats, along with hedgerows also sequester carbon at the same rate. However, modified grassland (amenity grassland) is not as efficient at sequestering carbon (cream areas 0.15 $tCO_2$/ha/year) (Figure 6), as are standing water and built up areas.

### Carbon storage capacity

Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation. 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. This model estimates the amount of carbon stored in each habitat type based on average values. Habitat management and condition can cause variation in a habitat's carbon storage capacity but management and condition were not taken into account for this model. Capacity is moderate to low across most of the site, with the broadleaved woodland storing between 150-200tC (cream areas, Figure 7). Coniferous woodland has a higher carbon storage capacity, but has minimal coverage across the parkland, with the small pockets sequestering 250-300tC (orange areas). Semi-natural grassland, scrub and hedgerows store between

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[†] The importance and value of an ecosystem service can often be dependent upon its location in relation to the demand for that service. Mapping demand was not, however, possible, for the other services where there was no obvious method to apply, or local demand is not relevant, such as food or timber production.

[5] R Gregg, J. L. Elias, I Alonso, I.E. Crosher and P Muto and M.D. Morecroft (2021) Carbon storage and sequestration by habitat: a review of the evidence (second edition) Natural England Research Report NERR094. Natural England, York.

[6] The RSPB. (2017) Accounting for Nature: A Natural Capital Account of the RSPB's estate in England. Annex 7.

100-150 tC (light blue areas, Figure 7). The built-up areas and infrastructure, water bodies, and modified (amenity) grassland, show low carbon storage potential, at 50-100 tC (blue areas).

**Air purification capacity (air quality regulation)**

According to Public Health England[7], 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 ($NO_x$). 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 $NO_X$. This air purification capacity model estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Capacity is low across the grassland and water areas of the site (blue areas, Figure 8) and highest in the woodland areas (red and cream areas).

**Air purification demand**

Components that influence air pollution removal demand include densely populated areas and vulnerable populations (the very old and young) in close proximity to sources of pollution (major roadways, major built-up areas). Demand for this service is low within the site, as there are no major roads or built up infrastructure through the site (blue and cream areas, Figure 9). However, the built up areas along the site's southern boundaries near the Hampstead Heath railway line to the southeast, and along the south and west boundaries (A502 and Finchley Road especially) have high demand (orange and red areas, Figure 9).

The demand for air purification is largely met by the capacity of the site to supply it, although there is no capacity to supply this service (blue areas Figure 8) in the south east of the site where the demand for it is high.

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

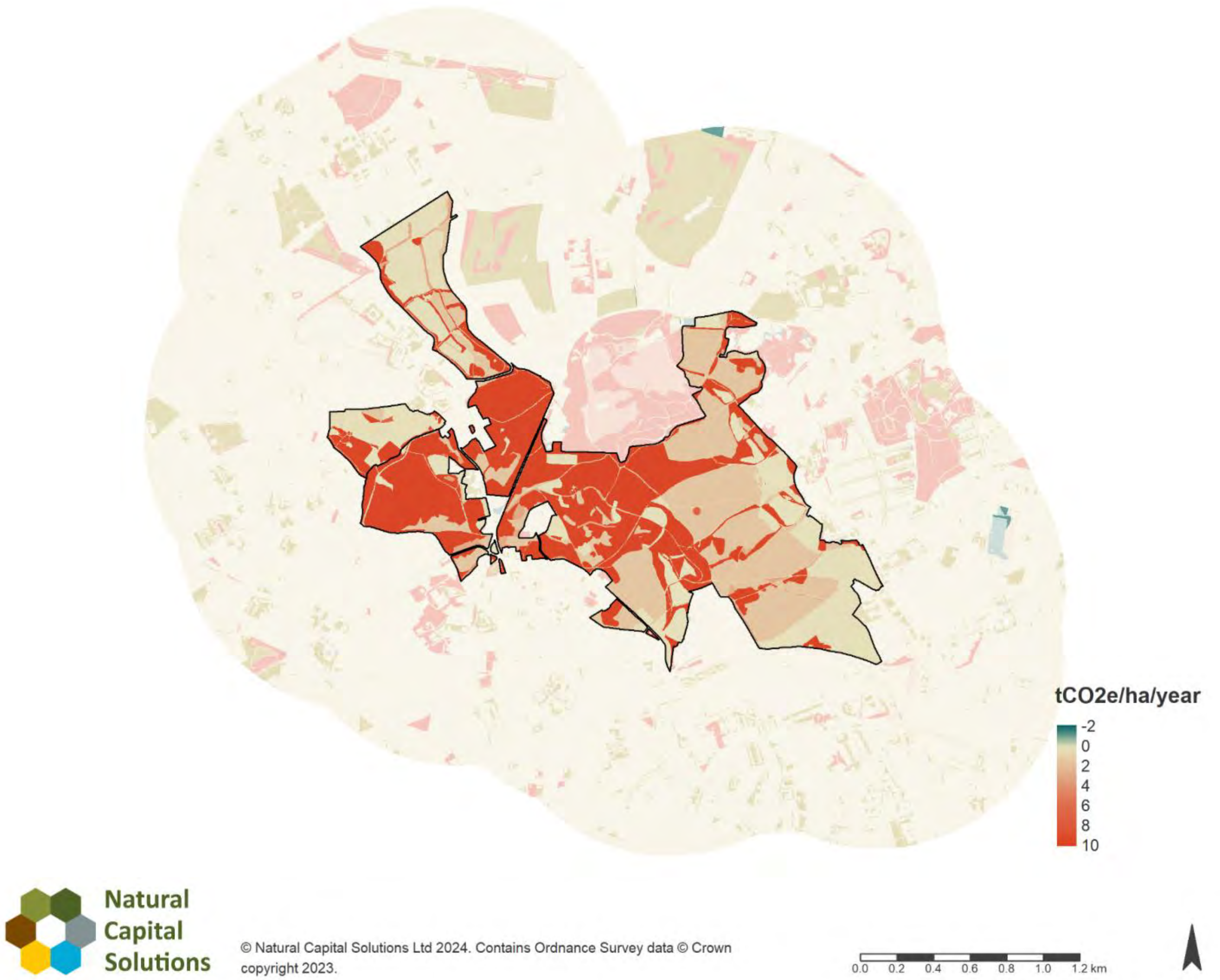


**Figure 6.** Carbon sequestration capacity at Hampstead Heath (in tonnes of $CO_2e$ per ha per year).


**Figure 7.** Carbon storage capacity at Hampstead Heath (in tonnes of carbon per ha).


**Figure 8**. Air purification capacity at Hampstead Heath (normalised on a scale of 0-100).

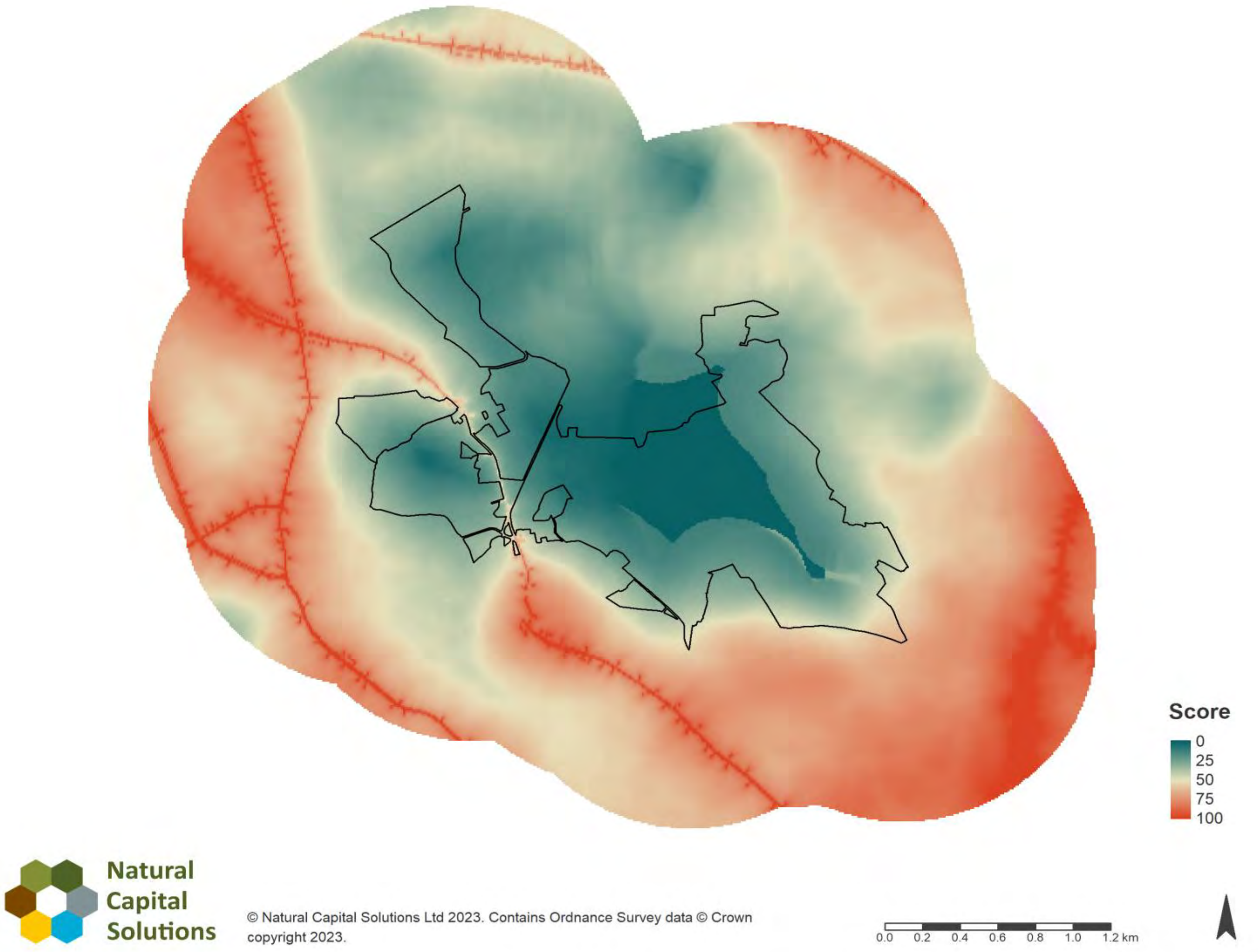


**Figure 9.** Air purification demand at Hampstead Heath (normalised on a scale of 0-100).

### Noise regulation capacity

Noise regulation capacity is the capacity of the land to diffuse and absorb noise pollution. Complex vegetation cover, such as woodland, trees and scrub, is considered to be most effective, and the effectiveness of vegetation increases with width. The use of vegetation can screen and reduce the effects on surrounding neighbourhoods. The provision of the noise regulation service is low to moderate across the grassland and water areas of the site (blue and cream areas, Figure 10) and is considerably higher in areas of woodland (red areas).

### Noise regulation demand

Demand for noise regulation will be highest in built up areas with vulnerable populations (the very old and young) living close to sources of noise (roads and railways). Whilst the site provides some level of the noise regulation service, there is unsurprisingly little demand on site for noise regulation (blue areas, Figure 11). However, on the built-up south eastern boundary of the site the demand increases where housing is in close proximity to the Hampstead Heath train line and Mansfield Road (cream area, Figure 11).

The demand for noise regulation, as with air purification, is largely met by the capacity of the site to supply it (Figure 10), although there is no capacity to supply this service in the south east of the site where the demand for it is high.

### Local climate regulation capacity

Local climate regulation capacity estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima. Local climate regulation capacity is mapped using an InVest model[8]. Natural vegetation, especially trees / woodland and rivers, can help reduce the urban heat island by providing shade, increasing cooling through evapotranspiration and make nearby areas cooler in summer and warmer in winter. The model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks) for each pixel. The scores generated shows the capacity of each habitat type to cool the air and is calculated relative to the average temperature across the summer months. The areas of woodland across the parkland are associated with moderate to high capacity (pink to red areas, Figure 12). The water bodies are associated with a moderate capacity (cream areas, Figure 12), while the areas of grassland are associated with low capacity (blue areas, Figure 12). Built-up areas are associated with no capacity (dark blue areas, Figure 12).

### Local climate regulation demand

Demand for climate regulation will be highest in built up areas with vulnerable populations (the very old and young). Generally, the demand for local climate regulation is limited, with no demand across the site itself (dark blue/green areas, Figure 13). Along the boundaries of the park, except along the northern boundary, the demand increases (pink and red areas, Figure 13). This increase in demand is associated with the built-up neighbourhoods of Highgate, Dartmouth Park, Hampstead, Gospel Oak and Golders Green that border the site. The low demand along the northern boundary is associated with the close proximity of the site to the Hampstead and Highgate Golf Clubs.

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[8] https://naturalcapitalproject.stanford.edu/software/invest

Somewhat similar to noise regulation and air purification, demand is largely met by the capacity of the site to supply it (Figure 12) although there is no capacity to supply this service in the south east of the site where there is moderate demand for it.

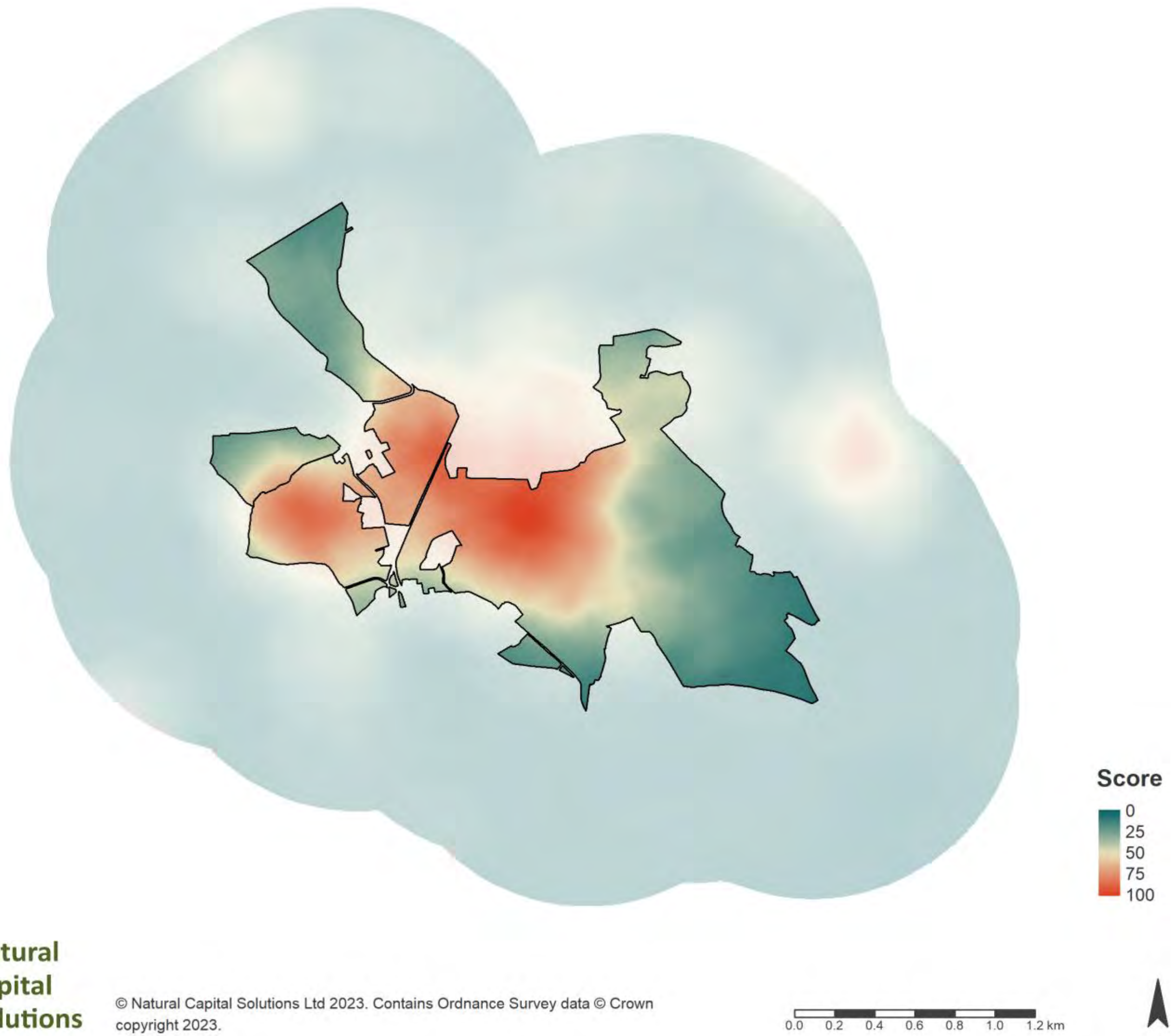




**Figure 10.** Noise regulation capacity at Hampstead Heath (normalised on a scale of 0-100).

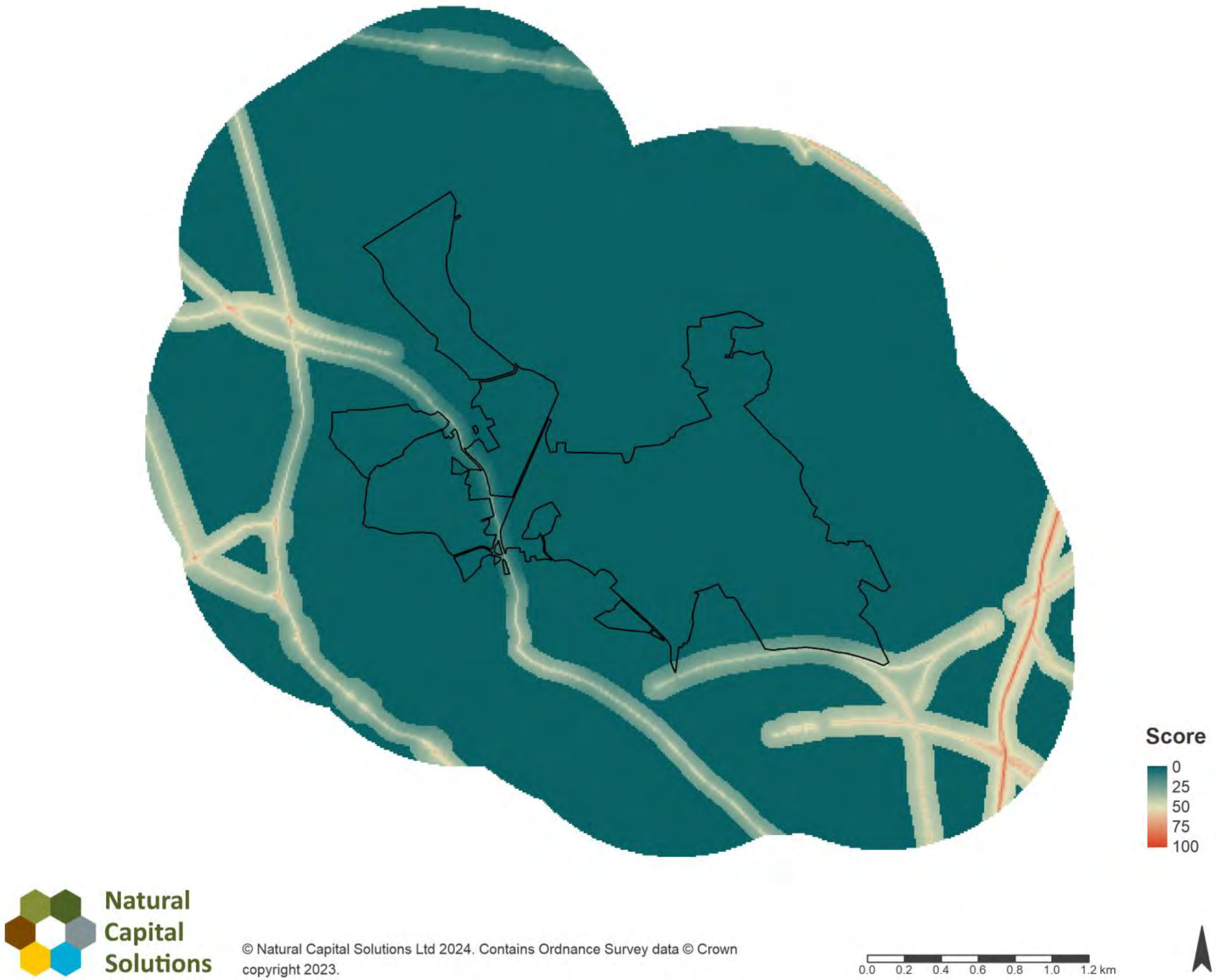


**Figure 11.** Noise regulation demand at Hampstead Heath (normalised on a scale of 0-100).


**Figure 12.** Local climate regulation capacity at Hampstead Heath (normalised on a scale of 0-100).

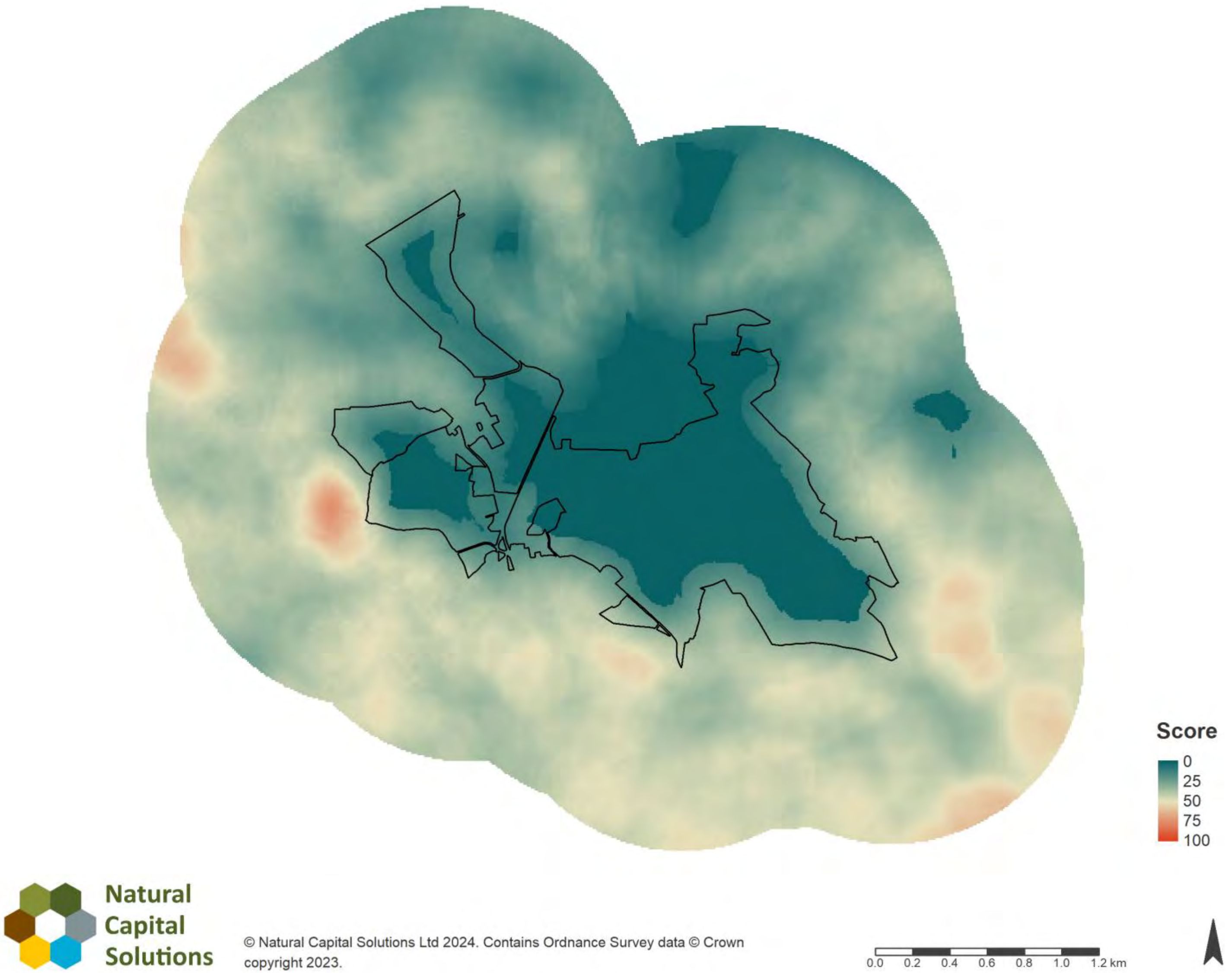


**Figure 13.** Local climate regulation demand at Hampstead Heath (normalised on a scale of 0-100).

### Pollination capacity

A key indication of local ecosystem health and biodiversity is the abundance and diversity of pollinators. Pollination capacity measures the capacity of the land to provide pollination services by estimating the visitation rate of each particular pixel of land (relative to the landscape analysed) for wild insect pollinators (assuming a steady state pollinator population). Different species of pollinators have different peak seasons, thus the pollinator visitation counts are completed in both the spring and summer season, to generate a more robust analysis of pollinator presence. The provision of this service throughout the site in the springtime is moderate to low, with woodland areas showing mainly moderate provision of this service (cream areas, Figure 14) and semi-natural and modified grasslands a low provision (light blue and blue areas, Figure 14). Garden areas have high visitation rates (orange/red areas, Figure 14), although they only occur in very small areas across the site.

In summer, pollination capacity increases across the site, with semi-improved grassland showing a moderate to moderately high visitation rate (cream to pink areas, Figure 15). Woodland areas have similar visitation rates as they do in spring, with moderate to low visitation (cream to blue areas, Figure 15). Modified grassland and built-up areas remain low (blue areas, Figure 15), while garden areas remain high (orange/red areas, Figure 15).

### Water flow regulation capacity

Water flow regulation capacity is the ability of the land to slow water runoff and thereby potentially reduce flood risk downstream, based on land use and slope. Certain habitats have a higher roughness score, meaning they are better at slowing water runoff, these habitats include woodland, heathland and scrub habitats (red and pink areas, Figure 16). Grasslands have a moderate capacity (pink and cream areas, Figure 16), while built up areas have a moderate to low capacity (cream and blue areas, Figure 16).

### Water quality regulation capacity (soil erosion)

Water quality regulation capacity maps the risk of surface runoff becoming contaminated with high sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. This model comprises four indicators: proximity to water courses, slope length, risk of erosion from land use and risk of sedimentation at the catchment scale. The pattern of capacity scores in the map (Figure 17) is driven mainly by distance to water course and slope, rather than habitat type (as they are all fairly low erosion risk). Areas in red are generally along an elevated slope (Figure 17), and the dark blue area towards the centre of the map is on a downward slope that is closer to water bodies, both of which increase the risk of surface runoff contamination which means a lower provision of the water quality service (Figure 17).


Natural Capital Solutions



**Figure 14.** Spring pollinator visitation rate at Hampstead Heath (normalised on a scale of 0-100).


**Figure 15.** Summer pollinator visitation rate at Hampstead Heath (normalised on a scale of 0-100).

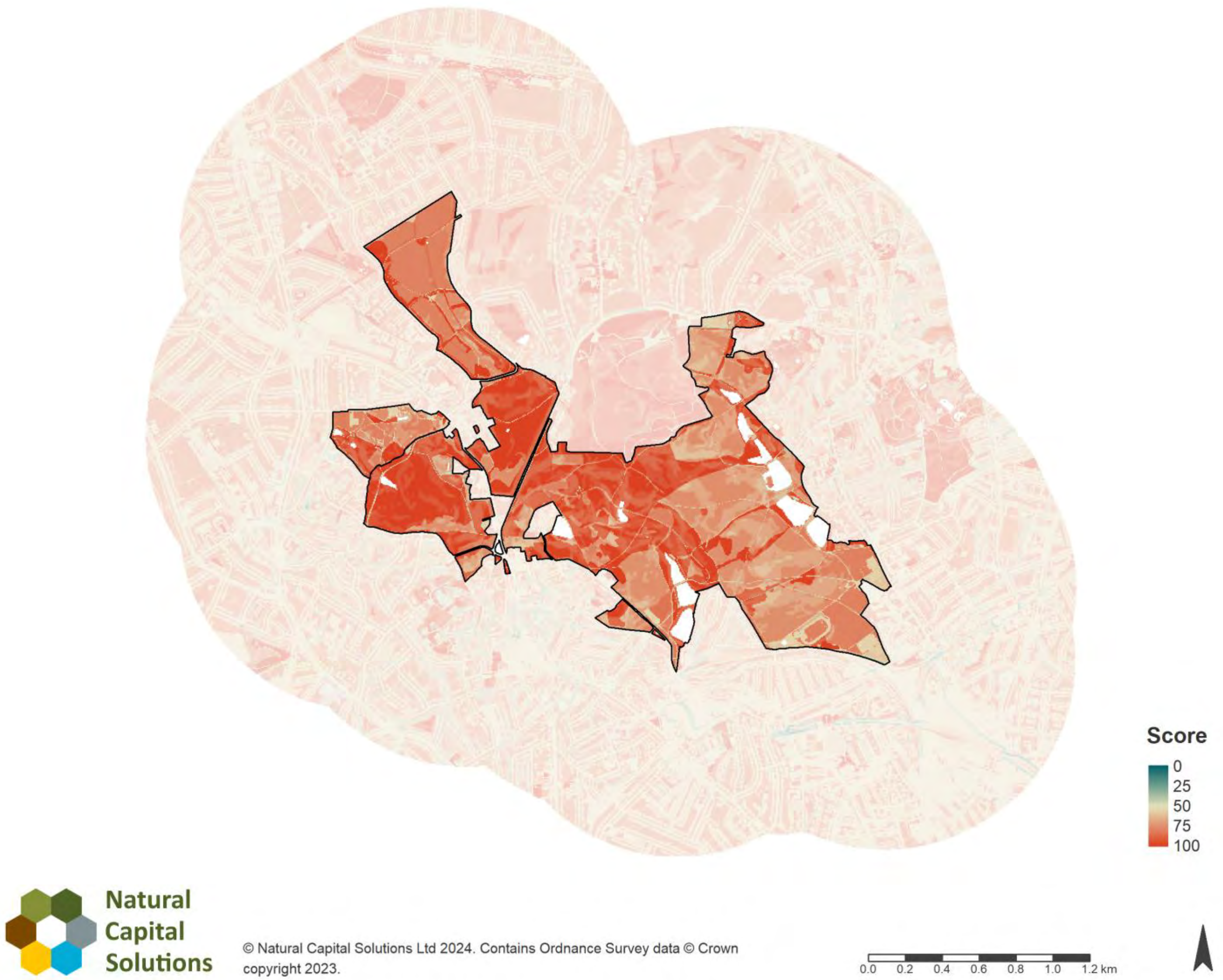


**Figure 16.** Water flow regulation capacity at Hampstead Heath (normalised on a scale of 0-100).


**Figure 17.** Water quality regulation capacity at Hampstead Heath (normalised on a scale of 0-100).

### Food production capacity

Food production models the capacity of the land to produce food. While this site does not currently have any farming activity, the ability of habitats to provide non-commercial food source, accounting for Agricultural Land Classification, is considered. The semi-natural grassland areas have a high capacity for food production (red areas, Figure 18). The rest of the parkland, comprising the woodlands, modified (amenity) grassland and water, has a low capacity for food production (blue areas, Figure 18), with the woodlands showing greater capacity than the modified grasslands.

### Timber and woodfuel production capacity

Timber is an important product of woodlands and is the raw resource of the timber industry. Sustainably managed woodland produces timber that is an important material for processing mills and factories that produce wood-based products. It also produces wood fuel for the generation of renewable heat and electricity. Note that this models the potential for production of timber and woodfuel, regardless of whether areas are actually being harvested (as these sites are managed for conservation, wood fuel production is only likely from managed thinnings). The small areas of coniferous woodland have the highest capacity (red areas, Figure 19), with the broadleaved woodland showing a lower capacity (light green areas, Figure 19).

### Accessible nature capacity

The two key components of accessible nature capacity are 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. Across the site, accessibility is high (red areas, Figure 20), with pathways through woodlands receiving particularly high scores. Built-up areas, water and areas of modified (amenity) grasslands have moderate and low accessibility scores (cream and blue areas, Figure 20). Blank areas indicate that there is no publicly accessible greenspace in that location.

### Accessible nature demand

Demand for this service is high in the built up areas all the way around the site (red areas, Figure 21), with the demand at the northern boundary of the site decreasing to moderate (cream area, Figure 21) as it is adjacent to the local golf club.

Hampstead Heath is a site that provides access to habitats of high naturalness (Figure 20) so the high demand for this service immediately outside of the site is being met.

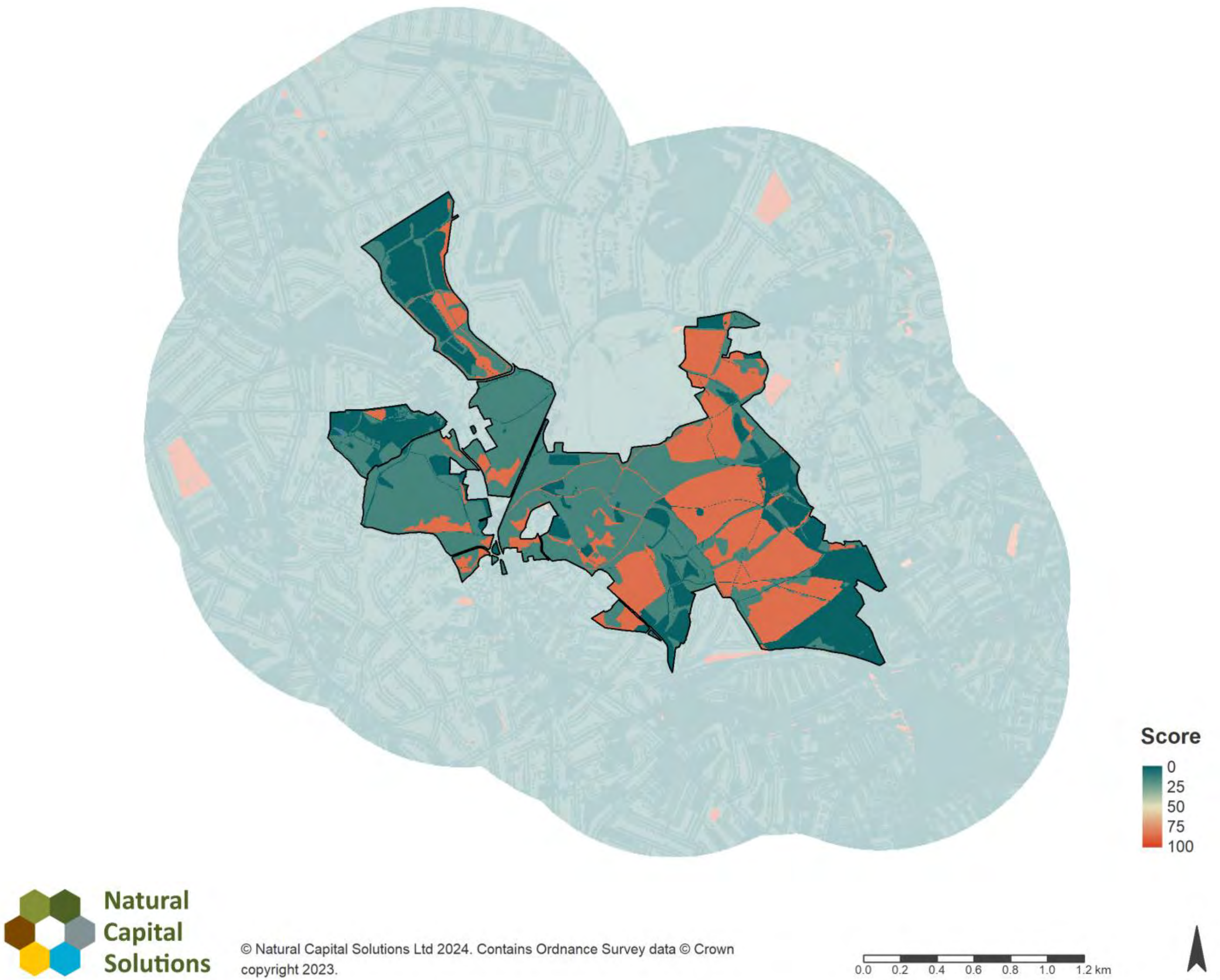


**Figure 18.** Food production capacity at Hampstead Heath (normalised on a scale of 0-100).

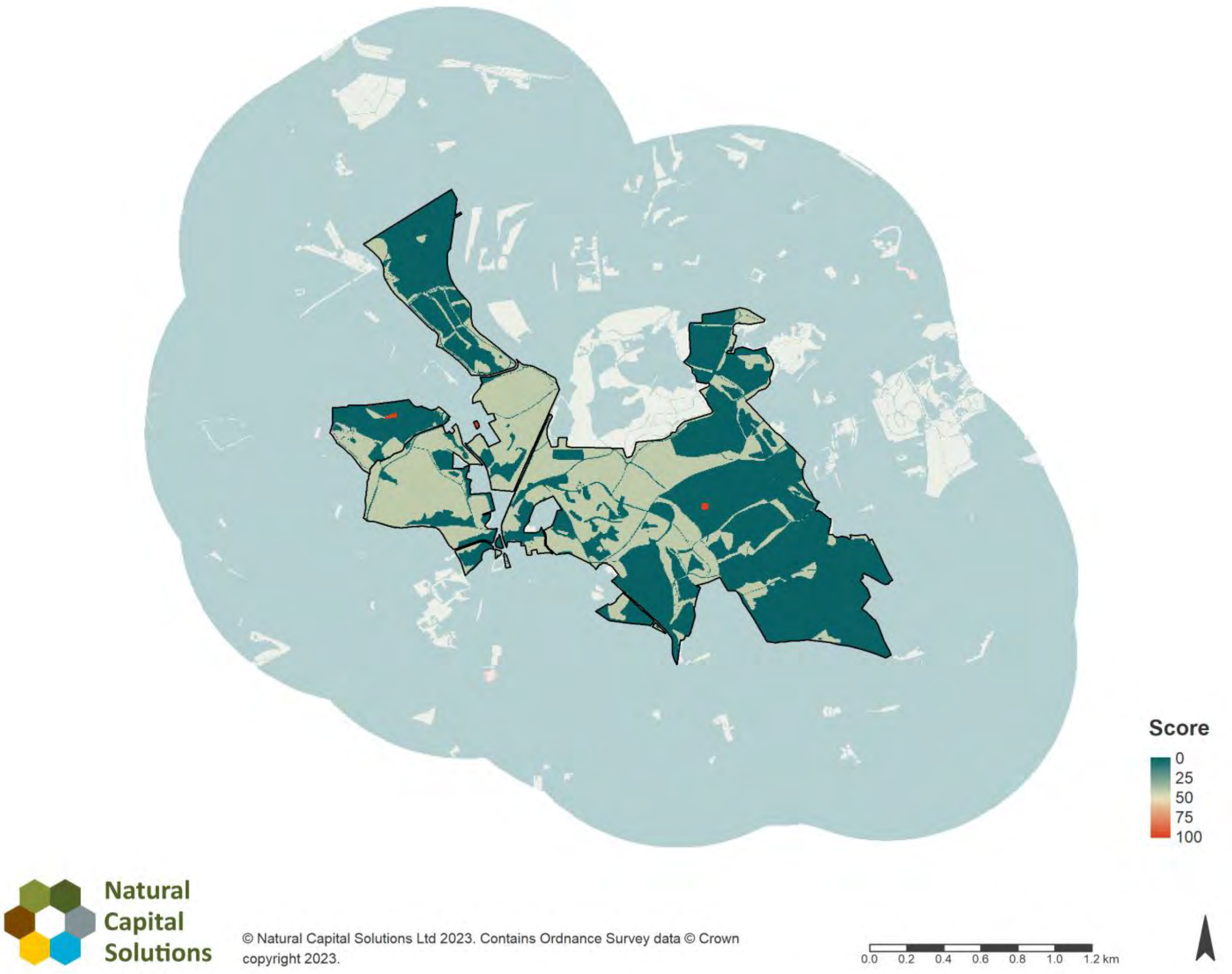


**Figure 19.** Timber production capacity at Hampstead Heath (normalised on a scale of 0-100).

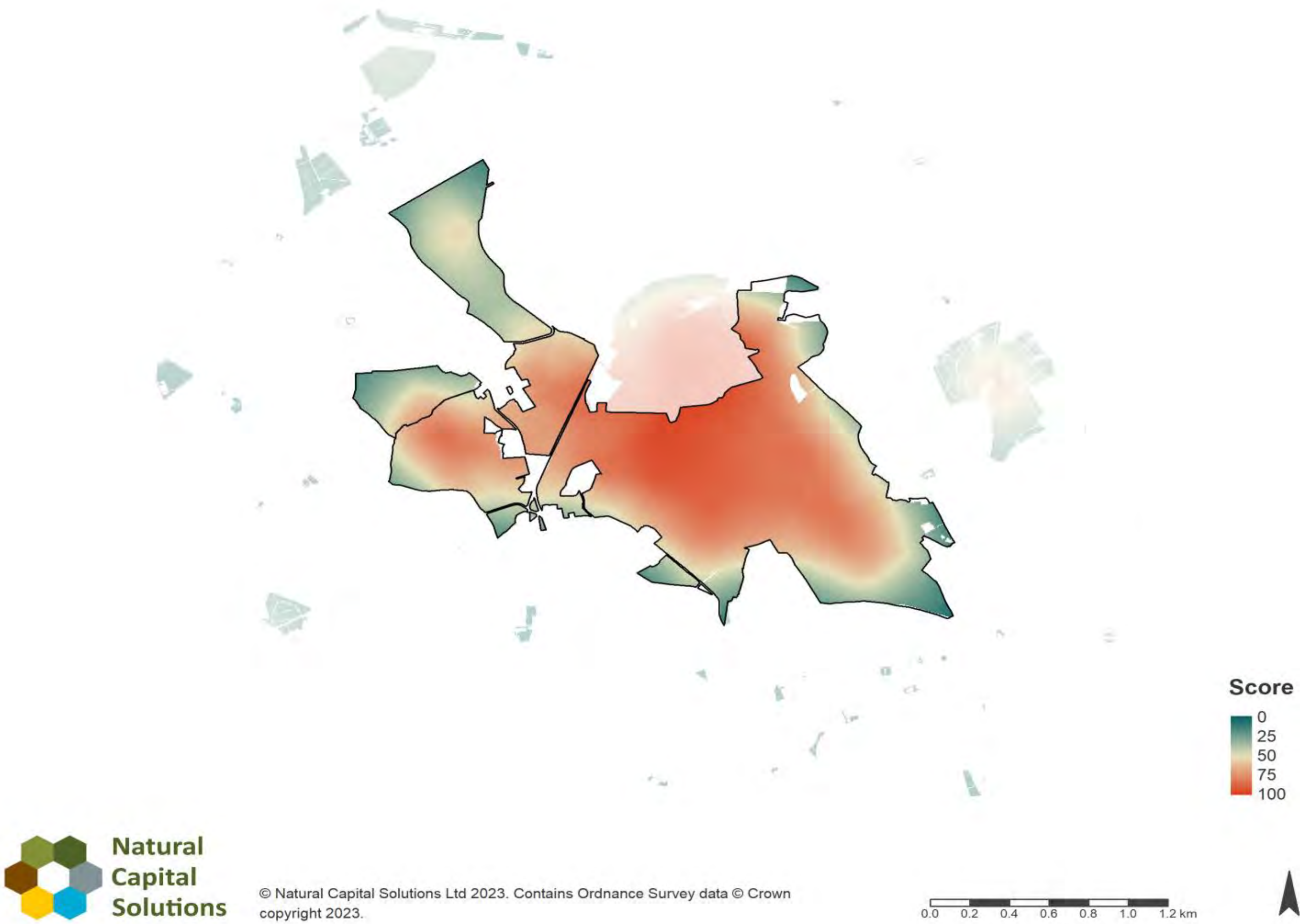


**Figure 20.** Accessible nature capacity at Hampstead Heath (normalised on a scale of 0-100).

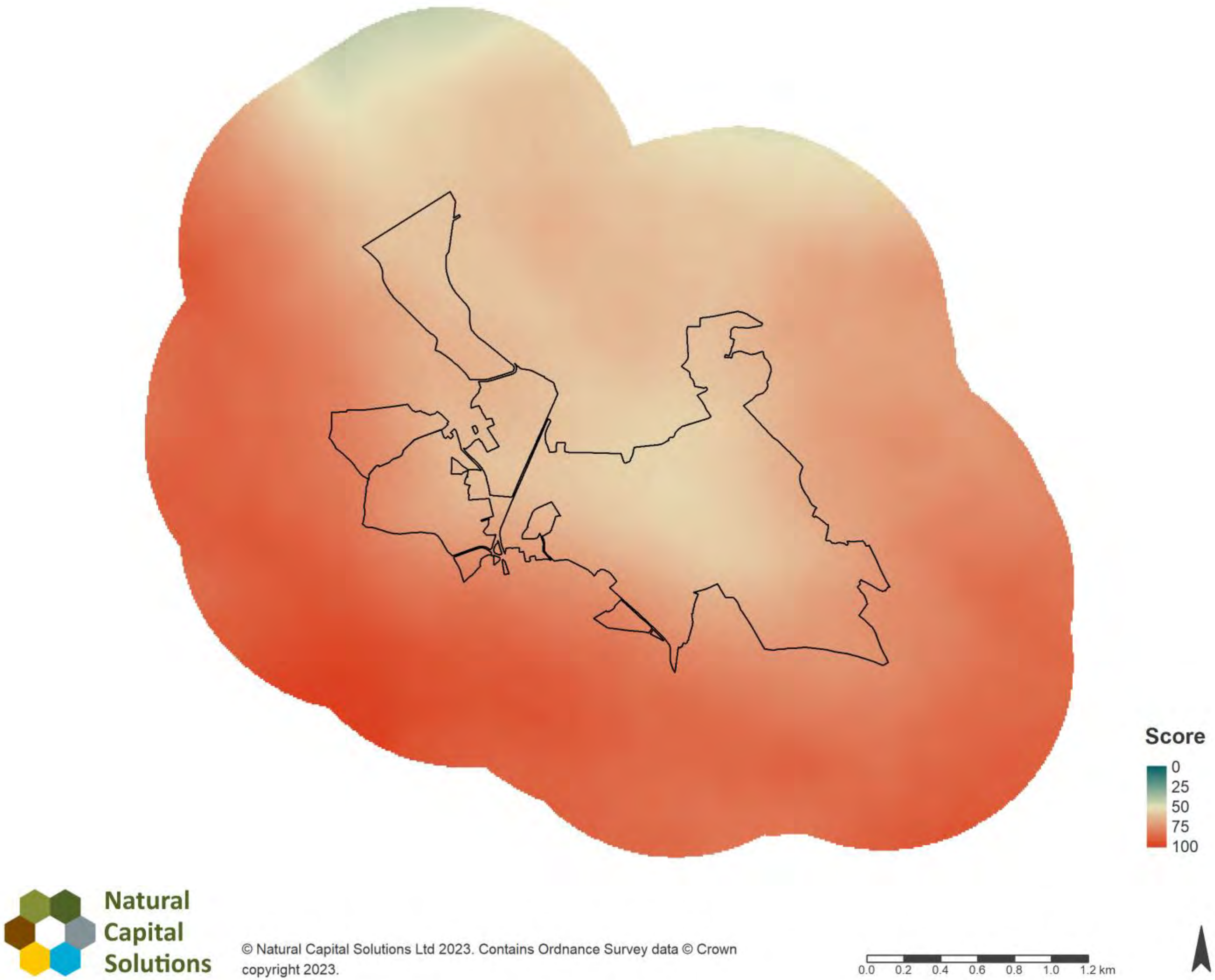


**Figure 21.** Accessible nature demand at Hampstead Heath (normalised on a scale of 0-100).

## 2.4 Baseline ecosystem service valuation (monetary flows)

The annual monetary flow of the following ecosystem services was estimated: air quality regulation, carbon sequestration and emissions (presented as the carbon balance), timber production, noise reduction, water quality, flood regulation, recreation, health benefits, and amenity. Table 4 outlines the indicators used to quantify both the physical and monetary flows of these services.

**Table 4.** Ecosystem services and indicators for physical and monetary measurement.

| Ecosystem service | Physical flow | Valuation |
|---|---|---|
| Air quality regulation | Tonnes of $PM_{2.5}$ | Damage costs avoided as estimates of avoided mortality and morbidity from improved air quality: £/tonne of $PM_{2.5}$ |
| Carbon balance | Quantity of $CO_2$ sequestered or emitted | £/tonne of $CO_2$ |
| Timber/woodfuel production | $m^3$/ha | £/$m^3$/year |
| Noise reduction | ha of woodland | Damage costs avoided as estimates of avoided mortality and morbidity from reduced noise pollution: £/ha/year |
| Water quality | ha of woodland | £/ha/year |
| Flood regulation | $m^3$/ha | £/ $m^3$/year |
| Recreation | Number of visits | Welfare gains obtained by an individual when accessing green spaces, in relation to their traveling costs (based on a model by University of Exeter's ORVal): £/visit/year |
| Health benefits | Number of visitors (>120' / week in nature) | QALY (Quality-Adjusted Life Year) is equivalent to one year of life in perfect health, accounting for both quantity and quality of life. Here we estimate the QALY units and benefits in monetary terms gained as a result of exposure to nature (the additional years of life in perfect health visitors who spend 120 minutes per week in nature (by visiting the study site) gain) £/QALY/year |
| Amenity | Number of houses within 500m of green and blue spaces | Value captured by the prices of property given their location within 500m of green and blue spaces: Uplift/ average house prices times number of houses |

* Welfare here means social well-being.

Annual monetary flows of ecosystem services were calculated in line with the System of Environmental-Economic Accounting (SEEA) framework and accounting principles (2017)[9], and the

[9] System of Environmental-Economic Accounting (SEEA) Central Framework (2012) and Experimental Ecosystem Accounting principles (2017).

British Standard for Natural Capital Accounting for Organisations (BS 8632:2021)[10]. They were based on the latest valuation techniques available in the scientific literature, and recent Defra guidance bringing together the latest valuation approaches for ecosystem services (Defra ENCA, 2020)[11]. The physical and monetary flows of the ecosystem services are presented below for Hampstead Heath. The methods used to calculate these are described in more detail at the end of the report along with any limitations (see Technical Appendix A.2).

Vegetation can be effective at contributing to **air quality regulation**, with the surface area being the most important determinant of capacity. Trees are much more effective than grass or heather at this, and capacity increases significantly as trees grow and their surface area increases. The woodland, heathland and grass vegetation across the site is estimated to adsorb 6.4 tonnes of $PM_{2.5}$ (particulate matter 2.5 micrometres or less in diameter) annually, at an annual value of £2.1 million with a present value (over 50 years) of £75.3 million (Table 5).

**Carbon balance** is the difference between carbon sequestered, the uptake of carbon by plants as they grow - with woodland being much the most effective habitat at this across the Hampstead Heath site – and carbon emitted. In total, the annual carbon sequestration across the site is 1,013 tonnes of carbon per year ($tCO_2e$), at an annual value of £280,000 (Table 5), with a present value (over 50 years) of £9.1 million.

The site supports approximately 593 $m^3$ of **timber and woodfuel** per year under the current management and averaged over a full woodland production cycle. This has an annual value of £30,000 and a present value (over 50 years) of £750,000 (Table 5).

Woodland can provide screening against noise pollution, especially in urban areas where it can provide a buffer between the noise sources, particularly from road transportation, and the population. We have calculated a **noise reduction** value for woodland at the urban areas within the Hampstead Heath site and assumed zero value for the rural parts of the site. Under these assumptions, Hampstead Heath provides noise reduction benefits of £70,000 a year with a present value over 50 years of £1.7 million (Table 5).

An estimate was made for **water quality** benefits through the presence of riparian and non-riparian woodland. The presence of non-riparian woodland is considered to provide a benefit in comparison to damage costs associated with land use as agriculture; whereas the riparian figures consider the ability for water quality improvements to be made through the woodlands ability to prevent pollution of water courses and a willingness to pay for this service. A total of 114 ha of non-riparian woodland and 0.02 ha of riparian woodland was identified in Hampstead Heath, collectively providing an annual value of £10,000 and a present value of £280,000 (Table 5).

Natural capital also provides benefits in the form of **water flow regulation**, which leads to downstream flood risk reduction. At present it is only possible to value this for woodland habitats, although it is acknowledged that other habitats will also provide some benefits. The calculation was based on

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[10] British Standard BS 8632 (2021) Natural capital accounting for organisations: https://www.bsigroup.com/en-GB/standards/bs-86322021/. Although this standard it aimed at applying natural capital accounting at the organisational level, the principles are the same when applied to geographic areas.
[11] Defra (2020) Enabling a Natural Capital Approach (ENCA). Available at: https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca on 1 July 2020.

national average figures from Forest Research (2023)[12], and provides an estimation of three physical processes: canopy interception, woodland soil water storage capacity, and floodplain woodland storage. The woodland within the Hampstead Heath site was estimated to intercept and store 75,700 m3 of water each year, which has an annual value of £40,000 and a present value (over 50 years) of £950,000 (Table 5).

**Table 5**. Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Hampstead Heath.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation *$tPM_{2.5}$* | 6.4 | 2,080 | 75,280 |
| Net carbon balance* *$tCO_2e$* | 1,013 | 280 | 9,130 |
| Woodland | 871 | 240 | 7,850 |
| Agriculture/ livestock emissions | N/A | N/A | N/A |
| Other habitats | 142 | 40 | 1,280 |
| Timber/woodfuel production *$m^3$* | 593 | 30 | 750 |
| Noise reduction *Ha of urban woodland* | 87 | 70 | 1,740 |
| Water quality regulation *Ha of woodland* | 114 | 10 | 280 |
| Flood reduction by woodland *$m^3$* | 75,700 | 40 | 950 |
| Recreation *Visits (Million)* | 8.1 | 34,750 | 858,150 |
| Health *QALY* | 817 | 13,520 | 489,810 |
| Amenity *Nr houses within 500m* | 9,825 | 420 | 9,870 |
| **Total values:** | **N/A** | **51,200** | **1,445,970** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

Hampstead Heath has high recreational value. We used the number of **recreational visits** made to the site provided by the client and estimated their welfare value using the Outdoor Recreation Valuation (ORVal) tool created by the University of Exeter[13]. There are an estimated 8.1 million recreational visits per year. The welfare value derived from these visits is valued at £34.8 million annually, with a present value (over 50 years) of approximately £858.2 million (Table 5).

A subset of these visitors will also receive **health benefits** from spending at least 120 minutes a week in nature, following the Exposure to Nature approach suggested by ONS (2022) and explained in the

[12] Broadmeadow, S. et al. (2023) Revised valuation of flood regulation services of existing forest cover to inform natural capital accounts. Forest Research

[13] Day, B. H., and G. Smith (2018). Outdoor Recreation Valuation (ORVal) User Guide: Version 2.0, Land, Environment, Economics and Policy (LEEP) Institute, Business School, University of Exeter.

Technical Appendix A.2. The estimated number of visitors to Hampstead Heath receiving health benefits every year is equivalent to 817 Quality-Adjusted Life Years (QALY). This delivers an annual value of £13.5 million and a present value over 50 years of £489.8 million (Table 5).

We use the principle of hedonic pricing and evidence of increases in property values as a means of capturing **amenity value**. There are 9,875 homes in close proximity – within 500 metres - to the greenspace provided by the Hampstead Heath site, having a positive impact on the average house values of those homes. This benefit of £9.9 million is considered a present value (in this case, over 50 years) rather than an annual flow, so we annualise it to estimate annual benefits of £420,000.

In total, the value of the benefits delivered by the natural capital assets that we quantified for Hampstead Heath is £51.2 million annually, with a present value of £1.5 billion over 50 years.

### 2.4.1 Sensitivity analysis

A sensitivity analysis examined the low, central and high estimates of the Hampstead Heath benefits that have been valued (Table 6). This demonstrates the overall sensitivity of natural capital values. The total natural capital value of the site ranges from a present value (over 50 years) of £933.1 million under the lowest benefits estimates up to £3.4 billion under the highest benefits estimates. This large difference highlights the challenges of placing a monetary value on some services. A key point, however, is that even under the low benefit estimate, the natural capital assets will deliver a substantial benefit worth at least £34.2 million annually, which is £933.1 million in present value terms.

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

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. For example, additional cultural services, such as aesthetic experiences, cultural heritage, spiritual experience and sense of place that are difficult to quantify. Consequently, the valuations presented in this section place values on several key benefits, but these are necessarily incomplete.

**Table 6.** Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets of Hampstead Heath.

| Ecosystem service | Annual values (2023) (£ 000's) | | | Present value (over 50 years) (£ 000's) | | |
|---|---|---|---|---|---|---|
| | Low | Central | High | Low | Central | High |
| Air quality regulation | 820 | 2,080 | 5,920 | 29,840 | 75,280 | 214,550 |
| Net carbon balance | 140 | 280 | 410 | 4,560 | 9,130 | 13,690 |
| Timber/ woodfuel production | 20 | 30 | 40 | 560 | 750 | 940 |
| Noise reduction | 50 | 70 | 90 | 1,310 | 1,740 | 2,180 |
| Water quality | 10 | 10 | 10 | 210 | 280 | 360 |
| Flood regulation | 30 | 40 | 50 | 710 | 950 | 1,190 |
| Recreation | 26,070 | 34,750 | 43,440 | 643,620 | 858,150 | 1,072,690 |
| Health | 6,760 | 13,520 | 57,180 | 244,900 | 489,810 | 2,071,840 |
| Amenity | 320 | 420 | 530 | 7,400 | 9,870 | 12,340 |
| **Total value:** | **34,210** | **51,200** | **107,670** | **933,120** | **1,445,970** | **3,389,760** |

NB. Figures shown to the closest 00's. Any discrepancies due to rounding.

For the services that have been included here, a range of assumptions have been made, and these are outlined when describing the methodology (see Technical Appendix A.2). In addition, a summary of the main uncertainties is provided for each service in Table 7 (above), along with a RAG rating highlighting the overall confidence in each estimate. For most ecosystem services these assumptions are minimal, as established production functions exist linking natural capital to ecosystem service production and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for health, and this estimate should, therefore, be used with care.

**Table 7.** Summary of uncertainties in the calculation of physical flows and monetary values of each natural capital benefit, and an overall assessment of confidence, using a red, amber, green (RAG) rating.

| Natural capital benefits | Assessment of uncertainties | RAG rating |
|---|---|---|
| Air quality regulation | Biophysical estimates based on averages for broadleaved and coniferous trees and grassland. Valuation follows ONS guidance. | |
| Carbon sequestration | Well studied. standardised carbon lookup tables available. Valuation uses UK Government non-traded carbon price. | |
| Timber production | Well studied over many years as part of forestry management. Valuation uses market prices. | |
| Noise reduction | Based on value transfer from another study (from Manchester), so a crude estimate. | |
| Water quality | The "water quality" figure is crude and a lower-bound estimate as it simply gives the average damage cost of agriculture over England. The "riparian" figure is based on a large number of major assumptions and should be treated with caution. | |
| Flood regulation | Widely accepted approach, based on a study by Forest Research. But is a relatively crude assessment as it is value transfer from England scale data. | |
| Recreation | Welfare values from a meta-analysis of a range of welfare value studies across a range of habitats. There is potential here for double counting with the health service (see Technical Appendix for discussion). | |
| Health benefits | The most uncertain of the services measured. High uncertainty over who would spend time weekly in green spaces and the monetary value of these benefits. | |
| Amenity | Follows the latest ONS study on the effect on house values of proximity to greenspaces. This uses travel to work area estimates of impact on house values for the local authority of reference only. These estimates may vary across the region. | |

## 2.5 Natural capital account

A natural capital account measures and values the natural capital assets of an area, based on the flow of ecosystem services and associated benefits from those assets. The benefits are then compared to the costs (capital and operational expenditure) in the form of a balance sheet. We have completed the first steps of the natural capital account in the previous chapters of this report: an asset register describing the extent of the natural capital assets (Section 2.1), and the physical and monetary flow account (Section 2.4). The final step of the process is to produce a maintenance cost account and a natural capital balance sheet for the site. This is where the value of the benefits derived from the natural capital assets are compared to the costs of maintaining those assets. Valuations are referred to as 'asset values' and the maintenance requirements as 'liabilities', following standard accounting terminology. In addition, two components of asset value are recognised: private value (benefits to the Corporation) and external value (wider benefits to society). Most of the benefits included here provide external value, except for timber/woodfuel production that is considered as providing private benefits. This approach follows general principles and methodology, which has been developed by Eftec et al. (2015)[14] and the British Standard for Natural Capital Accounting for Organisations (BS 8632:2021)[15] .

The high level estimates of maintenance costs (Table 8) are an average of actual operational costs from the Local Risk budget for the last five years (from 2018/19 to 2022/23), in 2023 prices, and include typical costs associated with forestry, management of the recreational greenspaces, fencing, and hedgerow maintenance. They are divided between employee costs, the most important expenditure, and other costs, which include premises costs, supplies and services, and transportation.

**Table 8.** Annual costs associated with the maintenance of natural capital on Hampstead Heath (£2023, Thousands).

| | **Hampstead Heath (£000's)** |
|---|---|
| Employees | 5,520 |
| Other costs | 1,440 |
| **Total** | **6,960** |

NB. Actual costs, five-year average (2018/19- 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding.

The natural capital balance sheet for Hampstead Heath is shown in Table 9. The total value of the natural capital assets of the site is quantified and reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site.

The gross asset value of the site (PV £1.5 billion, Table 9) is driven largely by the value of recreation, health services, air pollution regulation, and carbon sequestration (see Table 5). The net natural capital asset value of Hampstead Heath is £1.3 billion over 50 years. The site delivers a benefit to cost ratio of 8.4, which means that every £1 spent on maintenance delivers £8.4 in benefits.

[14] Eftec, RSPB & PWC (2015) Corporate Natural Capital Accounting Guidelines.
[15] British Standard BS 8632 (2021) Natural capital accounting for organisations: https://www.bsigroup.com/en-GB/standards/bs-86322021/. Although this standard it aimed at applying natural capital accounting at the organisational level, the principles are the same when applied to geographic areas.

**Table 9.** Natural capital balance sheet for Hampstead Heath presented as present values (PV) over 50 years.

| | **Present Value (PV £000's)** |
|---|---|
| **Assets** | |
| Natural capital benefits | 1,445,970 |
| **Gross asset value (benefits)** | **1,445,970** |
| | |
| **Liabilities** | |
| Maintenance costs | (171,830) |
| **Total liabilities (costs)** | **(171,830)** |
| | |
| **Net Natural Capital Value** | 1,274,140 |
| **Benefit-cost ratio** | **8.4** |

## 2.6 Conclusions

The natural capital maps and asset register shows that woodland covers a large proportion of the Hampstead Heath (41.1%). Consequently, the site delivers a high provision across a range of ecosystem services. The woodland delivers 86% of the sequestration ability of the site and is a significant store of carbon. It also has a high capacity for air pollution, noise, climate and water flow regulation. In addition, the woodland delivers a high accessible nature provision. These services are particularly important given the high demand for them immediately outside of the site in the surrounding urban areas.

Whilst woodland is always an important habitat for delivering a wide range of services, the assessment demonstrates that semi-natural grasslands, heathlands and water all provide important ecosystem service benefits. Most notably pollination, particularly in the summer, local climate regulation and natural habitats for recreation and health benefits.

The diversity of habitats at the site is also important for biodiversity, and the site has conservation designations at the local and the national level (SMINC and SSSI). The biodiversity baseline assessment shows that the majority of the habitats are in moderate or fairly poor condition. Consequently, there is room for improvement in the baseline biodiversity unit score (1,673). A focus on increasing the condition of the woodland from moderate to good, and the semi-natural grassland and water bodies that are fairly poor to moderate would increase the biodiversity units. The activities outlined in the management plan for the site should go a long way to achieving this.

The overall net natural capital value of the site is £1.3 billion over 50 years, and for every £1 spent on maintaining the natural capital at the site there is a £8.4 return in benefits. This high value is driven by the cultural services, recreation and health (£34.8 million and £13.5 million annually), air pollution regulation (£2.1 million annually), the amenity value (accessibility to green space and views provided by the site (£420,000 annually)), and the ability of the site to sequester carbon (£280,000 annually). The site provides important and valuable services in the context of a densely urban environment.

### 2.6.1 Recommendations

Given the aim of this project was to assess the natural capital benefits provided by the City of London Corporation owned sites, we will focus on how these benefits might be increased in the coming years. However, we are aware of the conservation importance of these sites, and the ongoing management to maintain and enhance biodiversity, so our recommendations are focused principally on where increasing the provision of benefits can occur alongside and in addition to the proposed management.

The management plan for the site (provided to us by the site manager) is focussed on maintaining and enhancing species rich semi-natural grasslands, managing woodlands, scrub, heathlands, hedgerows and ponds. These activities will maintain ecosystem service provision, especially if woodland management ensures a diverse age range of trees, so there will be successor trees that can sequester carbon in place of the older and veteran trees after the end of their lives. If the aim for the site is to continue to manage the habitats present as they are for the foreseeable future, then substantial increases in ecosystem service provision at this site will not be possible. However, modest gains can be made if site managers would consider planting some additional trees on the edges of the site where possible, and also incorporating more hedgerows and scrub to create ecotones between habitats. This will increase carbon sequestration, storage, help regulate climate and air pollution closest to where people live, and increase the water quality and flow services. The natural capital value of the site can also be increased by enhancing the number of recreational visitors and the exposure to nature that visitors receive. This could be achieved by increasing access to footpaths through diverse habitats, or through supporting particular recreational activities that might get people in the surrounding urban areas to visit the site (e.g. walks as part of green prescribing from local GPs, conservation activities etc). Clearly this is already a well visited site so it will be important to maintain footpaths and manage use carefully to ensure that the natural capital assets are not degraded, which is likely to impact negatively on other services and biodiversity.

# 3. Epping Forest and the Buffer Land baseline natural capital assessment

## 3.1 Natural capital assets

The first step of the natural capital assessment of Epping Forest and the Buffer Land was to establish a natural capital asset map and register for both the baseline and the scenario (see Technical Appendix A.1.1 for the methodology). Epping Forest, known for being London's largest green space and made up of established habitats and ancient woodlands, is a 2,505.1 ha site located between Greater London and Essex. Adjoining Epping Forest on its Northern boundary, the Buffer Land, a 734.4 ha area of woodland, grassland and gardens, has increased the total green space of Epping Forest to 3,239.5 ha. Figure 22 shows the distribution of broad habitat types across Epping Forest and the Buffer Land, and the area and percentage cover of habitats for the sites are shown in Tables 10 and 11.

Epping Forest is dominated by broad-leaved woodland (75% of the site). Semi-natural grassland makes up almost 16%, and grassland, scrub, water bodies and built-up areas make up the remaining 9% of the site. Approximately half (52%) of the Buffer Land site is semi-natural grassland, with a significant proportion of the site covered with broadleaved woodland (24%) with pockets of mixed and coniferous woodland (2%) and a reasonable coverage of arable (19%). The remaining area comprises scrub, modified grasslands, gardens and water.

**Table 10.** Baseline habitats for Epping Forest.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 1880.2 | 75.1 |
| Semi-natural grassland | 398.6 | 15.9 |
| Modified (amenity) grassland | 68.1 | 2.7 |
| Scrub | 51.7 | 2.1 |
| Water | 46.5 | 1.9 |
| Built-up areas and infrastructure | 32.1 | 1.3 |
| Heathland | 18.1 | 0.7 |
| Garden | 5.7 | 0.2 |
| Fen, marsh and swamp | 3.5 | 0.1 |
| Trees / Parkland | 0.4 | 0 |
| Mixed woodland | 0.2 | 0 |
| **Total** | **2505.1** | **100** |

**Table 11.** Baseline habitats for the Buffer Lands**.**

| Habitat | Area ha | Area % |
|---|---|---|
| Semi-natural grassland | 383 | 52.1 |
| Broadleaved woodland | 175.8 | 23.9 |
| Arable | 139.8 | 19.0 |
| Mixed woodland | 11.4 | 1.6 |
| Scrub | 6.6 | 0.9 |
| Built-up areas and infrastructure | 6.2 | 0.8 |
| Water | 4.8 | 0.7 |
| Coniferous woodland | 3.4 | 0.5 |
| Garden | 2.8 | 0.4 |
| Modified (amenity) grassland | 0.5 | 0.1 |
| Trees / Parkland | 0.1 | 0 |
| **Total** | **734.4** | **100** |

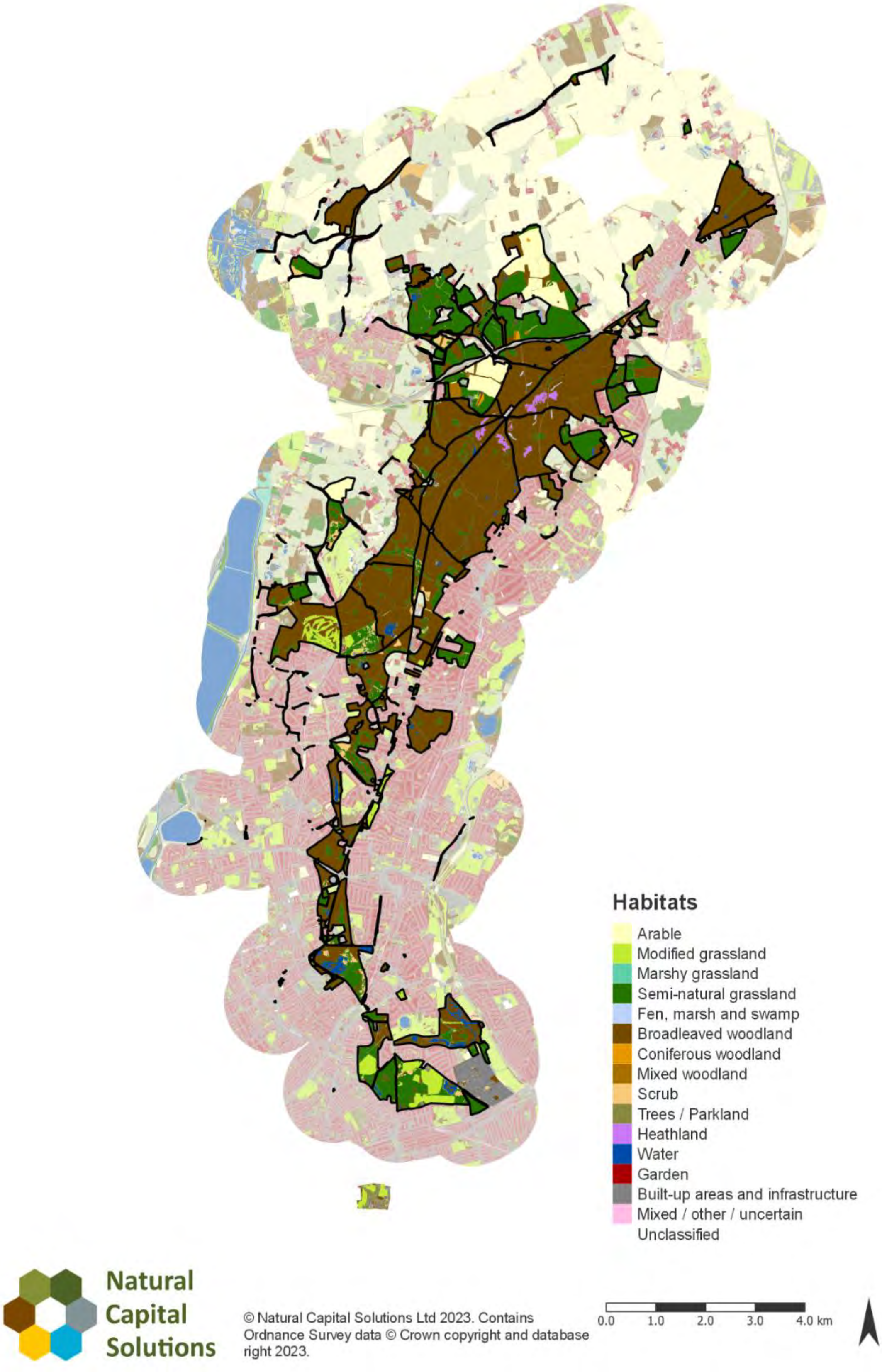


**Figure 22.** Baseline habitats for Epping Forest and the Buffer Land.

## 3.2 Biodiversity baseline

We used the Statutory Biodiversity Metric[16] to set a 'biodiversity unit' baseline for Epping Forest and the Buffer Land so that CoLC are able to quantify and monitor the impacts on biodiversity from future changes in habitats or in habitat management at the site. We have very slightly adapted this metric for its use in this circumstance[*].

The biodiversity unit score is based on a number of factors that influence the level of biodiversity: the area of the habitat, its distinctiveness and condition (area (ha) x distinctiveness score x condition score). 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, lower distinctiveness and condition scores.

For this site, once again we first assigned the distinctiveness scores to each natural surface/habitat polygon within the basemap, from the set scores in the Statutory Biodiversity Metric. Next, we assigned a habitat condition to each of the habitat polygons according to the Statutory Biodiversity Metric. This assigns categories from 'good' to 'poor' including two N/A categories for agriculture and other (non-natural) habitats (Table 12). When used in the metric, these categories are also given a score from 0-3 (Table 12). It is important to note that areas of ancient woodland are considered irreplaceable habitat, and not a distinct habitat type, and are now exempt from this version of the metric when used under development conditions. However, for the purposes of this project (setting a biodiversity baseline) ancient woodland has been included in the calculation, and given a distinctiveness score of six, like the other woodland categories.

It was possible to assign condition categories to a number of low quality land covers without the need for any further information. This included all built-up habitats such as buildings and infrastructure (N/A – other, dark blue areas, Figure 23). Epping Forest and the Buffer Land is dominated by woodland but also includes significant areas of semi-natural grasslands, modified grasslands, heathland, scrub and water. For the habitats that fall within the SSSI designation it was possible to translate the SSSI condition assessment into the metric condition categories (favourable = good (3), unfavourable recovering = moderate (2), unfavourable no change = moderately poor (1.5) and unfavourable declining = poor (1)). The condition of habitats in the rest of the site was estimated by the site manager. As a consequence, a condition was assigned to 99% of Epping Forest and Buffer Land, leaving 1% of the site without a condition score (areas where habitat type could not be classified due to gaps in data).

The condition map for the site (Figure 23) shows that most of the site (44.2% of the sites area) is in moderate (2) condition, with 15.42% of the area in good condition (3). Most of the broadleaved woodland at the site is in good to moderate condition (red and pink areas, Figure 23), as well as some areas of semi-natural grassland. There are areas of broadleaved woodland that are in fairly poor

[16] Defra (2023) The Statutory Biodiversity Metric. User Guide. Crown Copyright. https://assets.publishing.service.gov.uk/media/65673fee750074000d1dee31/The_Statutory_Biodiversity_Metric_-_Draft_User_Guide.pdf

[*] The adaptations made to the metric as used here are simply that the weightings for difficulty of habitat creation, strategic significance and spatial risk are not included. It is simply area x distinctiveness x condition. In addition, we have included the ancient woodland in the calculation as outlined above. The results of this baseline assessment could also be used in the context of a formal Biodiversity Net Gain (BNG) assessment at Epping Forest and Buffer Land to ensure any future development on the sites meets the mandatory 10% net gain, or to work out which parcels of land at the site could be managed as biodiversity off-sets purchased by a developer so they can achieve BNG on their development. If the results are to be used for these purposes, we advise that a condition assessment is carried out by an ecologist and the spreadsheet tool supplied by Defra is used to revise the estimate.

condition (cream areas, Figure 23), these woodlands are outside of the SSSI area and border modified grasslands, urban developments and cultivated / disturbed land. The areas in moderately poor and poor condition (8.6% and 30.76% of the sites area respectively) tend to be areas of modified grassland and cultivated / disturbed land (blue areas, Figure 23).

Figure 24 shows the pattern of biodiversity unit scores across Epping Forest and Buffer Land. Throughout the site, areas of broadleaved woodland have the highest scores (> 100 units shown in red). This is due to the moderate to good condition and size of the broadleaved woodland habitat throughout the site. There are also areas where semi-natural grassland has a high score (> 100 units, Figure 24), which tends to be areas which have greater continuous semi-natural grassland habitat. Modified grassland and cultivated / disturbed land have moderate to low scores (cream to dark blue, Figure 24). On the eastern border of the site, some areas of broadleaved woodland and semi-natural grassland have poor scores (dark blue areas, Figure 24), these areas are surrounded by urban infrastructure, and this affects their condition, and area. The total biodiversity unit score for Epping Forest and the Buffer Lands is 27,895.85.

**Table 12.** Biodiversity Metric 4.0 condition categories and associated scores.

| Condition Category | Condition score applied in the metric |
|---|---|
| Good | 3 |
| Fairly Good | 2.5 |
| Moderate | 2 |
| Fairly Poor | 1.5 |
| Poor | 1 |
| Condition assessment N/A (agriculture) | 1 |
| N/A - Other | 0 |

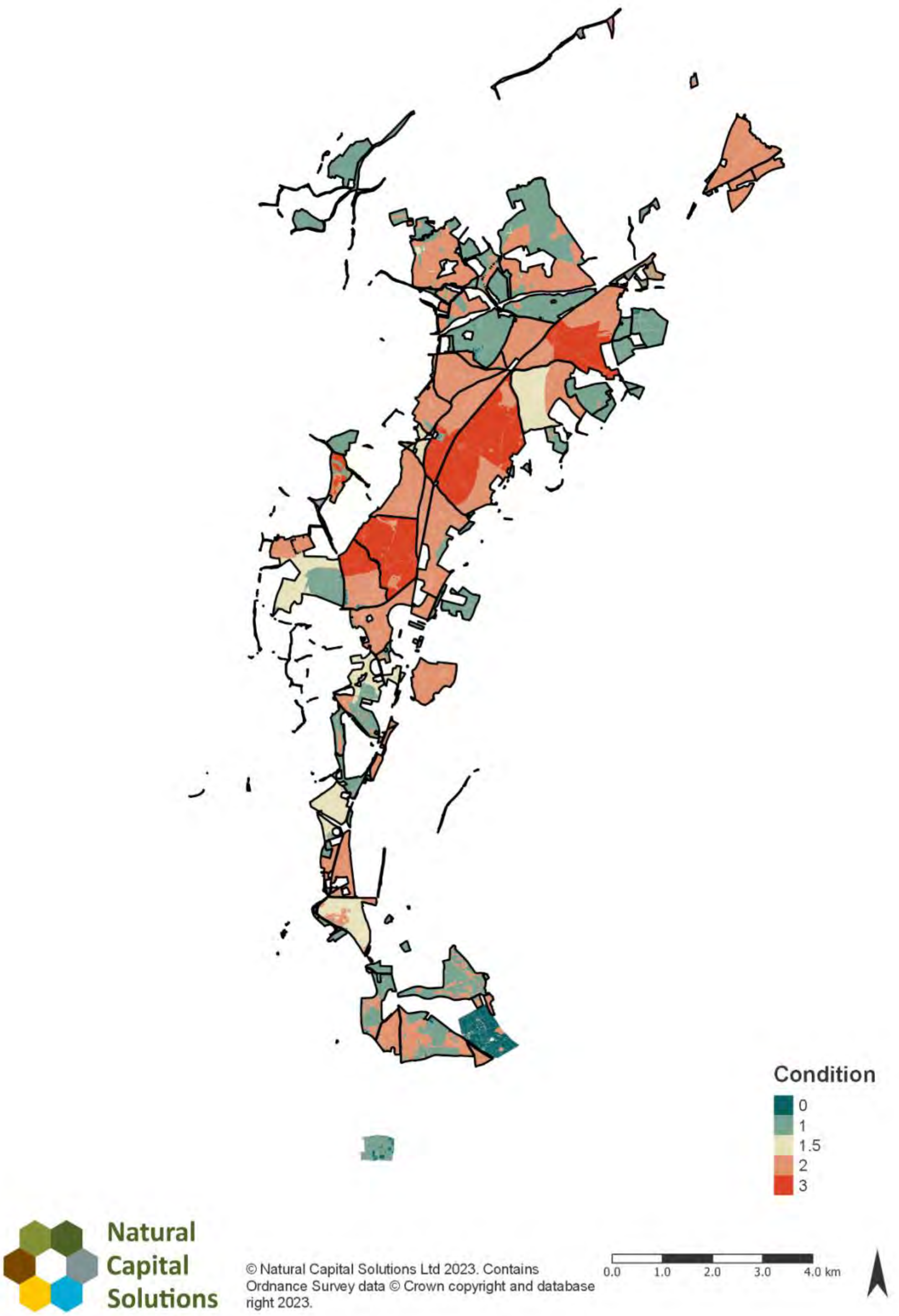


**Figure 23.** Habitat condition across Epping Forest and Buffer Land (areas in white are where it was not possible to assign a condition score).

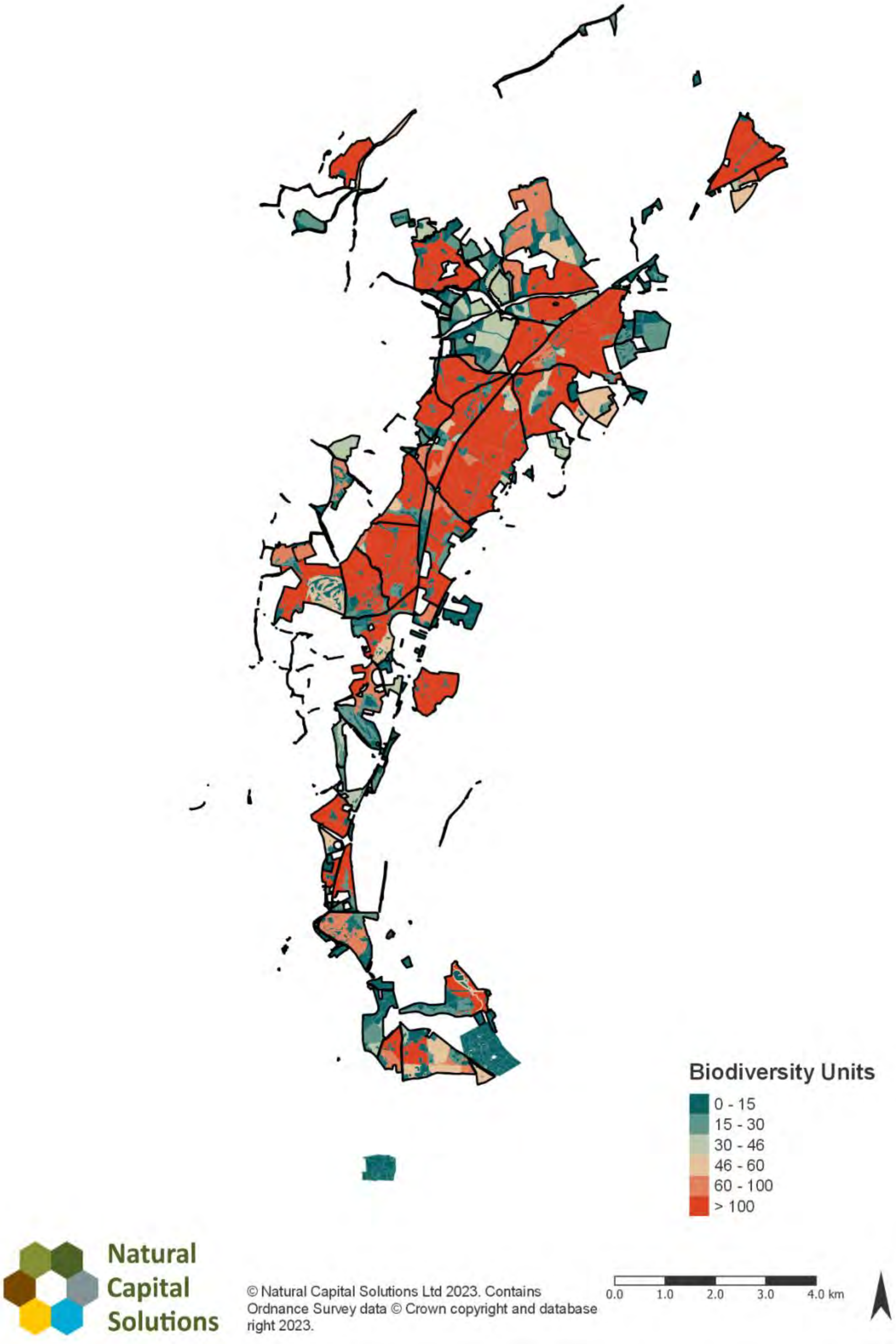


**Figure 24.** Biodiversity units across Epping Forest and Buffer Land.

## 3.3 Ecosystem service provision (physical flows)

Once a detailed natural capital (habitat) map had been created for Epping Forest and the Buffer Land sites, it was then possible to quantify and map the benefits that the natural capital provides. A variety of methods were used (see Technical Appendix A.1.2). In all cases the models were applied at a 5m-by-5m resolution to provide fine scale mapping across the area. The models are based on the detailed habitat information determined in the basemap (Section 3.1), together with a variety of other external data sets (e.g. digital terrain model data). Note, however, that most of the models are indicative (showing that certain areas have higher capacity than other areas) and are not process-based mathematical models (e.g. hydrological models). For every ecosystem service the capacity of the natural environment to deliver that service, or 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[†]. Both the capacity and demand of the services were mapped relative to the values present across the study site and buffer, and were normalised on a 0-100 scale (apart from carbon sequestration and storage for which the biophysical units were mapped). The resulting maps are shown in Figures 25 to 40. A brief description of each ecosystem service and the outcomes are provided below, detailed methodology is presented in Technical Appendix A.1.2.

### Carbon sequestration capacity

Carbon is sequestered (captured) by growing plants. This model applies average values (t$CO_2$/ha/year) for each habitat type taken from various sources including Natural England (2021)[17] and the RSPB's Accounting for Nature report[18]. Built up areas have no capacity for carbon sequestration in this model (light blue areas, Figure 25), with the patches of arable emitting carbon (-1.5 t$CO_2$/ha/year, dark blue areas). Broadleaved woodland dominates the site and is the best habitat at sequestering carbon (between 8 and 10 t$CO_2$/ha/year, red areas Figure 25). Heathland, scrub and semi-natural grassland have a moderate capacity for carbon sequestration (between 2 and 4 t $CO_2$/ha/year, pink areas, Figure 25), whereas modified (amenity) grassland has a moderate to low capacity for carbon sequestration (0.15 t$CO_2$/ha/year, cream areas, Figure 25).

### Carbon storage capacity

Carbon storage capacity indicates the amount of carbon stored naturally in soil and vegetation. 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. This model estimates the amount of carbon stored in each habitat type based on average values. Habitat management and condition can cause variation in a habitat's carbon storage capacity but management and condition were not taken into account for this model. This site is dominated by broadleaved woodland, which stores between 150-200tC (cream to pink areas). Coniferous woodland and heathland have a higher carbon storage capacity, with pockets sequestering 200-250tC (pink areas). Semi-natural grassland and scrub store a moderate amount as well, between 100-150 tC (cream areas, Figure 26). Semi-natural grassland varies in its carbon storage capacity across the site depending on the type of grassland (e.g. acid grassland in the south and rough grassland in the north), areas in the southern to middle area of the site (cream

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[†] The importance and value of an ecosystem service can often be dependent upon its location in relation to the demand for that service. Mapping demand was not, however, possible, for the other services where there was no obvious method to apply, or local demand is not relevant, such as food or timber production.

[17] R Gregg, J. L. Elias, I Alonso, I.E. Crosher and P Muto and M.D. Morecroft (2021) Carbon storage and sequestration by habitat: a review of the evidence (second edition) Natural England Research Report NERR094. Natural England, York.

[18] The RSPB. (2017). Accounting for Nature: A Natural Capital Account of the RSPB's estate in England. Annex 7.

areas) have a greater carbon storage capacity than in the northern area of the site (blue areas, Figure 26). The built-up areas and infrastructure, water bodies, modified (amenity) grassland, and arable show low carbon storage potential, at 0-100 tC (blue to dark blue areas, Figure 26).

### Air purification capacity (air quality regulation)

According to Public Health England[19], 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 ($NO_x$). 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 $NO_X$. This air purification capacity model estimates the relative ability of vegetation to trap airborne pollutants or ameliorate air pollution. Broadleaved woodland is the best habitat for capturing air purification (pink and cream areas, Figure 27). Capacity is low across the grassland, cultivated / disturbed land and water areas of the site (blue areas, Figure 27).

### Air purification demand

Components that influence air pollution removal demand include densely populated areas and vulnerable populations (the very old and young) in proximity to sources of pollution (major roadways, major built-up areas). Within the site, demand for this service is moderately low, with an increased demand in the southern end of the site (cream and pink areas, Figure 28) and in the buffer south of the site, where it is bordered by built up areas and major roadways cut through the site. At the northern end of the site, demand increases around the area where the M25 crosses through it (cream areas, Figure 28). Built up areas and infrastructure in the middle of the site also show demand for air purification within the site (cream and light blue areas, Figure 28). The Epping Forest and Buffer Land woodland goes some way to meeting the demand (Figure 27) but capacity is lower in the south of the site where demand is highest.

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

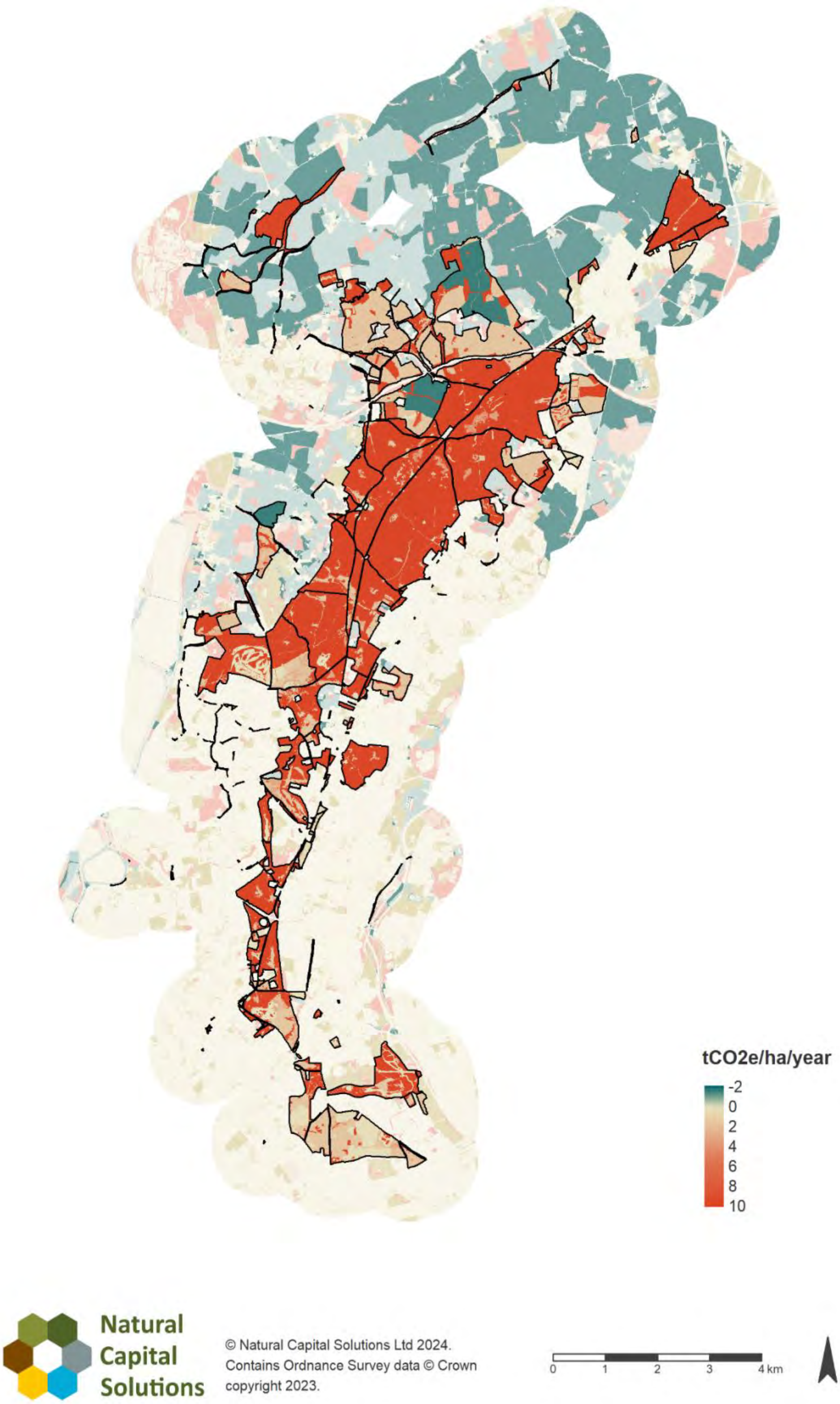


**Figure 25.** Carbon sequestration capacity at Epping Forest and Buffer Land (in tonnes of $CO_2e$ per ha per year).

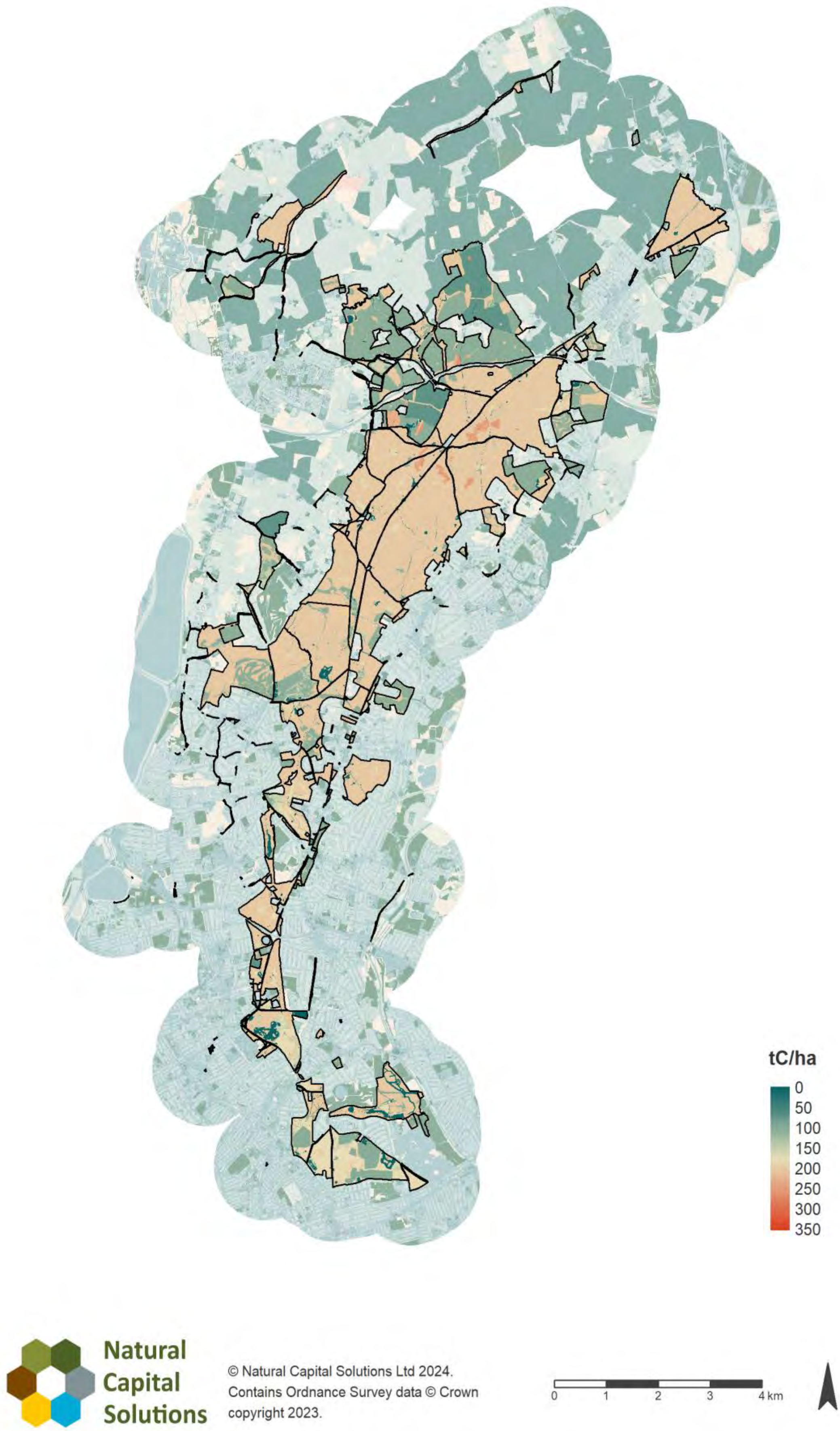


**Figure 26.** Carbon storage capacity at Epping Forest and Buffer Land (in tonnes of carbon per ha).

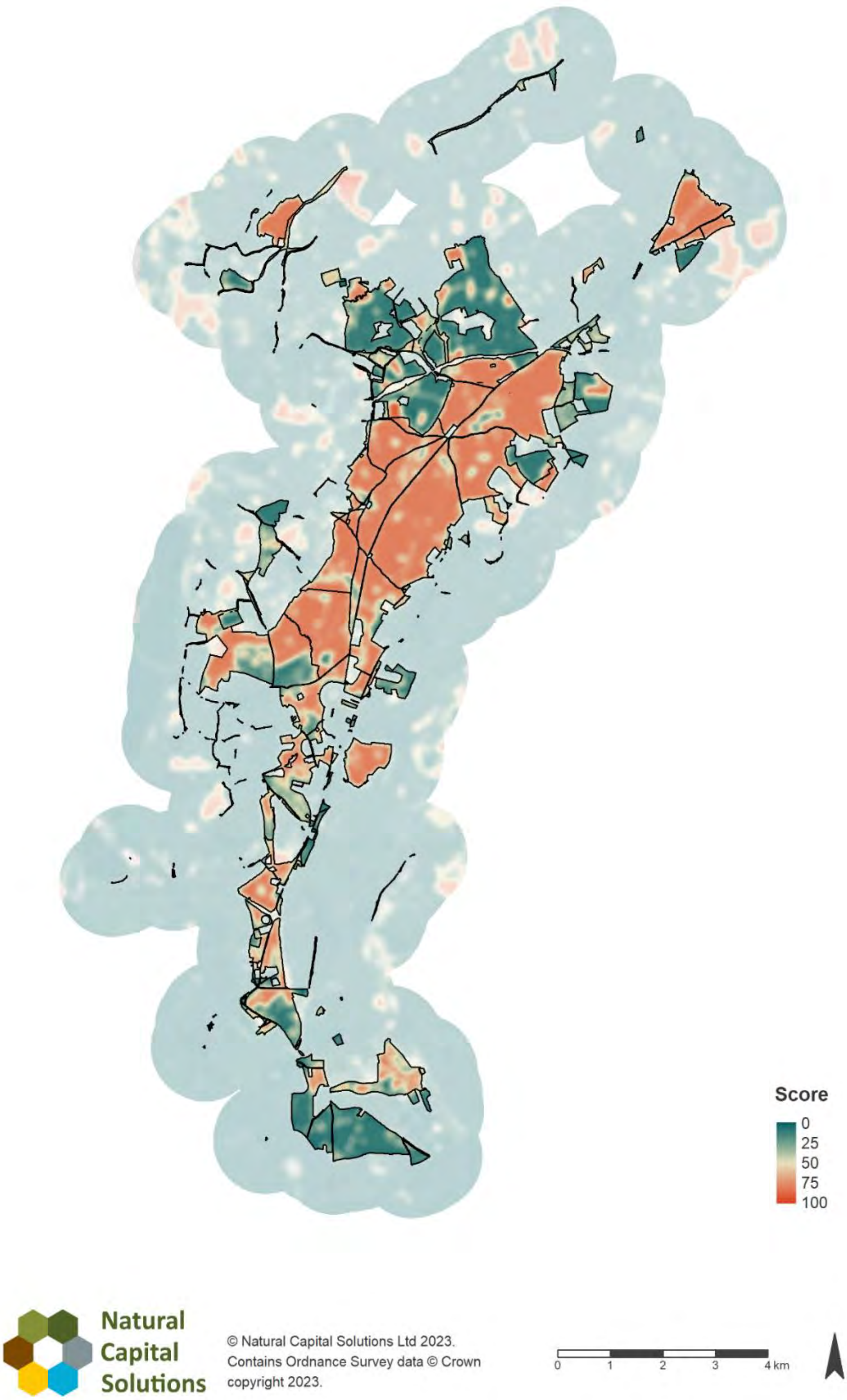


**Figure 27.** Air purification capacity (air quality regulation) at Epping Forest and Buffer Land (normalised on a scale of 0-100).

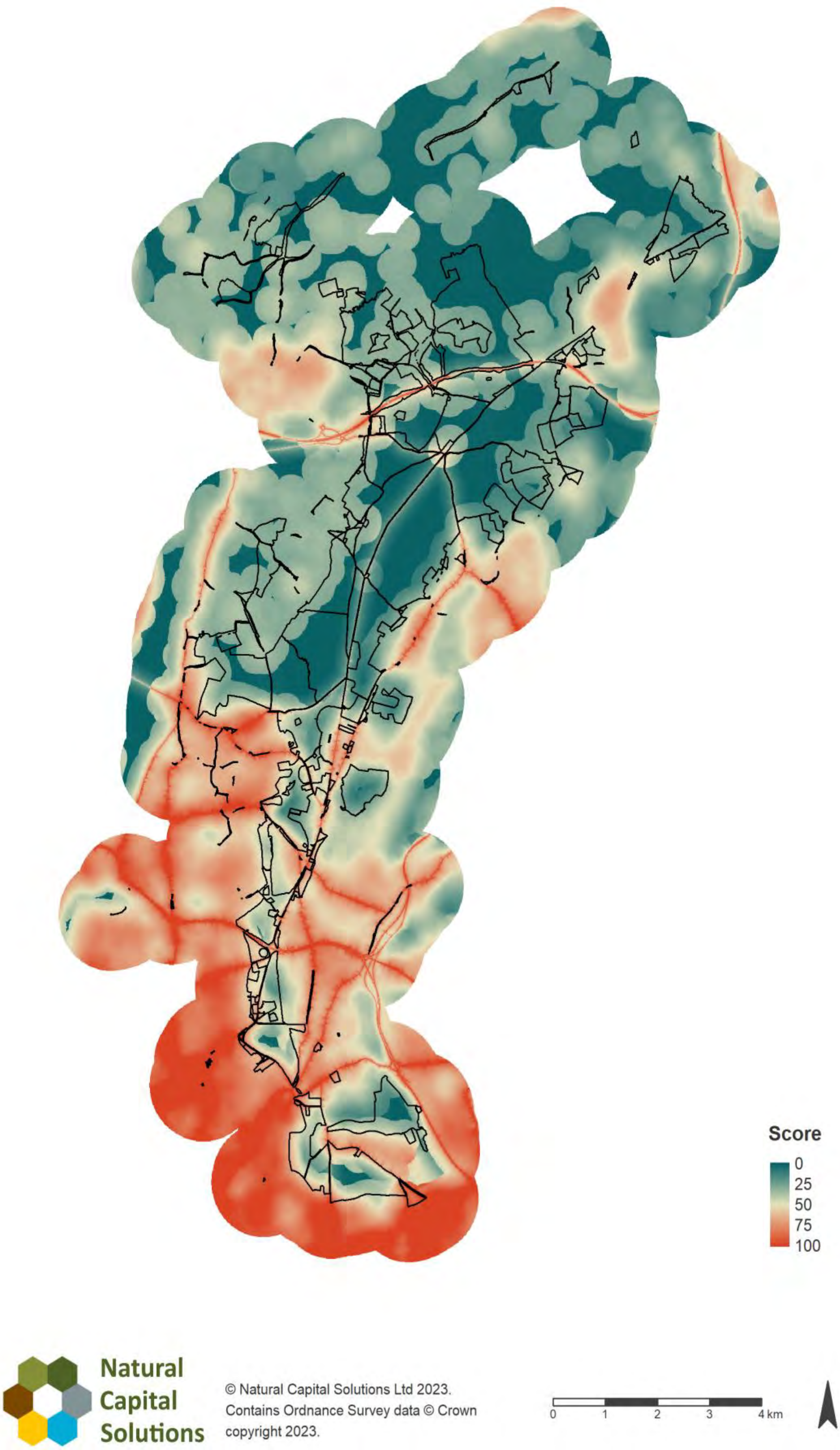


**Figure 28.** Air purification demand at Epping Forest and Buffer Land (normalised on a scale of 0-100).

### Noise regulation capacity

Noise regulation capacity is the capacity of the land to diffuse and absorb noise pollution. Complex vegetation cover, such as woodland, trees and scrub, is considered to be most effective, and the effectiveness of vegetation increases with width. The use of vegetation can screen and reduce the effects on surrounding neighbourhoods. Noise regulation capacity is high across the areas of broadleaved and coniferous woodland in this site (red and pink areas, Figure 29). The figure shows that larger areas of woodland with greater continuity increases the effectiveness of noise regulation by the vegetation. The provision of the noise regulation service is low to moderate across the grassland, arable and water areas of the site (blue and cream areas, Figure 29), with arable and water areas being particularly poor at providing noise regulation.

### Noise regulation demand

Demand for noise regulation will be highest in built up areas with vulnerable populations (the very old and young) living close to sources of noise (roads and railways). Throughout most of the site, noise regulation demand is low (dark blue areas, Figure 30). This site clearly shows that noise regulation demand is highest in areas where roads cut across or border the site (cream to light blue areas, Figure 30). There is increased noise regulation demand outside the site along the southern boundary in the built up boroughs of Redbridge and Newham, especially along the motorways.

As with air pollution regulation, the capacity of the site to provide noise regulation largely meets demand, although capacity is lower where the demand is highest in and around the south of the site (Figure 29).

### Local climate regulation capacity

Local climate regulation capacity estimates the capacity of an ecosystem to cool the local environment and cause a reduction in urban heat maxima. Local climate regulation capacity is mapped using an InVest model[20]. Natural vegetation, especially trees / woodland and rivers, can help reduce the urban heat island by providing shade, increasing cooling through evapotranspiration and make nearby areas cooler in summer and warmer in winter. The model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks) for each pixel. The scores generated shows the capacity of each habitat type to cool the air and is calculated relative to the average temperature across the summer months. Local climate regulation capacity is high across most of the site because of the large and continuous area of broadleaved woodland and areas of heathland (pink to red areas, Figure 31). Water bodies have a moderate capacity for climate regulation (pink and cream areas, Figure 31), while grasslands and cultivated areas are associated with low capacity (blue areas).

### Local climate regulation demand

Demand for climate regulation will be highest in built up areas with vulnerable populations (the very old and young). Local climate regulation demand is generally limited within the site itself, with almost no demand (blue areas, Figure 32), except moderately along the southern border (cream areas, Figure

[20] Natural Capital Project, 2024. InVEST 3.14.1. Stanford University, University of Minnesota, Chinese Academy of Sciences, The Nature Conservancy, World Wildlife Fund, Stockholm Resilience Centre and the Royal Swedish Academy of Sciences. https://naturalcapitalproject.stanford.edu/software/invest.

32). Outside the southern boundary of the site, there is a significant increase in demand, associated with the built-up boroughs of Newham and Redbridge (pink and cream areas, Figure 32). The demand decreases in the northern end of the site, especially along the western boundary, due to the parkland and forestlands of Waltham Abbey and Epping Upland. An increase in demand is seen outside the site in the northeast by the town of Epping and in the northwest near the town of Waltham Abbey.

As with air pollution regulation and noise regulation, the capacity of the site to provide local climate regulation largely meets demand, although capacity is lower where the demand is highest in and around the south of the site (Figure 31).

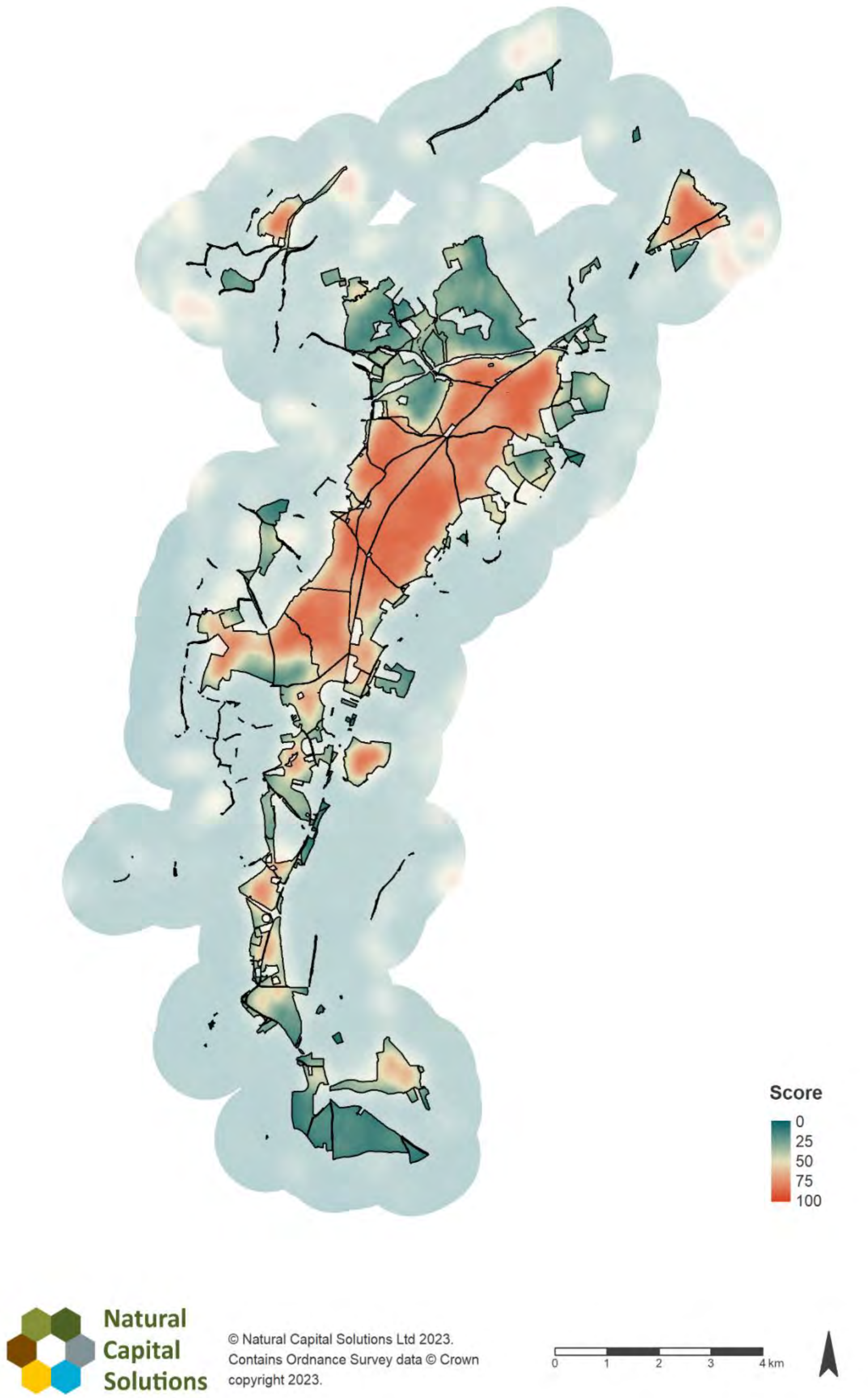


**Figure 29.** Noise regulation capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

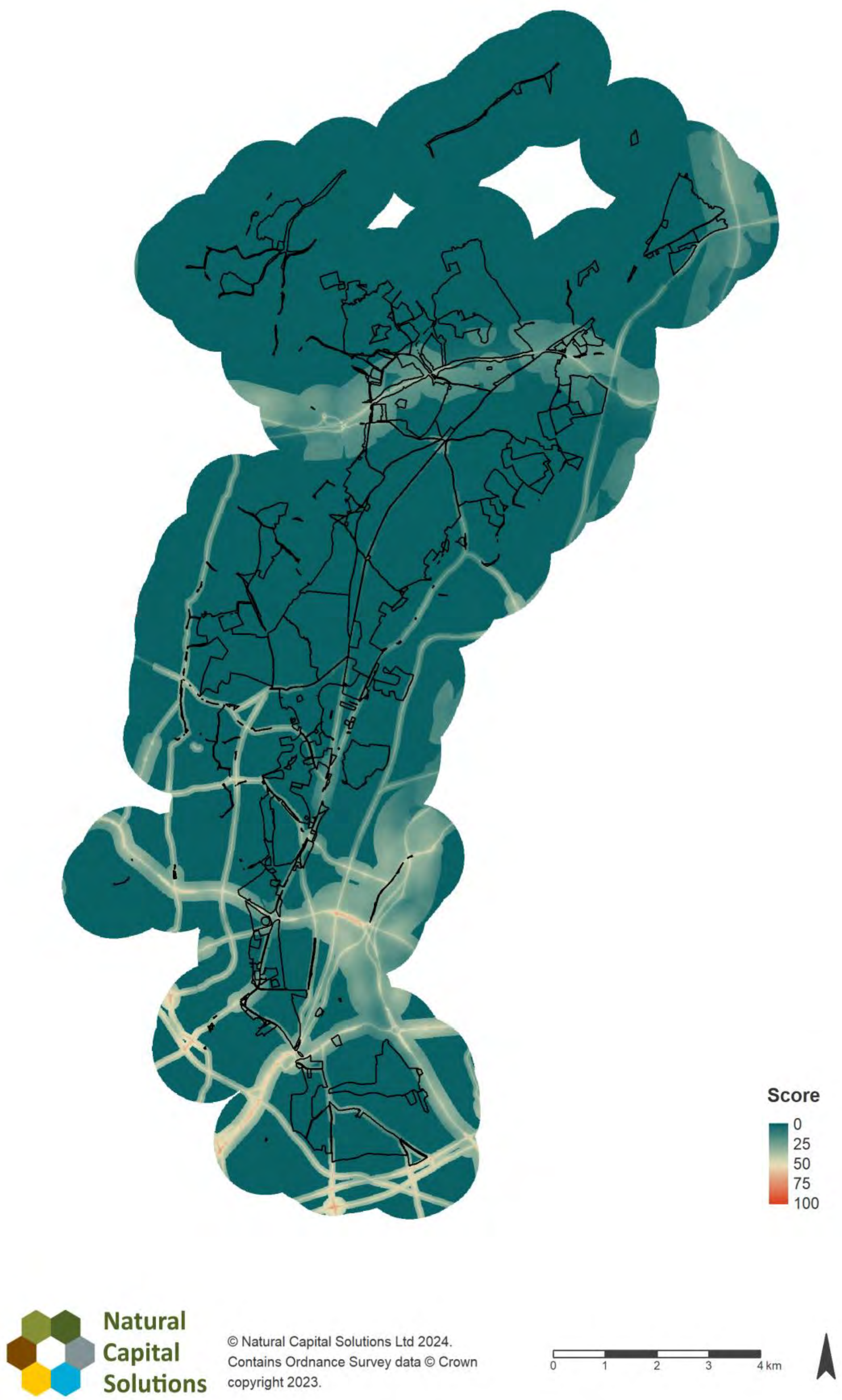


**Figure 30.** Noise regulation demand at Epping Forest and Buffer Land (normalised on a scale of 0-100).

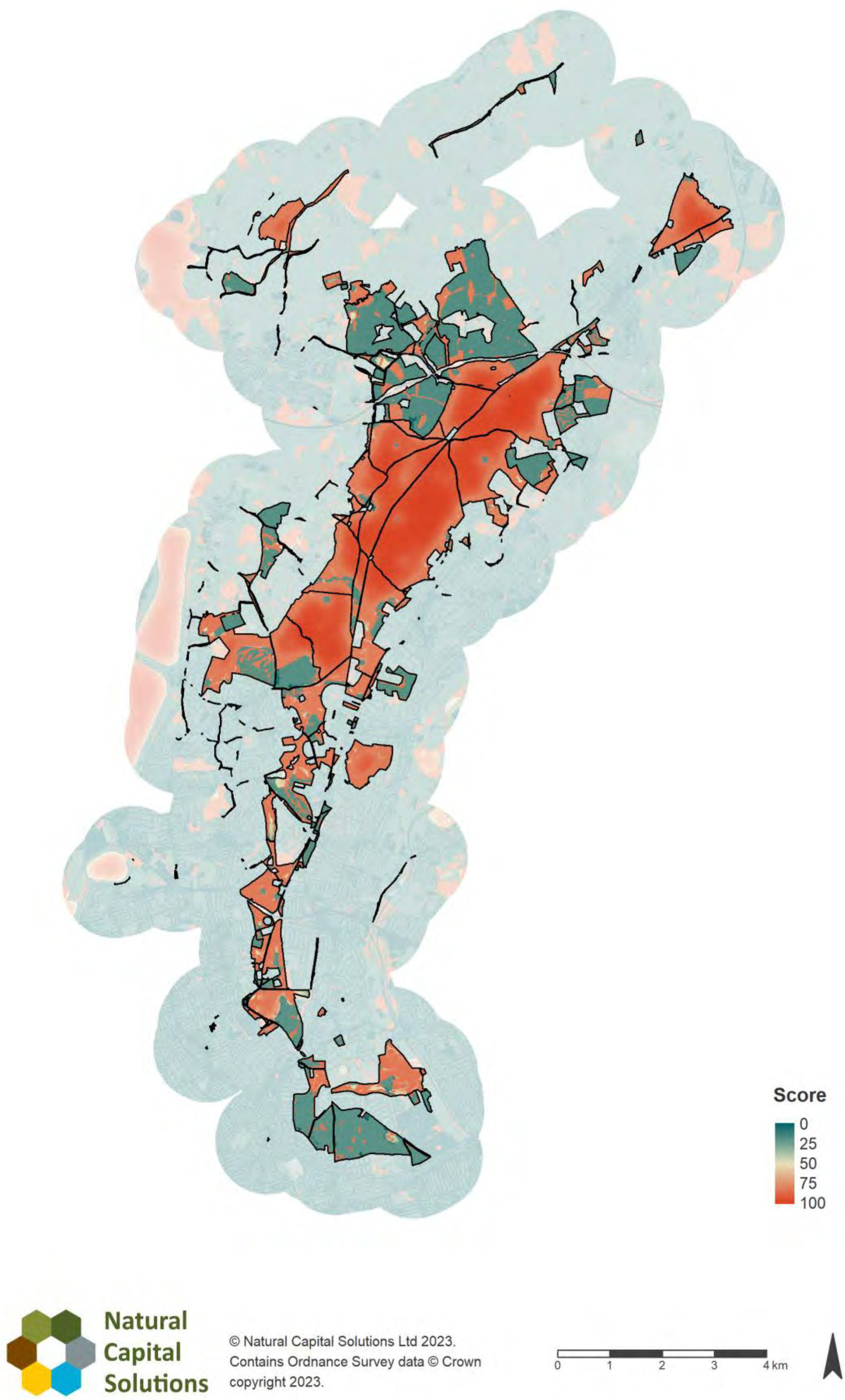


**Figure 31.** Local climate regulation capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

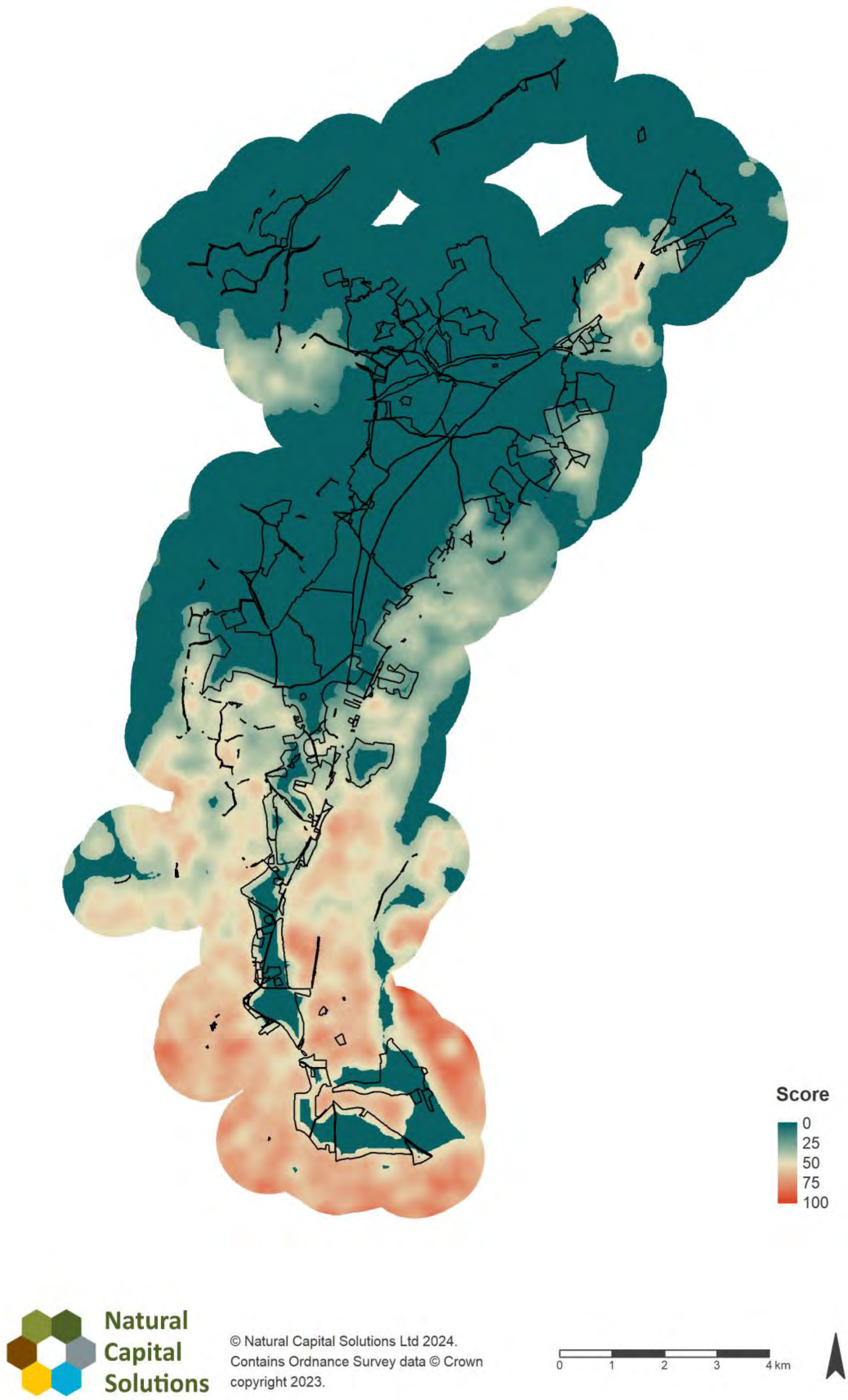


**Figure 32.** Local climate regulation demand at Epping Forest and Buffer Land (normalised on a scale of 0-100).

### Pollination

A key indication of local ecosystem health and biodiversity is the abundance and diversity of pollinators. Pollination capacity measures the capacity of the land to provide pollination services by estimating the visitation rate of each particular pixel of land (relative to the landscape analysed) for wild insect pollinators (assuming a steady state pollinator population). Different species of pollinators have different peak seasons, thus the pollinator visitation counts are completed in both the spring and summer season, to generate a more robust analysis of pollinator presence.

Areas of modified grassland and small garden areas throughout the site have a moderate pollination capacity in the springtime (pink areas, Figure 33). There are a couple of small areas of modified grassland on the east side of the site which are surrounded by built-up areas that show moderately high pollinator capacity, and this is likely due to these grassland areas being surrounded by gardens. The woodland areas have a moderate to low pollination capacity throughout the site (cream areas, Figure 33). Semi-natural grassland and arable areas have a low provision (light blue and blue areas, Figure 33).

In summer, the provision of the pollination capacity decreases throughout the woodland from the springtime capacity, (cream and blue areas, Figure 34), likely due to woodland pollinators having different peak seasons. Semi-improved grassland and heathlands both increase pollination capacity in the summer (cream and pink areas, Figure 34). Garden and modified grassland areas remain at moderate to high capacity (pink and red areas, Figure 34). Arable lands remain at low capacity (blue areas, Figure 34), which is likely due to the lack of floral attractiveness of those areas.

### Water flow regulation capacity

Water flow regulation capacity is the ability of the land to slow water runoff and thereby potentially reduce flood risk downstream, based on land use and slope. Water flow regulation capacity is generally high across most of the site, and much of the site is at relatively the same slope, so it is mainly land use that effects capacity at these sites. Woodland areas have a moderately high to high provision of this service (pink to red areas, Figure 35). Grassland areas and arable land have a moderate to low provision (pink to cream areas, Figure 35), with semi-natural grasslands having a slightly higher provision than modified and arable areas. Built up areas have no water flow regulation capacity (blue areas, Figure 35) and water areas are not included in this model (shown in white, Figure 35).

### Water quality regulation capacity

Water quality regulation capacity maps the risk of surface runoff becoming contaminated with high sediment loads before entering a watercourse, with a higher water quality capacity indicating that water is likely to be less contaminated. This model comprises four indicators: proximity to water courses, slope length, risk of erosion from land use and risk of sedimentation at the catchment scale.

The slope length and risk of sedimentation at the catchment scale were fairly uniform for this site, with proximity to water courses and risk of erosion from land use contributing more to the changes in capacity visible in the map. Arable land and built-up areas have a lower capacity, as they have a high score for risk of erosion from land use (blue areas, Figure 36). Woodland, semi-natural and modified grassland generally have a moderately high to moderate capacity at the sites (pink areas, Figure 36). There is an area with a downward slope in the eastern centre section of the site, with some blue areas appearing (Figure 36), that continue outside the site. Towards the southern end of the site, the woodlands and grasslands capacity decreases, and this is because there is a slope change, some water bodies and these areas are surrounded by built-up areas, all of which increase the risk of surface runoff contamination, providing a low capacity for the water quality regulation service (blue areas, Figure 36).

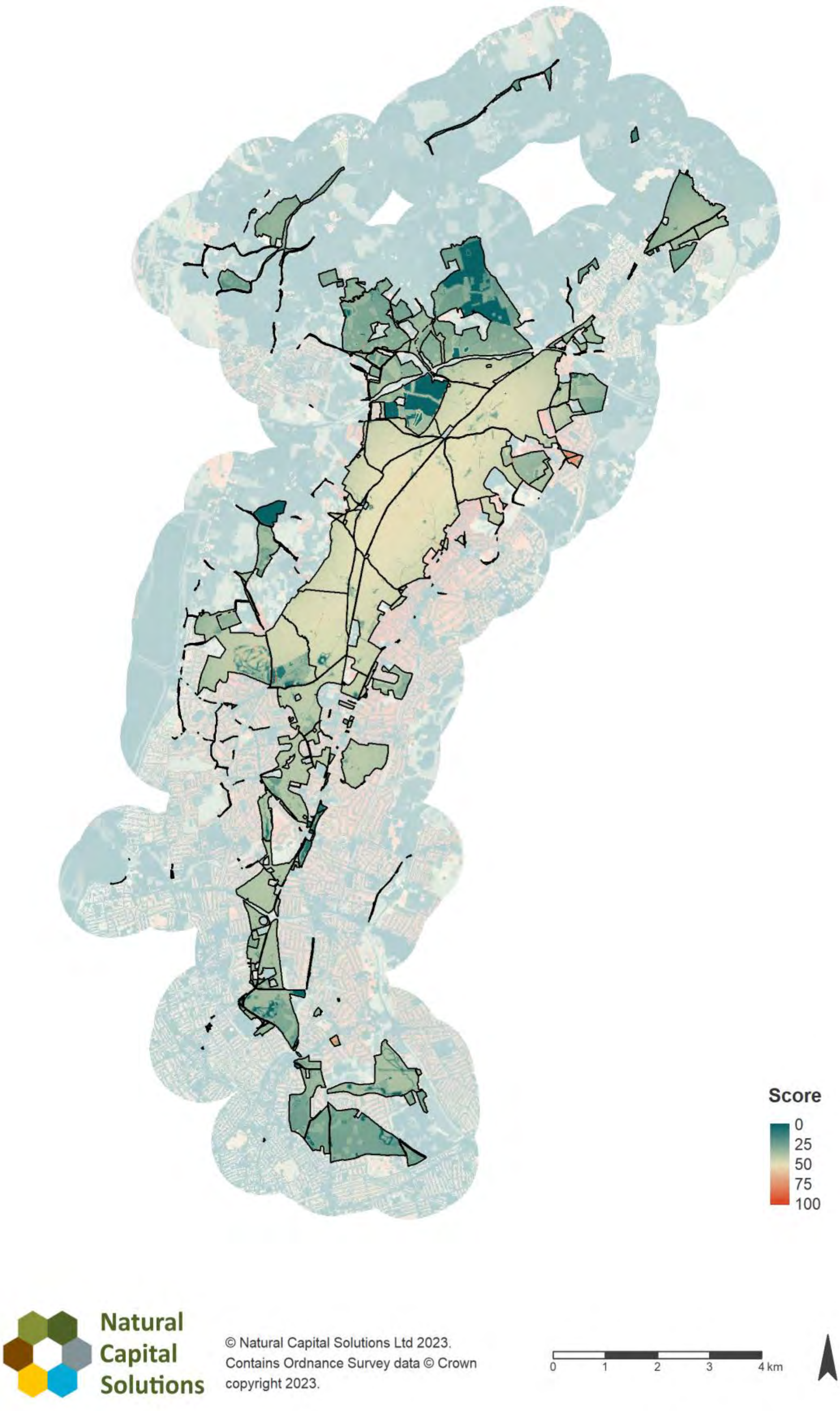


**Figure 33.** Spring pollinator visitation rates in Epping Forest and Buffer Land (normalised on a scale of 0-100).

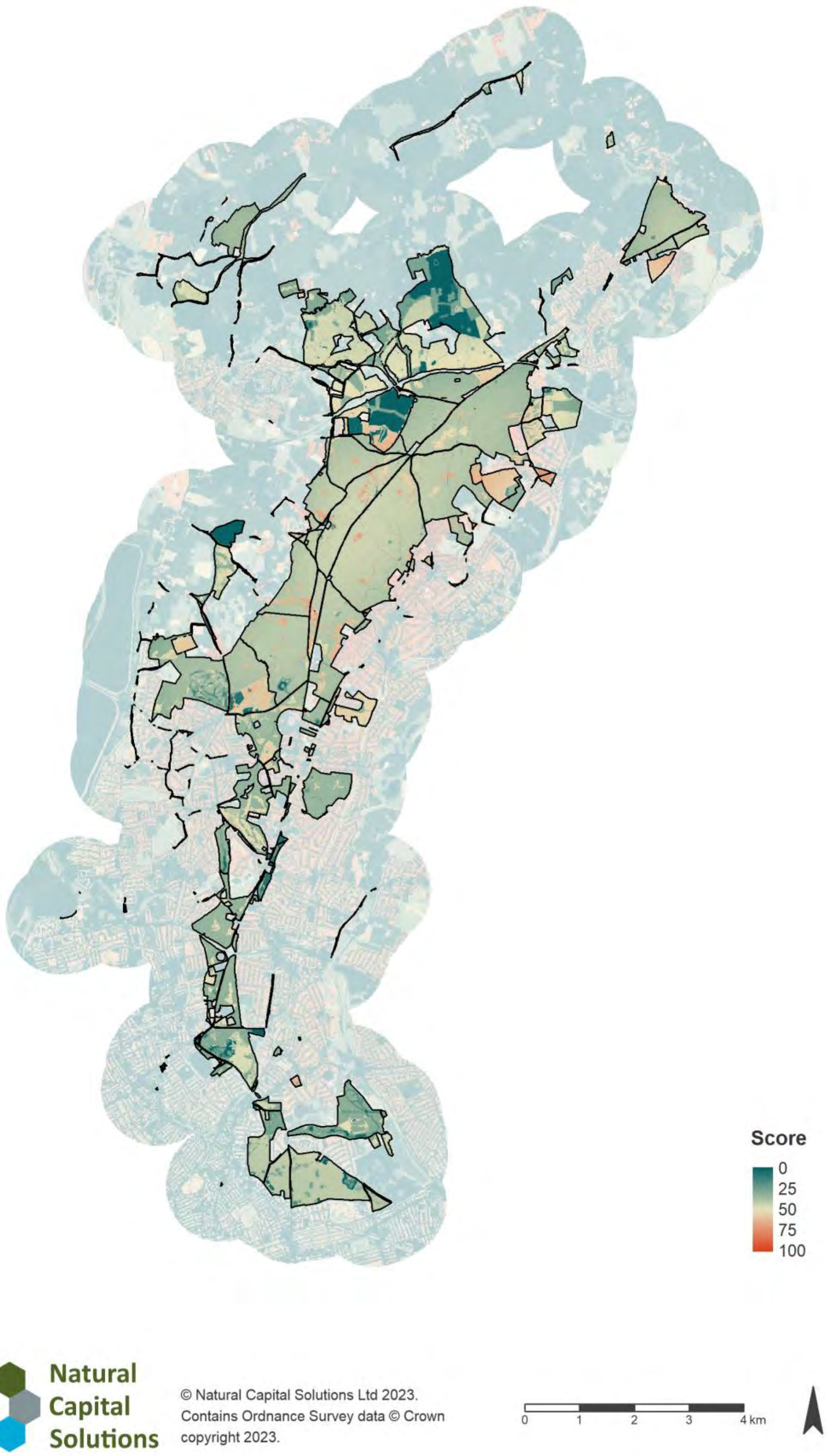




**Figure 34.** Summer pollinator visitation rate in Epping Forest and Buffer Land (normalised on a scale of 0-100).

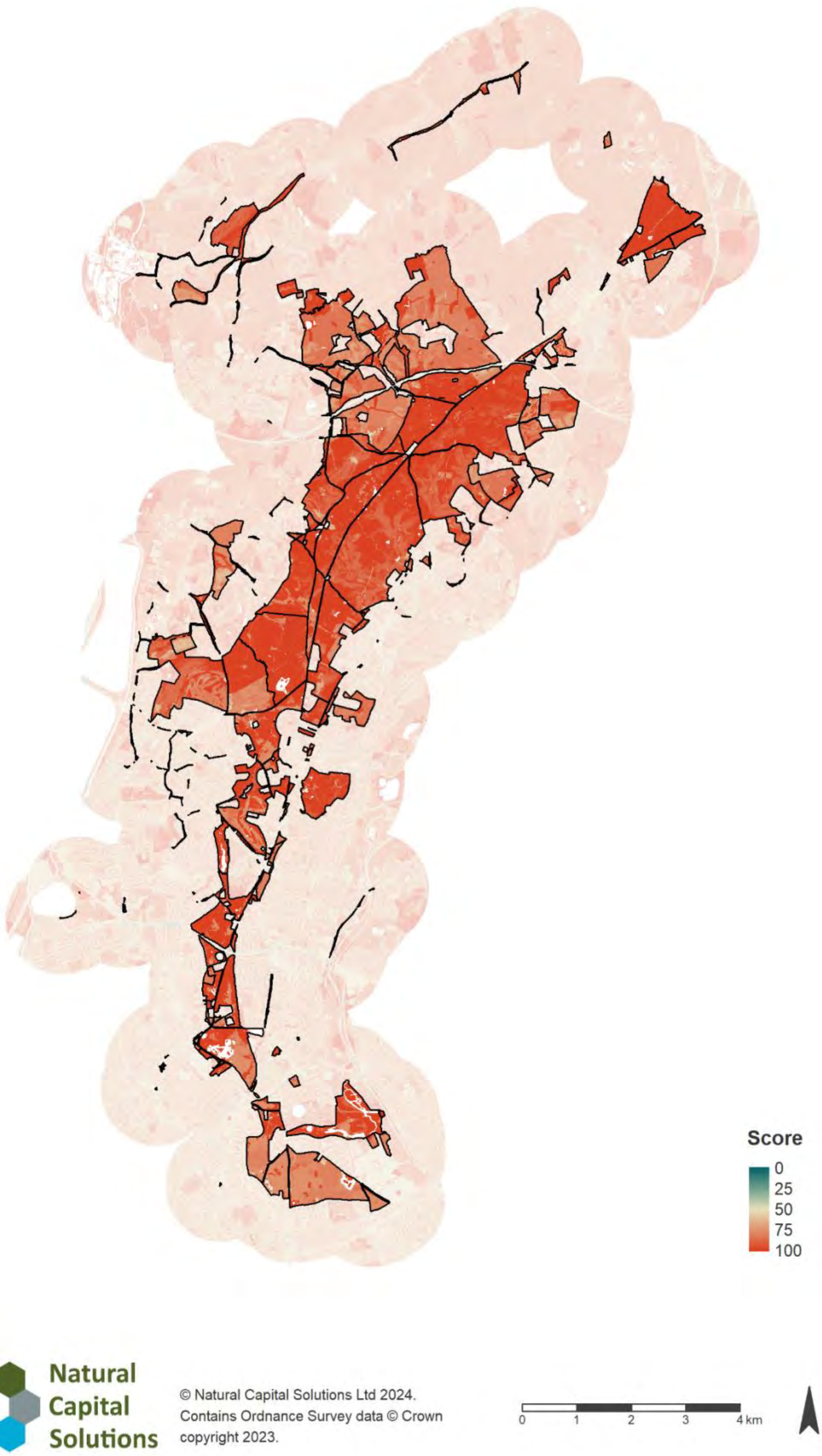


**Figure 35.** Water flow regulation capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

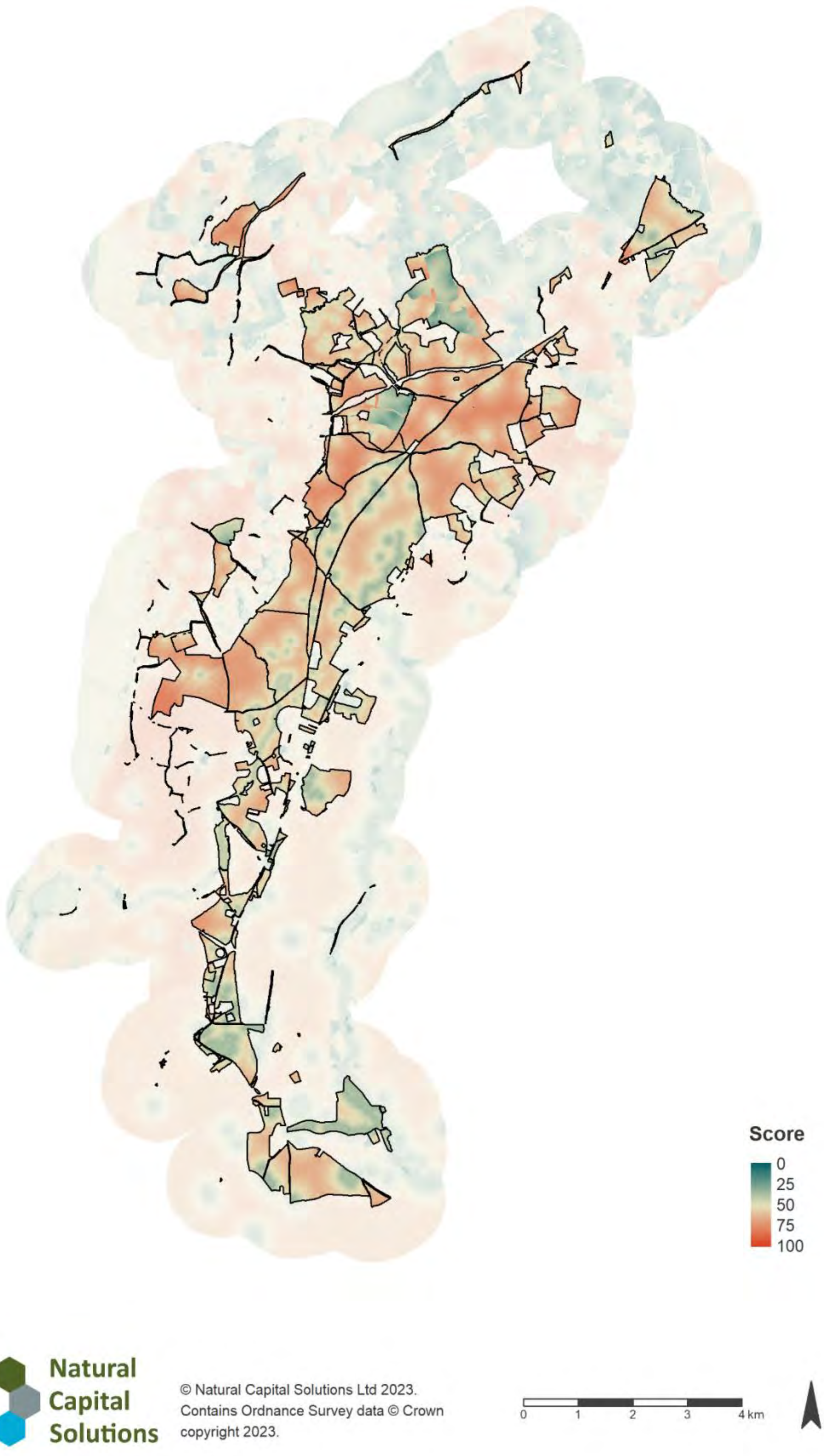


**Figure 36.** Water quality regulation capacity (soil erosion) at Epping Forest and Buffer Land (normalised on a scale of 0-100).

### Food production capacity

There are some areas of farming activity within this site, and the arable land in the north of the site shows the greatest capacity for food production (brown areas, Figure 37). For the other areas of this site which are not farmed, the ability of these habitats to provide non-commercial food source, accounting for Agricultural Land Classification, was mapped. Generally, food production capacity is low throughout the site (light blue to blue areas, Figure 37). The semi-improved grassland areas display a slightly higher capacity for food production than the woodland areas (light blue areas, Figure 37).

### Timber and woodfuel production capacity

Timber is an important product of woodlands and is the raw resource of the timber industry. Sustainably managed woodland produces timber that is an important material for processing mills and factories that produce wood-based products. It also produces wood fuel for the generation of renewable heat and electricity. Note that this models the potential for production of timber and woodfuel, regardless of whether areas are actually being harvested (as these sites are managed for conservation, wood fuel production is only likely from managed thinnings). Different woodland habitats have different timber and woodfuel production potential, and this is displayed across this site, with areas of broadleaved woodland displaying a moderate provision for this service (grey blue areas, Figure 38). There are small areas of mixed woodland (pink areas, Figure 38) and coniferous woodland, with coniferous woodland having the highest capacity for this service (red areas, Figure 38). Grasslands, heathlands, and arable areas all have a no capacity for this service (dark blue areas, Figure 38).

### Accessible nature capacity

The two key components of accessible nature capacity are 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. This site's accessibility and naturalness is generally high (red areas, Figure 39), driven by the large areas of continuous broadleaved woodland. Built-up and water areas have low accessibility scores (blue areas, Figure 39). Semi-natural grassland has a moderate to low score (pink to light blue areas, Figure 39), modified grasslands have a lower score (cream to dark blue, Figure 39), likely due to low perceived naturalness scores. Blank areas indicate that there is no publicly accessible greenspace in that location.

### Accessible nature demand

Demand for accessible nature is high in the built up areas along and outside the southern boundary of the site (red areas, Figure 40). To the north of the site demand is low as there are no settlements demanding access to greenspace.

Epping Forest and the Buffer Land sites are providing access to habitats of high naturalness (Figure 39) and is meeting the demand of the urban areas immediately to the south of the site. It is likely that it provides the accessible nature service to many visitors from further afield also.

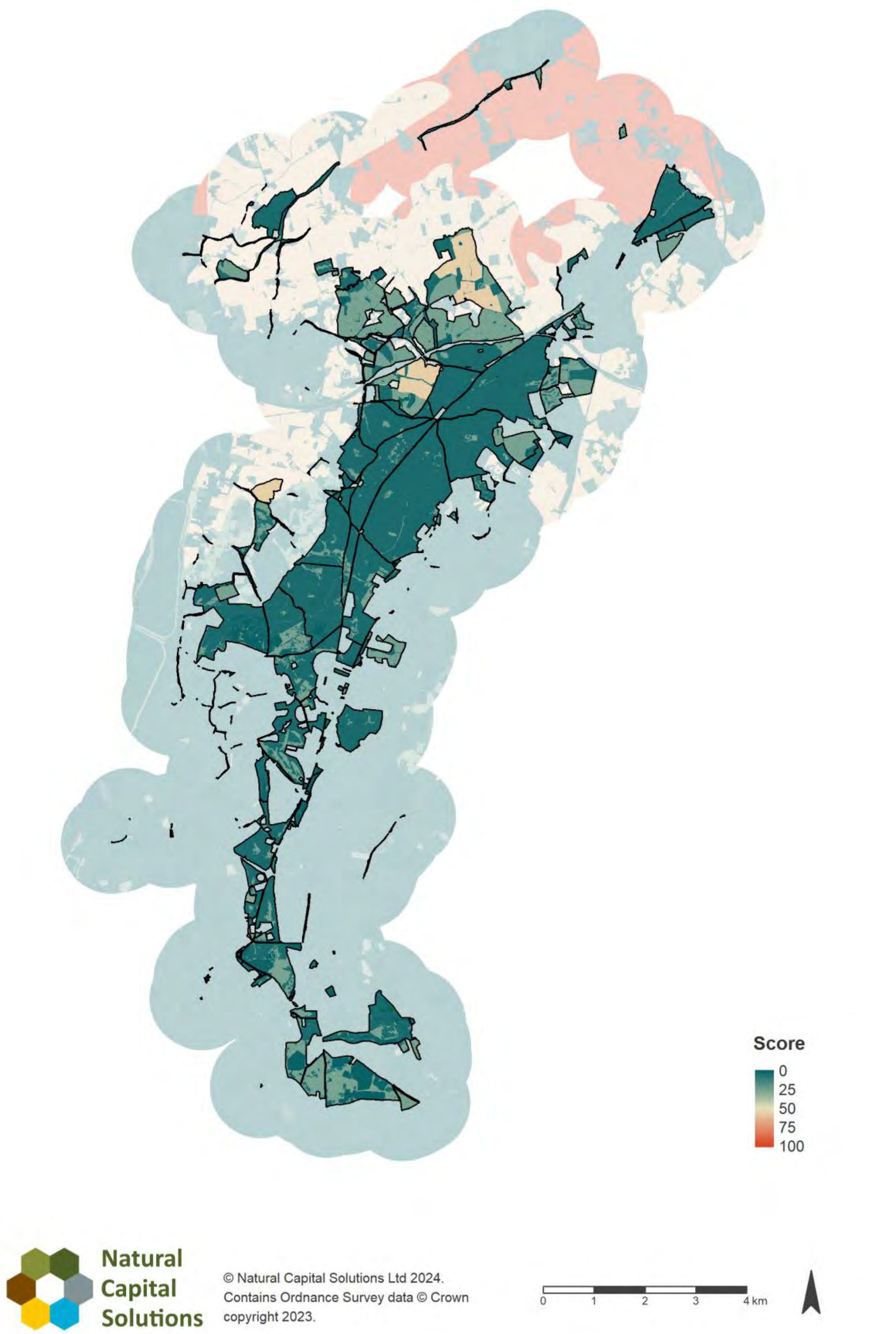


**Figure 37.** Food production capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

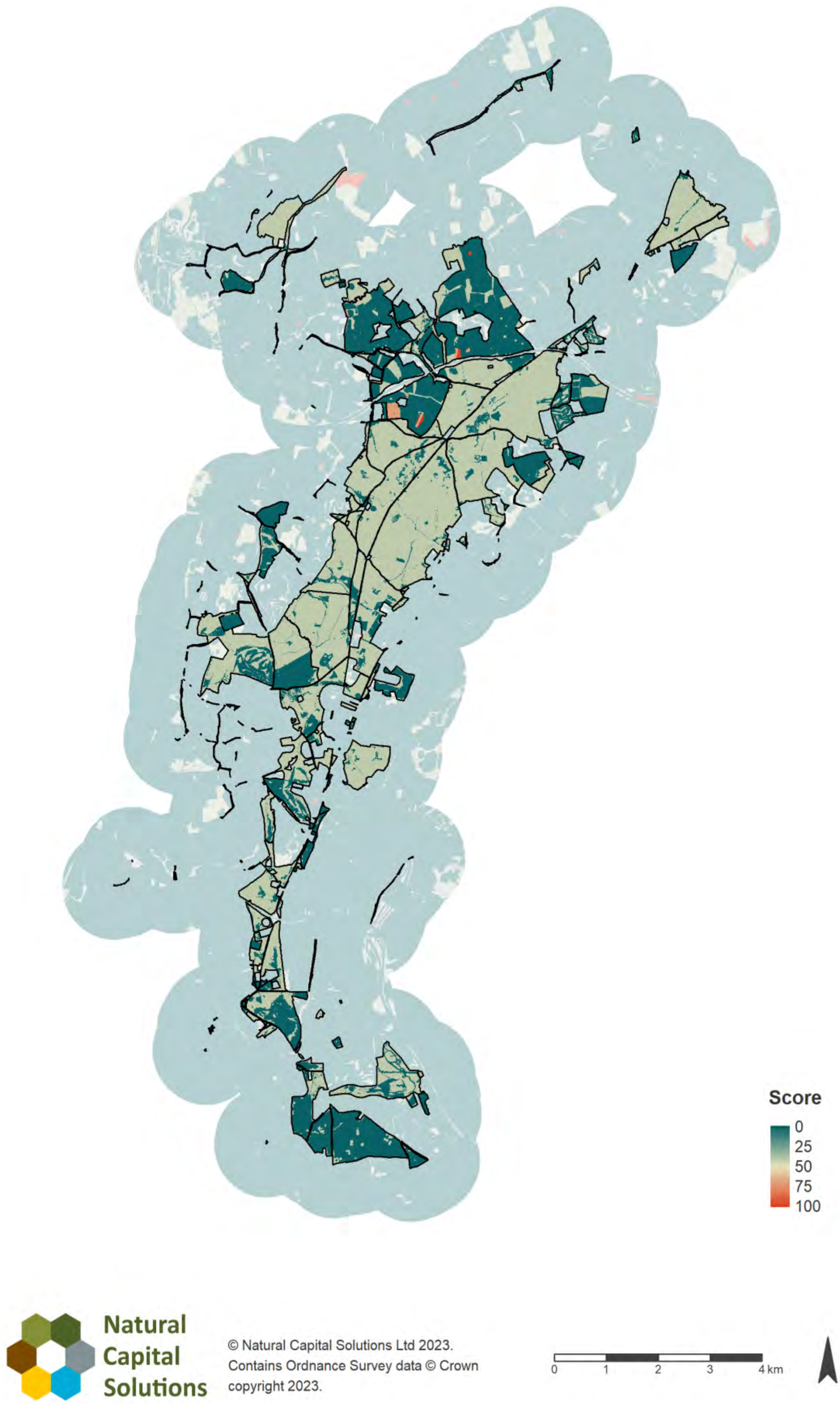


**Figure 38:** Timber and woodfuel production capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

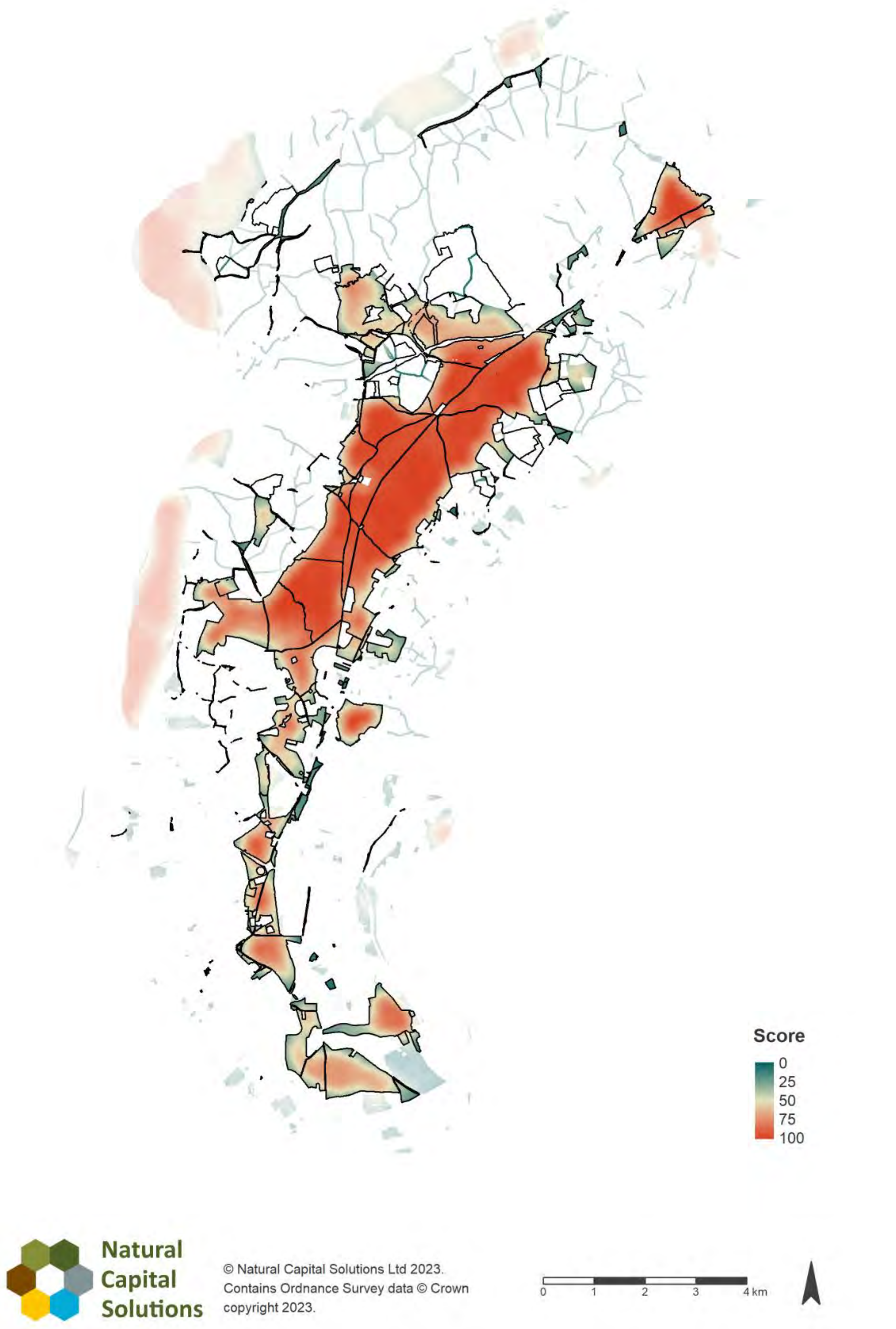


**Figure 39.** Accessible nature capacity at Epping Forest and Buffer Land (normalised on a scale of 0-100).

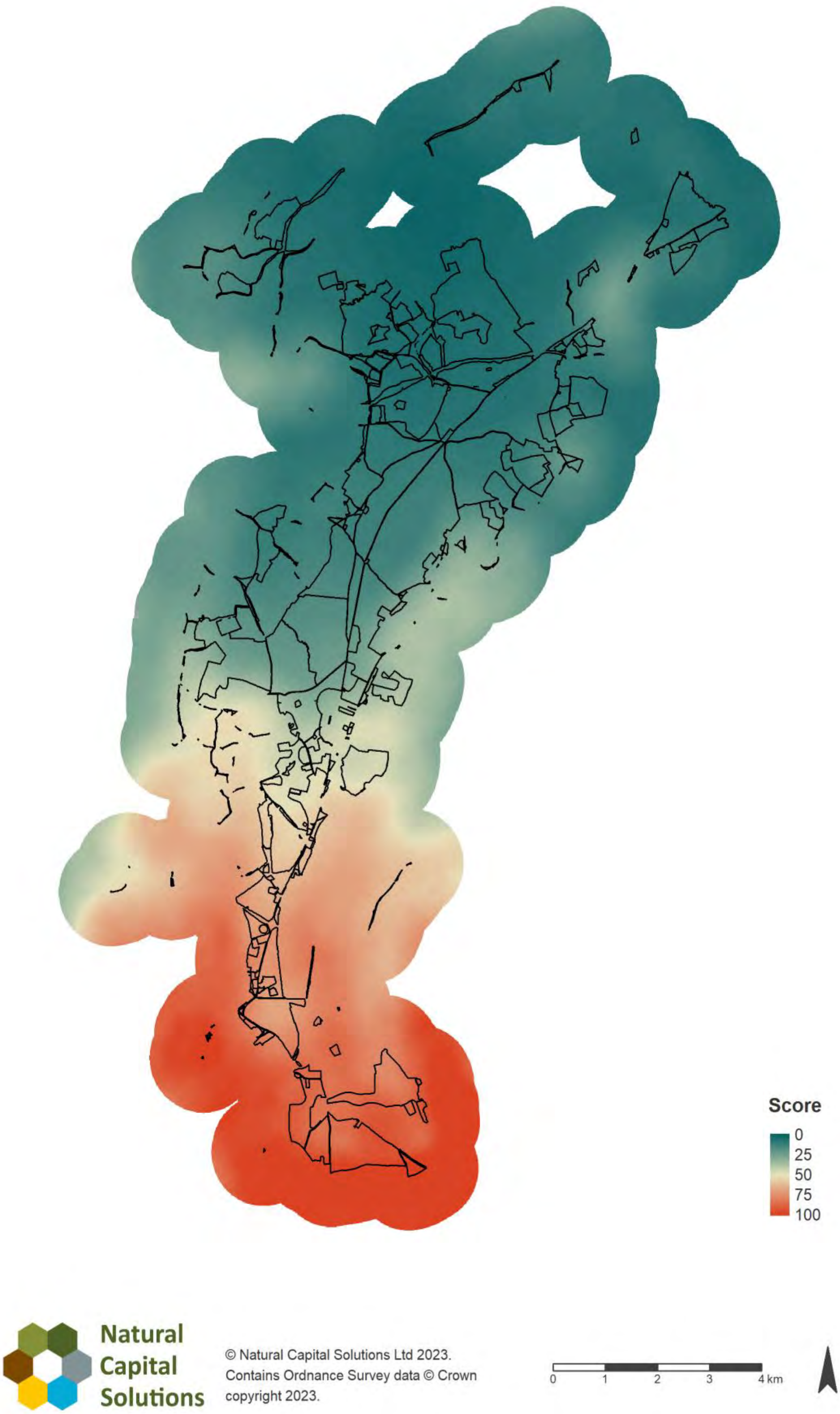


**Figure 40.** Accessible nature demand at Epping Forest and Buffer Land (normalised on a scale of 0-100).

### 3.4 Baseline ecosystem service valuation (monetary flows)

The annual monetary flow of the following ecosystem services were estimated: air quality regulation, carbon balance, agricultural production, timber production, noise reduction, water quality, flood regulation, recreation, health benefits, and amenity. Table 2.4 in Section 2.4 outlines the indicators used to quantify both the physical and monetary flows of these services.

Annual monetary flows of ecosystem services were calculated in line with the System of Environmental-Economic Accounting (SEEA) framework and accounting principles (2017)[21], and the British Standard for Natural Capital Accounting for Organisations (BS 8632:2021)[22]. They were based on the latest valuation techniques available in the scientific literature, and recent Defra guidance bringing together the latest valuation approaches for ecosystem services (Defra ENCA, 2020)[23]. The physical and monetary flows of the ecosystem services are presented below separately for Epping Forest and for the Buffer Land. The methods used to calculate these are described in more detail at the end of the report along with any limitations (see Technical Appendix A.2).

Vegetation can be effective at contributing to **air quality regulation**, with the surface area being the most important determinant of capacity. Trees are much more effective than grass or heather at this, and capacity increases significantly as trees grow and their surface area increases. The woodland and grass vegetation across the Epping Forest site is estimated to absorb 81.7 tonnes of $PM_{2.5}$ (particulate matter 2.5 micrometres or less in diameter) annually, at an annual value of £5.7 million with a present value (over 50 years) of £205.6 million. In the Buffer Land site, the annual absorption of $PM_{2.5}$ is estimated at 10.2 tonnes, with an annual value of £380,000 and a present value over 50 years of £13.6 million (Table 14).

**Carbon sequestration** is the uptake of carbon by plants as they grow, with woodland being the most effective habitat at this across the study sites. In total, the annual carbon sequestration across the Epping Forest site is 15,000 tonnes of carbon per year ($tCO_2e$). Emissions from the livestock used for grassland management (conservation grazing) are estimated at 24 $tCO_2e$ per year. Net sequestration, the difference between carbon sequestration and emissions, is estimated at 14,976 $tCO_2e$ per year, with an annual value of £4.1 million and a present value over 50 years of £135 million. In the Buffer Land sites, annual carbon sequestration is estimated at 2,000 tonnes of carbon per year ($tCO_2e$). Emissions from agriculture (arable) and livestock used for conservation grazing are estimated at 228 $tCO_2e$ per year. As with Epping Forest, the Buffer Land site is in net sequestration, with the carbon balance amounting up to 1,772 $tCO_2e$ per year at an annual value of £480,000 and a present value (over 50 years) of £16 million.

No significant arable area has been identified for the Epping Forest site, so agricultural production is considered nil. In the Buffer Land, the total area of arable land in **agricultural production** is 140 ha (Table 14). When all costs and subsidies (including the Basic Payment Scheme) are excluded, the annual value of agricultural production across the site is £120,000, with a present value (over 50 years) of £2.9 million.

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[21] System of Environmental-Economic Accounting (SEEA) Central Framework (2012) and Experimental Ecosystem Accounting principles (2017).

[22] British Standard BS 8632 (2021) Natural capital accounting for organisations: https://www.bsigroup.com/en-GB/standards/bs-86322021/. Although this standard it aimed at applying natural capital accounting at the organisational level, the principles are the same when applied to geographic areas.

[23] Defra (2020) Enabling a Natural Capital Approach (ENCA). Available at: https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca on 1 July 2020.

The Epping Forest site supports approximately 9,815 $m^3$ of **timber and woodfuel** per year under the current management and averaged over a full woodland production cycle. This has an annual value of £510,000 and a present value (over 50 years) of £12.5 million (Table 13). The Buffer Land sites support approximately 1,010 $m^3$ of timber and woodfuel per year, with an annual value of £50,000 and a present value (over 50 years) of £1.2 million (Table 14).

**Table 13.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Epping Forest.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 81.7 | 5,680 | 205,620 |
| Net carbon balance*<br>*$tCO_2e$*<br>Woodland<br>Agricultural/livestock emissions<br>Other habitats | 14,976<br><br>14,273<br>24<br>727 | 4,070<br><br>3,880<br>10<br>200 | 134,960<br><br>128,630<br>220<br>6,550 |
| Timber/woodfuel production<br>*$m^3$* | 9,815 | 510 | 12,470 |
| Noise reduction<br>*Ha of urban woodland* | 543 | 440 | 10,940 |
| Water quality regulation by woodland<br>*Ha of woodland* | 1,880 | 190 | 4,690 |
| Flood reduction by woodland<br>*$m^3$* | 1,239,550 | 630 | 15,660 |
| Recreation<br>*Visits (Million)* | 10 | 34,130 | 842,830 |
| Health<br>*QALY* | 1,004 | 16,610 | 601,730 |
| Amenity<br>*Nr houses within 500m* | 80,650 | 2,160 | 50,740 |
| **Total values:** | **N/A** | **64,420** | **1,879,640** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 14.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Buffer Land.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*tPM$_{2.5}$* | 10.2 | 380 | 13,580 |
| Net carbon balance*<br>*tCO$_2$e*<br>Woodland<br>Agricultural/ livestock emissions<br>Other habitats | 1,772<br><br>1403<br>228<br>598 | 480<br><br>380<br>60<br>160 | 15,970<br><br>12,640<br>2,060<br>5,390 |
| Agricultural production<br>*Ha* | 140 | 120 | 2,870 |
| Timber/woodfuel production<br>*m$^3$* | 1,010 | 50 | 1,230 |
| Noise reduction<br>*Ha of urban woodland* | 19 | 20 | 380 |
| Water quality regulation by woodland<br>*Ha of woodland* | 191 | 20 | 550 |
| Flood reduction by woodland<br>*m$^3$* | 133,810 | 70 | 1,680 |
| Recreation<br>*Visits (Million)* | 0.5 | 1,570 | 38,650 |
| Health<br>*QALY* | 45 | 750 | 27,090 |
| Amenity<br>*Nr houses within 500m* | 9,835 | 260 | 6,190 |
| **Total values:** | **N/A** | **3,710** | **108,180** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

Woodland can provide screening against noise pollution, especially in urban areas where it can function as a buffer between the noise sources, particularly road transportation, and the population. We have calculated a **noise reduction** value for woodland at the urban areas within the sites and assumed zero value for the rural parts of the site. Under these assumptions, Epping Forest provides noise reduction benefits of £440,000 a year and a present value over 50 years of £10.9 million (Table 13). Buffer Land, on the other hand, provides noise reduction benefits of £20,000 a year and a present value over 50 years of £380,000 (Table 14).

An estimate was made for **water quality** benefits through the presence of riparian and non-riparian woodland. The presence of non-riparian woodland is considered to provide a benefit in comparison to damage costs associated with land use as agriculture; whereas the riparian figures consider the ability for water quality improvements to be made through the woodlands ability to prevent pollution of water courses and a willingness to pay for this service. A total of 1,880 ha of non-riparian woodland was identified in Epping Forest, providing an annual value of £190,000 and a present value of £4.7

million (Table 13). In Buffer Land, 188 ha of non-riparian woodland and 3 ha of riparian woodland was identified, providing an annual value of £20,000 and a present value of £550,000 (Table 14).

Natural capital also provides benefits in the form of **water flow regulation**, which leads to downstream flood risk reduction. At present it is only possible to value this for woodland habitats, although it is acknowledged that other habitats will also provide some benefits. The calculation was based on national average figures from Forest Research (2023), and provides an estimation of three physical processes: canopy interception, woodland soil water storage capacity, and floodplain woodland storage. The woodland within the Epping Forest site was estimated to intercept and store 1.2 million $m^3$ of water each year, which has an annual value of £630,000 and a present value (over 50 years) of £15.7 million (Table 13). The Buffer Land was estimated to intercept and store 133,810 $m^3$ of water each year, which has an annual value of £70,000 and a present value (over 50 years) of £1.7 million (Table 14)

Both Epping Forest and the Buffer Lands have high recreational value. We used the data provided by the client on the number of **recreational visits** made to Epping Forest, while for Buffer Land we estimated the number of visits using the Outdoor Recreation Valuation (ORVal) tool created by the University of Exeter[24]. The welfare value of visits for both sites was estimated using the ORVal tool. In Epping Forest, there are an estimated 10 million recreational visits per year. The welfare value derived from these visits is valued at £34.1 million annually, with a present value (over 50 years) of £842.8 million (Table 13). In Buffer Land, the number of annual recreational visits is estimated at 0.5 million, providing an annual value of £1.6 million and a present value (over 50 years) of £38.7 million (Table 14).

A subset of these visitors will also receive **health benefits** from spending at least 120 minutes a week in nature, following the Exposure to Nature approach suggested by ONS (2022) and explained in the Technical Appendix A.2. The estimated number of visitors to Epping Forest receiving health benefits every year is equivalent to 1,004 Quality-Adjusted Life Years (QALY). This delivers an annual value of £16.6 million and a present value over 50 years of £601.7 million (Table 13). In the Buffer Lands, the estimated number of visitors receiving health benefits every year is equivalent to 45 Quality-Adjusted Life Years (QALY), providing an annual value of £750,000 and a present value over 50 years of £27.1 million (Table 14).

We use the principle of hedonic pricing and evidence of increases in property values as a means of capturing **amenity value**. There are 80,650 homes in close proximity – within 500 metres - to the greenspace provided by the Epping Forest site, having a positive impact on the average house values of those homes. This benefit of £50.7 million is considered a present value (in this case, over 50 years) rather than an annual flow, so we annualise it to estimate the annual benefits of £2.2 million (Table 13). In Buffer Land, there are 9,835 homes in close proximity, benefiting from an uplift value over 50 years of £6.2 million, with annualised benefits of £260,000 (Table 14).

In total, the value of the benefits delivered by the natural capital assets that we quantified for Epping Forest is £64.4 million annually, with a present value of £1.9 billion over 50 years. For Buffer Land, the

[24] Day, B. H., and G. Smith (2018). Outdoor Recreation Valuation (ORVal) User Guide: Version 2.0, Land, Environment, Economics and Policy (LEEP) Institute, Business School, University of Exeter.

value of natural capital benefits amount to £3.7 million annually, with a present value of £108.2 million over 50 years.

### 3.4.1 Sensitivity analysis

A sensitivity analysis examined the low, central and high estimates of the natural capital benefits that have been valued (Tables 15 and 16). This demonstrates the overall sensitivity of natural capital values. The total natural capital value of Epping Forest ranges from a present value (over 50 years) of £1.2 billion under the lowest benefits estimates up to £4.5 billion under the highest benefits estimates. This large difference highlights the challenges of placing a monetary value on some services. A key point, however, is that even under the low benefit estimate, the natural capital assets will deliver a substantial benefit worth at least £41.1 million annually, which is £1.2 billion in present value terms.

In the case of Buffer Land, the total natural capital value ranges from a present value (over 50 years) of £65.6 million under the lowest benefits estimates up to £242 million under the highest benefits estimates. Even under the low benefit estimate, the natural capital assets will deliver a substantial benefit worth at least £2.3 million annually, which is £65.6 million in present value terms.

**Table 15.** Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets of Epping Forest.

| Ecosystem service | Annual values (2023) (£ 000's) | | | Present value (over 50 years) (£ 000's) | | |
|---|---|---|---|---|---|---|
| | Low | Central | High | Low | Central | High |
| Air quality regulation | 2,250 | 5,680 | 16,290 | 81,550 | 205,620 | 590,310 |
| Carbon balance | 2,040 | 4,070 | 6,100 | 67,480 | 134,960 | 202,440 |
| Timber/ woodfuel production | 380 | 510 | 630 | 9,350 | 12,470 | 15,580 |
| Noise reduction | 330 | 440 | 550 | 8,210 | 10,940 | 13,680 |
| Water quality | 140 | 190 | 240 | 3,510 | 4,690 | 5,860 |
| Flood regulation | 480 | 630 | 790 | 11,750 | 15,660 | 19,580 |
| Recreation | 25,600 | 34,130 | 42,670 | 632,120 | 842,830 | 1,053,540 |
| Health | 8,300 | 16,610 | 70,240 | 300,870 | 601,730 | 2,545,260 |
| Amenity | 1,620 | 2,160 | 2,700 | 38,060 | 50,740 | 63,430 |
| **Total value:** | **41,140** | **64,420** | **140,220** | **1,152,890** | **1,879,640** | **4,509,670** |

NB. Figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 16.** Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets of Buffer Land.

| Ecosystem service | Annual values (2023) (£ 000's) | | | Present value (over 50 years) (£ 000's) | | |
|---|---|---|---|---|---|---|
| | Low | Central | High | Low | Central | High |
| Air quality regulation | 150 | 380 | 1,080 | 5,390 | 13,580 | 39,030 |
| Carbon balance | 240 | 480 | 720 | 7,990 | 15,970 | 23,960 |
| Agricultural production | 90 | 120 | 150 | 2,150 | 2,870 | 3,590 |
| Timber/ woodfuel production | 40 | 50 | 60 | 920 | 1,230 | 1,540 |
| Noise reduction | 10 | 20 | 20 | 280 | 380 | 470 |
| Water quality | 20 | 20 | 30 | 410 | 550 | 690 |
| Flood regulation | 50 | 70 | 90 | 1,260 | 1,680 | 2,100 |
| Recreation | 1,170 | 1,570 | 1,960 | 28,990 | 38,650 | 48,310 |
| Health | 370 | 750 | 3,160 | 13,540 | 27,090 | 114,560 |
| Amenity | 200 | 260 | 330 | 4,640 | 6,190 | 7,740 |
| **Total value:** | **2,340** | **3,710** | **7,590** | **65,570** | **108,180** | **241,990** |

NB. Figures shown to the closest 00's. Any discrepancies due to rounding.

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

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. For example, additional cultural services, such as aesthetic experiences, cultural heritage, spiritual experience and sense of place that are difficult to quantify. Consequently, the valuations presented in this section place values on several key benefits, but these are necessarily incomplete.

**Table 17.** Summary of uncertainties in the calculation of physical flows and monetary values of each natural capital benefit, and an overall assessment of confidence, using a red, amber, green (RAG) rating.

| Natural capital benefits | Assessment of uncertainties | RAG rating |
|---|---|---|
| Air quality regulation | Biophysical estimates based on averages for broadleaved and coniferous trees and grassland. Valuation follows ONS guidance. | |
| Carbon sequestration | Well studied. standardised carbon lookup tables available. Valuation uses UK Government non-traded carbon price. | |
| Agricultural emissions | Receiving increasing attention as part of climate change accounting. Valuation uses UK Government non-traded carbon price. | |
| Agricultural production | Based on extensive data collected by Defra annually and market prices. | |
| Timber production | Well studied over many years as part of forestry management. Valuation uses market prices. | |
| Noise reduction | Based on value transfer from another study (from Manchester), so a crude estimate. | |
| Water quality | The "water quality" figure is crude and a lower-bound estimate as it simply gives the average damage cost of agriculture over England. The "riparian" figure is based on a large number of major assumptions and should be treated with caution. | |
| Flood regulation | Widely accepted approach, based on a study by Forest Research. But is a relatively crude assessment as it is value transfer from England scale data. | |
| Recreation | Welfare values from a meta-analysis of a range of welfare value studies across a range of habitats. There is potential here for double counting with the health service (see Technical Appendix for discussion). | |
| Health benefits | The most uncertain of the services measured. High uncertainty over who would make frequent and active visits to the green spaces and the monetary value of these benefits. | |
| Amenity | Follows the latest ONS study on the effect on house values of proximity to greenspaces. This uses travel to work area estimates of impact on house values for Warrington and Chester only. These estimates may vary across the region. | |

For the services that have been included here, a range of assumptions have been made, and these are outlined when describing the methodology (see Technical Appendix A.2). In addition, a summary of the main uncertainties is provided for each service in Table 17 (above), along with a RAG rating highlighting the overall confidence in each estimate. For most ecosystem services these assumptions are minimal, as established production functions exist linking natural capital to ecosystem service production and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for health, and this estimate should, therefore, be used with care.

### 3.5 Natural capital account

A natural capital account measures and values the natural capital assets of an area, based on the flow of ecosystem services and associated benefits from those assets. The benefits are then compared to the costs (capital and operational expenditure) in the form of a balance sheet. We have completed the first steps of the natural capital account in the previous chapters of this report: an asset register describing the extent of the natural capital assets (Section 3.1), and the physical and monetary flow account (Section 3.4). The final step of the process is to produce a maintenance cost account and a natural capital balance sheet for the site. This is where the value of the benefits derived from the natural capital assets are compared to the costs of maintaining those assets. Valuations are referred to as 'asset values' and the maintenance requirements as 'liabilities', following standard accounting terminology. In addition, two components of asset value are recognised: private value (benefits to the Corporation) and external value (wider benefits to society). Most of the benefits included here provide external value, except for agricultural production (only estimated for Buffer Land) and timber/woodfuel production that is considered as providing private benefits. This approach follows general principles and methodology, which has been developed by Eftec et al. (2015)[25] and the British Standard for Natural Capital Accounting for Organisations (BS 8632:2021)[26] .

The maintenance costs of the Epping Forest and of the Buffer Land sites (Table 18) are an average of actual operational costs from the Local Risk budget for the last five years (from 2018/19 to 2022/23), in 2023 prices, and include typical costs associated with forestry, management of the recreational greenspaces, fencing, and hedgerow maintenance. They are divided between employee costs, the most important expenditure, and other costs, which include premises costs, supplies and services, and transportation. In the case of Buffer Land where we include agricultural production, the costs for farming are already captured and removed from the value of the agricultural production service, along with any subsidies, so they do not appear under the liabilities section of the natural capital account.

**Table 18.** Annual costs associated with the maintenance of natural capital on Epping Forest and Buffer Land (£2023 Thousands).

| | Epping forest (£000's) | Buffer Land (£000's) |
|---|---|---|
| Employees | 2,460 | 720 |
| Other costs | 1,310 | 380 |
| **Total** | **3,760** | **1,100** |

NB. Actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

[25] Eftec, RSPB & PWC (2015) Corporate Natural Capital Accounting Guidelines.
[26] British Standard BS 8632 (2021) Natural capital accounting for organisations: https://www.bsigroup.com/en-GB/standards/bs-86322021/. Although this standard it aimed at applying natural capital accounting at the organisational level, the principles are the same when applied to geographic areas.

The natural capital balance sheet for Epping Forest and for Buffer Land is shown in Table 19. The total value of the natural capital assets of the sites is quantified and reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets for each site.

The gross asset value of the Epping Forest site (PV £1.9 billion, Table 19) is driven largely by the value of recreational and health services, carbon sequestration and air pollution regulation (see Table 13). The net natural capital asset value of Epping Forest is £1.8 billion over 50 years. The site delivers a benefit to cost ratio of 20.2, which means that every £1 spent on maintenance delivers £20.2 in benefits. In the Buffer Land site, the gross asset value (PV £108.2 million, Table 19) is similarly driven largely by the value of air pollution regulation, carbon sequestration and recreational and health benefits (see Table 14). The net natural capital asset value of Buffer Land is £80.9 million over 50 years. The site delivers a benefit to cost ratio of 4, which means that every £1 spent on maintenance delivers £4 in benefits.

**Table 19.** Natural capital balance sheet for Epping forest and for Buffer Land shown as present values (PV) over 50 years (£2023 Thousands).

| | **Epping forest PV** | **Buffer Land PV** |
|---|---|---|
| **Assets** | | |
| Natural capital benefits | 1,879,640 | 108,180 |
| **Gross asset value (benefits)** | **1,879,640** | **108,180** |
| | | |
| **Liabilities** | | |
| Maintenance costs | (92,900) | (27,240) |
| **Total liabilities (costs)** | **(92,900)** | **(27,240)** |
| | | |
| **Net Natural Capital Value** | 1,786,740 | 80,940 |
| **Benefit-cost ratio** | **20.2** | **4** |

### 3.6 Conclusions

The natural capital asset register shows that broadleaved woodland covers the majority of Epping Forest and Buffer Land (63.5%). There are small pockets of mixed and coniferous woodlands across the sites (0.5%). The ecosystem services maps for the site show a high provision for a wide range of ecosystem (carbon sequestration, air purification, noise regulation, local climate regulation, water flow and quality regulation, access to nature). The woodland delivers 97% of the sequestration capacity of the site and is a significant store of carbon. It also has a high accessible nature capacity, which is particularly important in the southern end of the site, where the demand for this service is high because of the surrounding urban settlements.

Whilst woodland is always an important habitat for delivering a wide range of services, the assessment demonstrates that the semi-natural grasslands, the dominant habitat type across the Buffer Land, heathland and scrub also provide important ecosystem service benefits. These include carbon sequestration and storage, water flow and quality regulation, albeit to a lesser extent than the woodland, but are particularly important for pollinators, especially in the summer, and access to nature.

This site has conservation importance at the national level, with SSSI and SAC designations. The diversity of habitat types across this site is important for biodiversity, and the biodiversity baseline assessment shows that the majority of habitats are in good to moderate condition. The biodiversity baseline score for the combined site is high (the highest of all of the CoLC sites, which is driven largely by the size of the site) 27,895.85. A focus on increasing the condition of the poor and moderate condition habitats should be a priority. Efforts should be made to improve the areas of semi-natural grassland and woodland from moderate to good condition throughout Epping Forest, and particular attention should be focused on the Buffer Lands, where 66% of the site is in poor condition. Improving these areas of grassland and their condition scores from poor to moderate and eventually to good, would increase the biodiversity units. The activities outlined in the management plan should help achieve this.

The overall net natural capital value of both sites combined is £1.9 billion over 50 years. For every £1 spent on maintaining the natural capital at the Epping Forest site there is a £20.2 return in benefits, and a lower £4 return in benefits in the Buffer Land area. This high natural capital value is driven by the recreation and health services (£35.7 million and £17.4 million annually), the ability of the site to sequester carbon (£4.6 million annually) and air pollution regulation (£6.0 million annually) across the sites. The sites provide important and valuable services in the context of a densely urban environment.

### 3.6.1 Recommendations

Given the aim of this project was to assess the natural capital benefits provided by the City of London Corporation owned sites, we will focus on how these benefits might be increased in the coming years. However, we are aware of the conservation importance of these sites, and the ongoing management to maintain and enhance biodiversity, so our recommendations are focused principally on where increasing the provision of benefits can occur alongside and in addition to the proposed management.

The conservation management priorities at the Epping Forest and Buffer Land sites are concerned with increasing woodland condition by controlling deer, increasing the extent and condition of the heathland habitat (removing trees and scrub), creating wood pasture, and improving acid grassland condition, cutting and grazing meadows, scrub management, maintaining hedgerows, ponde creation and opening up ditches. The planned activity on these habitats is extensive and will be very beneficial to a range of ecosystem services, carbon storage, sequestration, water flow and quality regulation and pollination. It will also increase attractiveness to visitors. It is important to note that the removal of trees and scrub on heathland, and opening up woodland to create wood pasture will impact on a range of ecosystem service benefits, as they are key habitats for delivering carbon sequestration, storage, local climate regulation, water flow and quality regulation. However, this trade-off in favour of biodiversity may be acceptable given the extent of woodland at the site, and the need to maintain the heathland habitats. It really depends on what CoLC see as the most pressing priority.

Where trees and scrub are removed in the Epping Forest site, it would be beneficial to introduce new trees and scrub in other more appropriate areas of the site (woodland edges, amenity grassland areas) to maintain service provision, or perhaps offset their loss in the Buffer Land area. Hedgerows and wildflower / pollinator field margins could be introduced around arable fields in the Buffer Land if they are not already present, which would enhance both ecosystem services and biodiversity. When managing woodlands at the sites it is important to manage for a diverse species and age structure to build ecological resilience and ensure carbon sequestration can be maintained into the future.

The Epping Forest site is clearly a highly visited site and supports a great deal of recreational activity. Access to the south of the site could be improved as the highest demand for accessible nature lies there. Whist increasing the number of visitors may be desirable from a benefits point of view, it is important that visitor pressure is managed carefully to avoid degrading other ecosystem service benefits at the site. The recreation and health services are the most valuable and further value can be added by increasing visitors exposure to nature through participation in organised activities such as walking groups, conservation volunteering, and ensuring access for active travel. The sites could host green social prescribing activities which would increase health and wellbeing of those taking part.

## 4. Natural capital assessment summaries (remaining sites)

This section summarises the mapped natural capital and biodiversity baseline assessment results for each of the remaining sites. The asset registers, valuation and natural capital account tables are presented for each site, but the biodiversity baseline and ecosystem services maps are not included. All of the maps are available as GIS layers to be viewed by the client.

### 4.1 Ashtead Common

#### 4.1.1 Natural capital assets

Ashtead common is dominated by broadleaved woodland with pockets of heathland, scrub and semi-natural grassland.

**Table 20.** Baseline habitats at Ashtead Common.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 148.2 | 74.1 |
| Semi-natural grassland | 19.1 | 9.5 |
| Scrub | 16.2 | 8.1 |
| Mixed / other / uncertain | 8.6 | 4.3 |
| Modified (amenity) grassland | 5.9 | 2.9 |
| Built-up areas and infrastructure | 1.3 | 0.7 |
| Water | 0.5 | 0.3 |
| Garden | 0.1 | 0.1 |
| **Total** | **199.9** | **100** |

#### 4.1.2 Biodiversity baseline

A total of 95.9% of the habitats were assigned a condition; the majority of the site (89.7% of the site area) is in good condition, 5% in moderate condition and 0.2% in poor condition. The site has a total of 2,153 biodiversity units.

#### 4.1.3 Ecosystem services

Carbon storage, sequestration, accessible nature capacity, water flow regulation and local climate regulation capacity are relatively high given the large amount of woodland. Pollination, air purification, noise regulation and water quality provision are moderate, while food production capacity is low (given no arable or improved grassland is present on the site).

Demand for services such as local climate, air purification and noise regulation is highest to the south of the site and where there are busy roads that are pollution and noise sources. There is also high demand for accessible nature to the south of the site where the main urban settlements are located (Ashstead).

#### 4.1.4 Natural Capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Ashtead Common is £1.9 million annually, with a present value of £56.3 million over 50 years (Table 21). The ecosystem services that provide the largest value in this site are recreation (PV £16.4 million), carbon sequestration (PV £13 million) and health benefits (PV £12.4 million).

**Table 21.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Ashtead Common.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*tPM2.5* | 6.1 | 240 | 8,680 |
| Net carbon balance*<br>*$tCO_2e$* | 1,448 | 390 | 13,050 |
| Woodland | 1,410 | 380 | 12,710 |
| Agriculture/ livestock emissions | 6 | 0 | 50 |
| Other habitats | 44 | 10 | 400 |
| Timber/woodfuel production<br>*$m^3$* | 1,013 | 50 | 1,290 |
| Noise reduction<br>*Ha of urban woodland* | 28 | 20 | 560 |
| Water quality regulation<br>*Ha of woodland* | 148 | 20 | 390 |
| Flood reduction by woodland<br>*$m^3$* | 100,115 | 50 | 1,260 |
| Recreation<br>*Visits (Million)* | 0.2 | 670 | 16,430 |
| Health<br>*QALY* | 21 | 340 | 12,390 |
| Amenity<br>*Nr houses within 500m* | 2,960 | 90 | 2,220 |
| **Total values:** | **N/A** | **1,880** | **56,260** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

The natural capital balance sheet for Ashtead Common is shown in Table 22. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Ashtead Common is £45 million over 50 years. The site delivers a benefit to cost ratio of 5, which means that every £1 spent on maintenance delivers £5 in benefits.

**Table 22.** Natural capital balance sheet for Ashtead Common presented as present values (PV) over 50 years.

| | **Present Value (PV £000's)** |
|---|---|
| **Assets** | |
| Natural capital benefits | 56,260 |
| **Gross asset value (benefits)** | **56,260** |
| | |
| **Liabilities** | |
| Maintenance costs | (11,220) |
| **Total liabilities (costs)** | **(11,220)** |
| | |
| **Net Natural Capital Value** | 45,040 |
| **Benefit-cost ratio** | **5** |

NB. Maintenance costs are actual costs, five-year average (2018/19- 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

### 4.1.5 Recommendations

The site is managed for biodiversity and the aim is for the SSSI habitats to attain favourable condition in the coming 6-7 years[27]. This will increase the biodiversity unit baseline. In terms of opportunities for increasing ecosystem service provision at this site, the planned conservation management activities are likely to achieve this, particularly through the restoration of wood pasture, woodland management to maintain age structures for the continuation of carbon sequestration in future years, and through the management of pond riparian zones. Along with improving the condition of heathland these activities are likely to increase carbon storage and sequestration, local climate and air quality regulation, water flow and quality regulation. Grazing of grasslands will improve species diversity and when in flower is likely to increase pollinator visits. Any increase of scrub and hedgerow habitats at the site would be very beneficial for increasing this range of ecosystem services further.

Cultural services are particularly valuable at this site, and the management plan for Ashtead Common already has a focus on recreation, education and research benefits. Maintaining good access is key, and expanding on activities that local visitors of all abilities can get involved in will increase the natural capital value of this site further. The planned management will also increase the perceived naturalness of the site making it more attractive to visitors.

## 4.2 Burnham Beeches

### 4.2.1 Natural capital assets

Burnham Beeches predominantly comprises broadleaved woodland with pockets of heathland, semi-natural grassland and fen.

[27] Ashtead Common Management Plan 2021-2031. City of London.

**Table 23.** Baseline habitats at Burnham Beeches.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 166.3 | 79.7 |
| Semi-natural grassland | 18.8 | 9 |
| Heathland | 9.3 | 4.5 |
| Built-up areas and infrastructure | 7.3 | 3.5 |
| Fen, marsh and swamp | 6.5 | 3.1 |
| Unclassified | 0.4 | 0.2 |
| Garden | 0.1 | 0 |
| **Total** | **208.7** | **100** |

### 4.2.2 Biodiversity baseline

A condition score was assigned to 99.5% of the site area, with 96.3% of the site in good condition and 2.5% in moderate condition, resulting in 2,873 biodiversity units.

### 4.2.3 Ecosystem services

Since the site is dominated by broadleaved woodland, water flow and water quality regulation, accessible nature capacity, local climate, air quality and noise regulation, carbon storage and sequestration are all provided to a relatively high level. Pollination, timber production and water quality regulation are provided to a moderate level. Food production capacity is low due to the absence of arable and improved grassland.

The demand for air purification, noise and climate regulation and accessible nature is mainly low, although some demand can be found at the eastern side of the site, due a larger settlement outside the eastern boundary.

### 4.2.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Burnham Beeches is £3.6 million annually, with a present value of £105.8 million over 50 years (Table 24). The ecosystem services that provide the largest value in this site are recreation (PV £43.5 million), health benefits (PV £33.2 million), carbon sequestration (PV £12 million) and air quality regulation (PV £11.4 million).

The natural capital balance sheet for Burnham Beeches is shown in Table 25. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Burnham Beeches is £85.1 million over 50 years. The site delivers a benefit to cost ratio of 5.1, which means that every £1 spent on maintenance delivers £5.1 in benefits.

**Table 24.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Burnham Beeches.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*tPM2.5* | 8.1 | 310 | 11,370 |
| Net carbon balance*<br>*tCO2e* | 1,327 | 360 | 11,960 |
| Woodland | 1,247 | 340 | 11,230 |
| Agriculture/ livestock emissions | 7 | 0 | 60 |
| Other habitats | 87 | 20 | 790 |
| Timber/woodfuel production<br>*m3* | 823 | 40 | 1,050 |
| Noise reduction<br>*Ha of urban woodland* | 29 | 20 | 580 |
| Water quality regulation<br>*Ha of woodland* | 166 | 20 | 410 |
| Flood reduction by woodland<br>*m3* | 110,540 | 60 | 1,390 |
| Recreation<br>*Visits (Million)* | 0.6 | 1,760 | 43,520 |
| Health<br>*QALY* | 55 | 920 | 33,180 |
| Amenity<br>*Nr houses within 500m* | 1,800 | 100 | 2,350 |
| **Total values:** | **N/A** | **3,590** | **105,810** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 25.** Natural capital balance sheet for Burnham Beeches presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| Natural capital benefits | 105,810 |
| **Gross asset value (benefits)** | **105,810** |
| | |
| **Liabilities** | |
| Maintenance costs | (20,670) |
| **Total liabilities (costs)** | **(20,670)** |
| | |
| **Net Natural Capital Value** | 85,140 |
| **Benefit-cost ratio** | **5.1** |

NB. Maintenance costs are actual costs, five-year average (2018/19- 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

### 4.2.5 Recommendations

We are aware from one of our previous studies (Rouquette et al. 2023[28]) that included Burnham Beeches that there are plans to thin woodland in favour of wood pasture habitat and to restore heathland, although how much of this is intended for the Burnham Beeches site we are unsure. This will enhance the biodiversity of the site, but reducing the woodland area will lower the provision of ecosystem services at the site.

To maintain the natural capital of the site there should be a focus on improving and maintaining the age structure of the woodlands (there are many veteran trees and ancient woodland on site) for optimal carbon sequestration into the future. Improving the condition of heathland and grassland, along with incorporating more hedgerows, scrub and young trees will help improve the capacity of the site to sequester and store carbon, increase air purification, noise regulation, water flow and regulation capacity and increase pollinator visitation. All of these features can be placed to ensure connectivity with the surrounding landscape.

Recreational and health benefits are important and there is a plan[29] at the site to manage visitors. Enhancing these benefits through footpath creation may not be viable here if visitor pressure is already high, but managing paths to ensure accessibility for all and a diversity of good quality habitats is key. Organised activities at sites like these, e.g. organised walks, or routes that support green prescribing, or conservation activities can help increase the health and wellbeing of local populations.

## 4.3 Cemetery and Crematorium

### 4.3.1 Natural capital assets

The Cemetery and Crematorium site is dominated by built-up areas and infrastructure[*] across the site, with some areas of broadleaved woodland, mixed woodland, scrub and arable land.

**Table 26.** Baseline habitats at the Cemetery and Crematorium.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Built-up areas and infrastructure | 61 | 89.9 |
| Broadleaved woodland | 4.7 | 6.9 |
| Scrub | 1.1 | 1.6 |
| Allotment | 0.9 | 1.3 |
| Mixed woodland | 0.2 | 0.3 |
| **Total** | **67.9** | **100** |

[28] Rouquette, J.R., Hobbs, L. & Zini, V. (2023) A natural capital assessment of nature enhancement in the Burnham Beeches and wider landscape. Natural Capital Solutions Ltd.
[29] Burnham Beeches Management Plan 2020-2030. City of London.
[*] This was the dominant habitat from the UKhabitat survey of the site provided by the client. This doesn't match with satellite images of the site which show this area to be grassland, perhaps amenity grassland. The CoLC may want to check this.

### 4.3.2 Biodiversity baseline

A total of 96.67% of this site was assigned a condition. Most of this site is dominated by built-up areas and infrastructure (89.65% of the site area) which has a biodiversity condition score of zero. Most of the rest of the site is in moderate condition (6.99% of the site area), with 0.02% of the site in poor condition. The site has a total of 38.1 biodiversity units, which is low compared to the other larger sites owned by the City of London Corporation, that have a more diverse range of semi-natural habitats.

### 4.3.3 Ecosystem services

The Cemetery and Crematorium site has a low capacity to provide ecosystem services which is due to the proportion of built up areas and infrastructure at the sites. Water quality regulation is low, but this erosion risk model is not reliable for use at small and built up sites. The patches of woodland and scrub habitats have high water regulation capacity, but these cover only a small proportion of the site.

The demand for accessible nature for this site is high, due to the surrounding boroughs of Redbridge and Newham. Noise regulation is low within the site due to there being no sources of noise, but demand for air purification is high where the site borders the A116 to the west and A118 to the south of the site.

### 4.3.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Cemetery and Crematorium is £3.9 million annually, with a present value of £110.7 million over 50 years (Table 27). The ecosystem services that provide the largest value in this site are recreation (PV £62.2 million), health benefits (PV £45.1 million), and amenity (PV £2.1 million).

The natural capital balance sheet for Cemetery and Crematorium is shown in Table 28. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Cemetery and Crematorium is £61.9 million over 50 years. The site delivers a benefit to cost ratio of 2.3, which means that every £1 spent on maintenance delivers £2.3 in benefits.

**Table 27.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Cemetery and Crematorium.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 0.3 | 20 | 800 |
| Net carbon balance*<br>*$tCO_2e$*<br>Woodland<br>Agriculture/ livestock emissions<br>Other habitats | 41.3<br><br>41.3<br>N/A<br>0 | 10<br><br>10<br>N/A<br>0 | 370<br><br>370<br>N/A<br>0 |
| Timber/woodfuel production<br>*$m^3$* | 26 | 0 | 30 |
| Noise reduction<br>*Ha of urban woodland* | 1 | 0 | 20 |
| Water quality regulation<br>*Ha of woodland* | 5 | 0 | 10 |
| Flood reduction by woodland<br>*$m^3$* | 3,398 | 0 | 40 |
| Recreation<br>*Visits (Million)* | 0.8 | 2,520 | 62,160 |
| Health<br>*QALY* | 75 | 1,250 | 45,130 |
| Amenity<br>*Nr houses within 500m* | 4,110 | 90 | 2,110 |
| **Total values:** | **N/A** | **3,890** | **110,670** |

***Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 28**. Natural capital balance sheet for Cemetery and Crematorium presented as present values (PV) over 50 years.

| | **Present Value (PV £000's)** |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 110,670 |
| **Gross asset value (benefits)** | **110,670** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (48,770) |
| **Total liabilities (costs)** | **(48,770)** |
| | |
| **Net Natural Capital Value** | **61,900** |
| **Benefit-cost ratio** | **2.3** |

NB. Maintenance costs based on 2022/23 actual figures. Figures shown to the closest 00's. Any discrepancies due to rounding

#### 4.3.5 Recommendations

This site's current management plan[30] is to maintain the habitat as it is, and whilst the site is managed for a specific function, it still does has the potential to improve its ecosystem service provision and biodiversity scores if there was connectivity between habitat types within the site. For example, the introduction of trees, hedgerows and scrub. Lines of trees, or hedgerows with trees on the boundaries of the site, would help regulate air pollution, noise, local climate, water flow and quality, as well as sequestering and storing carbon and attracting pollinators.

## 4.4 City Gardens

### 4.4.1 Natural capital assets

The City Gardens sites (c. 200 small sites in central London) collectively are dominated by built up areas and infrastructure, with broadleaved woodland and water areas making up a significant portion of the sites. The remaining habitats in this collection of sites are scrub and modified (amenity) grassland.

**Table 29.** Baseline habitats at City Gardens.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Built-up areas and infrastructure | 5.5 | 66.3 |
| Broadleaved woodland | 1.4 | 16.9 |
| Water | 0.9 | 10.8 |
| Modified (amenity) grassland | 0.4 | 4.8 |
| Scrub | 0.1 | 1.2 |
| **Total** | **8.3** | **100** |

### 4.4.2 Biodiversity baseline

The City Garden sites are comprised of built-up areas and consequently 65% of the combined area of the sites has a condition score of 0. A small percentage of this area (5.2%) is in poor condition, while 16.7% is in moderate condition. The total biodiversity units score calculated across the City Gardens is 12.25.

### 4.4.3 Ecosystem services

The City Garden sites are very small in area and highly fragmented. This means that the ecosystem service model results for each site are not very reliable (apart from the carbon sequestration and storage models) as it is difficult to gain accurate results at such small scale. The habitats at these sites will offer some benefits as little oases of green in a dense urban fabric, but these will be limited. The maps show that trees or small pockets of woodland at these sites have a moderate capacity for sequestering and storing carbon.

Demand for local climate, air pollution regulation and accessible nature are high as the sites occur within a very built up urban area.

[30] Plans for management were from the site manager.

### 4.4.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for City Gardens is £126.8 million annually, with a present value of £3.6 billion over 50 years (Table 30). The ecosystem services that provide the largest value across these sites (and indeed across the whole CoLC portfolio) are recreation (PV £2.2 billion) and health benefits (PV £1.3 billion).

**Table 30.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for City Gardens.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*tPM2.5* | 0.1 | 40 | 1,300 |
| Net carbon balance*<br>*tCO2e* | 11 | 0 | 100 |
| Woodland | 11 | 0 | 100 |
| Agriculture/ livestock emissions | N/A | N/A | N/A |
| Other habitats | 0 | 0 | 0 |
| Timber/woodfuel production<br>*m3* | 7 | 0 | 10 |
| Noise reduction<br>*Ha of urban woodland* | 1.4 | 0 | 30 |
| Water quality regulation<br>*Ha of woodland* | 1.4 | 0 | 0 |
| Flood reduction by woodland<br>*m3* | 14,005 | 10 | 180 |
| Recreation†<br>*Visits (Million)* | 21.9 | 90,250 | 2,228,540 |
| Health<br>*QALY* | 2,198 | 36,370 | 1,317,790 |
| Amenity<br>*Nr houses within 500m* | 2,690 | 150 | 3,420 |
| **Total values:** | **N/A** | **126,810** | **3,551,360** |

***Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

† As with all of the recreation values in this study, these estimates were provided by the client and based on the most recent surveys of visit numbers. Where there were no surveys, visit numbers were estimated using surveys from sites that were similar in size, character and geographic location (as is the case for this set of sites). The visits for these sites seem very high, but these are the total visits across approximately 200 separate sites in the heart of London that are intensively used.

The natural capital balance sheet for City Gardens is shown in Table 31. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of City Gardens is £3.5 billion over 50 years. The site delivers a benefit to cost ratio of 87.7, which means that every £1 spent on maintenance delivers £87.7 in benefits.

**Table 31**. Natural capital balance sheet for City Gardens presented as present values (PV) over 50 years.

| | **Present Value (PV £000's)** |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 3,551,360 |
| **Gross asset value (benefits)** | **3,551,360** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (40,510) |
| **Total liabilities (costs)** | **(40,510)** |
| | |
| **Net Natural Capital Value** | **3,510,850** |
| **Benefit-cost ratio** | **87.7** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

### 4.4.5 Recommendations

The current biodiversity strategy across the sites is to increase nesting cover from ground to canopy, increase berry, nectar and pollen rich species[31]. This will deliver multiple biodiversity benefits, and will likely increase the pollination service. Due to the small and fragmented nature of the sites there is limited scope for any increases in ecosystem service benefits. Introducing hedgerows, trees and scrub where possible within the sites would be beneficial, especially if there was a focus on native species that are efficient at taking up carbon, and are good at trapping air pollutants (particularly where trees are on road verges). Trees would also offer shade and regulate local climate, and water features also help with local cooling. The introduction of rain gardens would also help to regulate water flow. These additions are also likely to increase wellbeing of visitors. Whilst these sites are small they are vitally important for recreation, health and well-being benefits in a densely urban area.

## 4.5 City of London Schools

### 4.5.1 Natural capital assets

This site (Freemen's School) is mostly modified grassland and broadleaved woodland, with a significant amount of built-up areas as well. The remaining areas of the site are parkland, coniferous woodland, garden and arable areas.

**Table 32.** Baseline habitats at City of London Schools.

| **Habitat Type** | **Area ha** | **Area %** |
|---|---|---|
| Modified (amenity) grassland | 12 | 41.4 |
| Broadleaved woodland | 9 | 31 |
| Built-up areas and infrastructure | 5.6 | 19.3 |
| Trees / Parkland | 1.2 | 4.2 |
| Garden | 0.8 | 2.8 |
| Arable | 0.3 | 1 |
| Coniferous woodland | 0.1 | 0.3 |
| **Total** | **29** | **100** |

[31] City of London Biodiversity Action Plan 2021-2026.

### 4.5.2 Biodiversity baseline

The majority of this site (95.75%) was assigned a condition. This site has a moderate amount of built up area that received a condition assessment score of zero (19.63% of the site area). Most of this site was in poor condition (45.19% of the site area). The remainder of the site was in moderate condition, (30.93%). This site has a biodiversity unit score of 98.95.

### 4.5.3 Ecosystem services

This site has a high capacity for carbon storage, likely due to the amount of broadleaved and coniferous woodland habitat. This site has a moderate capacity for water flow regulation, water quality regulation and local climate regulation, due to the woodland and grassland habitats.

There is some high demand for local climate and air pollution regulation around the site, and accessible nature demand is high to the north of the site (although the site is not accessible to the general public).

### 4.5.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for City of London Schools is £110,000 annually, with a present value of £3.1 million over 50 years (Table 33). The ecosystem services that provide the largest value in this site are air quality regulation (PV £1 million), amenity (PV £890,000) and carbon sequestration (PV £790,000).

The natural capital balance sheet for City of London Schools is shown in Table 34. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of City of London Schools is negative at -£4.6 million over 50 years. The maintenance costs for this site are high and the natural capital benefits gained low.

### 4.5.5 Recommendations

As this site is a school the management[32] is tailored towards its use for sports. However, there are two wildflower meadows and an area of orchard. Mowing is limited where possible and grass left to grow longer near the woodland. If there is adequate amenity grassland provision for recreation, the rest of the site could be managed more proactively for biodiversity. Expanding wildflower meadows and improved quality grassland, or unmowed grass around the edges of the amenity areas would increase pollination, water flow regulation and carbon sequestration and storage, and may slightly reduce maintenance costs. Extending the woodland would also be very beneficial, perhaps around the edges of the site, or in a suitable area within the site, would increase the provision of all of the ecosystem services, as well as increasing biodiversity.

[32] Current mangement outlined by the site manager.

**Table 33.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for City of London Schools.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation *$tPM_{2.5}$* | 0.4 | 30 | 1,010 |
| Net carbon balance* *$tCO_2e$* | 87.5 | 20 | 790 |
| Woodland | 84.4 | 20 | 760 |
| Agriculture/ livestock emissions | N/A | N/A | N/A |
| Other habitats | 3.1 | 0 | 30 |
| Timber/woodfuel production *$m^3$* | 63 | 0 | 80 |
| Noise reduction *Ha of urban woodland* | 9 | 10 | 190 |
| Water quality regulation *Ha of woodland* | 9 | 0 | 20 |
| Flood reduction by woodland *$m^3$* | 6,097 | 0 | 80 |
| Recreation *Visits (Million)* | 0 | 0 | 0 |
| Health *QALY* | 0 | 0 | 0 |
| Amenity *Nr houses within 500m* | 1,190 | 40 | 890 |
| **Total values:** | **N/A** | **110** | **3,060** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 34**. Natural capital balance sheet for City of London Schools presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 3,060 |
| **Gross asset value (benefits)** | **3,060** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (7,610) |
| **Total liabilities (costs)** | **(7,610)** |
| | |
| **Net Natural Capital Value** | **-4,550** |
| **Benefit-cost ratio** | **-** |

NB. Maintenance costs based on 2022/23 actual figures. Figures shown to the closest 00's. Any discrepancies due to rounding

## 4.6 Couldon Commons group

### 4.6.1 Natural capital assets

The majority of the Couldon Commons group is dominated by semi-natural grassland. The other major habitat area across the sites is broadleaved woodland, with the remaining area a mix of scrub, modified (amenity) grassland, garden, built up areas and a very small area of arable land.

**Table 35.** Baseline habitats at Couldon Commons.

| Habitat Types | Area ha | Area % |
|---|---|---|
| Semi-natural grassland | 145.5 | 59.3 |
| Broadleaved woodland | 82.3 | 33.6 |
| Built-up areas and infrastructure | 6.3 | 2.6 |
| Scrub | 6.4 | 2.6 |
| Garden | 2.7 | 1.1 |
| Modified (amenity) grassland | 2 | 0.8 |
| Arable | 0.1 | 0 |
| **Total** | **245.3** | **100** |

### 4.6.2 Biodiversity baseline

It was possible to assign a condition to 70.17% of the Couldon Commons group of sites. Couldon Commons habitat condition scores were moderately good overall, with 33.27% of the site in good condition. Thirty three percent of the site is in moderate condition. Only a small proportion of the site was in poor condition (1.79%). This site has a biodiversity unit score of 1619.12.

### 4.6.3 Ecosystem services

This site has a high provision for both water quality regulation and carbon storage capacity, particularly due to the amount of broadleaved woodland at the site, but also influenced to some extent by the semi-natural grassland. This site has a moderate provision of the pollinator service, local climate regulation, accessible nature, noise regulation, air purification and water flow regulation capacity.

The Commons are surrounded by urban settlements to the north, east and south, so any demand for air pollution and noise regulation will be where major roads occur near to these (e.g. A22). In these areas particularly the north, accessible nature demand is high.

### 4.6.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Coulsdon Commons is £4.6 million annually, with a present value of £136.2 million over 50 years (Table 36). The ecosystem services that provide the largest value in this site are recreation (PV £53.5 million), health benefits (PV £34.5 million) and air quality regulation (PV £31.7 million).

**Table 36.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Coulsdon Commons.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 4.5 | 870 | 31,680 |
| Net carbon balance*<br>*$tCO_2e$* | 807 | 220 | 7,270 |
| Woodland | 640 | 170 | 5,770 |
| Agriculture/ livestock emissions | 64 | 20 | 580 |
| Other habitats | 230 | 60 | 2,070 |
| Timber/woodfuel production<br>*$m^3$* | 428 | 20 | 540 |
| Noise reduction<br>*Ha of urban woodland* | 80 | 70 | 1,620 |
| Water quality regulation<br>*Ha of woodland* | 82 | 10 | 210 |
| Flood reduction by woodland<br>*$m^3$* | 54,717 | 30 | 690 |
| Recreation<br>*Visits (Million)* | 0.6 | 2,170 | 53,460 |
| Health<br>*QALY* | 58 | 950 | 34,480 |
| Amenity<br>*Nr houses within 500m* | 10,350 | 270 | 6,250 |
| **Total values:** | **N/A** | **4,600** | **136,190** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

The natural capital balance sheet for Coulsdon Commons is shown in Table 37. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Coulsdon Commons is £133.9 million over 50 years. The site delivers a benefit to cost ratio of 59, which means that every £1 spent on maintenance delivers £59 in benefits. The benefit to cost ratio is high as the maintenance costs for this site seem low given the areas that are being managed and maintained.

**Table 37.** Natural capital balance sheet for Coulsdon Commons presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| Assets | |
| Natural capital benefits | 136,190 |
| Gross asset value (benefits) | **136,190** |
| | |
| Liabilities | |
| Maintenance costs | (2,310) |
| Total liabilities (costs) | **(2,310)** |
| | |
| Net Natural Capital Value | **133,880** |
| Benefit-cost ratio | **59** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

### 4.6.5 Recommendations

The current management goals[33] for the site of promoting wildlife through maintaining and restoring semi-natural grasslands, ponds, managing woodland, scrub and hedgerows, with a focus on heritage and visitor access will maintain and potentially increase the value of the site's natural capital assets.

These sites support important grassland habitats and if areas are restored then this will increase the provision of the pollination service, carbon storage, along with water quality and flow regulation services. Woodland and parkland is also important and if well managed will sustain carbon sequestration into the future. To increase ecosystem service benefits further, the connectivity of distinct habitat types and the expansion of edge habitats and ecotone areas may be beneficial, if trees, scrub and hedgerows are incorporated.

The expansion of the woodland (to create a continuous belt) on the south western edges of Riddlesdown Common would be very beneficial to the local inhabitants (regulating air pollution and providing carbon sequestration and storage). Similarly this would also be beneficial on the western edge of Farthing Downs.

## 4.7 Highgate Woods

### 4.7.1 Natural capital assets

The dominant habitat type throughout Highgate Woods is broadleaved woodland. Other major habitat types at this site include mixed woodland and modified (amenity) grassland. The remaining area of this site is a mix of built up areas and gardens.

[33] Couldon Common, Riddlesdown and Farthing Downs management plans 2021-2031. City of London.

**Table 38.** Baseline habitats at Highgate Woods.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 17 | 55.9 |
| Mixed woodland | 8 | 26.3 |
| Modified (amenity) grassland | 3.2 | 10.6 |
| Built-up areas and infrastructure | 1.8 | 5.9 |
| Garden | 0.4 | 1.3 |
| **Total** | **30.4** | **100** |

### 4.7.2 Biodiversity baseline

The entirety of this site was assigned a condition. The majority of the site was in moderate condition (82.62%), 11.78% of the site is in poor condition, and 5.6% of the site received a condition score of zero because it was built up area. The total biodiversity unit score for this site is 305.42.

### 4.7.3 Ecosystem services

Highgate Woods had a high capacity for local climate regulation, noise regulation, air purification, carbon storage, water flow regulation and water quality regulation. This is due to the large areas of broadleaved woodland and mixed woodland throughout the site. Broadleaved woodland and mixed woodland have a moderate to high capacity for timber production, and broadleaved woodland and modified grassland has a moderate to low capacity for pollinator visitation.

The surrounding neighbourhoods of Muswell Hill and Highgate that border the site to the north and west, create demand for air pollution regulation (near the A1 in the south western edge of the site), noise regulation from the roads and train depot that borders the site in the same location. These communities have a moderate demand for accessible nature.

### 4.7.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Highgate Wood is £6.1 million annually, with a present value of £178.5 million over 50 years (Table 39). The ecosystem services that provide the largest value in this site are recreation (PV £84.3 million), health benefits (PV £67.4 million) and air quality regulation (PV £21.7 million).

The natural capital balance sheet for Highgate Wood is shown in Table 40. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Highgate Wood is £167.7 million over 50 years. The site delivers a benefit to cost ratio of 16.5, which means that every £1 spent on maintenance delivers £16.5 in benefits.

**Table 39**. Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Highgate Wood.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*tPM$_{2.5}$* | 1.3 | 600 | 21,680 |
| Net carbon balance*<br>*$tCO_2e$*<br>Woodland<br>Agriculture/ livestock emissions<br>Other habitats | 188<br><br>187<br>N/A<br>1 | 50<br><br>50<br>N/A<br>0 | 1,700<br><br>1,690<br>N/A<br>10 |
| Timber/woodfuel production<br>*$m^3$* | 128 | 10 | 140 |
| Noise reduction<br>*Ha of urban woodland* | 25 | 20 | 500 |
| Water quality regulation<br>*Ha of woodland* | 25 | 0 | 60 |
| Flood reduction by woodland<br>*$m^3$* | 16,593 | 10 | 210 |
| Recreation<br>*Visits (Million)* | 1.1 | 3,410 | 84,290 |
| Health<br>*QALY* | 112 | 1,860 | 67,390 |
| Amenity<br>*Nr houses within 500m* | 3,300 | 110 | 2,530 |
| **Total values:** | **N/A** | **6,070** | **178,520** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 40.** Natural capital balance sheet for Highgate Wood presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 178,520 |
| **Gross asset value (benefits)** | **178,520** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (10,840) |
| **Total liabilities (costs)** | **(10,840)** |
| | |
| **Net Natural Capital Value** | **167,680** |
| **Benefit-cost ratio** | **16.5** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

### 4.7.5 Recommendations

The current management plan* to improve and manage the areas of ancient woodland by thinning, encouraging natural regeneration and wildflower meadows, and habitat improvements for bat species, will help increase this site's overall habitat condition and biodiversity score. Maintaining a good age structure within woodland habitat throughout the site will help maintain carbon sequestration into the future. Ecosystem service provision could be enhance through transforming the amenity grassland to semi-natural grassland, if the amenity grassland is not required for practical reasons. This can increase carbon storage, pollination, water flow and quality regulation. Hedgerows and scrub could be introduced at the edge of, especially around the amenity grassland, garden and built up areas. This will also increase the pollinator service, sequester and store carbon, as well as taking up air pollutants, at the same time as enhancing biodiversity.

## 4.8 Queen's Park

### 4.8.1 Natural capital assets

Queen's Park's has significant areas of broadleaved woodland, parkland, modified grassland and built up areas, with broadleaved woodland as the most prominent. Other habitats in this site include semi-natural grassland and gardens.

**Table 41.** Baseline habitats at Queen's Park.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 5 | 41.7 |
| Trees / Parkland | 2.4 | 20.0 |
| Modified (amenity) grassland | 2.1 | 17.5 |
| Built-up areas and infrastructure | 1.7 | 14.1 |
| Garden | 0.5 | 4.2 |
| Semi-natural grassland | 0.3 | 2.5 |
| **Total** | **12** | **100** |

### 4.8.2 Biodiversity baseline

The entirety of this site was assigned a condition score. Queen's Park had 77.26% in poor condition, and 13.87% of the site was built up areas, which received a condition score of zero, resulting in 38.56 biodiversity units.

### 4.8.3 Ecosystem services

Queen's Park has a high capacity for carbon sequestration, air pollution regulation and water flow regulation, as the site is dominated by broadleaved woodland and parkland with trees. This site had a moderate capacity for pollinator visitation rates for both spring and summer (due to the grassland, woodland and garden areas), local climate regulation, and water quality regulation. The site has low accessible nature capacity, as although it is open to the public, it is not as accessible in terms of roads and footpaths as other greenspaces in that area.

* Derived from notes from the site manager.

There is no significant demand for the air and noise regulation services, but some demand for local climate regulation in the settlements around the site, along with a very high demand for access to nature.

#### 4.8.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Queen's Park is £4.1 million annually, with a present value of £119.9 million over 50 years (Table 42). The ecosystem services that provide the largest value in this site are recreation (PV £57.7 million) and health benefits (PV £54.8 million).

**Table 42.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Queen's Park.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 0.3 | 80 | 2,740 |
| Net carbon balance*<br>*$tCO_2e$* | 43 | 10 | 390 |
| Woodland | 41 | 10 | 370 |
| Agriculture/livestock emissions | N/A | N/A | N/A |
| Other habitats | 2 | 0 | 20 |
| Timber/woodfuel production<br>*$m^3$* | 26 | 0 | 30 |
| Noise reduction<br>*Ha of urban woodland* | 5 | 0 | 100 |
| Water quality regulation<br>*Ha of woodland* | 5 | 0 | 10 |
| Flood reduction by woodland<br>*$m^3$* | 3,331 | 0 | 40 |
| Recreation<br>*Visits (Million)* | 0.9 | 2,340 | 57,720 |
| Health<br>*QALY* | 91 | 1,510 | 54,760 |
| Amenity<br>*Nr houses within 500m* | 4,050 | 170 | 4,070 |
| **Total values:** | **N/A** | **4,120** | **119,860** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

The natural capital balance sheet for Queen's Park is shown in Table 43. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Queen's Park is £110 million over 50 years. The site delivers a benefit to cost ratio of 12.1, which means that every £1 spent on maintenance delivers £12.1 in benefits.

**Table 43.** Natural capital balance sheet for Queen's Park presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 119,860 |
| **Gross asset value (benefits)** | **119,860** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (9,900) |
| **Total liabilities (costs)** | **(9,900)** |
| | |
| **Net Natural Capital Value** | **109,960** |
| **Benefit-cost ratio** | **12.1** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

#### 4.8.5 Recommendations

The goals of increasing woodland (by closing gaps in the existing canopy), creating ponds, and managing a woodland walk area will all help improve habitat condition, biodiversity and ecosystem service provision*. This will also help improve natural capital asset value by promoting increases in carbon storage and sequestration, water flow and quality regulation, air purification, noise and local climate regulation, recreation, and health. The mowing regime and introduction of hedgerows should also increase some of these services along with pollination. If the amenity grassland area in the park is not required for specific recreational purposes, this could be either transformed into a semi-natural grassland or made into parkland with trees for further provision of benefits.

### 4.9 Stoke Common

#### 4.9.1 Natural capital assets

Stoke Common is dominated by heathland while woodland is located all around the site boundary. There is a small area of semi-natural grassland in the northern part of the site and scrub in the east.

#### 4.9.2 Biodiversity baseline

All the habitats were assigned a condition score and 99.9% were in moderate condition, with only a 0.1% in poor condition, resulting in 839 biodiversity units.

#### 4.9.3 Ecosystem services

Accessible nature and local climate regulation capacity are relatively high across the site. Carbon sequestration and storage are highest in the woodland areas. Air pollution and noise regulation provision is low. Food production capacity is also low given no arable or improved grassland is present on the site and so is timber.

Demand for services is also generally low since there aren't any built up areas around the site, however, demand is not zero due to the small settlement near the south-western corner

* The management plan for Queen's Park was derived from the site manager.

**Table 44.** Baseline habitats at Stoke Common.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Heathland | 49.4 | 61.6 |
| Broadleaved woodland | 22.9 | 28.6 |
| Scrub | 4.6 | 5.7 |
| Semi-natural grassland | 2.8 | 3.5 |
| Fen, marsh and swamp | 0.2 | 0.25 |
| Water | 0.2 | 0.25 |
| Hedgerows | 0.1 | 0.1 |
| **Total** | **80.2** | **100** |

#### 4.9.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for Stoke Common is £850,000 annually, with a present value of £23.9 million over 50 years (Table 45). The ecosystem services that provide the largest value in this site are recreation (PV £12 million) and health benefits (PV £5.4 million).

The natural capital balance sheet for Stoke Common is shown in Table 46. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of Stoke Common is £22.4 million over 50 years. The site delivers a benefit to cost ratio of 15.6, which means that every £1 spent on maintenance delivers £15.6 in benefits.

#### 4.9.5 Recommendations

The current management plan to improve the heathland and woodland of the SSSI area to achieve favourable status on this site will enhance biodiversity and may increase ecosystem service provision slightly [*]. There are few substantial ecosystem service gains to be had at this site. However, using scrub and hedgerows where appropriate to create ecotones between habitats will likely increase carbon sequestration and storage, pollination, water flow and quality regulation. Whilst the site is important for biodiversity, increasing opportunities for recreation at the site will enhance the health and wellbeing benefits which drive the natural capital value of the site.

[*] Burnham Beeches and Stoke Common Management Plan 2020-2030

**Table 45**. Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for Stoke Common.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 1.5 | 50 | 1,750 |
| Net carbon balance*<br>*$tCO_2e$* | 348 | 100 | 3,140 |
| Woodland | 189 | 50 | 1,700 |
| Agriculture/ livestock emissions | 16 | 10 | 150 |
| Other habitats | 176 | 50 | 1,580 |
| Timber/woodfuel production<br>*$m^3$* | 113 | 10 | 140 |
| Noise reduction<br>*Ha of urban woodland* | 0 | 0 | 0 |
| Water quality regulation<br>*Ha of woodland* | 23 | 0 | 60 |
| Flood reduction by woodland<br>*$m^3$* | 15,215 | 10 | 190 |
| Recreation<br>*Visits (Million)* | 0.1 | 480 | 11,950 |
| Health<br>*QALY* | 9 | 150 | 5,420 |
| Amenity<br>*Nr houses within 500m* | 960 | 50 | 1,260 |
| **Total values:** | **N/A** | **850** | **23,910** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 46**. Natural capital balance sheet for Stoke Common presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 23,910 |
| **Gross asset value (benefits)** | **23,910** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (1,530) |
| **Total liabilities (costs)** | **(1,530)** |
| | |
| **Net Natural Capital Value** | **22,380** |
| **Benefit-cost ratio** | **15.6** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

## 4.10 West Ham Park

### 4.10.1 Natural capital assets

The main habitat types in West Ham Park are parkland, modified grassland and built up areas. Other significant habitat types across this site are broadleaved woodland and garden areas. The remaining areas of this site are scrub and semi-natural grassland.

**Table 47.** Baseline habitats at West Ham Park.

| Habitat Type | Area ha | Area % |
|---|---|---|
| Trees / Parkland | 11 | 37.7 |
| Modified (amenity) grassland | 9.3 | 31.9 |
| Built-up areas and infrastructure | 5.7 | 19.5 |
| Broadleaved woodland | 2.2 | 7.5 |
| Garden | 0.7 | 2.4 |
| Scrub | 0.2 | 0.7 |
| Semi-natural grassland | 0.1 | 0.3 |
| **Total** | **29.2** | **100** |

### 4.10.2 Biodiversity baseline

The entirety of this site was assigned a condition score and 80.34% of the site area was in poor condition, with 19.64% of the area assigned a score of zero due to built up areas. The remaining 0.02% was in moderate condition, resulting in 74 biodiversity units in total.

### 4.10.3 Ecosystem services

Carbon sequestration and water flow regulation capacity of the site is moderate, with pockets of high sequestration where the broadleaved woodland is located. Although a good deal of the site has some tree cover, the open nature of the parkland means that the provision of air pollution, noise and local climate regulation is quite low. Timber production is moderate where woodland occurs and food production capacity is low. Pollinator visitation for both spring and summer is moderate for this site.

There are built up areas all around the site, and demand for air purification and noise regulation is high where the A114 passes the site. Demand for accessible nature is high, especially to the east of the site.

### 4.10.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for West Ham Park is £9.9 million annually, with a present value of £288.5 million over 50 years (Table 48). The ecosystem services that provide the largest value in this site are recreation (PV £145.8 million) and health benefits (PV £133.6 million).

**Table 48**. Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for West Ham Park.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 0.3 | 140 | 4,900 |
| Net carbon balance*<br>*$tCO_2e$*<br>Woodland<br>Agriculture/ livestock emissions<br>Other habitats | 36<br><br>34<br>N/A<br>3 | 10<br><br>10<br>N/A<br>0 | 330<br><br>300<br>N/A<br>20 |
| Timber/woodfuel production<br>*$m^3$* | 12 | 0 | 10 |
| Noise reduction<br>*Ha of urban woodland* | 2 | 0 | 40 |
| Water quality regulation<br>*Ha of woodland* | 2 | 0 | 10 |
| Flood reduction by woodland<br>*$m^3$* | 1,465 | 0 | 20 |
| Recreation<br>*Visits (Million)* | 2.2 | 5,910 | 145,810 |
| Health<br>*QALY* | 223 | 3,690 | 133,580 |
| Amenity<br>*Nr houses within 500m* | 7,190 | 160 | 3,830 |
| **Total values:** | **N/A** | **9,900** | **288,530** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

The natural capital balance sheet for West Ham Park is shown in Table 49. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of West Ham Park is £263.9 million over 50 years. The site delivers a benefit to cost ratio of 11.7, which means that every £1 spent on maintenance delivers £11.7 in benefits.

### 4.10.5 Recommendations

The planned expansion and improvement of semi-natural grassland (wildflower meadows) and woodland areas (woodland, hedgerow and fruit trees)* is designed to enhance biodiversity. However, it will also enhance the capacity of the site to store and sequester more carbon, regulate air pollution noise and climate, and will increase food production capacity, timber and woodfuel production, water flow and quality regulation and pollinator visitation rates. This will provide important public benefits, going some way to meeting the demand from the settlements around the site. The creation of a forest school will improve the recreation and health value of the site. As the grassland and woodland areas are improved and expanded, it would be good to place woodland at the edges of the site nearest to

* The management plan for West Ham Park was derived from the site manager.

the residential areas and roads as this will provide air pollution regulation and noise regulation benefits where they are needed most, this may also enhance the amenity value of the site. Wildflower meadows created where the modified (amenity) grassland is currently located would increase the service provision further.

**Table 49**. Natural capital balance sheet for West Ham Park presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 288,530 |
| **Gross asset value (benefits)** | **288,530** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (24,620) |
| **Total liabilities (costs)** | **(24,620)** |
| | |
| **Net Natural Capital Value** | **263,910** |
| **Benefit-cost ratio** | **11.7** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

## 4.11 West Wickham Spring Park

### 4.11.1 Natural capital assets

West Wickham Spring Park is dominated by broadleaved woodland. The other prominent habitat type throughout the site is semi-natural grassland. Other habitat types that make up the remaining area of the site is a mix of built-up areas, water, scrub, garden and arable land.

### 4.11.2 Biodiversity baseline

A condition score was assigned to 77.2% of the habitats in this site, with 74.25% of the site in moderate condition. One percent of the site is in poor condition, with 1.99% of the site scoring a zero because due to built-up areas. This resulted in a total biodiversity unit score of 240.66.

**Table 50.** Baseline habitats at West Wickham Spring Park.

| Habitat Types | Area ha | Area % |
|---|---|---|
| Broadleaved woodland | 22.8 | 74 |
| Semi-natural grassland | 6.8 | 22.1 |
| Built-up areas and infrastructure | 0.6 | 2 |
| Garden | 0.2 | 0.65 |
| Scrub* | 0.2 | 0.65 |
| Arable | 0.1 | 0.3 |
| Water | 0.1 | 0.3 |
| **Total** | **30.8** | **100** |

* It appears that the UK Habitat survey of this site did not pick up on the heathland habitat, and it may have instead been classified as scrub.

#### 4.11.3 Ecosystem services

Carbon sequestration, air pollution and noise regulation, water flow and quality regulation and accessible nature are all high at this site, which is due to the large areas of woodland throughout the sites. Capacity for timber production, pollination and carbon storage is moderate, with food production low.

Demand for accessible nature is high around the park, particularly in the north. Demand for air, noise and climate regulation is generally low particularly to the south of the site.

#### 4.11.4 Natural capital accounting

The value of the benefits delivered by the natural capital assets that we quantified for West Wickham Spring Park is £1.4 million annually, with a present value of £41.8 million over 50 years (Table 51). The ecosystem services that provide the largest value in this site are recreation (PV £16.3 million), health benefits (PV £11.4 million) and air quality regulation (PV £9.4 million).

The natural capital balance sheet for West Wickham Spring Park is shown in Table 52. The total value of the natural capital assets of the site is reported along with the total liabilities (maintenance costs) in present value terms discounted over 50 years. This results in a net value for the natural capital assets of the site. The net natural capital asset value of West Wickham Spring Park is £22.1 million over 50 years. The site delivers a benefit to cost ratio of 2.1, which means that every £1 spent on maintenance delivers £2.1 in benefits.

#### 4.11.5 Recommendations

The aim of the management at the site is to create new heath, to hay cut grasslands, and to manage woodlands, creating habitat mosaics to achieve favourable condition[34]. This will enhance biodiversity and will also increase service provision to some extent. Introducing hedgerows, scrub and trees to create ecotones may be a way to enhance service provision, particularly carbon sequestration and storage, pollination and water flow regulation. Continuing to promote access for recreation, education and research will be key to maintaining and enhancing the valuable cultural services at the site. Taking opportunities to create new footpaths, information boards and expanding conservation activities or organized walks would help increase benefits to those who live locally.

[34] West Wickham Commons Management Plan 2021-2031. City of London.

**Table 51**. Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for West Wickham Spring Park.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 1 | 260 | 9,350 |
| Net carbon balance*<br>*$tCO_2e$* | 183 | 50 | 1,650 |
| Woodland | 172 | 50 | 1,550 |
| Agricultural/livestock emissions | N/A | N/A | N/A |
| Other habitats | 11 | 0 | 100 |
| Timber/woodfuel production<br>*$m^3$* | 119 | 10 | 150 |
| Noise reduction<br>*Ha of urban woodland* | 23 | 20 | 460 |
| Water quality regulation<br>*Ha of woodland* | 23 | 0 | 60 |
| Flood reduction by woodland<br>*$m^3$* | 15,160 | 10 | 190 |
| Recreation<br>*Visits (Million)* | 0.2 | 660 | 16,310 |
| Health<br>*QALY* | 19 | 320 | 11,410 |
| Amenity<br>*Nr houses within 500m* | 3,150 | 90 | 2,210 |
| **Total values:** | **N/A** | **1,410** | **41,780** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 52.** Natural capital balance sheet for West Wickham Spring Park presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| **Natural capital benefits** | 41,780 |
| **Gross asset value (benefits)** | **41,780** |
| | |
| **Liabilities** | |
| **Maintenance costs** | (19,640) |
| **Total liabilities (costs)** | **(19,640)** |
| | |
| **Net Natural Capital Value** | **22,140** |
| **Benefit-cost ratio** | **2.1** |

NB. Maintenance costs are actual costs, five-year average (2018/19 - 2022/23). Figures shown to the closest 00's. Any discrepancies due to rounding

## 5. Conclusions and recommendations (portfolio level)

This project has mapped the natural capital assets of the 13 categories of sites owned by the City of London Corporation. Using these baselines, we have been able to map the capacity of the natural capital assets to supply eleven different ecosystem services, showing how the level of provision of each of these services varies across the sites. We have also mapped the demand for a set of important public benefits around the sites. The biodiversity baseline assessment has mapped the variation in condition of habitats and biodiversity units across the sites, quantifying the total biodiversity units for each site category. The monetary value of a suite of ecosystem services has also been estimated, demonstrating which services are providing the most value. Using information on the high level costs of maintaining the sites we have calculated the net natural capital value of each set of sites and can show the value of benefits delivered for every pound invested.

Clearly the majority of these sites are important for biodiversity. The management strategies for these sites are largely to maintain, and in some cases restore, the valuable habitats and enhance their condition over the next decade. The biodiversity assessment shows the variation in biodiversity unit scores (a quantification of the level of habitat biodiversity) across the groups of sites. Some sites (e.g. Epping Forest and Buffer Land, Burnham Beeches and Ashtead Common) score very highly as they have distinctive habitats (relatively rare), are in moderate or good ecological condition, and occur over a large area. Other sites, such as the City Gardens and Cemetery and Crematorium score much lower due to their small size and lack of semi-natural habitat. The scores are interesting to compare across sites, but importantly they have been set up so that the CoLC can track the impacts of management on the level of biodiversity in the future, recalculating the scores to scope out scenarios and to quantify the impact of management change.

However, the location of these sites in London and the Greater London region makes them crucial areas of green and blue infrastructure that are vital for the provision of natural capital benefits to a densely populated and highly urbanised city. The natural capital assessment shows that they provide a vast area of woodland, semi-natural grassland and heathland assets. The woodland particularly is important for providing a wide range of public benefits to the local urban inhabitants e.g. carbon sequestration, air pollution regulation, noise regulation, local climate regulation, water flow and quality regulation, although other natural habitats can provide these, albeit to a lesser extent, with additional services such as pollination. Although the accessibility of these sites varies slightly (all but except the City of London School site are wholly or partially publicly accessible), they are providing good quality natural spaces to the inhabitants of London, and are used for a wide range of recreational activities. The health and wellbeing benefits from these visits are important, and the site management plans do recognise this.

The natural capital accounting demonstrates the high monetary value of these sites. The estimated value of the benefits delivered by the natural capital assets quantified across the whole portfolio is £282.6 million annually, with a present value of £8.1 billion over 50 years (Table 53 and see Annex 1 Table 55 for a break down of the valuation for each site in the portfolio, for each ecosystem service). Interestingly, but unsurprisingly given the location of the sites, the ecosystem services that provide the largest value are recreation (PV £4.5 billion) and health benefits (PV £2.8 billion), followed by air quality regulation (PV £389.7 million) and carbon sequestration (£200.8 million). Even accounting for the maintenance costs, that is the costs associated with managing the natural capital assets at each of the site groups, the net natural capital asset value of all sites combined is high (£7.6 billion over 50 years, Table 54). While the benefit to cost ratios vary considerably at the sites level, at the portfolio scale there is a benefit to cost ratio of 16.4, which means that every £1 spent on maintenance delivers £16.4 in benefits. This suggests that while maintenance costs can be considerable (in one site, Freemen's School, the costs are so high relative to the natural capital benefits that the overall net natural capital is negative), overall the investment is delivering a good return in public natural capital benefits.

**Table 53.** Annual physical flows, annual monetary flows (£2023) and present value over 50 years of ecosystem services for all sites.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | Present value over 50 years (£2023 000's) |
|---|---|---|---|
| Air quality regulation<br>*$tPM_{2.5}$* | 122 | 10,780 | 389,740 |
| Net carbon balance*<br>*$tCO_2e$* | 22,279 | 6,050 | 200,810 |
| Woodland | 20,603 | 5,590 | 185,670 |
| Agricultural/livestock emissions | 345 | 100 | 3,120 |
| Other habitats | 2,024 | 540 | 18,240 |
| Agricultural production | 140 | 120 | 2,870 |
| Timber/woodfuel production<br>*$m^3$* | 14,172 | 730 | 17,920 |
| Noise reduction<br>*Ha of urban woodland* | 852 | 690 | 17,160 |
| Water quality regulation<br>*Ha of woodland* | 2,675 | 270 | 6,760 |
| Flood reduction by woodland<br>*$m^3$* | 1,799,718 | 910 | 22,480 |
| Recreation<br>*Visits (Million)* | 47.1 | 180,620 | 4,459,820 |
| Health<br>*QALY* | 4,727 | 78,240 | 2,834,160 |
| Amenity<br>*Nr houses within 500m* | 142,060 | 4,160 | 97,940 |
| **Total values:** | **N/A** | **282,550** | **8,049,730** |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 54.** Natural capital balance sheet for all sites presented as present values (PV) over 50 years.

| | Present Value (PV £000's) |
|---|---|
| **Assets** | |
| Natural capital benefits | 8,049,730 |
| **Gross asset value (benefits)** | **8,049,730** |
| | |
| **Liabilities** | |
| Maintenance costs | (489,590) |
| **Total liabilities (costs)** | **(489,590)** |
| | |
| **Net Natural Capital Value** | **7,560,140** |
| **Benefit-cost ratio** | **16.4** |

### 5.1 Recommendations

We have made recommendations tailored to each site category in the previous sections (Section 2, 3 and 4) of this report. We have endeavoured to make recommendations that will enhance biodiversity and ecosystem services. In many cases the proposed management strategy for the sites, which are tailored largely to maintaining and enhancing biodiversity, will actually also maintain and enhance a range of ecosystem services. Where it is possible to make further gains we have suggested some possible opportunities. For example, lines of trees at the edges of sites where they run along residential areas, particularly where there are busy roads, as this will increase the provision of air pollution and noise regulation where they are most in demand.

Overall, there are no opportunities for substantive increases in ecosystem service benefits, largely because there are few opportunities to create sizable areas of new habitat. However, if natural capital benefits are considered alongside biodiversity in management strategies, it will be possible to make some significant increases. For example, incorporating more hedgerows, scrub and trees at the edges of the sites and to create ecotones (transitions between habitat types).

The biggest increases in natural capital value are likely to be made by focusing on increasing recreational opportunities that will also increase health and wellbeing. The open spaces business plan and the management strategies for the sites all demonstrate that the CoLC already recognise the importance of people having access to ecologically diverse spaces with heritage value, and the natural capital assessment shows these areas are well used. However, there will be room for improvement. The facilitation of groups of people that are not able to access these sites so easily should be considered. A particular focus on events such as walking groups, green gyms, wild/outdoor swimming clubs, conservation programmes, and gardening, will increase the health and wellbeing of those who take part. This could be part of a formal social green prescribing programme linked with local health bodies and professionals. The National Academy for Green Social Prescribing's Green Social Prescribing Toolkit[35] may be worth using to consider the kind of partnerships required, funding that can be accessed, and the type of activities that some of these sites can host.

[35] Alford, Sam. (2023). Green Social Prescribing Toolkit, Version 1.0. National Academy of Social Prescribing and the 7 Green Social Prescribing Test and Learn sites. Access at: nhs-green-social-prescribing-toolkit.pdf (socialprescribingacademy.org.uk).

There may be sites where new footpaths can be created. These need to be well maintained and where there is high visitor pressure this needs to be carefully managed, to ensure that the natural capital assets are not degraded, which in turn can negatively impact on the provision of other benefits. Creating areas for active travel to work (cycle paths), areas where people can sit, as well as areas for other activities will increase the provision of the recreation and wellbeing services. This is likely not necessary at every site, but certain activities may be prioritised at particular sites, depending on the demand.

Natural capital benefits should be integrated into business plans and performance measures for the open spaces. This assessment provides an evidence base on which to justify the current maintenance costs of these sites, and potentially for expanding management activities. It also demonstrates the value of these spaces, some of which may be under pressure from urban development. In the face of biodiversity and climate crises these are important areas to maintain and enhance, particularly because of their role in providing important public benefits such as reducing air pollution, reducing the heat island effect, reducing run off, and supporting recreation and increases in health and wellbeing.

### 5.2 Next steps

This natural capital and biodiversity assessment sets a baseline, but is only as good as the habitat information on which it is based. It is a snapshot in time and there may have already been some changes to these habitats already since the UKHab surveys were completed. The natural capital asset GIS layer that encompasses all the sites can be updated by the CoLC as things change. The biodiversity baseline can be re-run when substantial changes have been made that reflect the changes in condition or habitats from ongoing management. This can also be done by CoLC in the natural capital asset GIS layer. The best way to track changes in ecosystem service provision and value is through the natural capital account. This account can be updated every 2 years, or when substantial changes have occurred, so the CoLC are able to track the impact of the management changes at the sites.

The GIS layers produced for this project provide an extensive evidence base for the CoLC. The layers can also be combined in a wide variety of ways to explore different issues and key priorities. The natural capital concept is embedded across multiple policy areas that will impact how the sites are managed. For example, developing the Local Nature Recovery Strategy (LNRS), Net Carbon Zero, the need for Biodiversity Net Gain for development and contributing to solutions for the climate and environmental emergencies that have been declared in the Greater London region. The assessment will also be useful should the CoLC want to consider natural capital financing, e.g. gaining revenue from their assets through payments for carbon credits, biodiversity net gain or nutrient neutrality.

## Annex. 1.

**Table 55.** Sensitivity analysis showing low, central and high estimates of the benefits provided by the natural capital assets in total and for each individual site.

| Ecosystem service | Annual physical flow | Annual monetary flow (£2023 000's) | | | Present value over 50 years (£2023 000's) | | |
|---|---|---|---|---|---|---|---|
| | | Low | Central | High | Low | Central | High |
| Air quality regulation *$tPM_{2.5}$* | 122 | 4,260 | 10,780 | 30,820 | 154,560 | 389,740 | 1,116,680 |
| Ashtead Common | 6 | 100 | 240 | 690 | 3,440 | 8,680 | 24,920 |
| Buffer Land | 10 | 150 | 380 | 1,080 | 5,390 | 13,580 | 39,030 |
| Burnham Beeches | 8 | 120 | 310 | 900 | 4,510 | 11,370 | 32,670 |
| Cemetery and crematorium | 0 | 10 | 20 | 60 | 320 | 800 | 2,290 |
| City gardens | 0 | 10 | 40 | 100 | 520 | 1,300 | 3,700 |
| City of London schools | 0 | 10 | 30 | 80 | 400 | 1,010 | 2,900 |
| Coulsdon Commons group | 5 | 350 | 870 | 2,510 | 12,560 | 31,680 | 90,910 |
| Epping forest | 82 | 2,250 | 5,680 | 16,290 | 81,550 | 205,620 | 590,310 |
| Hampstead Heath | 6 | 820 | 2,080 | 5,920 | 29,840 | 75,280 | 214,550 |
| Highgate Woods | 1 | 240 | 600 | 1,700 | 8,590 | 21,680 | 61,700 |
| Queens park | 0 | 30 | 80 | 220 | 1,090 | 2,740 | 7,860 |
| Stoke Common | 2 | 20 | 50 | 140 | 700 | 1,750 | 5,040 |
| West Ham park | 0 | 50 | 140 | 390 | 1,940 | 4,900 | 13,950 |
| West Wickham Spring park | 1 | 100 | 260 | 740 | 3,710 | 9,350 | 26,850 |
| Net carbon balance* *$tCO_2e$* | 22,279 | 3,060 | 6,050 | 9,090 | 100,390 | 200,810 | 301,180 |
| Woodland | 20,603 | 2,821 | 5,590 | 8,420 | 92,840 | 185,670 | 278,500 |
| Agricultural/livestock emissions | 345 | 40 | 100 | 140 | 1,560 | 3,120 | 4,660 |
| Other habitats | 2,024 | 270 | 540 | 830 | 9,130 | 18,240 | 27,370 |
| Ashtead Common | 1,448 | 200 | 390 | 590 | 6,530 | 13,050 | 19,580 |
| Buffer Land | 1,772 | 240 | 480 | 720 | 7,990 | 15,970 | 23,960 |
| Burnham Beeches | 1,327 | 180 | 360 | 540 | 5,980 | 11,960 | 17,940 |
| Cemetery and crematorium | 41 | 10 | 10 | 20 | 190 | 370 | 560 |
| City gardens | 11 | 0 | 0 | 10 | 50 | 100 | 150 |
| City of London schools | 86 | 10 | 20 | 40 | 390 | 790 | 1,180 |
| Coulsdon Commons group | 807 | 110 | 220 | 330 | 3,630 | 7,270 | 10,900 |
| Epping forest | 14,976 | 2,040 | 4,070 | 6,100 | 67,480 | 134,960 | 202,440 |
| Hampstead Heath | 1,013 | 140 | 280 | 410 | 4,560 | 9,130 | 13,690 |
| Highgate Woods | 188 | 30 | 50 | 80 | 850 | 1,700 | 2,540 |
| Queens park | 43 | 10 | 10 | 20 | 190 | 390 | 580 |
| Stoke Common | 348 | 50 | 100 | 140 | 1,570 | 3,140 | 4,700 |
| West Ham park | 36 | 10 | 10 | 20 | 160 | 330 | 490 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| West Wickham Spring park | 183 | 30 | 50 | 70 | 820 | 1,650 | 2,470 |
| Agricultural production | 140 | 90 | 120 | 150 | 2,150 | 2,870 | 3,590 |
| Buffer Land | 140 | 90 | 120 | 150 | 2,150 | 2,870 | 3,590 |
| Timber/woodfuel production *$m^3$* | 14,172 | 530 | 730 | 910 | 13,450 | 17,920 | 22,410 |
| Ashtead Common | 1,013 | 40 | 50 | 70 | 970 | 1,290 | 1,610 |
| Buffer Land | 1,007 | 40 | 50 | 60 | 920 | 1,230 | 1,540 |
| Burnham Beeches | 823 | 30 | 40 | 50 | 780 | 1,050 | 1,300 |
| Cemetery and crematorium | 26 | 0 | 0 | 0 | 20 | 30 | 40 |
| City gardens | 7 | 0 | 0 | 0 | 10 | 10 | 10 |
| City of London schools | 63 | 0 | 0 | 0 | 60 | 80 | 100 |
| Coulsdon Commons group | 428 | 20 | 20 | 30 | 410 | 540 | 680 |
| Epping forest | 9,814 | 380 | 510 | 630 | 9,350 | 12,470 | 15,580 |
| Hampstead Heath | 593 | 20 | 30 | 40 | 560 | 750 | 940 |
| Highgate Woods | 128 | 0 | 10 | 10 | 110 | 140 | 180 |
| Queens park | 26 | 0 | 0 | 0 | 30 | 30 | 40 |
| Stoke Common | 113 | 0 | 10 | 10 | 110 | 140 | 180 |
| West Ham park | 12 | 0 | 0 | 0 | 10 | 10 | 20 |
| West Wickham Spring park | 119 | 0 | 10 | 10 | 110 | 150 | 190 |
| Noise reduction *Ha of urban woodland* | 852 | 520 | 690 | 870 | 12,870 | 17,160 | 21,460 |
| Ashtead Common | 28 | 20 | 20 | 30 | 420 | 560 | 700 |
| Buffer Land | 19 | 10 | 20 | 20 | 280 | 380 | 470 |
| Burnham Beeches | 29 | 20 | 20 | 30 | 440 | 580 | 730 |
| Cemetery and crematorium | 1 | 0 | 0 | 0 | 10 | 20 | 20 |
| City gardens | 1 | 0 | 0 | 0 | 20 | 30 | 40 |
| City of London schools | 9 | 10 | 10 | 10 | 140 | 190 | 230 |
| Coulsdon Commons group | 80 | 50 | 70 | 80 | 1,210 | 1,620 | 2,020 |
| Epping forest | 543 | 330 | 440 | 550 | 8,210 | 10,940 | 13,680 |
| Hampstead Heath | 87 | 50 | 70 | 90 | 1,310 | 1,740 | 2,180 |
| Highgate Woods | 25 | 20 | 20 | 30 | 380 | 500 | 630 |
| Queens park | 5 | 0 | 0 | 10 | 80 | 100 | 130 |
| Stoke Common | - | 0 | 0 | 0 | 0 | 0 | 0 |
| West Ham park | 2 | 0 | 0 | 0 | 30 | 40 | 60 |
| West Wickham Spring park | 23 | 10 | 20 | 20 | 340 | 460 | 570 |
| Water quality *Ha of woodland* | 2,675 | 200 | 270 | 330 | 5,050 | 6,760 | 8,470 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ashtead Common | 148 | 10 | 20 | 20 | 290 | 390 | 480 |
| Buffer Land | 191 | 20 | 20 | 30 | 410 | 550 | 690 |
| Burnham Beeches | 166 | 10 | 20 | 20 | 310 | 410 | 520 |
| Cemetery and crematorium | 5 | 0 | 0 | 0 | 10 | 10 | 20 |
| City gardens | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| City of London schools | 9 | 0 | 0 | 0 | 20 | 20 | 30 |
| Coulsdon Commons group | 82 | 10 | 10 | 10 | 150 | 210 | 260 |
| Epping forest | 1,880 | 140 | 190 | 240 | 3,510 | 4,690 | 5,860 |
| Hampstead Heath | 114 | 10 | 10 | 10 | 210 | 280 | 360 |
| Highgate Woods | 25 | 0 | 0 | 0 | 50 | 60 | 80 |
| Queens park | 5 | 0 | 0 | 0 | 10 | 10 | 20 |
| Stoke Common | 23 | 0 | 0 | 0 | 40 | 60 | 70 |
| West Ham park | 2 | 0 | 0 | 0 | 0 | 10 | 10 |
| West Wickham Spring park | 23 | 0 | 0 | 0 | 40 | 60 | 70 |
| Water flow regulation *$m^3$* | 1,799,718 | 690 | 910 | 1,140 | 16,840 | 22,480 | 28,090 |
| Ashtead Common | 100,115 | 40 | 50 | 60 | 940 | 1,260 | 1,570 |
| Buffer Land | 133,810 | 50 | 70 | 90 | 1,260 | 1,680 | 2,100 |
| Burnham Beeches | 110,540 | 40 | 60 | 70 | 1,040 | 1,390 | 1,730 |
| Cemetery and crematorium | 3,398 | 0 | 0 | 0 | 30 | 40 | 50 |
| City gardens | 14,005 | 10 | 10 | 10 | 130 | 180 | 220 |
| City of London schools | 6,097 | 0 | 0 | 0 | 60 | 80 | 100 |
| Coulsdon Commons group | 54,717 | 20 | 30 | 40 | 510 | 690 | 860 |
| Epping forest | 1,249,548 | 480 | 630 | 790 | 11,750 | 15,660 | 19,580 |
| Hampstead Heath | 75,724 | 30 | 40 | 50 | 710 | 950 | 1,190 |
| Highgate Woods | 16,593 | 10 | 10 | 10 | 160 | 210 | 260 |
| Queens park | 3,331 | 0 | 0 | 0 | 30 | 40 | 50 |
| Stoke Common | 15,215 | 10 | 10 | 10 | 140 | 190 | 240 |
| West Ham park | 1,465 | 0 | 0 | 0 | 10 | 20 | 20 |
| West Wickham Spring park | 15,160 | 0 | 0 | 10 | 70 | 90 | 120 |
| Recreation *Visits (Million)* | 47.1 | 135,460 | 180,620 | 225,780 | 3,344,870 | 4,459,820 | 5,574,760 |
| Ashtead Common | 0.2 | 500 | 670 | 830 | 12,320 | 16,430 | 20,540 |
| Buffer Land | 0.5 | 1,170 | 1,570 | 1,960 | 28,990 | 38,650 | 48,310 |
| Burnham Beeches | 0.6 | 1,320 | 1,760 | 2,200 | 32,640 | 43,520 | 54,400 |
| Cemetery and crematorium | 0.8 | 1,890 | 2,520 | 3,150 | 46,620 | 62,160 | 77,690 |
| City gardens | 21.9 | 67,690 | 90,250 | 112,810 | 1,671,400 | 2,228,540 | 2,785,670 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| City of London schools | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coulsdon Commons group | 0.6 | 1,620 | 2,170 | 2,710 | 40,100 | 53,460 | 66,830 |
| Epping forest | 10 | 25,600 | 34,130 | 42,670 | 632,120 | 842,830 | 1,053,540 |
| Hampstead Heath | 8.1 | 26,070 | 34,750 | 43,440 | 643,620 | 858,150 | 1,072,690 |
| Highgate Woods | 1.1 | 2,560 | 3,410 | 4,270 | 63,220 | 84,290 | 105,370 |
| Queens park | 0.9 | 1,750 | 2,340 | 2,920 | 43,290 | 57,720 | 72,140 |
| Stoke Common | 0.1 | 360 | 480 | 610 | 8,960 | 11,950 | 14,940 |
| West Ham park | 2.2 | 4,430 | 5,910 | 7,380 | 109,360 | 145,810 | 182,260 |
| West Wickham Spring park | 0.2 | 500 | 660 | 830 | 12,230 | 16,310 | 20,380 |
| Health<br>*QALY* | 4,727 | 39,110 | 78,240 | 330,840 | 1,417,090 | 2,834,160 | 11,988,190 |
| Ashtead Common | 21 | 170 | 340 | 1,450 | 6,200 | 12,390 | 52,420 |
| Buffer Land | 45 | 370 | 750 | 3,160 | 13,540 | 27,090 | 114,560 |
| Burnham Beeches | 55 | 460 | 920 | 3,870 | 16,590 | 33,180 | 140,350 |
| Cemetery and crematorium | 75 | 620 | 1,250 | 5,270 | 22,570 | 45,130 | 190,890 |
| City gardens | 2,198 | 18,180 | 36,370 | 153,830 | 658,890 | 1,317,790 | 5,574,110 |
| City of London schools | - | - | - | - | - | - | - |
| Coulsdon Commons group | 58 | 480 | 950 | 4,030 | 17,240 | 34,480 | 145,840 |
| Epping forest | 1,004 | 8,300 | 16,610 | 70,240 | 300,870 | 601,730 | 2,545,260 |
| Hampstead Heath | 817 | 6,760 | 13,520 | 57,180 | 244,900 | 489,810 | 2,071,840 |
| Highgate Woods | 112 | 930 | 1,860 | 7,870 | 33,700 | 67,390 | 285,070 |
| Queens park | 91 | 760 | 1,510 | 6,390 | 27,380 | 54,760 | 231,620 |
| Stoke Common | 9 | 80 | 150 | 630 | 2,710 | 5,420 | 22,910 |
| West Ham park | 223 | 1,840 | 3,690 | 15,590 | 66,790 | 133,580 | 565,050 |
| West Wickham Spring park | 19 | 160 | 320 | 1,330 | 5,710 | 11,410 | 48,270 |
| Amenity<br>*Nr houses within 500m* | 142,060 | 3,140 | 4,160 | 5,230 | 73,470 | 97,940 | 122,460 |
| Ashtead Common | 2,960 | 70 | 90 | 120 | 1,660 | 2,220 | 2,770 |
| Buffer Land | 9,835 | 200 | 260 | 330 | 4,640 | 6,190 | 7,740 |
| Burnham Beeches | 1,800 | 80 | 100 | 130 | 1,770 | 2,350 | 2,940 |
| Cemetery and crematorium | 4,110 | 70 | 90 | 110 | 1,580 | 2,110 | 2,640 |
| City gardens | 2,690 | 110 | 150 | 180 | 2,560 | 3,420 | 4,270 |
| City of London schools | 1,190 | 30 | 40 | 50 | 670 | 890 | 1,120 |
| Coulsdon Commons group | 10,350 | 200 | 270 | 330 | 4,690 | 6,250 | 7,810 |
| Epping forest | 80,650 | 1,620 | 2,160 | 2,700 | 38,060 | 50,740 | 63,430 |
| Hampstead Heath | 9,825 | 320 | 420 | 530 | 7,400 | 9,870 | 12,340 |
| Highgate Woods | 3,300 | 80 | 110 | 140 | 1,900 | 2,530 | 3,170 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Queens park | 4,050 | 130 | 170 | 220 | 3,060 | 4,070 | 5,090 |
| Stoke Common | 960 | 40 | 50 | 70 | 950 | 1,260 | 1,580 |
| West Ham park | 7,190 | 120 | 160 | 200 | 2,870 | 3,830 | 4,790 |
| West Wickham Spring park | 3,150 | 70 | 90 | 120 | 1,660 | 2,210 | 2,770 |
| Total values – all sites | N/A | 187,030 | 282,550 | 605,140 | 5,140,800 | 8,049,730 | 19,187,330 |
| Ashtead Common | N/A | 1,140 | 1,880 | 3,850 | 32,770 | 56,260 | 124,600 |
| Buffer Land | N/A | 2,340 | 3,710 | 7,590 | 65,570 | 108,180 | 241,990 |
| Burnham Beeches | N/A | 2,260 | 3,590 | 7,820 | 64,060 | 105,810 | 252,580 |
| Cemetery and crematorium | N/A | 2,600 | 3,890 | 8,610 | 71,350 | 110,670 | 274,210 |
| City gardens | N/A | 86,000 | 126,810 | 266,950 | 2,333,590 | 3,551,360 | 8,368,170 |
| City of London schools | N/A | 60 | 110 | 180 | 1,740 | 3,060 | 5,650 |
| Coulsdon Commons group | N/A | 2,850 | 4,600 | 10,060 | 80,510 | 136,190 | 326,100 |
| Epping forest | N/A | 41,140 | 64,420 | 140,220 | 1,152,890 | 1,879,640 | 4,509,670 |
| Hampstead Heath | N/A | 34,210 | 51,200 | 107,670 | 933,120 | 1,445,970 | 3,389,760 |
| Highgate Woods | N/A | 3,860 | 6,070 | 14,100 | 108,940 | 178,520 | 458,990 |
| Queens park | N/A | 2,680 | 4,120 | 9,780 | 75,140 | 119,860 | 317,530 |
| Stoke Common | N/A | 560 | 850 | 1,610 | 15,170 | 23,910 | 49,660 |
| West Ham park | N/A | 6,460 | 9,900 | 23,580 | 181,190 | 288,530 | 766,630 |
| West Wickham Spring park | N/A | 880 | 1,410 | 3,130 | 24,770 | 41,780 | 101,800 |

*Emissions are minus values and shown in red. NB. Physical flow figures shown to 1 decimal place. Monetary figures shown to the closest 00's. Any discrepancies due to rounding.

**Table 56.** Natural capital balance sheet in total for all sites and for each individual site presented as present values (PV) over 50 years.

| | PV Gross asset value (£000's) | PV Total liabilities (£000's) | Net Natural Capital Value (£000's) | Benefit-cost ratio |
|---|---|---|---|---|
| Ashtead Common | 56,260 | 11,220 | 43,640 | 5 |
| Buffer Land | 108,180 | 27,240 | 80,940 | 4 |
| Burnham Beeches | 105,810 | 20,670 | 85,140 | 5.1 |
| Cemetery and crematorium | 110,670 | 48,770 | 61,900 | 2.3 |
| City gardens | 3,551,360 | 40,510 | 3,510,850 | 87.7 |
| City of London schools | 3,060 | 7,610 | -4,550 | - |
| Coulsdon Commons group | 136,190 | 2,310 | 133,880 | 59 |
| Epping forest | 1,879,640 | 92,900 | 1,786,740 | 20.2 |
| Hampstead Heath | 1,445,970 | 171,830 | 1,274,140 | 8.4 |
| Highgate Woods | 178,520 | 10,840 | 167,680 | 16.5 |
| Queens park | 119,860 | 9,900 | 109,960 | 12.1 |

| | | | | |
|---|---|---|---|---|
| Stoke Common | 23,910 | 1,530 | 22,380 | 15.6 |
| West Ham Park | 288,530 | 24,620 | 263,910 | 11.7 |
| West Wickham Spring park | 41,780 | 19,640 | 22,140 | 2.1 |
| **Total – all sites** | **8,049,730** | **489,590** | **7,560,140** | **16.4** |

**Table 57.** Number of livestock heads for conservation grazing by site, used for agricultural emissions calculations.

| | **Cattle** | | | **Sheep** | | **Ponies** |
|---|---|---|---|---|---|---|
| | **Calves** | **Yearlings** | **Adults** | **Lambs** | **Adults** | |
| Ashtead Common | | | 5 | | | |
| Buffer Land | | 45 | 25 | | | |
| Burnham Beeches | | | 5 | | | 2 |
| Coulsdon Commons | 10 | 7 | 36 | 20 | 40 | |
| Epping Forest | | | 20 | | | |
| Stoke Common | | | 13 | | | 2 |
| **Total** | **10** | **52** | **103** | **20** | **40** | **4** |

NB. Annual average figures. Any discrepancies due to rounding.

# Technical Appendix

## A.1 Ecosystem service assessment

### A.1.1 Approach to mapping the baseline natural capital assets

The first step was to produce a detailed map of the habitats present across the 13 categories of sites owned by the City of London Corporation and the surrounding area, under the current (baseline) situation. To do this, we used Ordnance Survey MasterMap polygons as the underlying mapping unit, and then a series of different data sets to classify each polygon to a detailed habitat type, and to associate a range of additional data with each polygon. In particular, the habitat basemap was informed the UK Habitat surveys that have been competed for all the sites and that CoLC shared with us. The complete data that were used to classify habitats is shown in Box 1. Polygons were classified into Phase 1 habitat types for mapping, and were also classified into broader habitat groups.

The baseline was mapped with a large buffer (3km). The buffer is presented in the maps for context, as the habitats in the buffer will impact on the ecosystem services scores and consequently the maps. In particular, it will affect the demand maps, which are heavily influenced by neighbouring towns, and so needed to be captured in the modelling. The ecosystem services trends for the baseline are quoted for the sites themselves only for the capacity, and are focused on the trends outside of the site for the demand maps.

One issue to note is that the UKHab surveys across the sites did not distinguish between improved and amenity grasslands. In UKHab the broad habitat classification used for both of these grasslands is 'modified grassland'. In the natural capital assessment it is important to distinguish between improved and amenity grasslands. The former grasslands are usually agricultural habitats that are managed using inputs for silage or are grazed by livestock. Consequently, improved grasslands associated with carbon emissions from land and livestock, but will also then be valued for agricultural production. The amenity grasslands are not associated with such management. Where possible the areas surveyed as modified grassland were checked against satellite imagery to try and distinguish between these two grassland types, but this is not completely without error. We, therefore, made an assumption that all modified grassland was amenity grassland across the sites. This seemed reasonable as we were dealing mostly with urban green spaces. However, it is possible that we have missed some improved grassland sites in the Buffer Land site. If we have missed such areas the emissions associated with the sites may be slightly higher, and there may be some missed agricultural value. This is likely to be minimal.

### A.1.2 Mapping the ecosystem services (physical flows)

Once a detailed habitat basemap had been created for each of the sites, it was then possible to quantify and map the benefits that these habitats (natural capital) provide to people. The following benefits (ecosystem services) were mapped where possible:

- Carbon storage
- Carbon sequestration
- Air purification
- Noise regulation
- Local climate regulation
- Pollination
- Food production
- Timber/woodfuel production
- Water flow regulation
- Water quality regulation
- Accessible nature

The list of services assessed was considered to capture the most important benefits provided by the natural capital assets of the CoLC sites.

A variety of methods were used, and these are described for each individual ecosystem service in the sections below. The models are based on the detailed habitat information determined in the natural capital basemap, together with a variety of other external data sets (e.g. digital terrain model, and many other data sets and models mentioned in the methods for each ecosystem service). The models were applied at a 5m resolution to provide fine-scale mapping across the area (the demand models are at 10m resolution). Note, however, that several of the models are indicative (showing that certain areas have higher capacity than other areas) and are mapped relative to the values present across the sites. Most ecosystem services were scaled to be out of a maximum possible of 100, except for carbon storage which was measured in tC/ha, and carbon sequestration which shows $tCO_2e$/ha/yr.

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). Food and timber, for example, are not more valuable when grown close to people's houses, whereas trees that ameliorate air pollution or block noise are.

***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 (see below) 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) [36]. A multiplier [37] 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 5m by 5m cell across the study area. Scores are measured in tonnes of carbon per ha.

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

***Carbon sequestration***

**What is it and why is it important?**

Carbon is sequestered (captured) by growing plants. Plants that are harvested annually (e.g. arable crops, improved grassland) will be approximately carbon-neutral over 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 ($tCO_2e$/ha/year) for each habitat type taken from Natural England (2019) [38] and the RSPB's Accounting for Nature report [39]. It is calculated for every 5m by 5m cell across the study area and takes soil type into account, although note that it does not take into account the age structure of the trees. Unlike most of the other services which are on a 0-100 scale, amounts are in tonnes $CO_2e$/ha/yr.

[36] 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, No. 078.

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

[38] 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.

[39] The RSPB. (2017) Accounting for Nature: A Natural Capital Account of the RSPB's area in England. Annex 7.

***Air purification capacity (air quality regulation)***

**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[40]. 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 5m-by-5m 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.

The final capacity score was calculated for every 5m-by-5m 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.

***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.

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

***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 [41]). 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?**

A modified EcoServ R noise regulation model was used. 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 5m by 5m 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.

***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, railways and airports, custom built for the study area based on Defra noise modelling and airport noise contour mapping) 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.

***Local climate regulation capacity***

**What is it and why is it important?**

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

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

**How is it measured?**

Local climate regulation capacity is mapped using an InVest model. Vegetation can help reduce the urban heat island by providing shade, modifying thermal properties of the urban fabric, and increasing cooling through evapotranspiration.

The model calculates an index of heat mitigation based on shade, evapotranspiration, and albedo, as well as distance from cooling islands (e.g. parks) for each pixel.
The raster generated by this process shows the capacity of each landuse to cool the air and is calculated relative to the average temperature across the summer months.
The temperatures recorded in each location will differ from the index shown here since landuse would generate a given temperature which in reality is blended with the temperatures generated by the landcover of the surroundings.

Scores are on a 1 to 100 scale, relative to values present within the study area. To retain consistency with the other models, high values (red) indicate areas that have the highest capacity for local climate regulation as a service, so are actually areas that are cooler.

***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 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) with one indicator showing the location of areas suffering from the urban heat island effect. The latter, is created using the InVest "Urban Cooling" tool and represents the average summer predicted temperatures over the study area.
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.

***Pollination***

**What is it and why is it important?**

Insect pollinators are essential for human survival and for the natural environment. They pollinate 75% of the native plant species in Britain (Ollerton et al. 2011)[42] and directly contribute an estimated £603 million per annum to the British economy through the pollination of agricultural crops (Vanbergen et al. 2014[43]). They also pollinate orchard, allotment and garden fruit and vegetables and are essential to the continuing existence of most wild plant species. They have high cultural value, both in their own right and through the maintenance of our countryside and gardens. Pollination capacity measures the capacity of the land to provide pollination services by estimating the visitation rate of each particular pixel of land (relative to the landscape analysed) for wild insect pollinators (assuming a steady state pollinator population).

[42] Ollerton, J., Winfree, R. & Tarrant, S. (2011) How many flowering plants are pollinated by animals? Oikos, 120, 321-326.
[43] Vanbergen, A.J., Heard, M.S., Breeze, T., Potts, S.G. & Hanley, N. (2014) Status and Value of Pollinators and Pollination Services. Report to the Department for Environment, Food and Rural Affairs (Defra).

**How is it measured?**

Adapted from the model created in Häussler et al. (2017) and Gardner, E. et al (2020); this model simulates population processes of colony building bumblebees (ground and tree nesting bumble bees) as well as short-lived ground nesting solitary bees. For each guild, the model generates a nesting resource as well as a floral resource map for each season, based on the nesting and floral attractiveness of each habitat. First, nests are randomly allocated across the landscape. The model then uses the foraging distance of the guild to calculate the floral resources gathered from the nest surroundings which in turn determines how many workers (if social) and new reproductive females the nest produces. New reproductive females disperse according to the dispersal distance of each guild. The number of reproductive females cannot exceed that of the expected number of nests according to the nesting resource map (carrying capacity). For each guild, a visitation rate per pixel per season is generated and these three rasters are then summed to create a total visitation rate raster for each season.

The final capacity score was calculated for each 10x10m 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 where the visitation rate (which will result in pollination) is highest.

***Water flow capacity***

**What is it and why is it important?**

Water flow capacity is the capacity of the land to slow water runoff and thereby potentially reduce flood risk downstream. Following a number of recent flooding events in the UK and the expectation that these will become more frequent over the coming years due to climate change, there is growing interest in working with natural process 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 two factors:

**Roughness score** – Manning's Roughness Coefficient provides a score for each land use type based on how much the land use will slow overland flow.
**Slope score** – based on a detailed digital terrain model, slope was re-classified into a number of classes based on the British Land Capability Classification and others.

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 have generally high or low capacity and is not a hydrological model. High values (dark orange and red) indicate areas that have the highest capacity to slow water runoff.

***Water quality capacity***

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. Note that although urban diffuse pollution is partially captured in the model at catchment scale, the focus is on sedimentation risk from agricultural diffuse pollution, hence built-up areas are not particularly well accounted for in the existing model.

**How is it measured?**

A modified 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 particularly sensitive 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 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.
- **Watershed risk** – for each catchment area there is a score for the risk of pollution.

Each of the three fine scale indicators and the catchment-scale indicator were 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 have generally 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).

***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 Burnham Beeches, with improved grassland associated with grazing livestock covering a greater area than arable land. 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?**

A model was developed using a methodology outlined in Smith (2020)[44] that was developed for the Eco-metric tool. Broad habitats in Burnham Beeches 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.

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

***Timber / woodfuel capacity***

**What is it and why is it important?**

Forestry remains an important component of the rural economy, and many areas of woodland are still valued primarily on their timber value. Timber is an important product of woodlands and is the raw resource of the timber industry. Sustainably managed woodland produces timber that is important in contributing to processing mills and factories that produce wood-based products and also produces wood fuel for the generation of renewable heat and electricity. Wood and trees that aren't actively managed for timber are still included in this model, as it indicates potential capacity, and also these areas may still provide wood fuel.

**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 Lothian (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 scores were scaled on a 0 to 100 scale relative to values present within the mapped area.

***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 public 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, Countryside and Rights of Way Act (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.

***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), and the subsequent People and Nature Survey (SPANS), have shown that there is greatest demand for accessible greenspace close to people's homes, especially for sites within walking distance.

**How is it measured?**

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

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

## A.2 Ecosystem service valuation (monetary flows)

**Air quality regulation**

The ability of the woodland, hedges, scrub, grassland and heathland vegetation across the CoLC sites to absorb particulate matter ≤2.5µm in diameter ($PM_{2.5}$) was measured. Quantifying the physical flow of the air quality regulation service provided by the woodland and grassland was based on the absorption calculation in Powe & Willis (2004)[45] and the method in ONS (2016)[46]. The deposition rates for $PM_{2.5}$ in coniferous woodland, deciduous woodland, and grassland were taken from Powe & Willis (2004)[45]. Average background pollution concentrations for $PM_{2.5}$ were calculated using Defra data for the local authority (Mapping background data for local authorities, https://uk-air.defra.gov.uk/data/laqm-background-maps?year=2018), including Mole Valley, Epping Forest, Slough, Newham, Camden, Croydon, City of London, Haringey, and Westminster. The surface area index of coniferous and deciduous woodlands in on-leaf and off-leaf periods was taken from Powe & Willis (2004)[45]. The proportion of dry days in 2022 (rainfall <1mm) for the south east of England was estimated using MET office regional value data (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using the Woodland Trust data averages tool.

The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2021)[47]. These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of

45 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.
46 ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts.
47 Defra (2021) Air quality damage costs guidance. Crown Copyright.

absorbed pollutant by the woodland and grassland habitats was equal to the average damage cost of that pollutant. The $PM_{2.5}$ damage cost estimates depend on the location of the CoLC site (urban size or rural) and source of pollution. Habitats across the CoLC sites were fall considered to fall into different categories: Central London, inner London, outer London, urban medium, and rural. We selected the estimates for $PM_{2.5}$ from road transport, as it is the major source of pollution in the area. The Defra damage cost of $PM_{2.5}$ is in 2022 prices, and so was adjusted to reflect inflation up to 2023. When calculating the present value over 50 years, the absorption rate was assumed to be constant. The discount rate used for air pollution reduction benefits is 1.5%, differing from the 3.5% rate recommended for other service indicators, following guidance from HM Treasury (2019)[48]. The central damage cost figures are presented in the monetary flow estimates, low and high damage costs from Defra (2021)[47] were used in the sensitivity analysis.

**Carbon balance**

The annual physical flow of the carbon sequestration service was calculated by using the sources of data outlined in the carbon sequestration capacity model (see Section A.1.2 above). This provided a positive (sequestration) or negative (emissions) value for each habitat type across the CoLC sites. We calculated the carbon sequestration for woodland on mineral soils as follows:

Carbon sequestration from woodland, parkland, hedges and scrub were calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2021)[49]. Coniferous woodland sequestration rates were averaged over a 60-year period and broadleaf woodland sequestration rates were averaged over a 100-year period, as this is the length of a typical forestry cycle for these woodland types. Information on species composition was taken from the Forestry Commission's National Inventory of Woodland and Trees, regional reports for Buckinghamshire, Essex, London, and Surrey (2002)[50]. Yield classes for each tree species across the CoLC sites were derived from Forest Research's Ecological Site Classification tool (http://www.forestdss.org.uk/geoforestdss/). The annual sequestration rate for each woodland type were then multiplied by the area of each and added together to give the total annual sequestration estimate for woodland at the site. Parkland areas were assumed to have 20% tree cover, hedges and scrub were set at 50% of the sequestration rate of woodland.

GHG emissions agriculture were calculated as follows:

Agricultural activities release $CO^2$ and other greenhouse gasses such as methane and $NO^2$ into the atmosphere, with emissions highly variable depending on the type of farming practices employed. These emissions can therefore negate the benefits obtained through carbon sequestration of habitats within a site.

The greenhouse gas emissions of the sites were calculated by multiplying the area of each crop type and the numbers of livestock by emissions figures for each crop type and livestock type in Bateman et al. (2013)[51]. These emission figures are based on three types of agricultural emissions:

[48] HM Treasury (2019) The Green Book. Crown Copyright.
[49] Woodland Carbon Code (2021) Carbon calculation guidance v2.4 March 2021. Forestry Commission.
[50] Forestry Commission (2002). National inventory of woodland and trees. Regional reports.
[51] Bateman, I. J. et al. (2013) Bringing ecosystem services into economic decision-making: Land use in the United Kingdom. Science 341 45-50.

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N2O from fertilizers
3. Emissions of N2O and methane from livestock, caused by enteric fermentation and the production of manure

The area of different crop types and livestock numbers across the CoLC sites were assumed to be relatively the same as the regional data from Defra for the relevant region, as we did not have data from the client. The total physical flow of greenhouse gas emissions was calculated by adding crop type and livestock emissions (in tCO2e).

The monetary flows of carbon sequestration and emissions were calculated using the Government's non-traded central carbon price for 2023 (DBEIS 2019)[52]. We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of carbon sequestration. The present value (PV) of the ability of the habitats to sequester carbon into the future was calculated by summing the values for each year over a 50-year period, after discounting using the discount rate suggested in HM Treasury (2019)[48] of 3.5%. The HM Treasury also provides low and high estimates of current and future non-traded carbon prices. These were used to provide a sensitivity analysis to the economic valuation of this ecosystem service.

**Agricultural production**
The physical annual flow of agricultural production for the Buffer Land site (the only one where we considered agriculture to take place) was simply measured as the area of land under agriculture derived from the asset register. These were classified to an appropriate Defra farming system, that is the proportion of different livestock and crops, using data on the structure of the farming system in England for the Southend-on-Sea & Essex CC region. Regional data were used as we did not have data from the client.

The monetary value of agricultural production was calculated as the economic value of land, net of all non-land costs. Net Farm Income (NFI), the return to farm operators once all expenses have been deducted, were obtained from Defra's Farm Accounts in England (Farm Business Survey) for the London and South East region. This takes into account yields and farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, husbandry, feed and forage costs) and fixed costs (labour, machinery, fuel, buildings). Annual NFI estimates were obtained over 5 years for the period 2015/16 to 2019/2020. These were then adjusted to remove the effects of Basic Farm Payments (income support), to remove any charges for imputed (unpaid) rent, and to include charges for the imputed value of unpaid family labour. This gives a return (an economic rent) to the land resource itself after deducting all costs associated with production except for land ownership and rental costs and excluding income support subsidies. The annual estimates of adjusted NFI were inflation adjusted to 2023 prices, and a mean estimate per hectare was derived for the period for each of the farming systems. Low and high estimate were also calculated. The per hectare estimates were multiplied by the area of land under each of the sites' farming systems, to derive the total annual value of agricultural production. Present Value was calculated over 50 years using the standard discount rate and assumes

[52] DBEIS (2019) Carbon priced and sensitivities 2010-2100 for appraisal in HM Treasury (2018) The Green Book. Central Government guidance on appraisal and evaluation, version 3. London.

that the mix of crops and livestock numbers stays approximately the same. The low and high production values were used for the sensitivity analysis.

**Timber/woodfuel production**

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

The annual monetary flows for the woodland areas were calculated by multiplying the yield by the standing price of timber or woodfuel. The average price for softwood in 2023 was taken from the Forestry Commissions Coniferous Standing Sales Price Index (Forestry Commission 2023[53]). The price for broadleaved timber in 2022 ranged from £50 to high quality timber reaching £350 per $m^3$ standing (ABC 2022[54]). We assume the lowest value here for woodfuel and convert this to 2023 priced using Government deflators. To convert to a present value the annual value was multiplied by the standard government discount rate (3.5%) for each respective year up to 50 years. It was assumed that the area of woodland remains static and the unit price was also assumed to be constant. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

**Noise reduction**

A national average figure for England was used to estimate the value of benefits that urban woodlands provide for regulating noise (£714/ha from Eftec *et al*. (2018)[55]). This figure was inflated to 2023 prices and multiplied by the area of woodland. The present value of the ability of the woodland to regulate noise into the future was calculated by summing the values for each year over a 100-year period, after discounting, using the standard discount rate suggested in HM Treasury (2019)[48]. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

**Flood regulation**

All natural surfaces can take up water, but it remains difficult to quantify and value for most habitats. A study by Forest research[56], that has been included in the Defra ENCA service data book, and has been used in the new Environment Agency Natural Capital Register and Account Tool (NCRAT) V1.2[57], allows this to be quantified and valued for woodland, in both non riparian and riparian areas. The physical flow is measured as the $m^3$ of annual potential flood water storage provided by woodland, derived from Broadmeadow et al. (2023)[56], relative to managed grassland and relative to bare soil. In this case, we used the values relative to bare soil as it reflects more comprehensively the flood regulation services from the natural assets.

This ecosystem benefit is valued using a replacement-cost (rather than damage cost) approach, which applies annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service.

The total area of woodland cover was simply multiplied by the annual flood storage provided by woodland (x m3). It was then valued by multiplying by the central estimate of the replacement cost

[53] Forestry Commission (2023) Timber price indices. Data to September 2023.

[54] ABC (2022) The agricultural budgeting and costing book. 94th edition, Argo Business Consultants.

[55] Eftec & CEH (2018). Scoping UK Urban Natural Capital Account – Noise Extension. Report for Defra.

[56] Broadmeadow, S. et al. (2023) Revised valuation of flood regulation services of existing forest cover to inform natural capital accounts. Forest Research.

[57] Environment Agency Natural Capital Register and Account Tool, Version 1.2 (July 2023).

adjusted to 2023 prices. To convert to a present value the annual value was multiplied by the standard government discount rate (3.5%) for each respective year up to 50 years. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

**Water quality**

Two different approaches were used to value the benefits of woodland on water quality, both matching the approach taken to valuation used by the Forestry Commission when developing their EWCO[58]. The first, or "water quality" approach is based on the annual cost of agricultural diffuse pollution in England, which was estimated by Defra[59] to range from £748-1,307M (in 2014 prices), which was itself based on an earlier study by IGER[60]. This amount is divided by the total area of agricultural land in England of 9.16 M ha, to give an average cost of £82-143 per ha per year. Note that this represents a national average of all types of agriculture and agricultural diffuse pollution can also vary greatly by location. The lower estimate was taken as a lower bound estimate of water quality benefits and inflated to 2023 prices.

The second, or "riparian" approach was based on the Environment Agency's NWEBS toolkit[61]. NWEBS calculates the value of improving the quality of 1km of river, based on a willingness to pay study. We used the value for improving rivers from poor to moderate levels, as recommended by the EA and also matching the FC EWCO approach[58]. NWEBS provides values for each catchment in England[62], hence we used the adjusted value for the catchment area as a ratio that reflects the difference with the national average. The NWEBS figure is based on 6 equal components, a number of which were directly related to biodiversity and recreation. To avoid double counting, these elements were stripped out, leaving 2 out of 6 components, following the approach taken by FC EWCO[58]. The final adjusted annual value per hectare in each of the CoLC sites was then inflated to 2023 prices. The present value of "water quality" and "riparian" benefits were both calculated by summing the values for each year over a 50-year period, after discounting, using the standard UK Government discount rate. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

**Recreation**

The number of visits to each site was provided by the client based on the most recent surveys of visit numbers. Where there were no surveys, visit numbers were estimated using surveys from sites that were similar in size, character and geographic location. The exception to this was the estimate of the Buffer Land visits that was determined using the University of Exeter's Outdoor Recreation Valuation Tool (ORVal) version 2.0: https://www.leep.exeter.ac.uk/orval/. It uses a statistical model called a Recreational Demand Model to predict the number of visits that are made to currently accessible greenspaces by adult residents of England. The number of visits is modelled using data from the Monitor of Engagement with the Natural Environment (MENE)[63] survey and adjusted based on factors such as socioeconomic characteristics of people, the day of the week, attributes of the greenspace, the availability and quality of any alternative greenspaces.

[58] ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts.

[59] Defra (2018) Water Quality and Agriculture: Basic Measures Impact Assessment. IA No: Defra1819.

[60] IGER (2006). Benefits and Pollution Swapping: Cross-cutting issues for Catchment Sensitive Farming Policy. Research Report WT0706CSF for Defra, Institute of Grassland and Environmental Research.

[61] EA (2013a) Valuing Environmental Benefits. External Briefing Note, Environment Agency.

[62] EA (2013b). Updating the National Water Environment Benefit Survey values: summary of the peer review. Environment Agency.

[63] Natural England (2020) Monitor of Engagement with the Natural Environment (MENE)

The annual monetary flows of recreation were estimated using this tool for all sites. The model, through a welfare function, describes the welfare an individual derives from making different recreational choices, and the welfare values are, therefore, provided by the tool. The welfare gained from a particular greenspace will depend on a number of factors (e.g., socio-economic status, month of the year) and the benefits experience at a site is traded-off against the costs of travelling to the site. The overall annual monetary value for recreation was the number of visits estimates provided by client (or calculated by the tool, in the case of Buffer Land) multiplied by the welfare values per visit for each accessible greenspace in those areas. For further details of the ORVal model see the advanced technical report for details:
https://www.leep.exeter.ac.uk/orval/pdfreports/ORValII_Modelling_Report.pdf.
The value was uplifted to 2023 prices using the Government Deflator Index. The present value of this service was calculated by summing the values for each year over a 50-year period, after discounting using the discount rate suggested in HM Treasury (2019)[48] of 3.5%. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

**Health benefits**
There is now a growing body of evidence to show that spending time in nature has positive effects on human health and well-being. ONS (2022)[64] proposes two different methodologies to value human health benefits from nature, one taking an outdoor exercise approach, and another one taking an exposure to nature approach. We use the latter methodology, developed by ONS (2022)[64] and building on the work of White et al (2019)[65] as it captures a wider set of health benefits beyond physical activity. The method relies on estimates of visitors to natural environments who spend at least 120 minutes per week in nature.

The recreational visit data used in the recreation service calculation (above) was converted from visits (which includes repeat visits by the same individuals) to the number of visitors (individuals), using a visit rate calculated from the latest 5 years of national MENE[63] survey data from Natural England. Among these visitors, we estimated the percentage of these that spend 120 minutes or more in nature per week, using data from Natural England (2023)[66]. Then these can be translated into Quality Adjusted Life Years (QALYs), using the value of QALY per person/ year estimated by ONS (2022)[64].

This physical health benefit can, therefore, be estimated by calculating the total number of QALYs by visitors to sites that meet the requirements of at least spending 120 minutes per week in nature, and multiplying this by the QALY value. The social value of one QALY remains under review. Estimates range from approximately £12,900 at 2008 prices (Claxton et al 2015[67]) to £70,000 (HM Treasury 2019[48]). We use as the central value the more conservative estimate of £12,900 as suggested by ONS (2022)[64]. We use the £70,000 estimate for the upper estimate of value in the sensitivity analyses, highlighting that the value of health benefits could be considered to be much higher. The lower estimate was 50% of the central value.

The present value (PV) of the area to deliver health benefits into the future was the sum of annual values over the 50-year period, using the discount rates suggested in HM Treasury (2019)[48]. Discount

[64] ONS (2022) Health benefits from recreation.
[65] White, M.P. et al. (2019) Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Scientific reports 9 7730.
[66] Natural England (2023) People and Nature Survey for England (2020-2022)
[67] Claxton et al (2015) Methods for the Estimation of the NICE Cost Effectiveness Threshold

rates for QALY effects are recommended at 1.5%, (differing from the 3.5% rate recommended for other service indicators).

A number of assumptions are used in these calculations and the results should therefore be interpreted with caution. It the ecosystem service with the greatest degree of uncertainty out of all those assessed.

**Amenity value**

The proximity of greenspace can have a positive effect on residential property values. House prices show significant positive price variations with greater proximity to greenspace and water considered separately and together (ONS 2019[68], Moranto et al. 2010[69]). Conversely, increasing distance to natural amenities is 'unambiguously associated with a fall in prices' (Moranto et al. 2010[69]). A study by the Office for National Statistics (ONS 2019)[68] has looked at this relationship in some depth, and has provided an average uplift in house value across Great Britain of 1.2% for residences within 500 metres of publicly accessible green spaces. They looked in detail at the effect of 100, 200 and 500 metre distances, at different residential property types and sizes, and the proximity to greenspaces of varying size. The analyses also included the average uplift in house value from proximity to greenspace in travel to work areas in England and Wales, because this varies considerably across these areas. We have been able to extract the values for the travel to work areas in each of the CoLC sites. The study also estimates that 12% of this uplift value is due to aesthetic benefits of proximity to green and blue spaces, while the rest is due to recreational services. To avoid double counting with the recreational benefits estimated previously, we reduced the total uplift to 12% so it does only include aesthetic benefits.

We used GIS software to locate the number of residential buildings within 500 metres of the greenspaces in the CoLC sites. We extracted the most recent estimate (March 2023) for average house prices for the local authority from 'House price statistics for small areas' from ONS, and applied the % uplift associated with the appropriate travel to work area to the relevant local authority. The house prices were adjusted to 2023 prices. The total value is considered a present value (the aesthetic value of the greenspaces embedded in housing prices over the long-run) so we estimated the annual benefits by annualising that figure, using the standard government discount rate (3.5%) and a time period of 50 years. Low and high estimates were calculated to be 0.75 and 1.25 times the central estimate respectively for the sensitivity analyses.

[68] ONS (2019) Valuing green spaces in urban areas: a hedonic price approach using machine learning techniques. ONS.

[69] Mourato, S. et al. (2010) Economic analysis of cultural services. UK NEA Economic Analysis Report.

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