Natural capital in Oxfordshire
Short report

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Contents

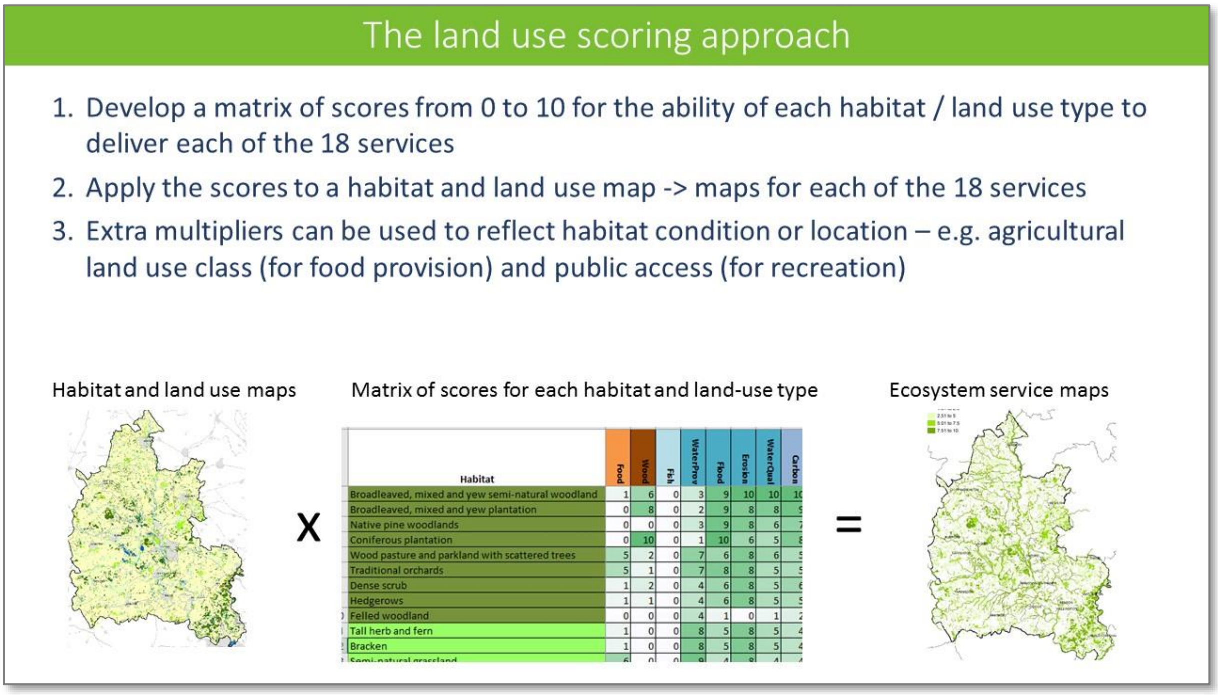
Version control

V1.0	5 November 2019	First draft. (The pdf is rather confusingly called V2!)
V2.0	7 February 2020	Updated Table 2 (units were m^2 not Ha). Added Monumental Trees (P10-11)
V3.0	7 September 2021	Updated habitat areas (Table 2, Figures 6 and 7) and methodology, and added analysis of overlaps with Nature Recovery Networks.

Summary

This is a short report of the method used to generate preliminary Natural Capital maps for Oxfordshire. The work was undertaken under an Oxford Policy Exchange Network fellowship, funded by the University of Oxford. This fellowship enabled a researcher to work with Oxfordshire County Council, with support from Cherwell District Council, developing evidence on natural capital to feed into development of the Oxfordshire Plan to 2050.

Natural capital maps were developed using a habitat scoring system (see summary diagram below), which is a simple and rapid method to allow spatial patterns to be identified. The method has been adapted from work being carried out by Natural England to develop an eco-metric scoring tool for assessing net gains or losses in natural capital due to land use change. This work is not a detailed natural capital assessment, and it does not produce monetary values that can be compared across different services. It is intended to be a first step that can be extended into more detailed assessments in future.



The first draft of the maps were presented and discussed at a stakeholder workshop in June 2019 (Appendix 2). This provided very useful feedback which helped to refine the way the maps are presented in this report. A full report has been produced that presents all the maps. This is a shorter version of that report that describes the method used and presents a few example maps.

Next steps

- The scoring approach assumes that all habitats of the same type (e.g. semi-natural broadleaved woodland) deliver the same level of ecosystem services. In practice, the services delivered by each patch of habitat will depend on the condition and location of the habitat. In some cases, additional multipliers have been applied to the generic habitat scores to take account of these factors, including agricultural land class, whether there is public access for recreation, and whether a site is designated for nature. However there is potential to expand this range of multipliers to consider other important condition factors.
- These maps show the potential of Oxfordshire's land cover to supply ecosystem services. For some services we have made some preliminary attempts at mapping the locations where there is a high demand for the service, in order to identify where there are gaps between supply and demand.

This could be improved and expanded to cover other services, helping to identify opportunities to invest in enhancing natural capital to meet the needs of people in Oxfordshire.

Structure of the report

The report first defines the meaning of natural capital, ecosystem services and green infrastructure and then describes the methods used to develop the natural capital scoring approach. We present and discuss the base map of land cover and show examples natural capital maps for nine of the 18 ecosystem services. Finally we suggest how the maps could be used within the planning process, and list recommendations for next steps to extend the analysis.

Acknowledgements

This work was funded by the Higher Education Innovation Fund via the **Oxford Policy Exchange Network** (OPEN). OPEN is a new initiative which provides fellowships to enable researchers from the University of Oxford to work with non-academic partners, in order to make academic research more relevant to the needs of policy makers and practitioners.

This project would not have been possible without the support of **Nick Mottram** and **Vicky Fletcher** at Oxfordshire County Council, and **Jenny Barker** at Cherwell District Council, who helped to set the direction for the research and supported the funding application to OPEN. Nick also provided office space to enable me to work within his department, and constant guidance and feedback which was invaluable for tailoring the outputs of this project to meet policymaker needs. Very useful feedback has also been provided by **Andrew Thomson** from the Oxfordshire Plan to 2050 team, **Dominic Lamb** from South Oxfordshire and the Vale of White Horse, **Mai Jarvis** from Oxford City Council, **Sue Marchand** from Cherwell District Council, and **Mel Dodd** from West Oxfordshire District Council.

I would like to thank the **thirty stakeholders from local councils, wildlife groups, government agencies and others** who attended the workshop at ECI on the 17th June 2019 (see Appendix 2). Their feedback was extremely useful for refining the maps and exploring their potential use in decision-making.

The method of generating the base map from multiple input habitat datasets while retaining the integrity of the underlying OS MasterMap layer was developed by **Martin Bésnier**, a visiting student from the Université Paris Sud. He developed an innovative technique which greatly improved the accuracy and quality of this assessment and laid the foundations for further applications. We are very grateful to Martin for his work on this project. **Kate Williamson,** a student from the University of Liverpool, also helped with flood zone analysis and summarising stakeholder comments from the workshop.

I am grateful to **Thames Valley Environmental Records Centre** for providing the Phase 1 Habitat and Land Use data for Oxfordshire and the datasets on Local Wildlife Sites and Local Geological Sites; the staff at **Ordnance Survey** (especially **Nick Groome**) for providing the dataset on hedges and linear woodland features (for research purposes) and for patiently answering my queries about license conditions; and to the **Woodland Trust** for providing the citizen science data from the Ancient Tree survey. It is very important to recognise the value of hedgerows and ancient trees within the natural capital maps. I was also provided with data on Important Freshwater Areas in Oxfordshire from the **Freshwater Habitats Trust**, and on B-lines networks for pollinators from **Buglife**. These have not yet been incorporated into the maps, but will be used within future work.

1 Definitions

1.1 Natural Capital and Ecosystem Services

Natural Capital is the elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions. Natural capital is a broad term that includes many different components of the living and non-living natural environment, as well as the processes and functions that link these components and sustain life. *(Natural Capital Committee, 2013)*

In the UK, the Natural Capital Accounts produced by the Office for National Statistics include minerals and fossil fuels (ONS, 2018), but some other definitions exclude these non-renewable resources.

If stocks of natural capital are maintained in good condition (in terms of both quantity and quality), they can deliver a sustainable flow of 'ecosystem services' – services delivered by natural and managed ecosystems, which underpin human health and wellbeing. In this work, we map Oxfordshire's natural capital in terms of its ability to deliver 18 different ecosystem services (Figure 1, Table 1), and we also include maps of two other aspects of natural capital - air quality and groundwater resources. We do not map the supply of non-renewable natural resources (minerals and fossil fuels).

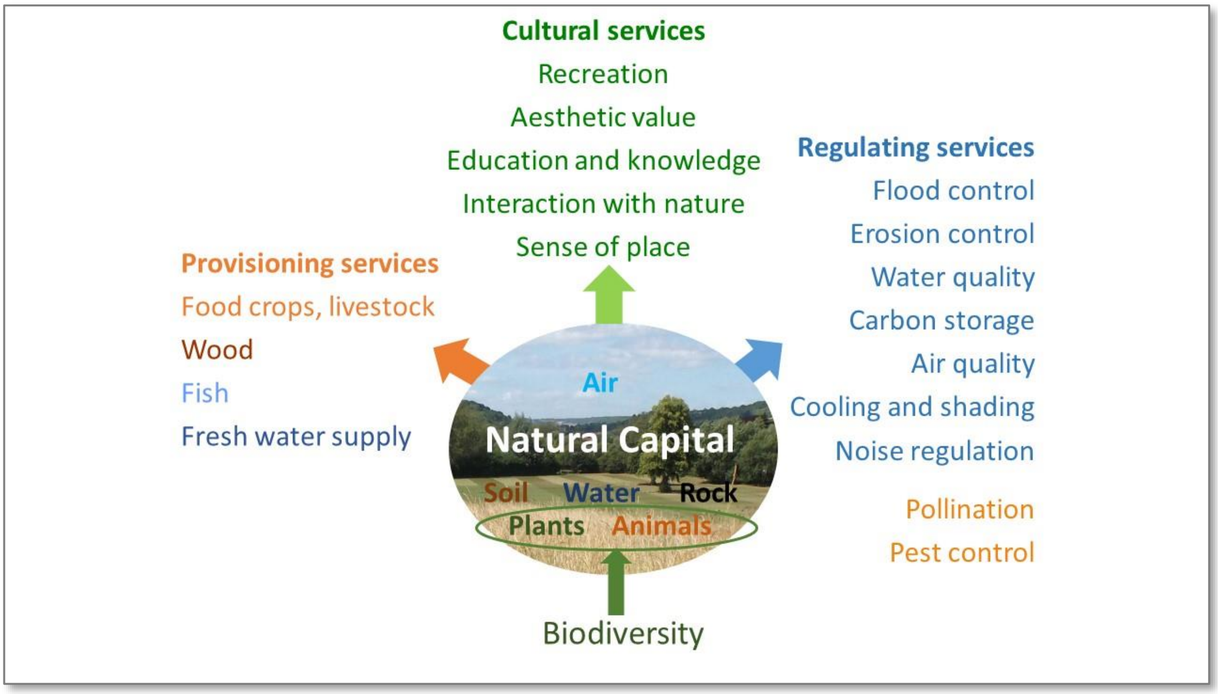


Figure 1: Natural capital stocks deliver flows of ecosystem services that underpin human health and wellbeing

1.2 Biodiversity

Biodiversity is a term that describes the variety of life on earth, including the variety of species and the genetic variation within a single species. Ecosystem service assessment only measures the direct and indirect value of biodiversity to people, not the intrinsic value of species (their right to exist regardless of their value to humans). However, biodiversity is an essential component of natural capital, and underpins the sustainable delivery of ecosystem services in the long term. Not only do more biodiverse ecosystems often deliver better services, but they will usually be more resilient to future environmental change. We have therefore mapped biodiversity as well as ecosystem services.

Table 1: Definitions of each of the 18 ecosystem services

Provisioning	**Food production**	**Arable crops, horticulture, livestock, orchards, allotments, urban food, wild food (e.g. gathering berries or mushrooms).**
	Wood production	Timber, wood production for paper, woody biofuel crops, coppice wood or wood waste used for biofuel.
	Fish production	Aquaculture, commercial fishing, recreational fishing (recreational fishing is also a cultural service, but the habitat conditions match those for fish production).
	Water supply	Impact of soil and vegetation on rainwater runoff and infiltration, and thus on groundwater recharge or surface water flow.
Regulating	**Flood protection**	Reduction of surface runoff, peak flow, flood extent and flood depth through canopy interception, evapotranspiration, soil infiltration and physical slowing of water flow.
	Erosion protection	The ability of vegetation to stabilise soil against erosion and mass wastage by protecting the soil from the erosive power of rainfall and overland flow, trapping sediment, and binding soil particles together with roots.
	Water quality regulation	Direct uptake of pollutants by terrestrial or aquatic vegetation; interception of overland flow and trapping / filtration of pollutants and sediment by vegetation before it reaches watercourses; breakdown of pollutants into harmless forms e.g. by denitrifying bacteria that convert nitrates into nitrogen gas. Also infiltration into the ground, allowing pollutants to be filtered out by the soil and preventing pollution of watercourses – though pollutants could enter groundwater supplies.
	Carbon storage	Carbon stored in vegetation and soil. In the context of land use change (with complete loss of habitats and often major soil disturbance), this is more relevant than carbon sequestered annually. The 'time to reach target condition' reflects the time taken for a new habitat to reach a typical carbon sequestration rate for a mature habitat.
	Air quality regulation	Removal of air pollutants by deposition, absorption and/or breakdown by vegetation. Fine particles ($PM_{2.5}$) are the most damaging type of pollution, but vegetation can also remove ozone and nitrogen oxides (by absorption into pores).
	Cooling and shading	Shade, shelter and cooling effect of vegetation and water, especially urban trees close to buildings, green roofs and green walls, which can reduce heating and cooling costs, or trees in urban parks which can provide shade on hot days.
	Noise reduction	Attenuation of noise by vegetation.
	Pollination	Pollination of crops (and wild plants, supporting other ES) by wild insects (mainly bees and hoverflies). Excludes pollination by managed honeybees.
	Pest control	Predation of crop or tree pests by invertebrates (e.g. beetles, spiders, wasps), birds and bats.
Cultural	**Recreation and leisure**	Provision of green and blue spaces that can be used for any leisure activity, e.g. walking, cycling, running, picnicking, camping, boating, playing or just relaxing.
	Aesthetic value	Provision of attractive views, beautiful surroundings, and pleasing, calming or inspiring sights, sounds and smells of nature.
	Education and knowledge	Opportunities for formal education (e.g. school trips), scientific research, local knowledge and informal learning (e.g. from information boards or experiences).
	Interaction with nature	Provision of opportunities for formal or informal nature-related activities, e.g. bird watching, botany, random encounters with wildlife, or feeling 'connected to nature'. There is some overlap with biodiversity, but access by people can have negative impacts on some wildlife habitats. Excludes recreational fishing; hunting / shooting (not covered); the intrinsic value of nature (covered by the biodiversity metric); existence value (from just knowing that nature exists).
	Sense of place	The aspects of a place that make it special and distinctive – this could include locally characteristic species, habitats, landscapes or features; places related to historic and cultural events, or places important to people for spiritual or emotional reasons.

1.3 Green and blue infrastructure

Green infrastructure is defined as "A network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities" (MHCLG, 2019). This includes a very wide range of features: parks, gardens, allotments, playing fields, grass verges, landscaping, sustainable drainage features, green roofs and walls, paths, nature reserves, hedges, street trees, woodlands, wetlands, watercourses, etc. Water features are sometimes referred to separately as '**blue infrastructure**', though often 'green infrastructure' is used as a catch-all term for both green and blue features.

Green infrastructure is a key part of natural capital, though natural capital also includes intensive farmland, which is not usually considered as green infrastructure (though the definitions are fuzzy). The two terms come from different contexts and were never designed to work together. 'Natural capital' is used in economics, to show the importance of nature alongside financial and manufactured capital, while 'green infrastructure' is used in civil engineering and urban planning, to show the role of natural infrastructure alongside grey infrastructure.

The natural capital maps we have developed can be used to identify high value natural capital assets, and these can then be used to help identify strategic networks of green and blue infrastructure, and options for strengthening these networks.

2 Creating the base map of natural capital assets in Oxfordshire

The starting point for our analysis is a base map of the land cover in Oxfordshire. The base map has been derived by combining a number of different sources.

1. **Ordnance Survey MasterMap** (Figure 2) – a very detailed and accurate map that shows individual features such as buildings, gardens, roads, roadside verges and water. Natural areas are mapped either as 'Agricultural land' (pale yellow in Figure 2) or 'Natural environment'. Natural environment may be mapped simply as 'General surface' (pale green in Figure 2), or may include a selection of terms to indicate whether the land parcel contains coniferous trees, non-coniferous trees, scrub, rough grass and/or marsh. Where trees and shrubs are present they may also be classified as 'scattered'.

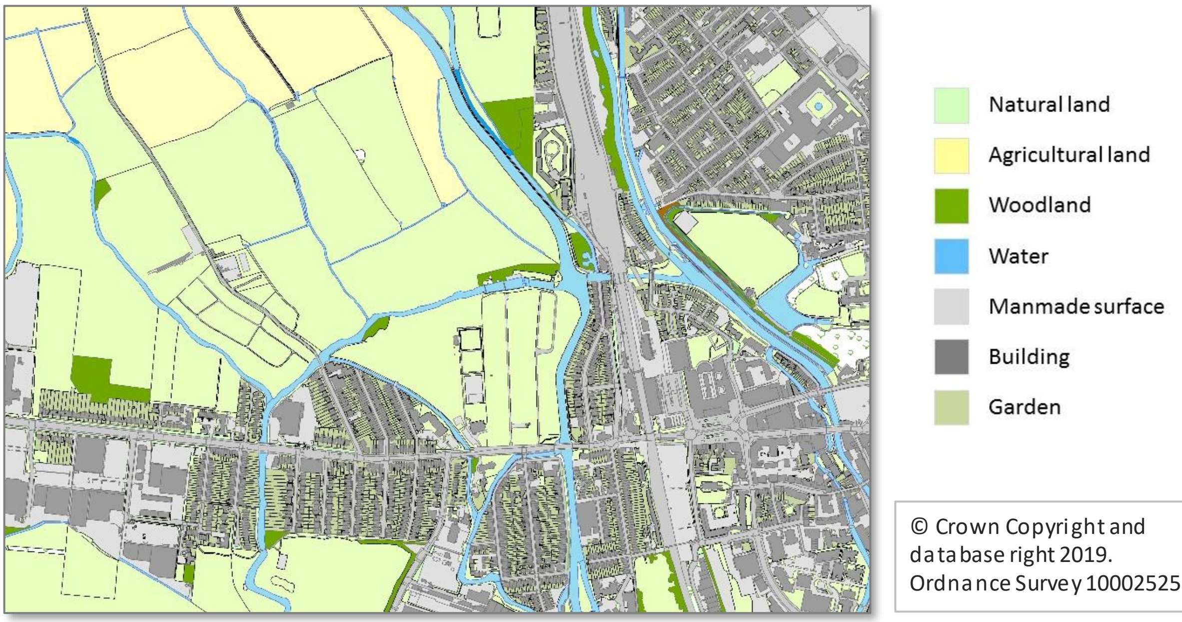


Figure 2: Ordnance Survey MasterMap: area around Oxford station

2. **The Phase 1 habitat and land use survey** for Oxfordshire, provided under license by the Thames Valley Environmental Records Centre (TVERC) (Figure 3). This does not include urban areas (except for relatively large green areas such as urban parks), but it provides more detailed ecological information on semi-natural grassland (acid, neutral or calcareous) and woodland (plantation or semi-natural) and also classifies agricultural land as either arable or improved grassland.

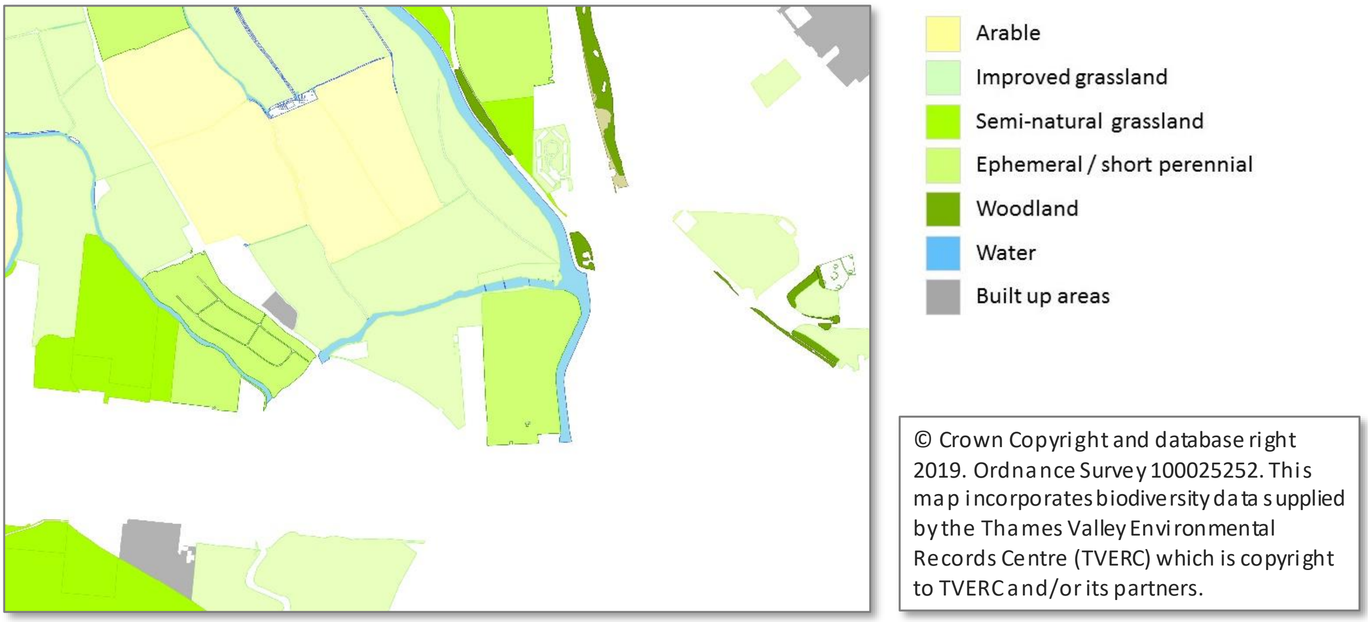


Figure 3: Phase 1 habitat and land use survey; area around Oxford station

3. **Biodiversity Action Plan habitats**, also provided under license by TVERC. These identify habitats of additional biodiversity interest, such as floodplain grazing marsh, open mosaic habitats on previously developed land, and wood pasture and parkland with scattered trees. Some of these areas are mapped as lower quality habitat in the Phase 1 survey, e.g. BAP floodplain grazing marsh may be mapped as improved grassland, and BAP open mosaic habitats may be mapped as quarries.

Figure 4: BAP habitats for the area near Oxford station

4. **Designations.** We combined the following habitat designations into a single layer. Note that Conservation Target Areas (which underpin the proposed Oxfordshire Nature Recovery Networks) are not included as designations because they represent opportunities for habitat restoration rather than signifying existing high-value habitats.
    a. AONBs
    b. National Nature Reserves
    c. Local Nature Reserves
    d. Road verge nature reserves
    e. SSSIs
    f. Special Areas of Conservation (SACs) (there are no SPAs or RAMSAR sites in Oxfordshire)
    g. Local Geological Sites
    h. Local Wildlife Sites and Proposed Local Wildlife Sites
    i. Ancient Woodland
    j. Country Parks
    k. Millennium Greens and Doorstep Greens
    l. Green belt land
    m. Historic Parks and Gardens
    n. World Heritage Sites (Blenheim Park)
    o. Scheduled ancient monuments

5. **OS greenspace maps**. These enabled identification of allotments, playing fields, playgrounds, cemeteries and churchyards, golf courses, bowling greens, other sports facilities and school grounds.

6. **Public access layers**. We identify areas that are publically accessible using various data sources. We first create a footpath network by merging the following datasets:
    - Public Rights of Way (provided by the Environment Agency)
    - Sustrans off-road cycle routes
    - National Trails
    - OpenStreetMap (OSM) paths, downloaded from GeoFabrik and created by extracting ‘roads’ where the attribute ‘fclass’ is in this list: bridleway,cycleway , footway , living street, path , pedestrian , steps , track , track_grade1, track_grade2, track_grade3, track_grade4 , track_grade5.
    - Paths from the ORVal model developed by the University of Exeter (University of Exeter, 2020).

    The OpenStreetMap paths and ORVal paths are useful for identifying extra paths, including permissive paths and urban paths, that are used locally but are not formal public rights of way. The original ORVal path network was itself derived from OpenStreetMap and used accessibility tags provided by users to identify which paths were accessible. However, inspection showed that this dataset (downloaded in 2016) omitted many paths in certain areas which had been updated in later versions of OSM. We therefore updated the path network to include the latest (August 2020) version of OSM paths, but the accessibility tags were not available to us in this version, so the resulting dataset is likely to include private paths that are not accessible. The recreation layer will therefore show an optimistic view of accessibility.

    For open spaces, we use:

    - CROW (Countryside and Rights of Way Act) open access land. (ORVal is supposed to use CROW but actually many CROW areas are missing from ORVal parks).

- ORVal 'parks', which are derived largely from Open Street Map. The ORVal team attempted to retain only publically accessible areas by removing areas tagged as 'private' access, and only retaining features with Access key null or tagged as 'public' 'yes' 'permissive' or 'destination':
  - OSM 'Parks' - keys Landuse or Leisure tagged as 'park' 'recreation ground' 'village_green' or 'common'. The Orval team removed small areas (<0.4ha), school grounds and areas tagged as 'FC', 'sports club', 'sports centre', 'leisure centre' or 'club'.
  - OSM nature reserves ('nature'), public gardens, 'cemeteries' (including churchyards and graveyards), allotments, Playgrounds, Parking and Picnic Sites.
  - OSM 'golf courses', but removing areas tagged as 'nets', 'driving range', 'putting', 'crazy', 'adventure' or 'mini'.
  - OSM features in which the keys Natural had an entry that was not 'water', 'beach' or 'sand' for which access was specifically labelled as 'public', 'yes', or 'permissive' or had a name that included one of the following: recreation, common, park, heath, open access, community, play area, play space were assumed to be publicly accessible natural areas. Of these areas, those with OSM Natural key of 'wood' or 'forest' were classified as ORVal type 'wood' and the rest as 'nature'.
  - Country Parks, NNR, LNR, Doorstep and Millennium Greens – we strip those out as we have already included them as designations.
  - FC National Forest Estate England Recreation Routes – used to define areas enclosed by recreational path networks.
  - Woodland Trust / Forestry Commission Woods for People – open access areas (2011 dataset). Cut into blocks separated by trunk roads, and areas <0.4 ha removed.
- Publically accessible National Trust properties
- RSPB reserves: those in Oxfordshire are all open to visitors
- Amenity grassland, though we exclude railside and roadside amenity grassland. This has the effect of excluding many grass verges in urban areas that are actually fully accessible and have a recreational value for people walking or running. However we do not yet have a method for distinguishing suburban grass verges from roundabouts and motorway embankments where clearly no access is possible.
- We exclude all 'Military Areas' as identified from OpenStreetMap.
- Rivers (running water), lakes (standing water), canals, weirs and reservoirs are set to Open access. We investigated the possibility of restricting open access to Navigable Rivers, but the legal position regarding this issue is not clear.

These layers were combined together using a customised and automated set of instructions written in python code. The aim was to retain the accurately mapped OS Mastermap boundaries, but split these to create new shapes where the Phase 1, BAP habitats and Designations followed different boundaries. The procedure was complex as sometimes these layers genuinely differed to OS Mastermap (e.g. cutting across the middle of a field), whereas often they only differed by a few metres due to less accurate delineation. Therefore it was difficult to achieve a harmonised layer that did not include millions of tiny slivers caused by inaccurate boundaries. However, with the help of a visiting MSc student from Paris (Martin Bésnier) we finally managed to develop a system of producing a reasonably harmonised base map.

We then developed a set of rules for classifying the habitat type in each land parcel, based on the Phase 1 and OS Mastermap habitat information. This was complex, because sometimes the Phase 1 habitat is more accurate than OS Mastermap (e.g. for identifying different types of semi-natural grassland), but sometimes OS Mastermap is more accurate (e.g. for showing small patches of trees and scrub in larger fields).

We have also compiled two other useful layers that can be superimposed on the base map:

7. **Hedges.** We have obtained a map of hedgerows in rural areas developed by the Ordnance Survey. This map is not designed for policy-making or spatial planning and is for research purposes only. It identifies hedges based on places where field boundaries coincide with elevation above ground level (using LIDAR) and dense vegetation (using a remote sensing technique that measures a parameter called the Normalised Difference Vegetation Index, NDVI). By kind permission of the Ordnance Survey, we can include images of the hedgerow map at county level in our published research outputs, but the underlying dataset may not be shared.
8. **Ancient trees.** We obtained a map of ancient trees from the Woodland Trust's citizen science survey (the Ancient Tree Hunt). This is not comprehensive as it shows only the trees mapped by citizens. A better source of tree data would be the Bluesky Mapshop National Tree Map, but this is expensive. This does not distinguish ancient trees from other trees, but it would include all the thousands of trees in urban areas as well as isolated field and hedgerow trees that are not currently included on the map. Exceptional trees are also listed at https://www.monumentaltrees.com.

The final base map for the Oxford station area is shown in Figure 5, including hedgerows and ancient trees (only one ancient tree is mapped in this area, on the road running east-west in the lower half of the map).

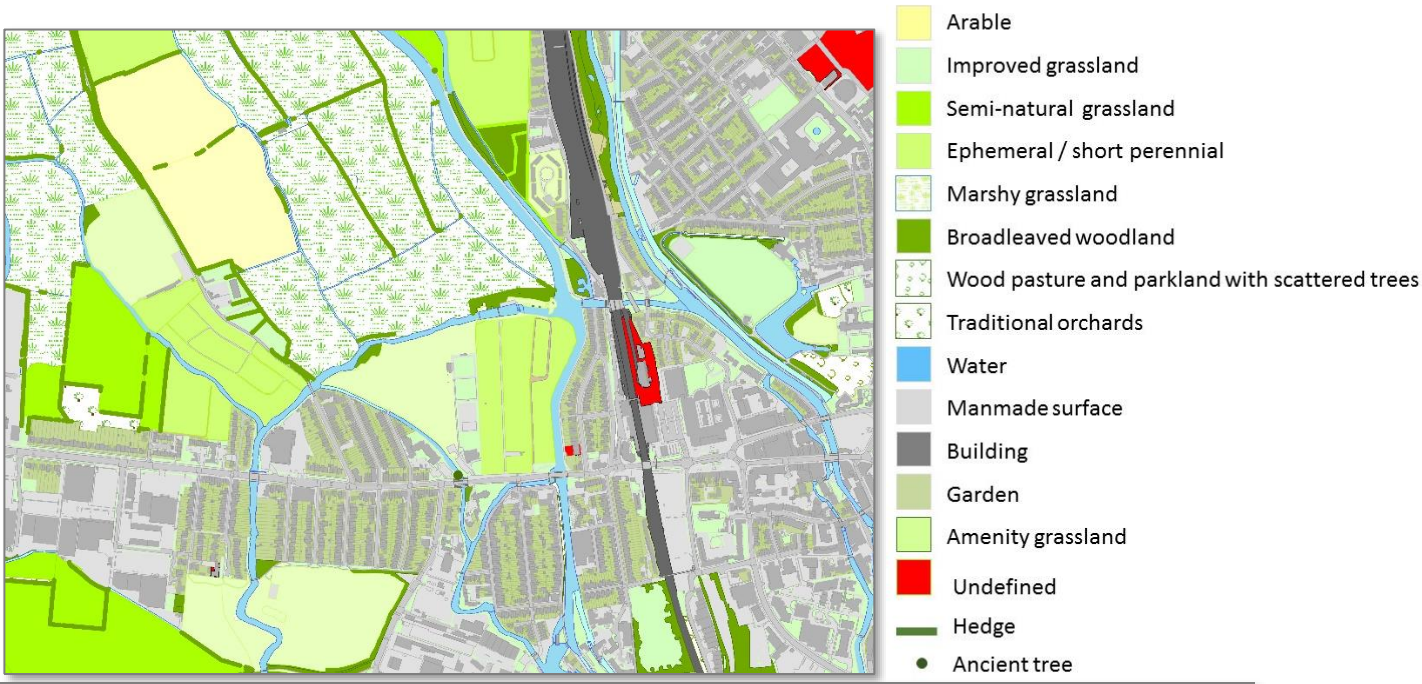


Figure 5: Complete base map for the Oxford station area, including hedges and ancient trees

3 Summary of habitats and land use in Oxfordshire

The habitat map for the whole county is shown in Figure 6, excluding hedgerows for clarity. The predominant land cover is arable (yellow) and improved grassland (pale green), but patches of semi-natural grassland (bright green) can be seen on the floodplains west of Oxford. Woodland is shown in dark green: the Chilterns beech woods are visible in the south-east, as well as the large woodlands north-west of Oxford at Wytham Woods, Blenheim Park and Wychwood.

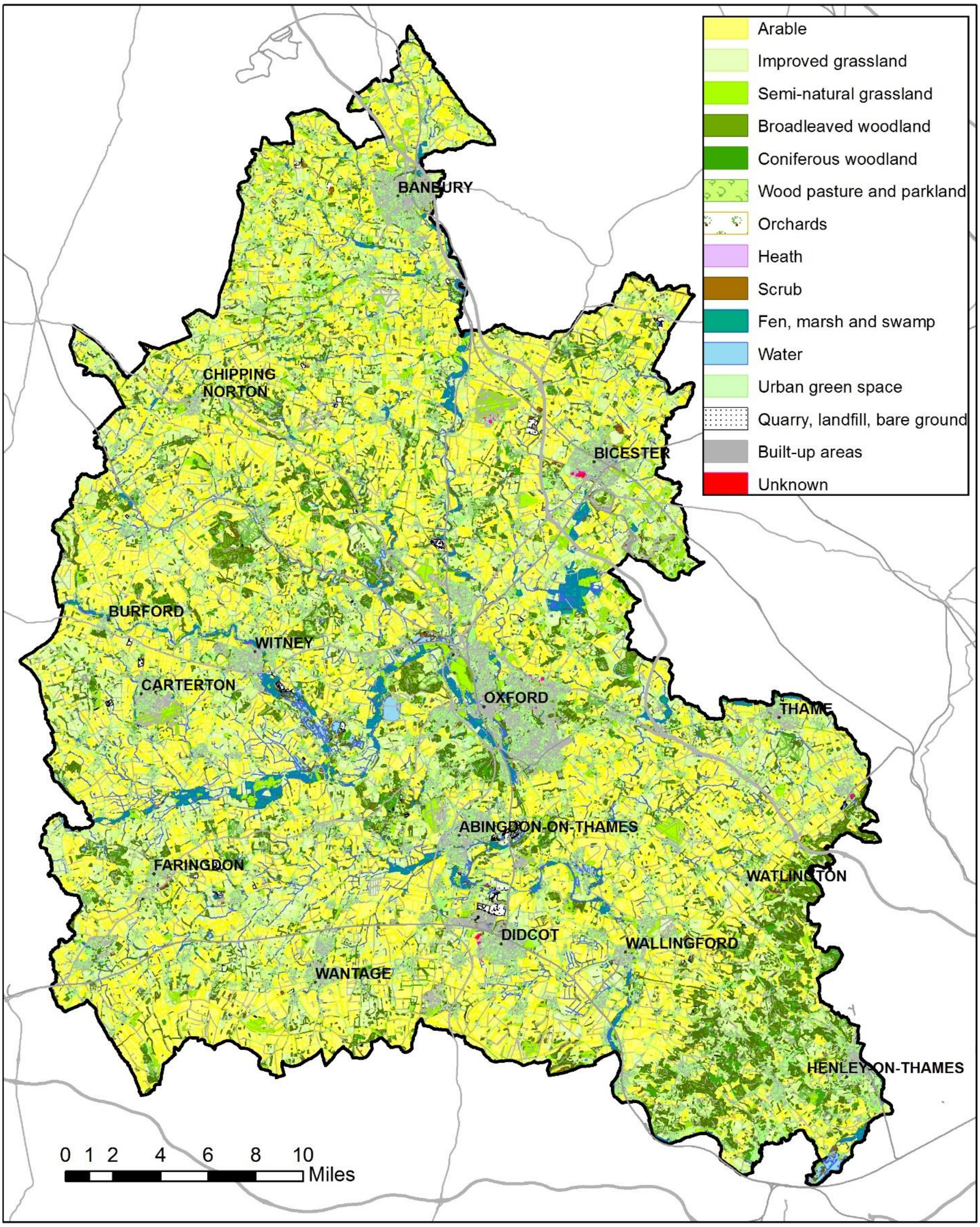


Figure 6: Base map of land cover in Oxfordshire

The split between broad habitat types is shown in Table 2 and ***Figure 7***. This shows that 70% of Oxfordshire is intensive farmland, of which almost two thirds is arable and one third improved grassland. Another 13% is urban, of which almost half (6%) is sealed surfaces (buildings, roads and car-parks) and the rest is domestic gardens (4%) and urban green space (3%). Of the remaining 16%, 1.3% is conifer plantation, leaving less than 15% of Oxfordshire for semi-natural habitats. This is composed of broadleaved, mixed and unknown woodland (7.7%), grassland (3.7%) and around 1% each of water, scrub, and wood pasture and parkland with scattered trees. Oxfordshire is just 0.1% wetland, and 0.002% heathland. Most of the 3.7% semi-natural grassland is semi-improved neutral grassland, with just 0.4% of Oxfordshire being calcareous grassland, and 0.014% acid grassland.

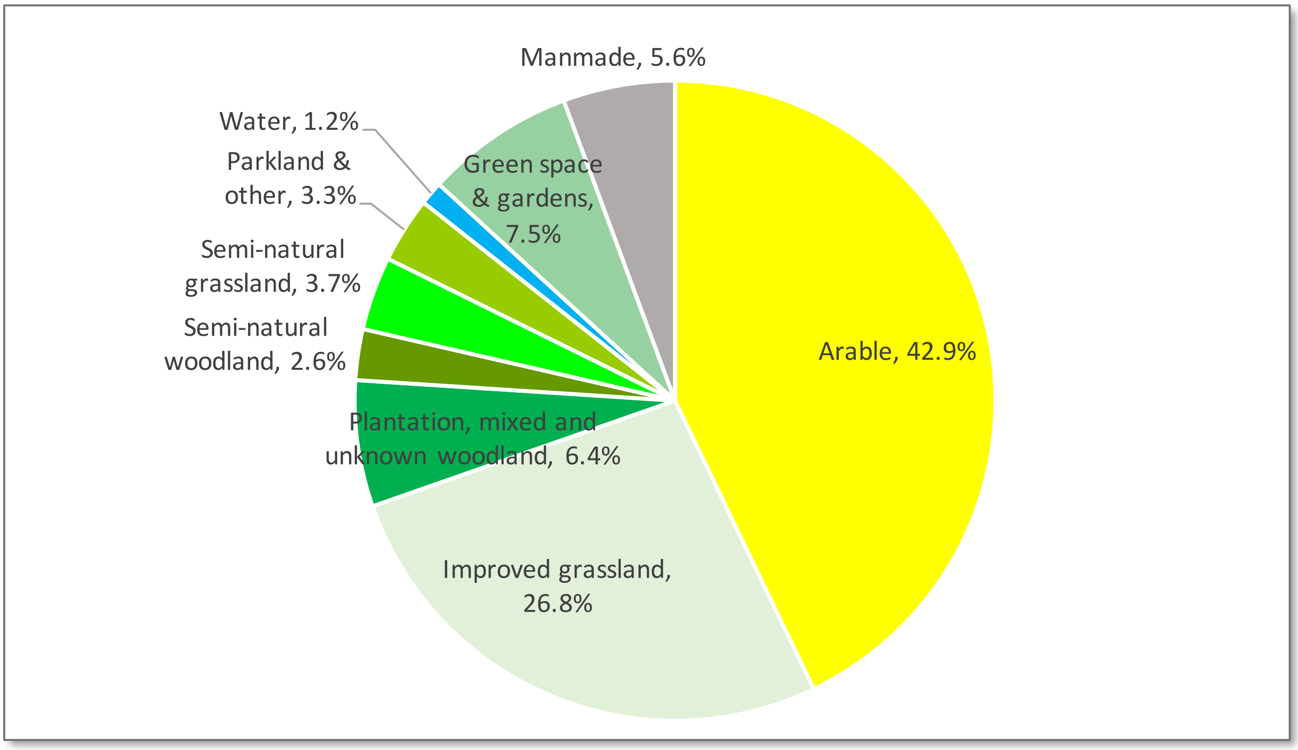


Figure 7: Land cover in Oxfordshire

In addition, the OS dataset maps 9,564 km of hedgerows along field boundaries in Oxfordshire, plus 7,407 km of linear tree or woodland features, making 16,971 km of hedges and linear woodland features in total.

The Woodland Trust lists 2251 ancient trees in its database for Oxfordshire, of which the most common species are oak (905), beech (373) and ash (155). As this is citizen science data it will not include all trees. Those mapped are concentrated in Blenheim Park, Shotover Woods, Wytham Woods, Radley Park, Buscot Park, Ashdown Park, Steeple Barton and the Chilterns. However there will undoubtedly be many more. A small number of trees are also listed at the global Monumental Trees citizen science website. These are trees with exceptional girth, height or age. There were 30 trees listed in Oxfordshire in February 2020. Their locations can only be downloaded individually so we do not show them on these maps, and they probably overlap to a large extent with the ancient trees. There are three trees with girth over 10 metres: a Cedar of Lebanon at Brightwell park, and two Oaks at Blenheim park. A further 10 trees have girth over 5 metres, including several in the grounds of Oxford colleges. The tallest tree is a 45m Douglas Fir at Warburg BBOWT Nature Reserve, 103 years old and still growing at 30cm per year.

Table 2: Habitats and land-use cover in Oxfordshire based on the integrated land-cover map

Habitat	ha	% of total
Arable and horticulture	111,716	43%
Improved grassland	69,782	27%
Total intensive farmland	**181,498**	**70%**
Conifer plantation	3,279	1.3%
Mixed woodland	2,977	1.1%
Broadleaved plantation	1,607	0.6%
Semi-natural broadleaved woodland	6,698	2.6%
Unknown and other broadleaved woodland	8,758	3.4%
Orchards	297	0.1%
Total woodland	**23,617**	**9.1%**
Wood pasture and parkland and scattered trees	3,183	1.2%
Scrub	1,545	0.6%
Heath	6	0.0%
Semi-natural grassland	9,681	3.7%
Wetland	3,345	1.3%
Open mosaic habitats on previously developed land	267	0.1%
Total non-woodland semi-natural habitats	**18,026**	**6.9%**
Total semi-natural habitats excl. water and conifer plantations	**38,364**	**14.7%**
Rivers and streams	1,167	0.4%
Lakes, reservoirs and ponds	1,646	0.6%
Total semi-natural habitats incl. rivers and lakes	**41,176**	**15.8%**
Canals, drains, fountains	277	0.1%
Standing water (lakes, canals, reservoirs)	1,735	0.7%
Running water (rivers, streams, drains)	1,354	0.5%
Water	**3,090**	**1.2%**
Buildings	3,882	1.5%
Road	3,914	1.5%
Sealed surface, bridge, manmade path	4,804	1.8%
Buildings, roads, sealed surfaces	12,600	4.8%
Manmade unsealed surface (rail, quarry, track, felled woodland)	1,979	0.8%
Unknown (usually building sites)	135	0.1%
Total buildings and manmade surfaces	**14,714**	**5.6%**
Gardens	10,479	4.0%
Amenity grassland	8,807	3.4%
Allotments	241	0.1%
Cemeteries and churchyards	121	0.0%
Total gardens and urban green space	**19,647**	7.5%
Total urban (buildings, manmade and green space)	**34,361**	**13.2%**
Total	**260,593**	**100%**

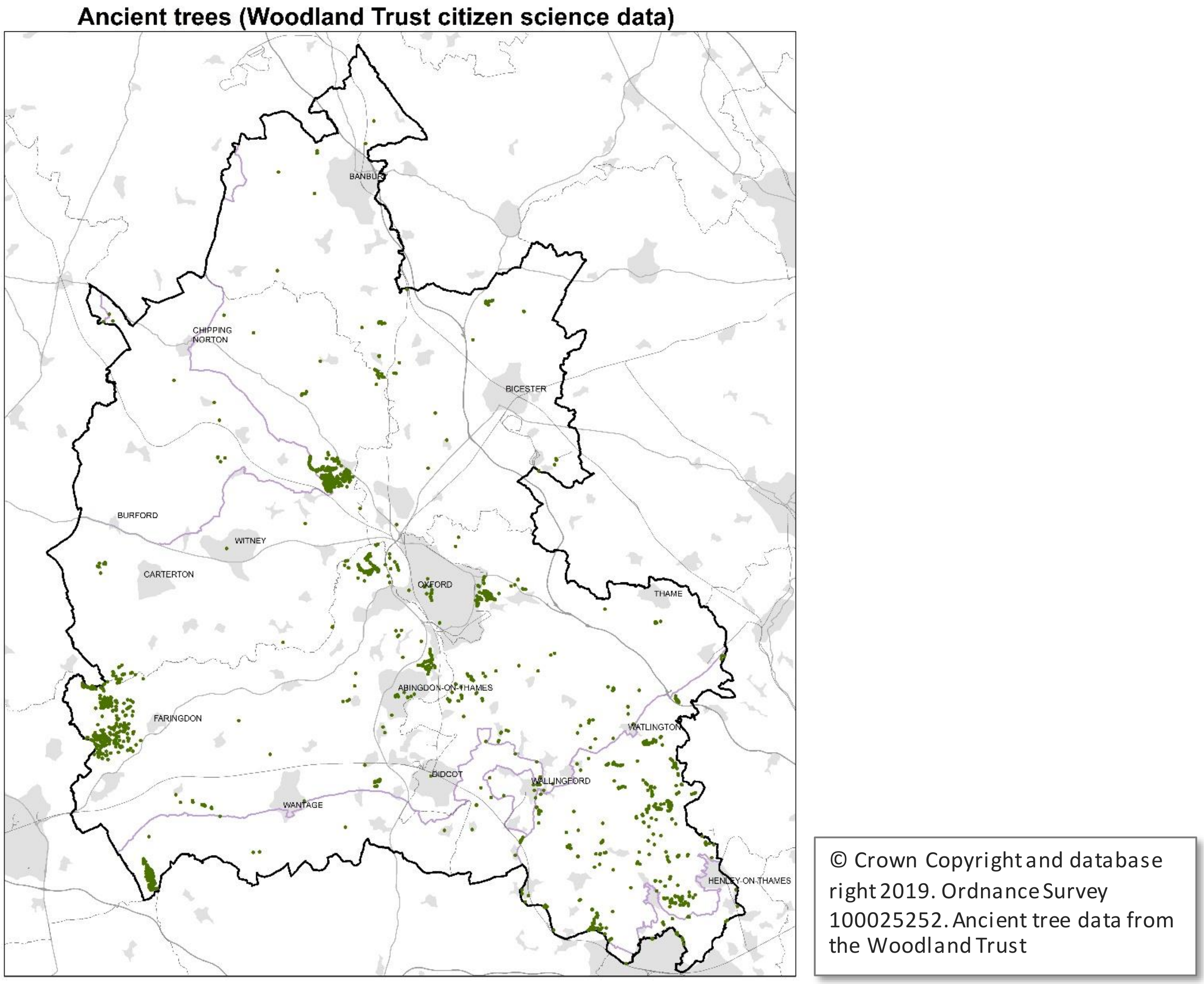


Figure 8: Ancient tree data from the Woodland Trust

4 The scoring approach

The natural capital maps are based on a matrix of scores (from 0 to 10) for the ability of different habitats to deliver ecosystem services. The matrix of scores has been developed over several years, drawing on the following sources:

- a literature review of 780 papers (Smith et al 2017);
- a comparison exercise with similar scoring systems and other evidence sources, as part of the development of the Environmental Benefits from Nature (EBN) Tool for Natural England (previously known as the Eco-metric) for assessing the net gains or losses in natural capital that are associated with biodiversity net gain (Smith et al., 2019)[1];
- a series of expert review consultations as part of the eco-metric project (Smith et al., 2019).

A technical report details the rationale for all the scores, and this will be published by Natural England in due course (the draft report is available on request). For carbon storage and air quality regulation, the scores are directly proportional to biophysical evidence (carbon stored in soils and vegetation, and estimates of the health benefits of air pollution removal by vegetation in the UK Natural Capital Accounts).

[1] See https://ecosystemsknowledge.net/environmental-benefits-from-nature for more information on the EBN Tool.

However the other scores are indicative rankings of different habitats based on best available evidence. Scores for the cultural services are quite subjective, as they are highly dependent on personal views. However, although some of the scores need further refinement, they are about as robust as this type of scoring system can be.

The scoring matrix is shown in Appendix 1. Woodland habitats tend to have high scores for the regulating and cultural services, because trees are highly effective for storing carbon, intercepting rainwater and stabilising soil as well as being attractive locations for recreation. Semi-natural grasslands also score highly for cultural services but less for services such as carbon storage and flood protection. Farmland has a maximum score of 10 for food production, but tends to have low scores for most of the other services (with the exception of water provision via groundwater recharge). However certain elements of farmed landscapes (hedges, field margins, woodlands, paths) do have higher scores for regulating and/or cultural services. The matrix also includes scores for watercourses, wetlands and urban green infrastructure.

5 Multipliers for habitat quality, condition and location

For some services, we have applied multipliers to the basic scores from the matrix, to take account of additional factors that influence the supply of the service, such as habitat quality, condition or spatial location (Figure 9). The multipliers are based on those developed for Natural England's EBN Tool. The EBN Tool includes 46 multipliers, but it is not possible to apply all of these at the scale of a whole county, partly because the data is not available (e.g. on tree size), and partly because it would make the analysis too complex. We have therefore selected a few key multipliers that can be applied at county scale:

- For food provision, we have applied a multiplier that takes account of the agricultural land class (i.e. the quality of the farmland);
- For recreation, we apply a multiplier based on the degree of public access (open access, restricted access or no access);
- For aesthetic value, we apply a multiplier of 1.1 if the area is within an AONB;
- For education, interaction with nature and 'sense of place', we apply a multiplier if the area is designated for nature, based on how many designations apply;
- For fish provision, we plan to apply a multiplier based on the overall ecological and chemical quality of water bodies (not yet implemented).

Details of the multipliers are in the sections for each ecosystem service.

There are various other multipliers that could be applied to reflect the impact of habitat condition, quality or location on the delivery of each service, and we discuss these in the final section on recommendations for future work.

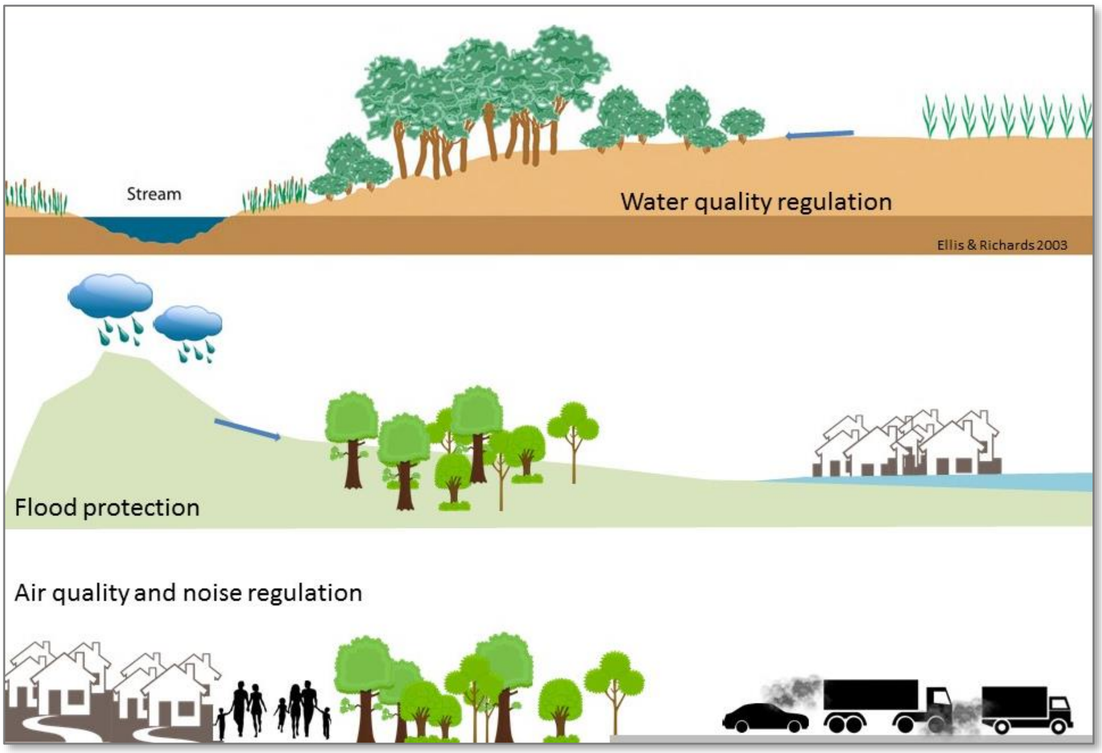


Figure 9: Spatial location with respect to the demand for the service is critical for certain ecosystem services, e.g. habitats must be between a pollution source and a watercourse in order to provide a water quality regulation service; upstream of a flood zone to provide flood protection; or between a pollution source and a place where people live or work to provide air quality regulation.

6 Examples of natural capital maps

We map ecosystem services by matching the ecosystem service scores in the matrix to the base map of land use in Oxfordshire.

The maps reflect the ability of the land to supply ecosystem services, i.e. they do not account for the demand for those services from people, such as how many people live close to a green space that can be used for recreation. In the final section we discuss the potential to extend the analysis to consider the balance between supply and demand.

The maps for the 18 ecosystem services are shown in the following sections, starting with the provisioning services, then the regulating and cultural services, and finally a map of the biodiversity that underpins all these services.

In these maps, the scores for each ecosystem service are shown on a scale of 1 to 10, split into broad bands, with the higher scoring areas shown in darker shades of green. For clarity, areas with very low scores (less than 1 out of 10) are omitted (i.e. white), although all areas scoring above zero will be providing some services at a low level.

For each map, we provide a brief description of the main features reflected in the map, with an indication of any limitations of the underlying data or the scoring system and how these could be overcome in future. We also consider the implications of the map in terms of future land use policy in Oxfordshire.

Hedgerows have been omitted from the maps of the whole county, because the dense hedgerow network would mask the other features in the map. However, the hedgerow network is a vitally important natural capital asset in Oxfordshire. We therefore show hedgerows and ancient trees on larger scale maps of selected areas, for certain services.

6.1 Food provision

The service of food production is provided mainly by cropland and grazing pasture. Arable fields, horticulture, improved (fertilised) grassland and intensive orchards all score 10 out of 10 for this service. Allotments score 7, semi-natural (rough) grassland scores 6, wood pasture and traditional orchards score 5, marshy grassland scores 4, and very rough grazing (bog or heath), domestic gardens and wild food sources such as woodlands and hedgerows (for gathering berries or mushrooms) all score 1. The basic map for food production is shown in Figure 10.

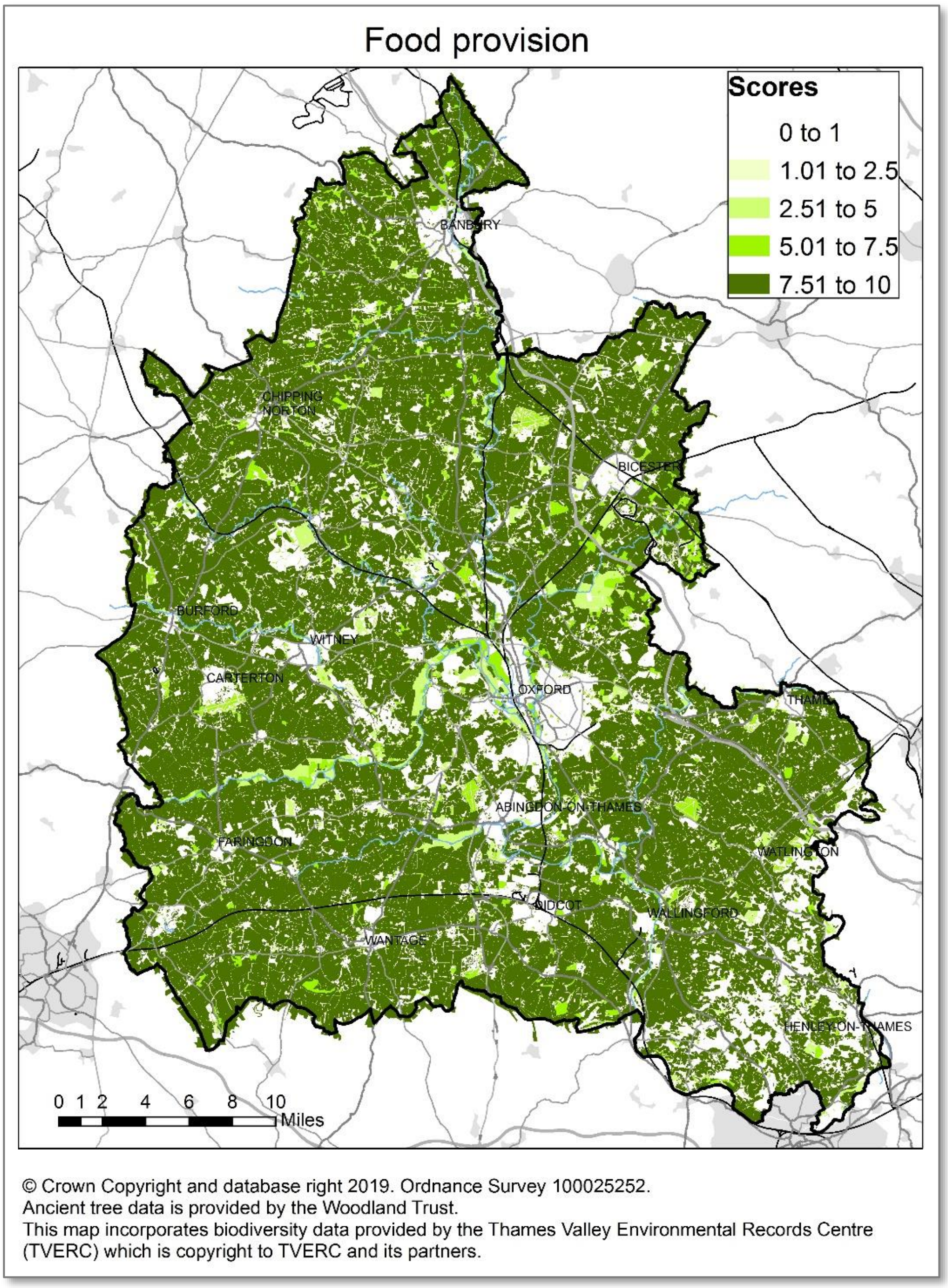


Figure 10: Ability of habitats in Oxfordshire to provide food (basic scores)

We have applied a multiplier to adjust these basic scores, based on Agricultural Land Class (ALC). This classifies land into grades 1 (best) to 5 (worst) for the whole of England. Grade 1 land is highly productive and also versatile, so that many types of crop can be grown. Grade 5 land is typically bog or moorland suitable only for extensive grazing. The 'average' grade is 3b. The ALC map of Oxfordshire is shown in Figure 11.

This multiplier is applied only to habitats where it is thought that the ALC could make a significant difference to the amount of food produced, i.e. arable fields, horticulture, and improved grassland. We may also include intensive orchards in subsequent updates. Lower scoring habitats that could be used for rough grazing (e.g. semi-natural grassland) are not included. It is not appropriate to apply a low multiplier to these habitats, as their low productivity is accounted for when setting the basic scores. Similarly, it is unlikely that they could produce more food even if they were within an area with a high ALC, because of the nature of the habitat.

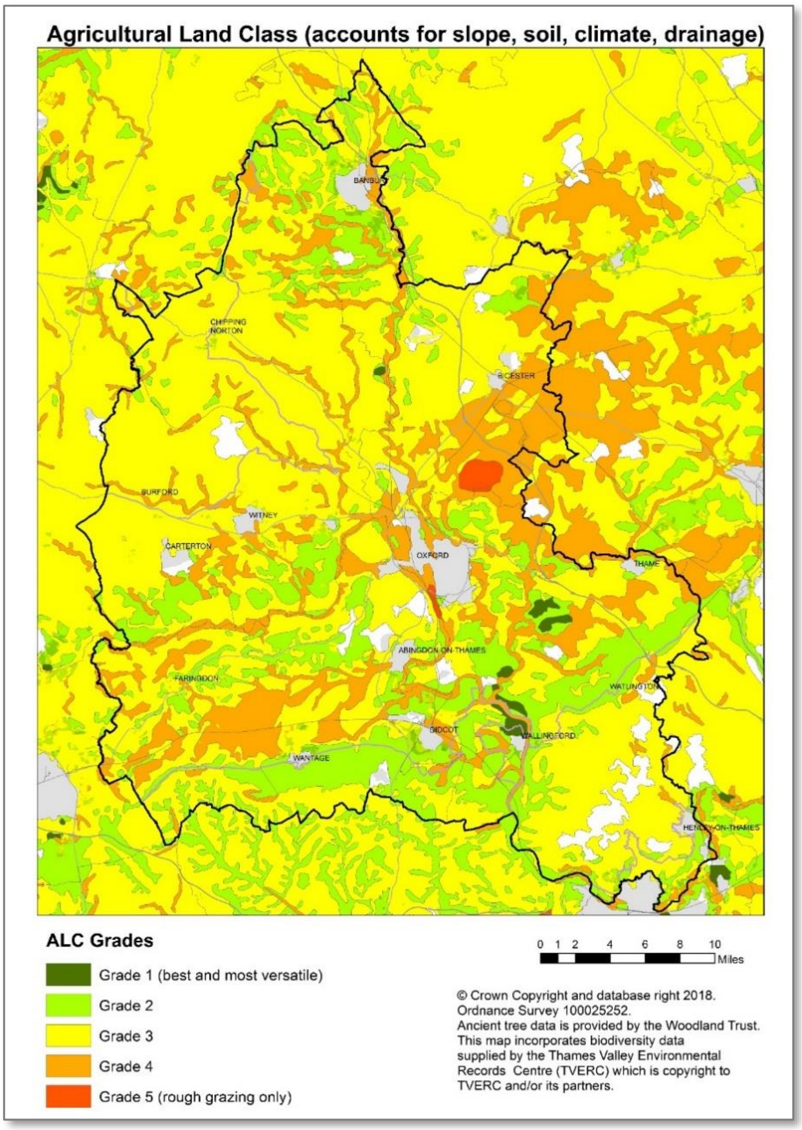


Figure 11: Agricultural Land Class in Oxfordshire

Rationale for the multiplier values. The multipliers are based on a rough estimate of the difference in productivity between alternative grades. Grade 3b is assigned a multiplier of 1 (i.e. no change from the basic score), as it represents a typical value for England. We assume that grade 1 land could typically produce 12 tonnes per ha of wheat under 'good but not outstanding' management, and Grade 3b could produce the UK average of 6 tonnes per ha of wheat, whereas Grade 5 land (rough grazing) might produce only around 3 tonnes per ha of dry matter. An additional (arbitrary) multiplier is applied to Grades 1, 2 and 3a to reflect their additional benefits in terms of versatility, as well as the link to yield.

Table 3. ALC multipliers for the service of food production

ALC grade	Potential yield (t/ha) of wheat or dry matter	Multiplier based on yield only	Normalised	Versatility multiplier (arbitrary)	Multiplier adjusted for versatility	Normalised multipliers
Grade 1	12	2.00	1.00	1.2	2.40	1.00
Grade 2	10	1.67	0.83	1.1	1.83	0.76
Grade 3a	8	1.33	0.67	1.05	1.40	0.58
Grade 3	7	1.17	0.58	1	1.17	0.49
Grade 3b	6	1.00	0.50	1	1.00	0.42
Grade 4	5	0.83	0.42	1	0.83	0.35
Grade 5	3	0.50	0.25	1	0.50	0.21

The map of food provision adjusted for ALC is shown in Figure 12. This shows that the highest food provision service is concentrated in the north of the county and also in several broad strips running east-west to the north of the Ridgeway. This is driven mainly by soil type and drainage: the high-scoring areas are Grade 2 ALC, composed of free-draining silty soils. Elsewhere in the county, productivity is often limited by poor drainage in the heavy clay soils. Nevertheless, food provision is still a very important service throughout Oxfordshire, with most of the county being classed as ALC grade 3 or above , and lower quality grade 4 and 5 land occurring only in narrow strips along river valleys where drainage and/or gradient limit production.

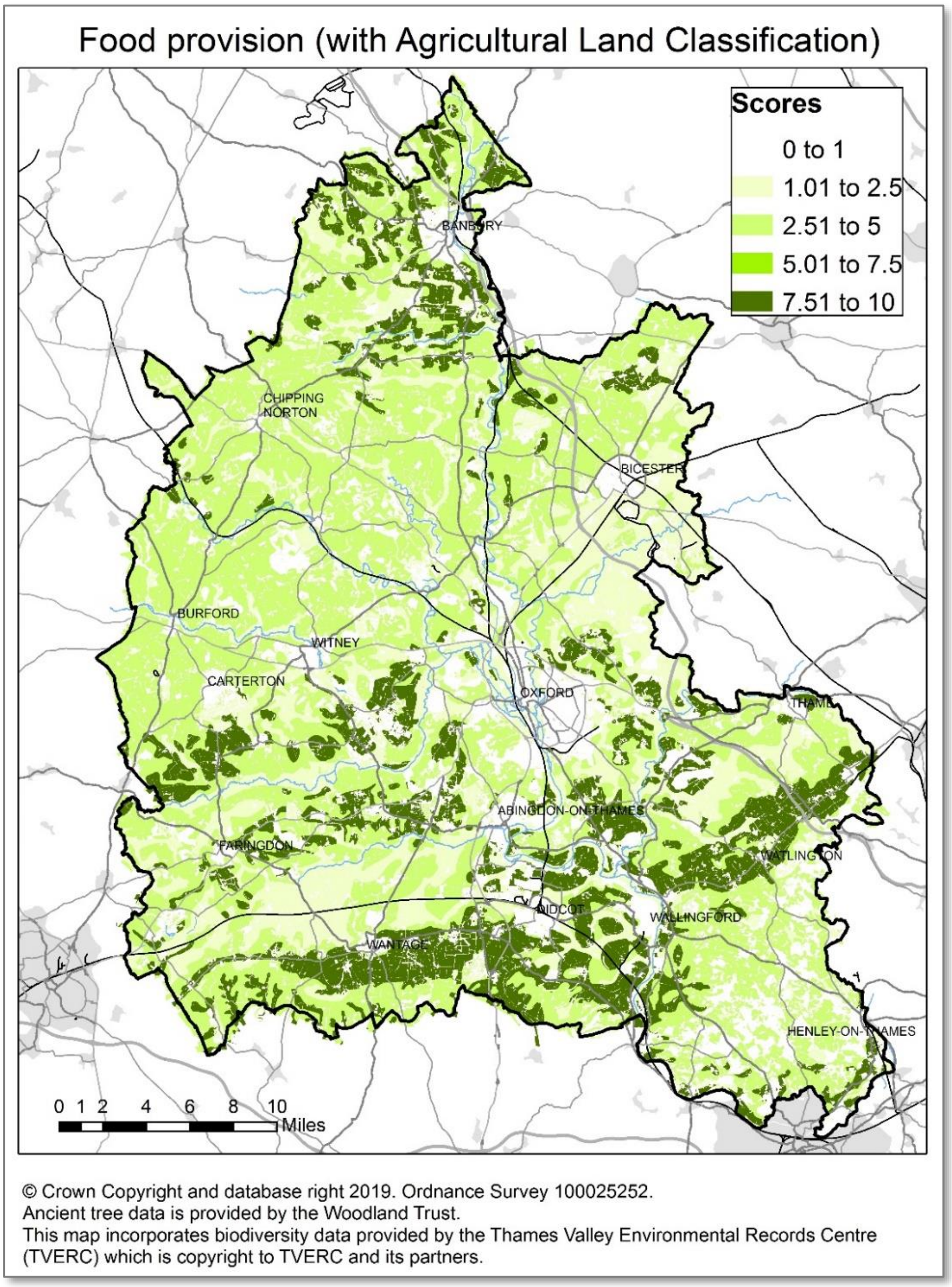


Figure 12: Ability of habitats to provide a food production service (taking account of Agricultural Land Classification)

6.2 Water supply

Ecosystems enable freshwater supply by providing surface water for direct abstraction, and by enabling rainwater to infiltrate into the ground and recharge groundwater or (indirectly) surface water supplies.

Freshwater scores the maximum 10 for water supply, as water can be abstracted directly from surface water. We do not currently distinguish between water bodies that flow into reservoirs and other surface water bodies.

In Oxfordshire, much of our water supply comes from ground water. We therefore allocate higher scores to types of land cover that permit groundwater recharge. Any permeable surface will either allow groundwater recharge or (if there is no connection to a groundwater body) will allow rainwater to infiltrate into the ground where it can then slowly recharge local surface water supplies via horizontal sub-surface flow. Bogs and wetlands are particularly good at storing water, and therefore also score 10.

Semi-natural grassland is expected to have a good soil structure allowing infiltration and groundwater recharge, so scores 9. More compacted grassland such as improved grass and amenity grass scores 7, as some rainwater will run off into drains and straight out to the river network rather than infiltrating. Arable land also scores 7, though in reality some crops are water-hungry and also many fields are under-drained, sending any rainwater straight out to the river network, so this score should probably be lower in those cases.

Trees tend to intercept rainwater and it can then be lost through evapo-transpiration. Coniferous plantations are often water-hungry, and so these score 1. However, broadleaved woodland loses its leaves in winter when rainfall is highest, and also tends to improve soil structure and infiltration. It therefore scores 3, and scrub (which uses less water) scores 4.

Sealed surfaces score zero, although if they are connected to a sustainable drainage system (SuDS), e.g. leading to a retention or detention basin, they may play a role in recharge. We do not yet take this into account in the scoring system but this could be done in future.

The map of scores for freshwater supply is shown in Figure 13. Most of the county scores medium-high, with higher scores along the river network, lower scores for woodland, and zero scores in built-up areas. This emphasises the role that both farmland and semi-natural grassland play in enabling groundwater recharge. However, as noted above, it is possible that the high score for arable land may be an overestimate.

Water scarcity is a major issue in Oxfordshire. The Thames catchment is under severe water stress, as it is one of the driest areas in the country with the highest population density and per-capita water use. The water abstraction strategies for the four Oxfordshire catchments (Thames; Cotswolds; Kennet and Vale of White Horse; Cherwell, Thame and Wye) state that the initial water resource assessment showed no further water was available for abstraction, although bespoke strategies have been devised that allow restricted abstraction at certain times of year (Environment Agency, 2014; 2019a-c). Ongoing losses of farmland for development, and expected increases in drought severity due to climate change, could further reduce the degree of groundwater recharge.

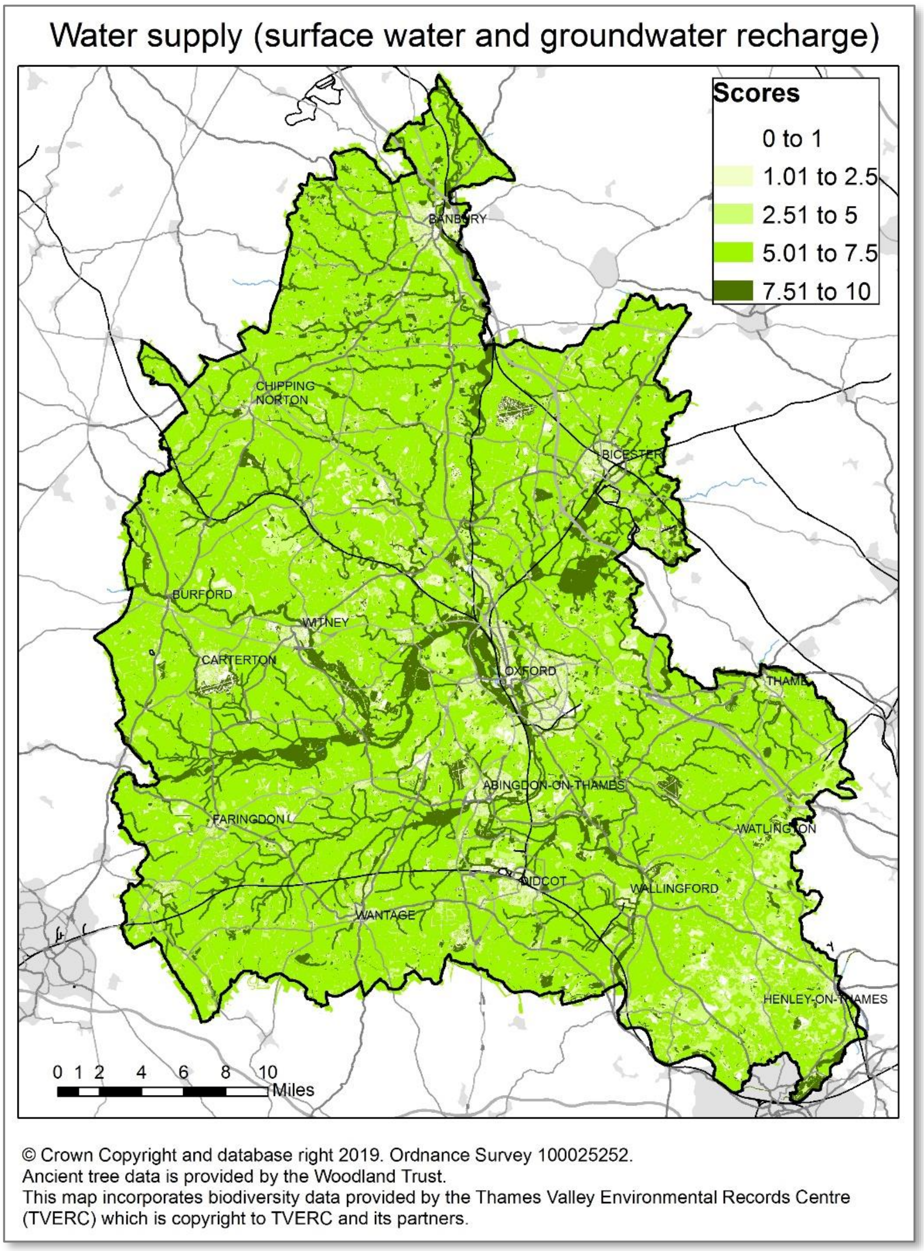
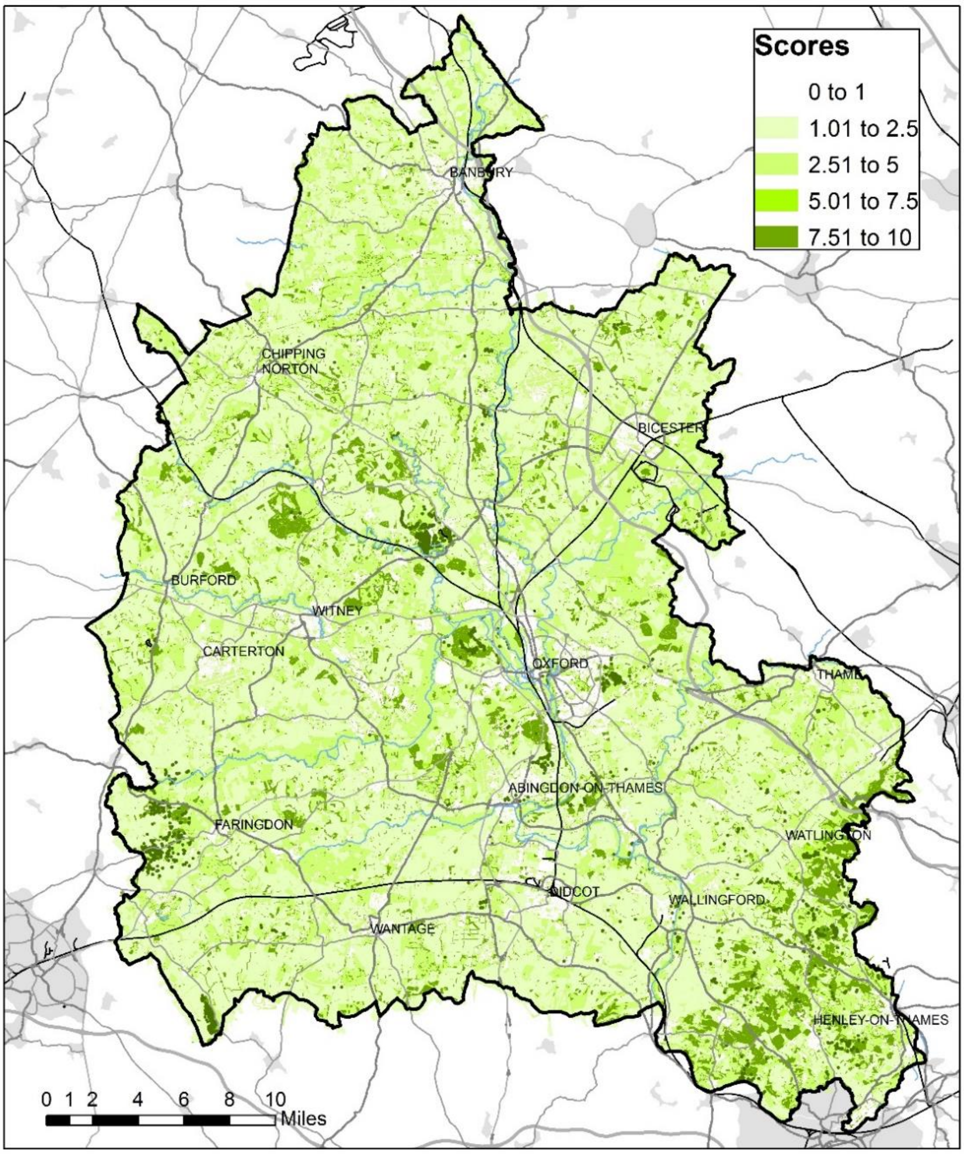


Figure 13: Ability of habitats in Oxfordshire to contribute to water supply (via direct surface water abstraction or indirectly via groundwater or surface water recharge)

6.3 Carbon storage

Scores for carbon storage are based on average values for the carbon stored in vegetation and the top 30 cm of soil in different UK habitats (Cantarello et al. 2013), normalised to a scale of 0-10. Semi-natural broadleaved woodland scores 10, conifer plantations score 8, dense scrub scores 7 and semi-natural grassland scores 4, with improved grassland scoring 3 and arable land 2. A multiplier of 2.0 would be applied for actively forming peat but there is no peat mapped in Oxfordshire. As most topsoil is completely removed during development, and no further sequestration can take place once soils are sealed, sealed surfaces score zero.

The map (Figure 14) shows generally low provision of carbon storage in Oxfordshire, except for the woodlands of the Chilterns, Wychwood, Wytham Woods etc. Note that this map does not incorporate detailed data on carbon storage in soils. Ideally, we would incorporate estimates of soil carbon storage based on soil thickness and percentage carbon, but this data is expensive to purchase from the National Soil Resource Inventory. Therefore our scores only reflect typical soil carbon storage values for different habitat types, accounting for the top 30cm of soil only. In particular, this will undervalue the carbon-rich soils of the Otmoor wetland area.



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Ancient tree data is provided by the Woodland Trust.
This map incorporates biodiversity data provided by the Thames Valley Environmental Records Centre (TVERC) which is copyright to TVERC and its partners.

Figure 14: Carbon storage by soil and vegetation in Oxfordshire

6.4 Air quality regulation (by vegetation)

Trees and other vegetation can help to capture air pollution, especially by trapping fine particles. Although this is no substitute for cutting pollution at source by reducing emissions, a dense barrier of trees or shrubs can help to protect people from pollution to some extent. As some types of pollution can drift a long way from roads, trees anywhere in the country can play a role in removing pollution. However the amount removed depends on many factors such as location, wind direction, weather, and type of pollution. Certain species of tree can also produce volatile organic compounds that react with traffic pollution to form ground-level ozone in sunny weather, potentially contributing to pollution, and corridors of tall trees along busy roads can sometimes trap pollution beneath the canopy.

For air quality regulation, scores are proportional to the amount of air pollution removed by each habitat, based on a modelling study carried out for the UK Natural Capital Accounts (Jones et al. 2017). Coniferous woodland scores maximum points (10), and deciduous woodland scores 6 because leaves are lost in winter. Hedgerows were allocated a score of 8 because they can form good barriers alongside roads – though this depends on the structure of the hedge. Other habitats score 1 if vegetated (heath, grass, marsh) and zero if unvegetated (hard surfaces, bare soil).

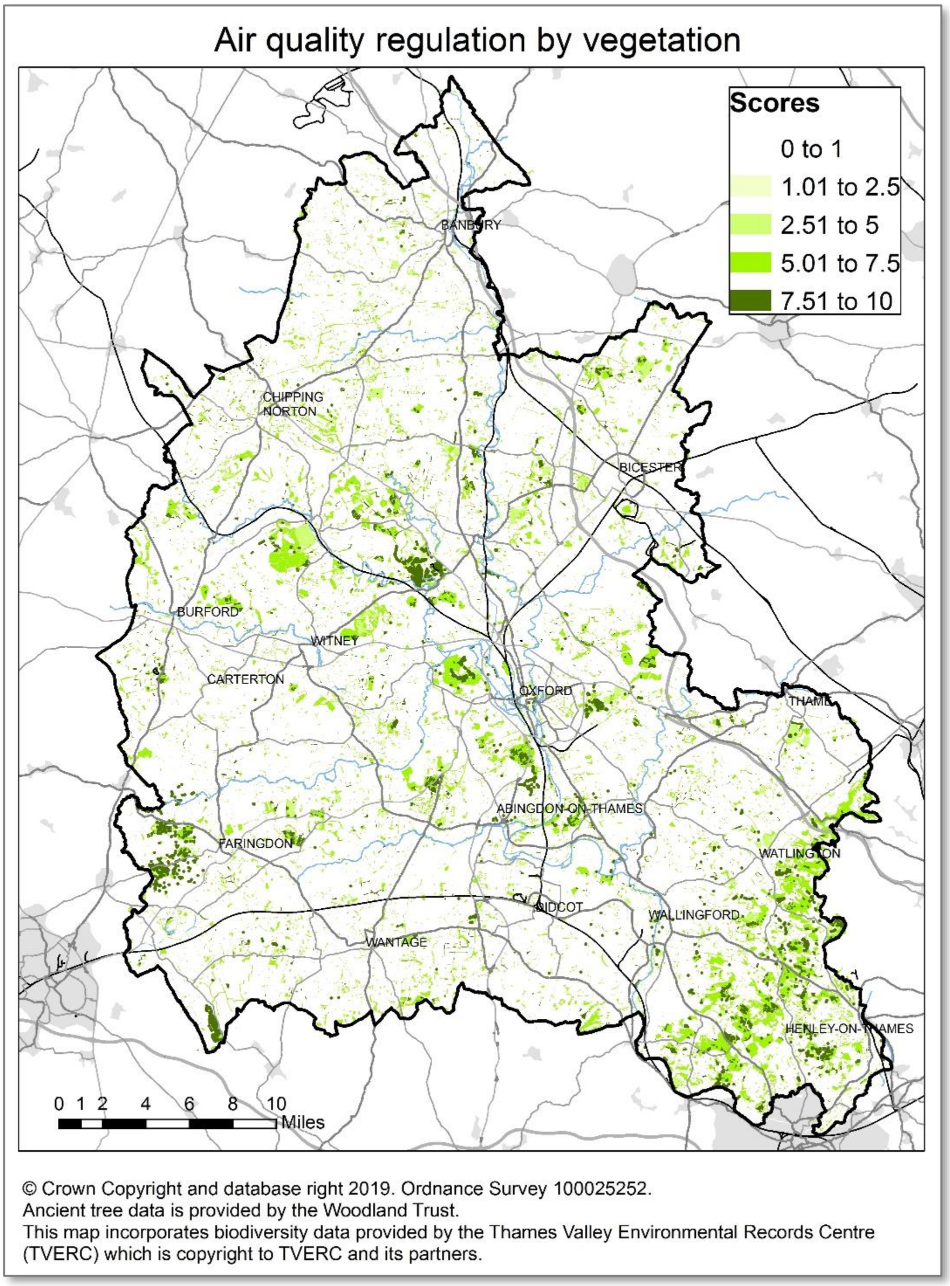

Figure 15: Ability of habitats in Oxfordshire to regulate air quality

The air quality regulation potential of habitats in Oxfordshire is shown in Figure 15, with the high scoring areas being Oxfordshire's woodlands. Note that hedges are not shown on the large scale map, for clarity, and we do not currently have access to data on urban trees (or urban hedges), which would also play a significant role.

The scoring approach indicates the potential supply of ecosystem services but not the demand for those services, and for many services this is partly dependent on location (see Section 5). For air quality regulation, the demand is greatest where pollution is highest and where larger numbers of people live. Figure 16 shows how the existing woodland areas overlap with the areas with high levels of fine particle (PM2.5) pollution, shown in brown, and areas of high population density, shown in blue hatching. This reveals a lack of woodland in the areas of highest demand – although, as noted above, street trees and hedges are not included in this map.

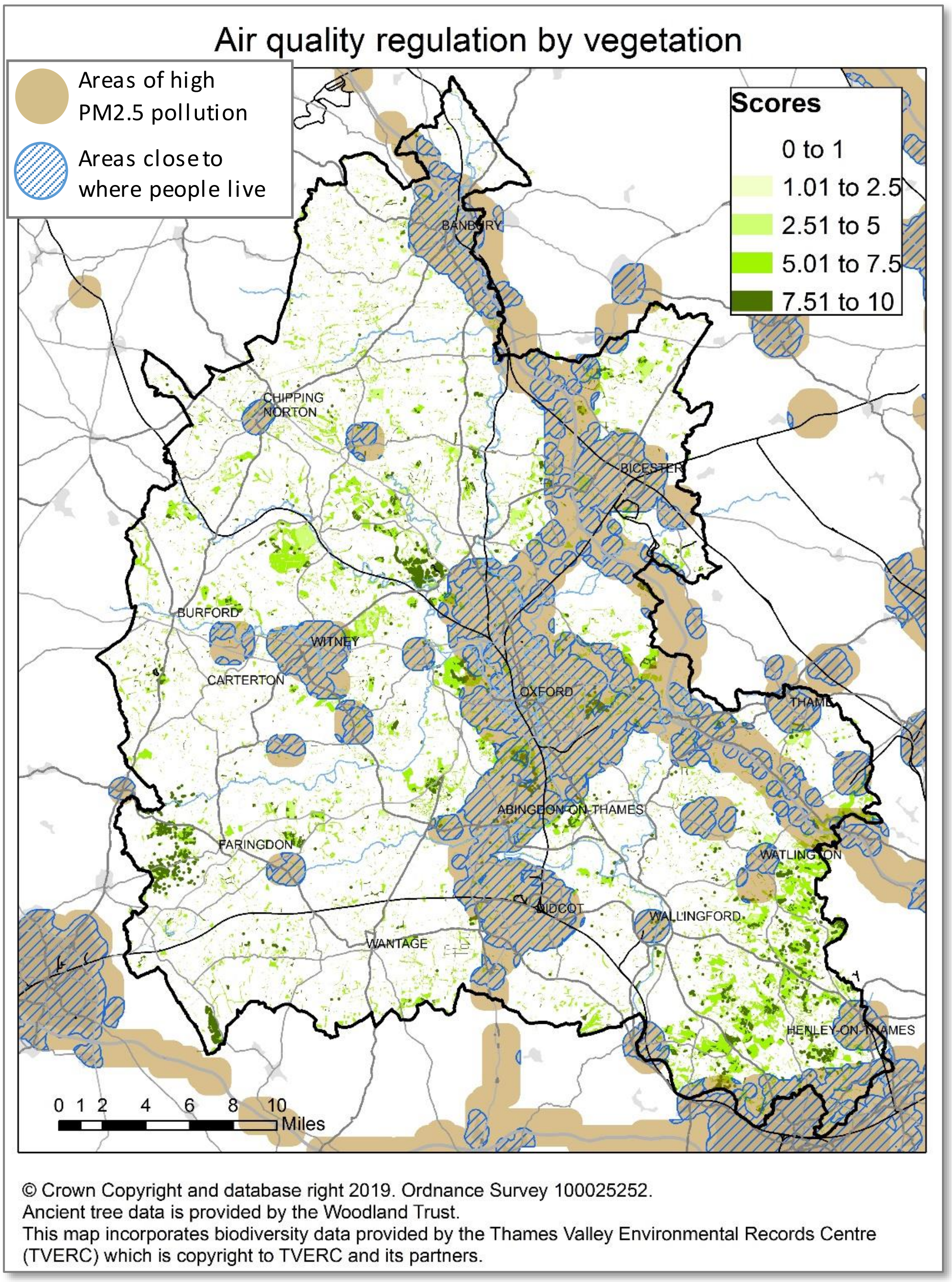

Figure 16: Overlap between demand and supply for the service of air quality regulation by vegetation.

The map shows areas of high PM2.5 pollution (brown) and areas within this zone with high population density (blue hatching), superimposed on the map of habitats that supply the service (i.e. woodland).

6.5 Pollination

In the UK, pollination of crops is partly carried out by managed hives of non-native honeybees, but wild pollinators also play an important role and help to improve the resilience of the pollination service. Wild pollinators are also critical for pollinating wild flowers, which are an integral part of the ecosystems that underpin all ecosystem services.

Crop pollination is mainly provided by a few species of common bumblebees and solitary bees, while pollination of wild flowers is carried out by several hundred species of wild bee, hoverfly, be etle, wasp, butterfly and moth. Both crop pollinators and wild flower pollinators require food (flower-rich habitats) and nesting sites such as dead hollow stems, tree cavities, flaking bark or dry earth (for ground-nesting bees). Many types of semi-natural habitat (woodland, grassland, shrubland, wetland, brownfield sites) can provide these resources, as well as some urban habitats (parks, gardens, green and brown roofs), but some species have specific requirements. Structurally complex vegetation such as tall grasses and ‘weeds’, dead leaves, scrub, hedgerows, old trees and dead wood are particularly important for nesting and hibernation sites.

Pollinating insects often require more than one habitat during their life cycle, e.g. woodland for nesting and flower-rich grassland for feeding, so landscape diversity is important.

The map of the ability of habitats in Oxfordshire to support pollinators (Figure 17) highlights woodland, scrubland and semi-natural grasslands and also shows ancient trees (important as nesting sites). The larger scale inset also shows hedges, which are important habitats for pollinators. However the map also reveals a general lack of good habitats to support pollinators, with the remaining semi-natural grassland areas being small and fragmented, and a scarcity of calcareous grassland and heathland in particular.

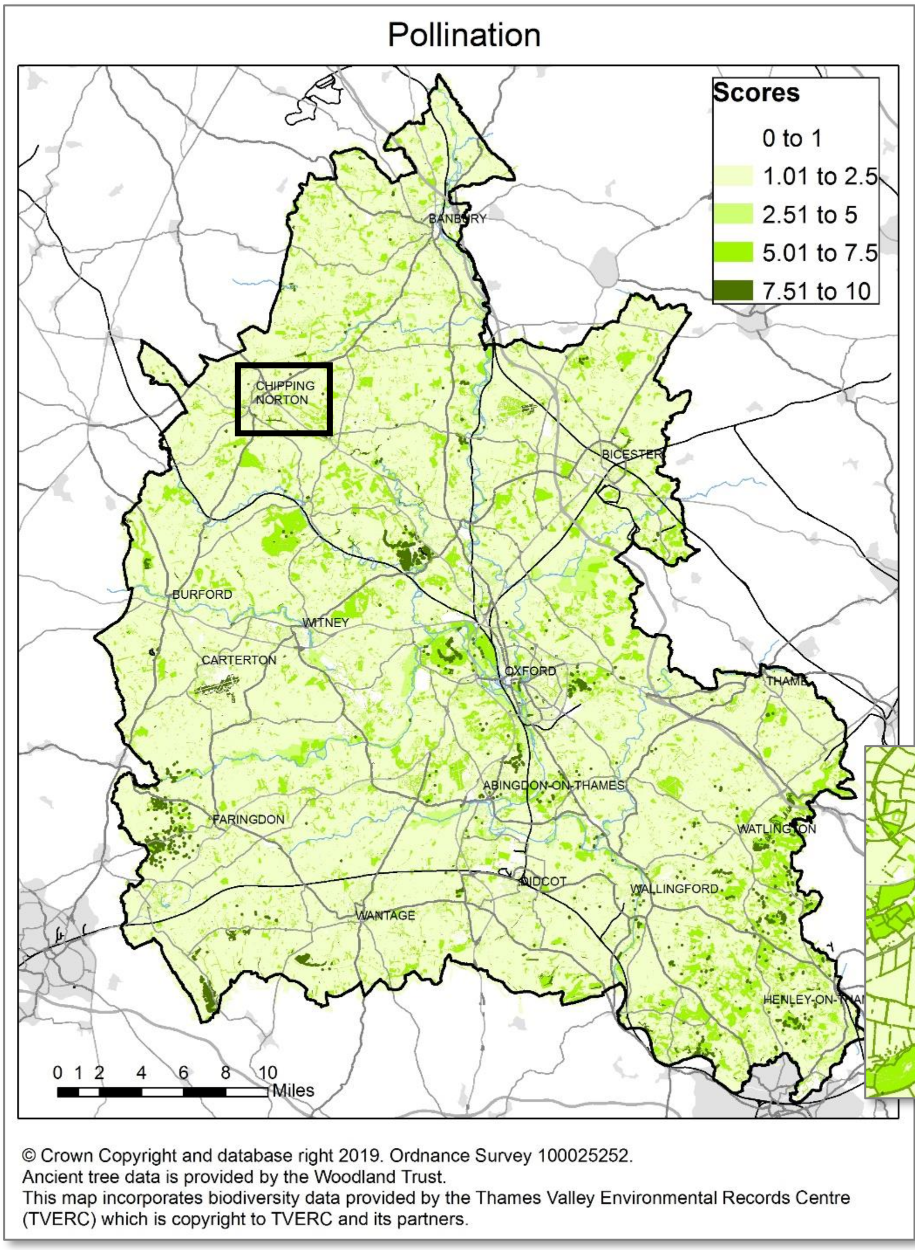

Figure 17: Ability of habitats in Oxfordshire to support pollinators. The inset for the area around Chipping Norton illustrates the importance of hedges in the landscape, as connected habitats for pollinators.

6.6 Recreation

Accessible land provides opportunities for sport and other recreational activities such as walking, cycling, running, picnicking, camping, boating, playing or just relaxing. There is considerable literature evidence that exercise in green space has additional benefits for health and wellbeing compared to exercise in manmade settings.

Any habitats that are accessible could deliver a recreational ecosystem service, including urban green space and the wider countryside, as well as lakes, rivers and canals for boating. Allotments and sports facilities have a high value though these are not necessarily open to all. Accessibility is critical, but there is a difference between restricted access e.g. a path through farmland, and unlimited access, e.g. open parkland.

The scores in the matrix reflect the 'usability' of different types of habitat and land use for recreation, and we then apply a multiplier to reflect the degree of public access. Habitats such as amenity grassland, which can be used for a wide variety of recreational activities such as walking, picnicking or playing games, score the maximum 10 points. Habitats which are less usable for some activities, such as marshy land or dense scrub, have lower scores, and those which are normally not usable for recreation, such as arable fields, have the lowest scores.

For paths, the ecosystem service of recreation is delivered not from the path itself (which could even be a sealed surface which scores zero) but from the way in which the path enables the user to experience a green space setting. We therefore assume that the service of recreation in green space is delivered by the area within a 50m buffer zone on each side of the path. This is consistent with the South and Vale GI strategy, which considers that paths provide access to natural green space if they have a 50m buffer of non-urban land. Habitats within this 50m buffer receive a 'public access' multiplier of 0.75, reflecting that although they are not actually accessible to the path user, they contribute to the experience of recreation in green space.

The multiplier for public access is allocated as follows:

- Open access 'go anywhere' land such as parks, publicly accessible woods or common land (CROW) has a multiplier of 1. This is identified from the CROW dataset, National Trust properties marked as 'open access', the OrVal parks dataset (which in turn is derived largely from Open Street Map, taking account of user tags which identify the degree of public access) and OS green space maps.
- 0.9 for schools, which are accessible only to pupils and only during school hours but are nevertheless very important and heavily used for recreation by schoolchildren. School grounds are identified from OS green space maps.
- 0.75 for the zone 50m each side of paths (see above). 'Paths' includes public rights of way, SUSTRANS routes and additional paths from the OrVAL 'paths' dataset, which is derived from Open Street Map (using accessibility tags) and includes permissive paths and urban paths.
- 0.75 for semi-restricted access (areas restricted to clubs or members but where access is not expensive or exclusive, e.g. allotments, bowling greens, National Trust properties marked as 'restricted access').
- 0.5 for restricted access (e.g. golf courses, where membership is expensive)
- 0.25 for private gardens (very useful to residents but not anyone else).

Some data is still missing from our public access map, Earth Trust (Wittenham Clumps) and Oxford Preservation Trust areas. Many SSSIs, Ancient Woods and Local Wildlife Sites are not shown as accessible according to the datasets above, but more accurate information may be available from District Councils and wildlife groups.

We considered using the Environment Agency 'navigable rivers' dataset to identify which rivers are available for recreational use, e.g. for fishing, swimming or boating. However, further investigation revealed that there are complex issues surrounding the right to use waterways for recreation, with 'navigability' not necessarily being a pre-requisite for recreational use. Therefore we currently map all waterways as having the potential for recreational use.

Figure 18 shows the public access map. This still needs further refinement – for example, Blenheim Park is mapped as being open access whereas it should be semi-restricted access as there is a charge for entry (unless keeping to the public footpaths). Figure 19 shows the recreation scores for different habitats adjusted by the access multipliers. The maps show an excellent network of rural footpaths, especially in the Chiltern woodlands. This network undoubtedly provides an important recreational asset. There are some larger areas including Blenheim Park, Wytham Woods, Port Meadow and Wychwood, and zooming in to a large scale shows the many urban green spaces and parks (Figure 20), but there is a general lack of large open-access areas for recreation.

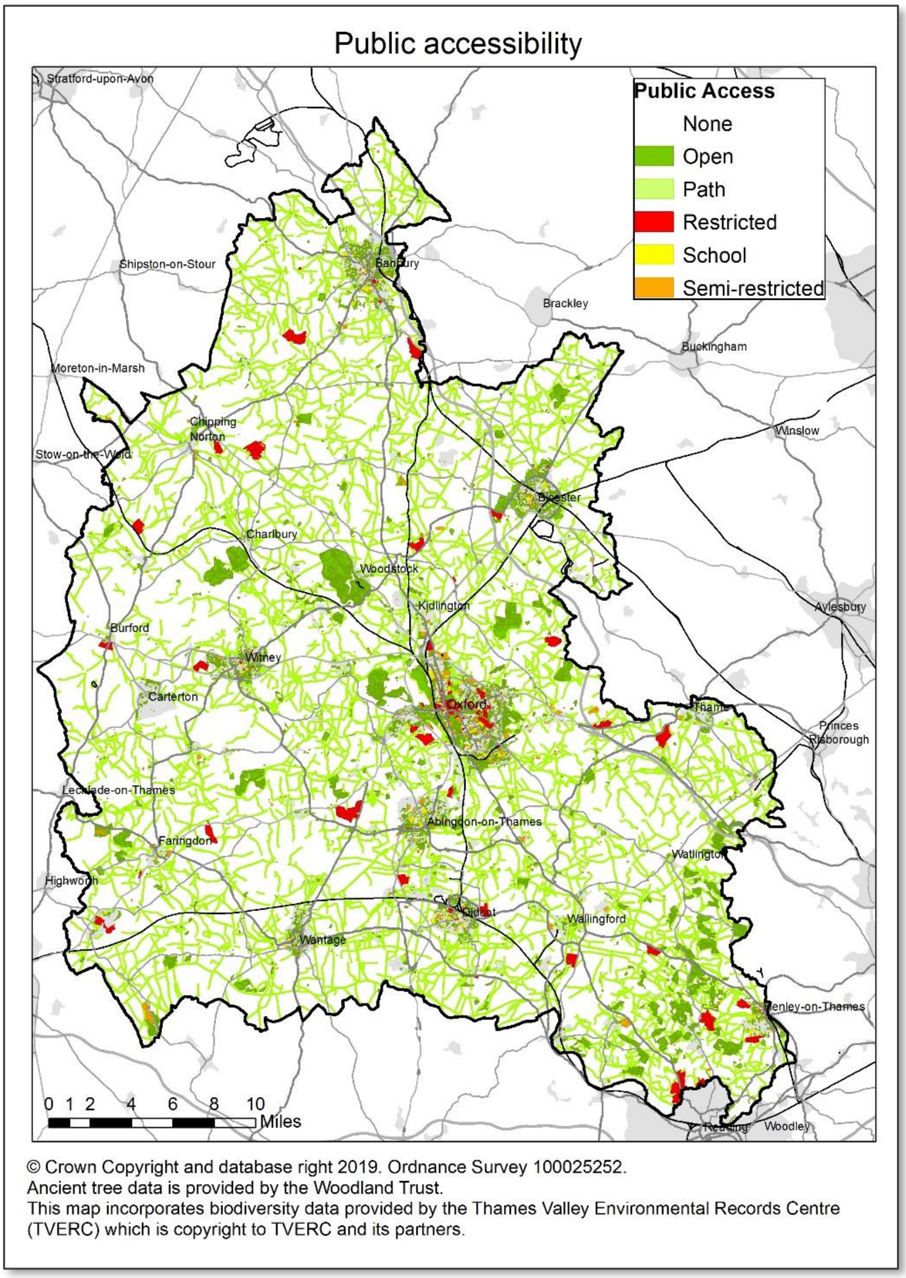

Figure 18: Public access in Oxfordshire

Our analysis does not take account of how close green spaces are to the areas where people live. This could be considered in future work. The Index of Multiple Deprivation could be used to help identify where accessible green space for recreation is most needed.

Future work could investigate the potential to combine nature recovery networks with strategic networks of green infrastructure including footpaths and cycle paths that enable travel between major towns. These can play a major role in offering alternatives to car use for commuting and leisure activities, which will be vital for reducing carbon emissions, air pollution, traffic noise and congestion.

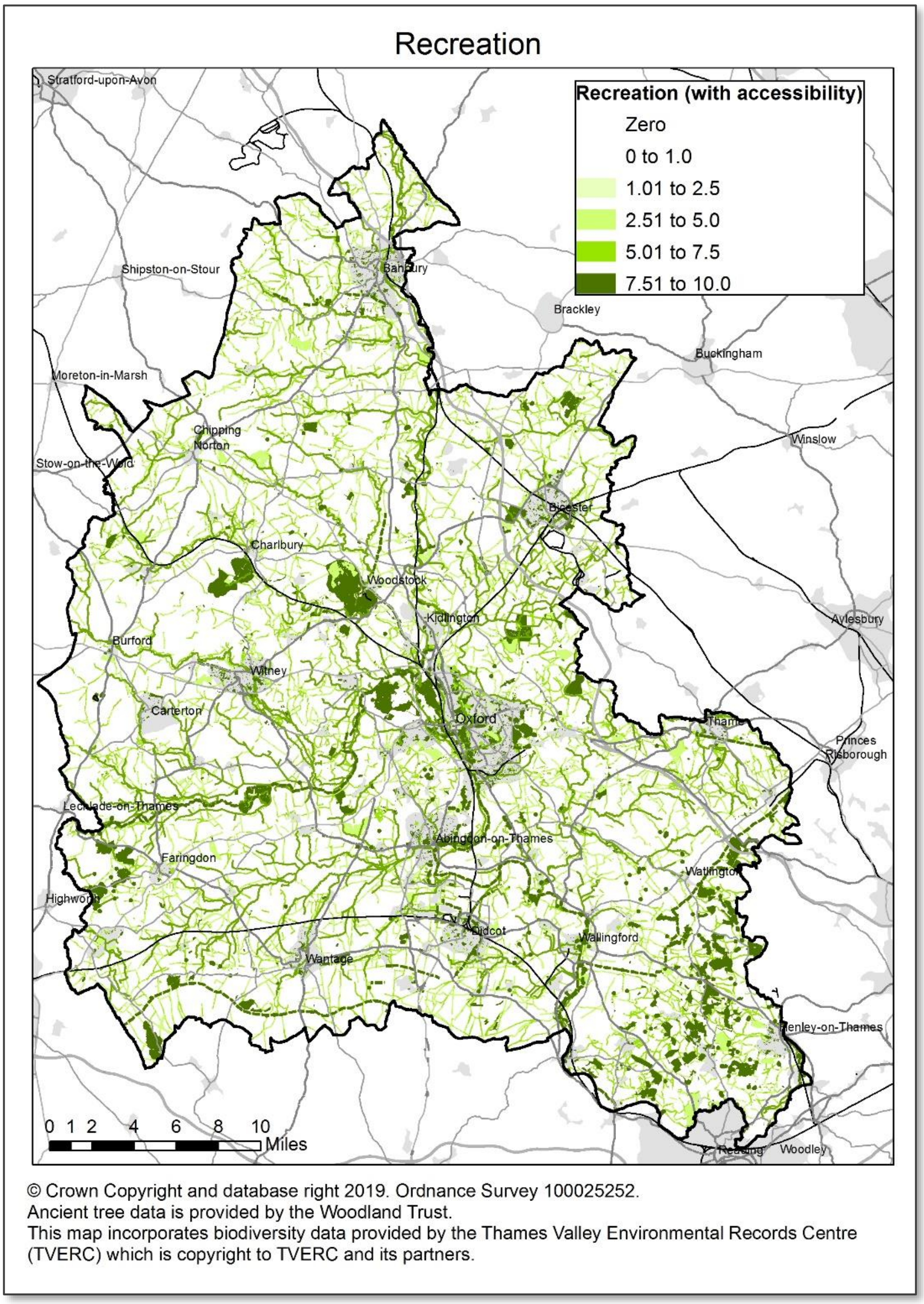

Figure 19: Opportunities for recreation in green and blue spaces, based on habitat type and public accessibility

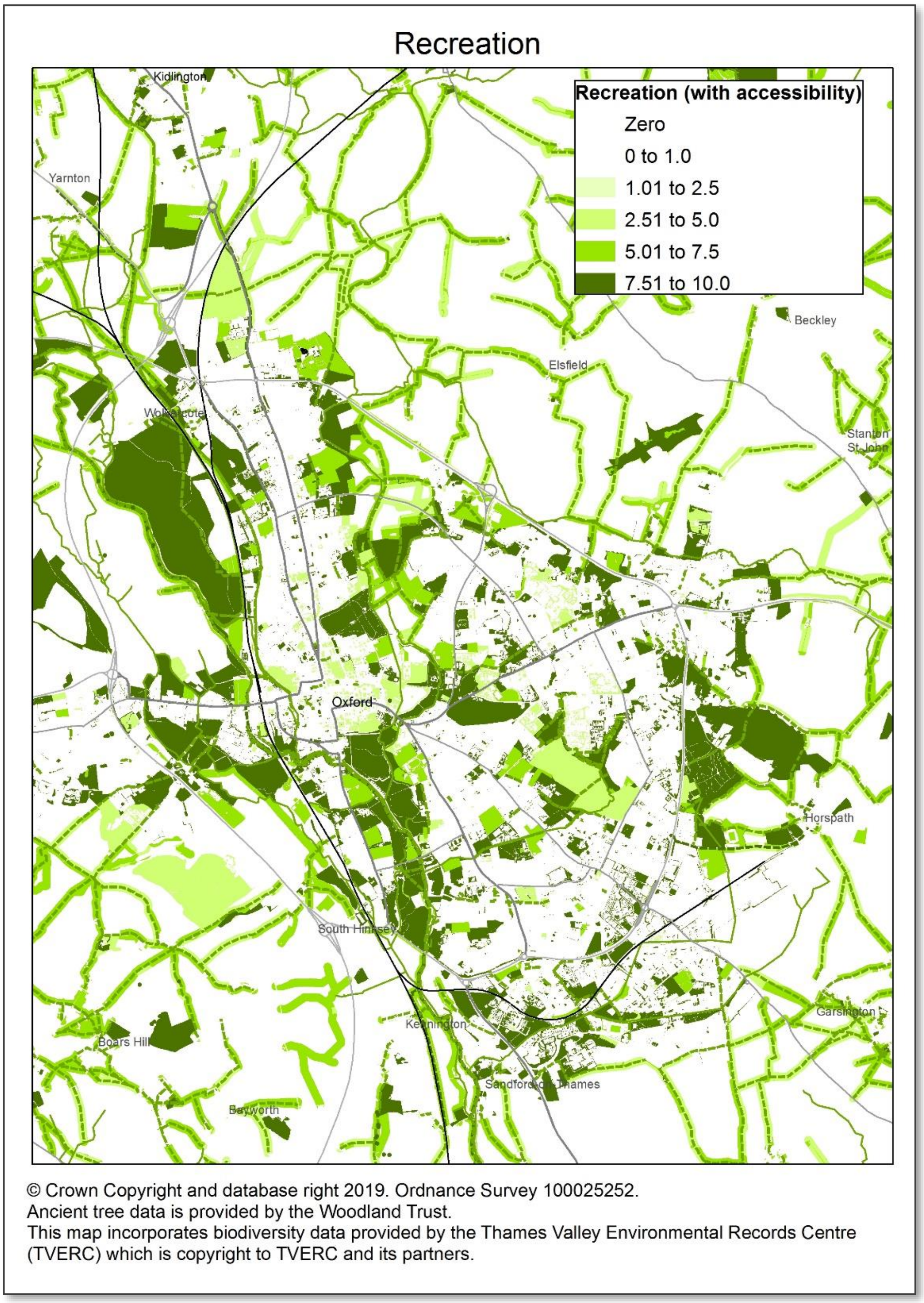

Figure 20: Recreational ecosystem services in Oxford, showing detail of urban green spaces

6.7 Interaction with nature

'Interaction with nature' includes formal or informal activities such as birdwatching or plant-spotting, random encounters with wildlife, and a general feeling of being 'connected to nature', all of which have benefits for health and wellbeing.

This service can be delivered in any habitat where wildlife and nature can be encountered, including urban green spaces. More abundant and diverse wildlife is likely to be found in natural or semi-natural areas and/or in protected areas, but domestic gardens often have more wildlife than surrounding areas if the region is intensively farmed. While areas with high biodiversity can be good places for people to interact with nature, there can also be conflicts such as when dogs disturb nesting birds or hunt small mammals.

We assign higher scores to the most distinctive semi-natural habitats, such as semi-natural broad-leaved woodland, hedgerows, semi-natural grassland, freshwater and wetlands, and lower scores to habitats with less biodiversity interest. We also apply a multiplier for areas with nature designations, including:

- Local and National Nature Reserves, and Special Areas of Conservation
- Local wildlife sites (including proposed sites), Road verge nature reserves
- SSSIs and Ancient woodlands

The multiplier is 1.1 if one of these designations applies, 1.15 if two apply and 1.2 if three or more apply.

We also show the river network, national trails and cycle routes as a separate layer, to highlight the value of these features for allowing people to access nature. The full path network is not shown at county scale, for clarity, and neither are hedges, but these features are shown in more detail in the inset.

Proximity to population is important, but more remote 'wilderness' areas can also be very valuable for high-quality interaction with nature. Also, the wider countryside beyond accessible areas is important for maintaining populations of species that can then be seen in accessible areas such as gardens. Therefore we do not account for accessibility in this map.

The map (Figure 21) highlights the value of the woodlands, river valleys and semi-natural grasslands in Oxfordshire, as well as urban green spaces. Large high value areas stand out at Otmoor RSPB reserve, Wychwood, Wytham woods, Port Meadow and Blenheim Park. Although high value areas are relatively fragmented, there are strong networks along the river valleys and many clusters of good habitat in the Chiltern woodlands. However, many parts of the county appear to be poorly served, due to the lack of semi-natural habitats. It is likely that there will be many small local spaces that contribute to this service, which do not appear obvious on the county-scale map.

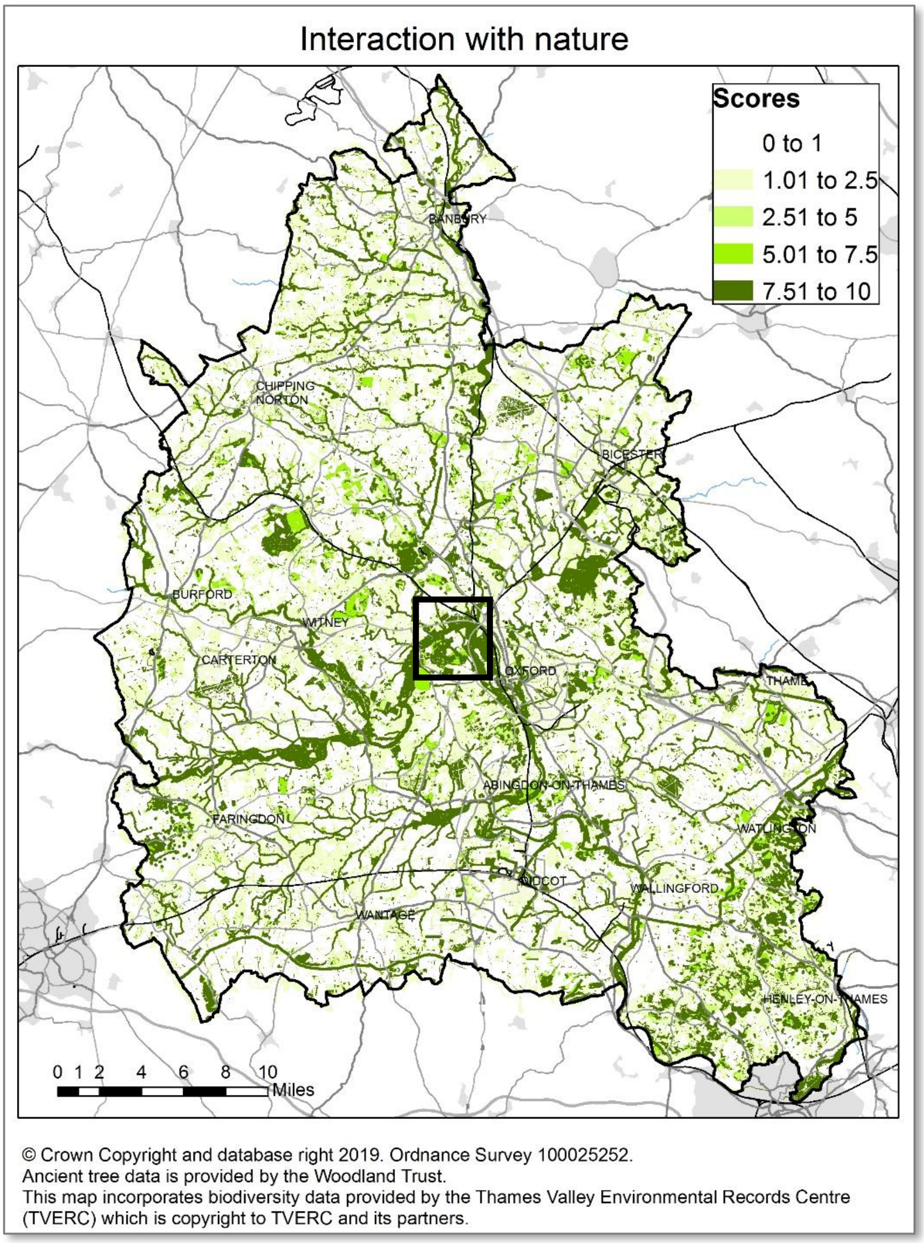

Figure 21: Ability of habitats in Oxfordshire to provide opportunities for interaction with nature. Inset of Wytham Woods and Port Meadow shows detail of hedges and paths.

6.8 Sense of place

This service is hard to measure but very important. It covers the aspects of a place that make it special and distinctive – this could include locally characteristic species, habitats, landscapes or features (such as dry stone walls or hedges), or places related to historic and cultural events or people, or just places that are important to individuals for personal reasons. Any habitat could be important for sense of place, and ideally these places should be identified by the people who use the area. However, in the absence of detailed survey information we assign higher scores to locally distinctive habitats, and those that support local species, and lower scores to 'bland' habitats such as amenity green space and intensive farmland that is not locally distinctive.

We also apply a multiplier for areas with nature or cultural designations. These include nature designations (Local and National Nature Reserves, Special Areas of Conservation, Local wildlife sites and proposed LWS, Road verge nature reserves, SSSIs and Ancient woodlands) as well as cultural designations including Local geological sites, Millennium and Doorstep Greens, Country parks, AONBs, the Green Belt (important for preserving the distinctiveness of villages from the nearby urban areas), Scheduled Ancient Monuments, Historic Parks and Gardens and World Heritage Sites. We also have a layer of data on historical and archaeological interest (e.g. field enclosures from different periods) but this has not yet been integrated into the scores. Figure 22 shows the number of designations applying to each area: the maximum applying to any one area is five.

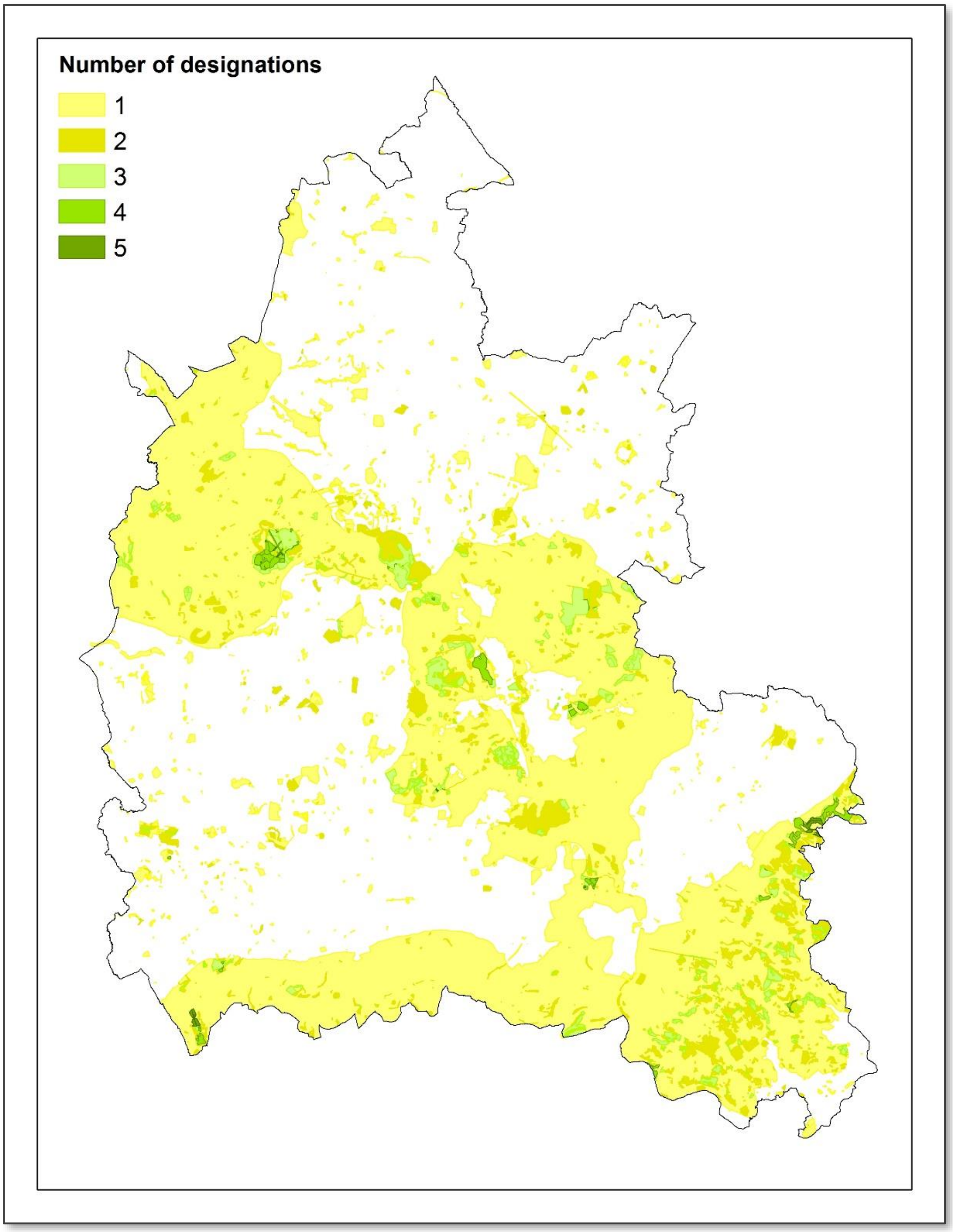

Figure 22: Number of nature or cultural designations

The Sense of Place map (Figure 23) highlights semi-natural habitats such as woodlands, semi-natural grassland and rivers. As for the other cultural and regulating services, these are in relatively short supply in Oxfordshire due to the dominance of intensive farmland and urban areas, but the high value areas along river valleys and in large parks and woodlands stand out on the map.

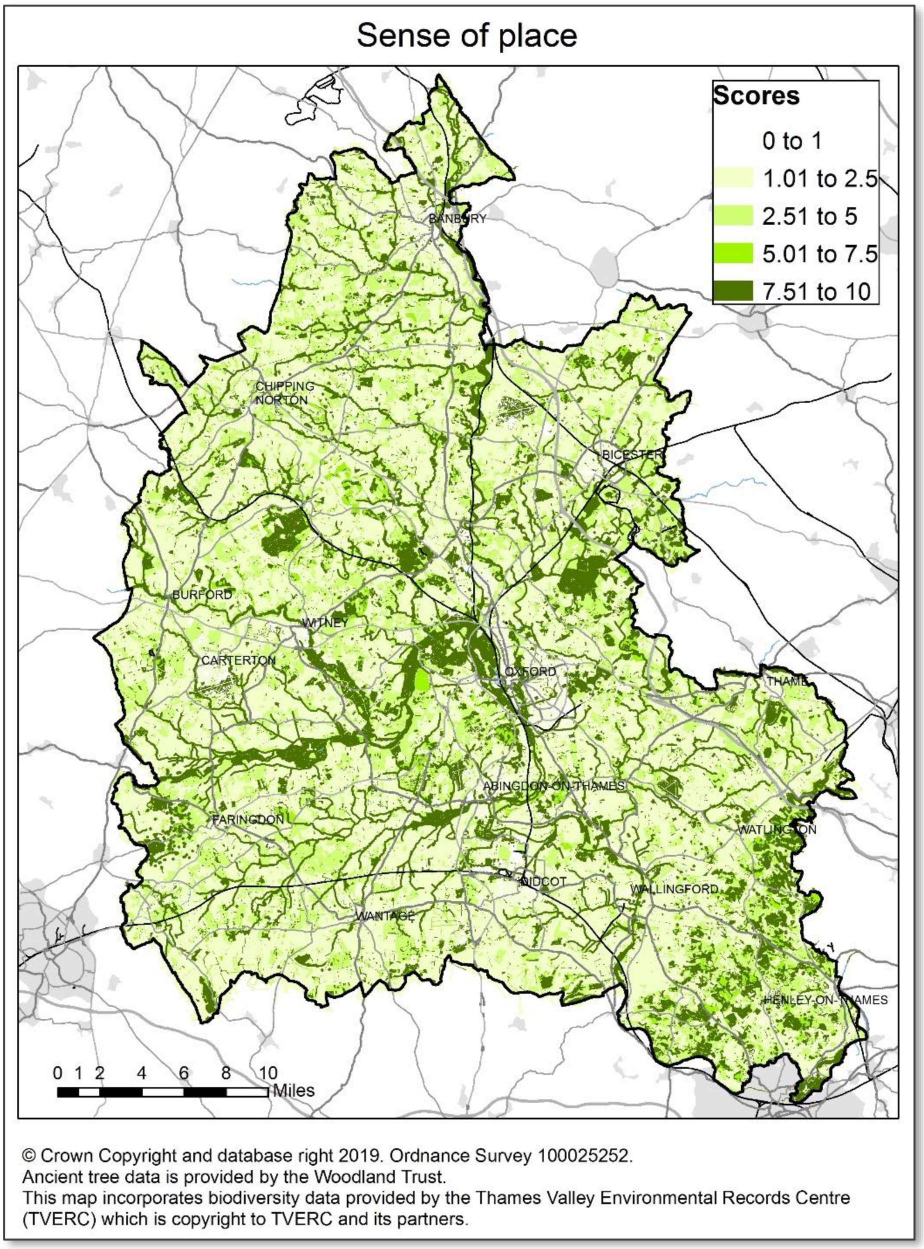

Figure 23: Ability of habitats in Oxfordshire to contribute to a 'sense of place' via distinctive local species, habitats and landscapes, or special cultural or historic value

6.9 Biodiversity

We have provided basic maps of biodiversity value, using scores derived from the Defra biodiversity metric habitat distinctiveness scores. Note that this approach does not take account of habitat condition, or the presence of particular species, so it is a very simple proxy for biodiversity value. This report focuses on assessing ecosystem services (i.e. the value of nature for people), and this is only a cursory look at biodiversity per se. Other more detailed assessments are available (especially Wild Oxfordshire's report on the State of Nature in Oxfordshire, and data provided directly from TVERC on habitats and species).

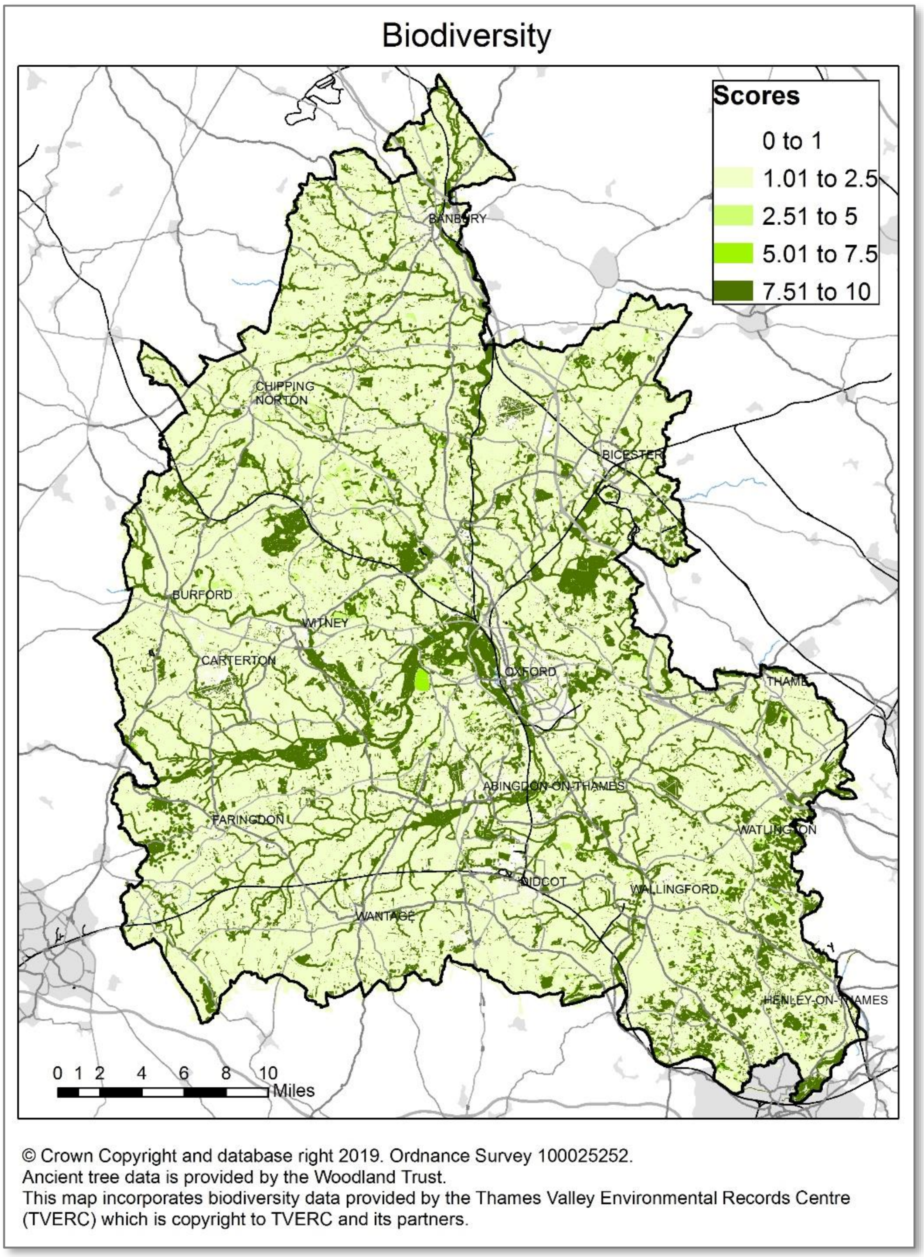

Figure 24: Estimated biodiversity value of habitats in Oxfordshire, based on Defra biodiversity metric habitat distinctiveness scores

Figure 24 shows the basic scores, while Figure 25 adjusts these scores with a multiplier for areas with nature designations (Local and National Nature Reserves, Special Areas of Conservation, Local wildlife sites and proposed LWS, Road verge nature reserves, SSSIs and Ancient woodlands). The multiplier is 1.1 if one of these designations applies, 1.15 if two apply and 1.2 if three or more apply.

Because all the scores are scaled back to a scale of 0-10 after the multiplier is applied, this has the result that areas that are not designated end up with a lower score. Thus only the ancient woodlands, SSSIs and nature reserves are still shown in the dark green colours in Figure 25, while other woodlands and grasslands appear in paler shades of green.

Both maps reveal the generally sparse and fragmented provision of semi-natural habitats in Oxfordshire. However, the good network of hedgerows (not shown on the county scale map) does play a key role in potentially linking some of these fragmented habitats.

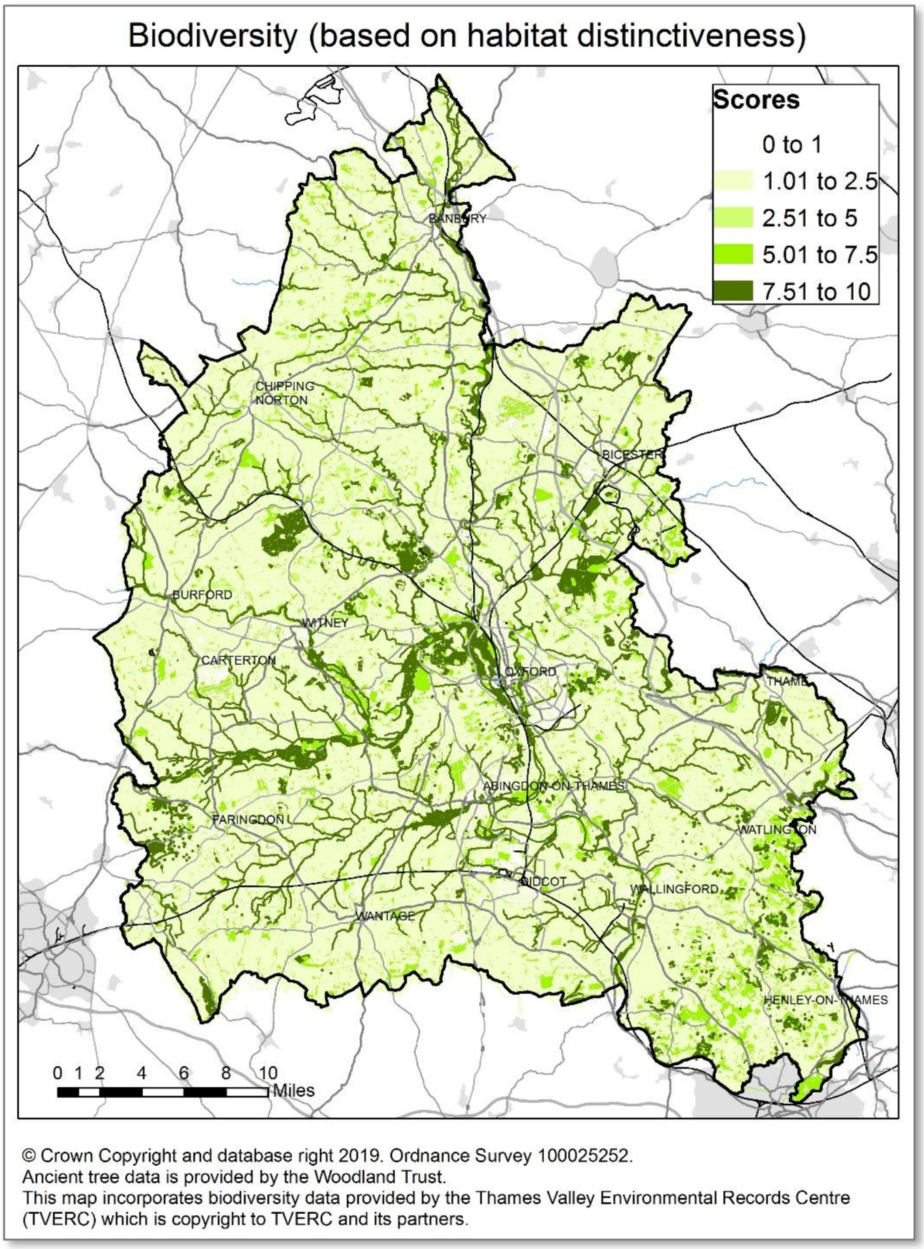

Figure 25: Biodiversity, with multiplier for designated areas

7 Using the maps in planning

There are three main ways in which these maps could be used within the land use planning process:

- Identifying high value natural capital assets that should be protected from inappropriate development;
- Identifying strategic networks of green and blue infrastructure, which can form part of future nature recovery networks
- Identifying low value areas where there may be opportunities to enhance natural capital, perhaps as part of nature recovery networks. This would be facilitated by extension of this approach to map demand for services, in order to identify gaps between supply and demand (see 'Next steps').

In this section, we first provide some guidance on interpreting and comparing the ecosystem service maps and then we address each of these three issues in turn.

7.1 Interpreting and comparing the maps for different services

We have created maps for 18 individual ecosystem services. When interpreting these maps, it is important to remember that scores for different services are not in comparable units. For example, a score of 10 for recreation does not necessarily reflect the same value to society as a score of 10 for carbon storage or air quality regulation. The scores reflect the extent to which the land in Oxfordshire achieves its full potential for delivering each service. Thus a score of 10 shows that the habitat is ideally suited for delivering that service.

Because the scores are not in comparable units, it does not make sense to add them together unless a weight has been applied that indicates the relative value of each service. If they are added together without explicit weights, this is equivalent to saying that all the services are considered to be of equal value in decision-making (i.e. all weights are 1). This also applies to average values for groups of services, as in order to derive an average score, the scores for different services must first be added together.

The alternative approach would be to attempt to convert the scores into a common unit of value. This could be a monetary unit (£). However, although methods exist for converting some of these services into monetary units, they are notoriously unreliable and often involve gross simplifications and assumptions. For example, the standard carbon prices that are used in government calculations are based on assumptions about the price needed to achieve carbon targets. However they have not been updated to reflect the new climate goals following the Paris agreement, or the new urgency in reducing emissions due to the lack of progress over the last 15 years. Therefore these prices are much lower than those that would be needed to achieve our carbon targets today. Similarly, valuing cultural services such as 'Interaction with nature' is hard to do in a meaningful way, as it typically involves 'willingness-to-pay' surveys of a small number of people. Yet once valuations have been produced, they tend to be readily taken up into the decision-making process as a monetary value can be take to imply a false degree of certainty. The simple scoring approach in this report is useful to map spatial patterns, but it should not be taken to reflect the exact values to society.

7.2 Identifying high value natural capital assets

The maps for each of the 18 ecosystem services identify the assets that deliver each of these services. However, it can be difficult trying to take the results of 18 different maps into account in decision-making. To simplify the outputs, the services can be grouped into bundles that all depend on similar characteristics of the environment. These groups are:

1. **Food production**. This is clearly an essential service but it tends to come at a cost to the regulating and cultural services.
2. **Wood production** is delivered mainly by commercial plantations. These can also deliver certain regulating services (e.g. flood protection) and recreation, but tend to be less good for the biodiversity-related cultural services.
3. **Fish production** depends on water bodies of good ecological quality.
4. **Water supply.** This depends primarily on the permeability of the ground to allow rainwater infiltration. Tree cover can reduce this service, though this is mainly an issue for coniferous plantations which are water-hungry and retain their leaves all year round. Deciduous woods lose their leaves in winter when most groundwater recharge takes place. Farmland scores highly as it is permeable, but it is possible that groundwater recharge from farmland has been over-estimated due to water use by crops and the presence of field under-drainage. More information is required to assess this

5. **Soil-water regulating services** (flood protection, erosion protection and water quality regulation). These services all depend on the presence of good ground cover or tree cover, and the permeability of the ground to allow rainwater infiltration.
6. **Carbon storage, air quality regulation, cooling / shading and noise regulation.** These services are all strongly dependent on tree cover, with larger trees delivering a better service (though carbon storage also depends on soil carbon).
7. **Pollination and pest control.** These services both depend on the presence of structurally diverse vegetation, e.g. woodland, shrub and semi-natural grassland with long grass, dead wood etc, with linear features such as field boundaries and hedgerows forming important networks.
8. **Recreation.** This depends largely on the degree of public access, and whether access is open or restricted to a path. Urban green spaces such as allotments, playgrounds and playing fields are important assets, as well as the rural and urban networks of footpaths and cycle paths.
9. **Other cultural services** (aesthetic value, education, interaction with nature and sense of place). These services are all hard to value as they depend on individual preferences. However, the available evidence suggests that diverse semi-natural habitats (including rivers and lakes, woodlands, wetlands and grassland) and good quality urban green spaces such as parks deliver these services best. It is likely that protected and designated areas may deliver a greater service.

Grouping the services like this offers some options to simplify the overall interpretation. As the scores for the services within each of these groups are very similar, the full range of services could be represented in three ways, all of which cut down the number of maps from 18 to nine (five individual services and four groups):

- Taking one service from each group as a proxy for that group;
- Mapping the maximum score for each group;
- Mapping the average score for each group, although this is technically incorrect (as explained above). Feedback from the stakeholder workshop was that mapping average score for small groups of similar services would be more acceptable than mapping the average score for all cultural and regulating services together. The full report contains examples of this approach.

We show the *maximum* score from the full range of all 18 ecosystem services in Figure 26. This shows that although certain high value natural assets stand out, almost all of the land in Oxfordshire is delivering one or more services at a medium to high level, scoring over 5 out of 10. Woodlands, semi-natural grasslands, wetlands and freshwater all score highly for most of the cultural and regulating services (dark green), while grade 1 and 2 farmland scores highly for food provision. Following feedback from the stakeholder workshop, the high scoring farmland is shown in orange, to distinguish land that is good for food provision from land that is good for all the other services.

The lower grade farmland shows as a medium band score (bright green) because it scores 7 for water supply, as it is assumed to allow groundwater recharge. However, as noted above, this may be an optimistic assumption where fields are under-drained. Therefore in Figure 27 we show the same map but without the score for water supply, for comparison.

Particular assets that stand out on the county scale maps, as mentioned frequently in the previous sections, include large areas of woodland, parkland and semi-natural grassland such as Wychwood, Blenheim Park, Wytham Woods, Port Meadow, Otmoor, Buscot Park and the Chiltern woodlands, as well as the river network and the string of associated flood plain meadows. However, these maps emphasise that it is not just these assets (and other protected and designated areas) that deliver value, but also the wider network of farmland, small woodlands, hedgerows and urban green spaces.

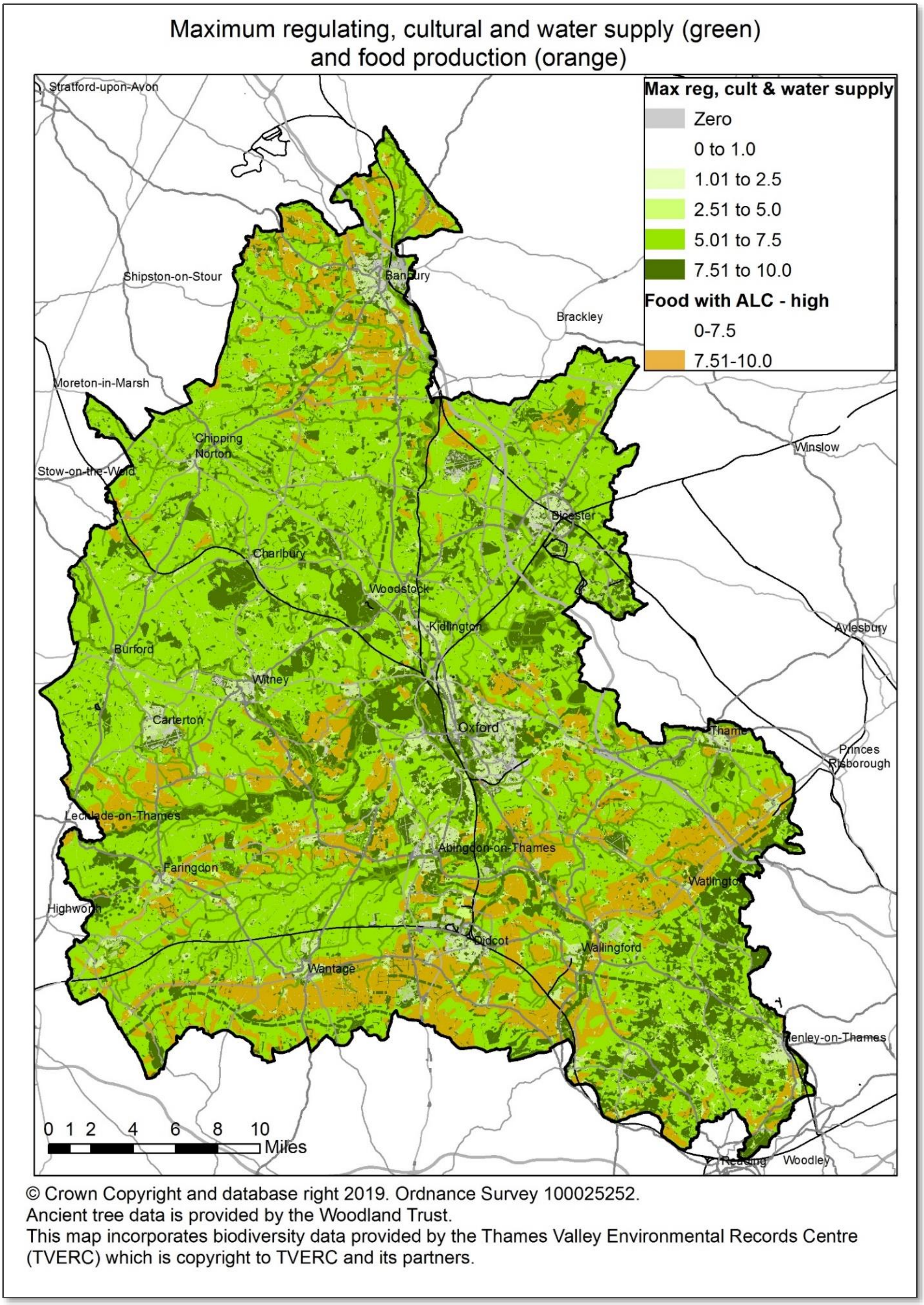

Figure 26: Maximum score for all ecosystem services (where the maximum score is for food production, this is shown in orange to distinguish it from the other services)

Natural capital scores

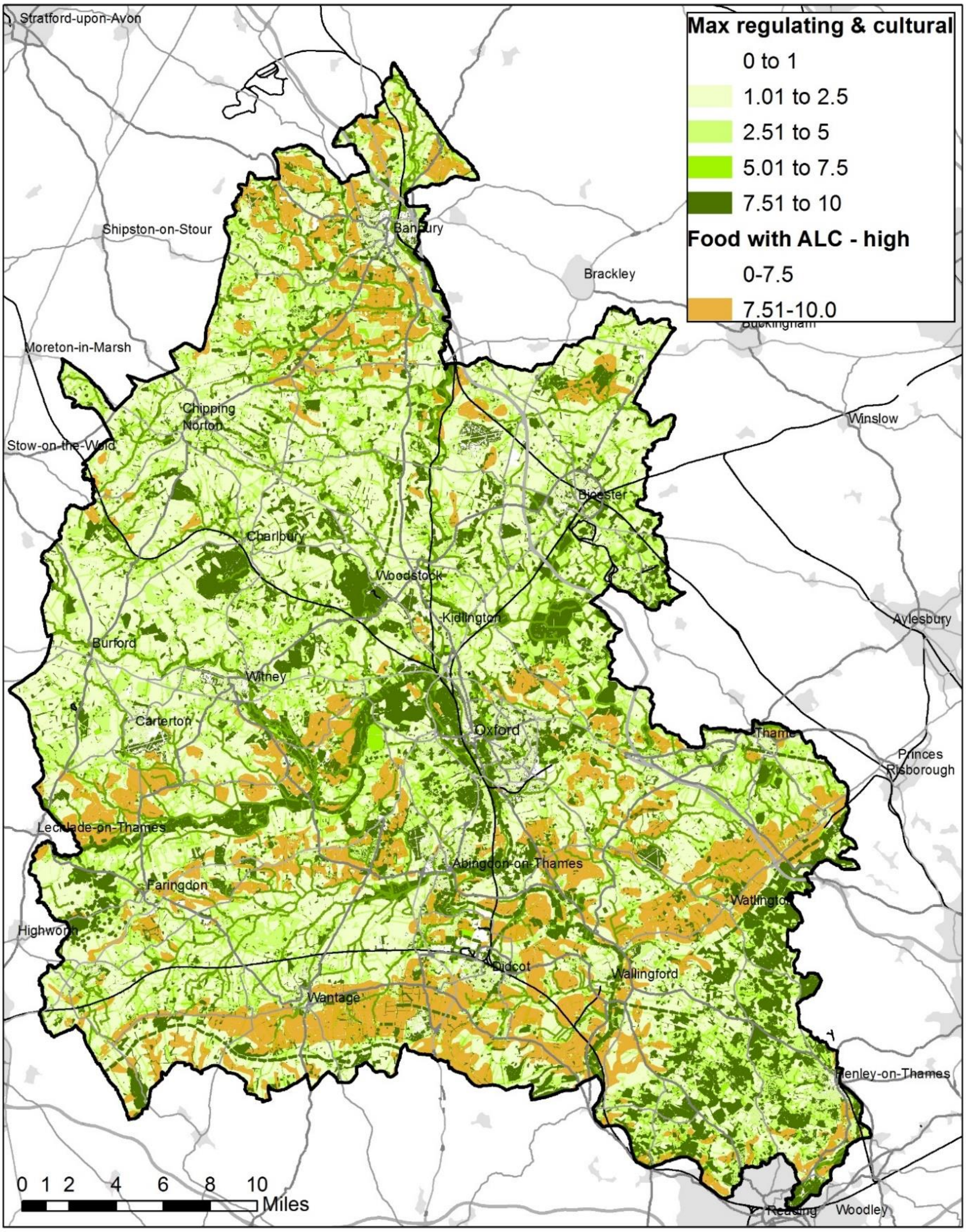

Figure 27: Maximum score for cultural and regulating services (green) or food provision (orange). This map does not show the score for water supply.

Note that mapping the maximum score does not distinguish between areas that provide multiple services and those that only provide one service. It would be possible to map the number of services delivered. However, this could be misleading as areas delivering 'only' food production could appear to be unimportant, yet clearly this is an essential service.

7.3 Strategic networks of green infrastructure for people and nature

One major use of these natural capital maps is that they can help to inform the identification of current and future strategic networks of high value green infrastructure. These could be developed in tandem with the new Nature Recovery Networks (NRNs) for Oxfordshire, to create robust habitat networks that also deliver benefits for people[2]. We have produced a separate report showing how the areas of high natural capital value overlap significantly with the draft NRNs (Smith and Hopkins, 2020), as shown in Figure 28. It is important to be aware of these network opportunity areas when deciding where to site new development, so that potential high value green infrastructure networks are not cut off by inappropriate development.

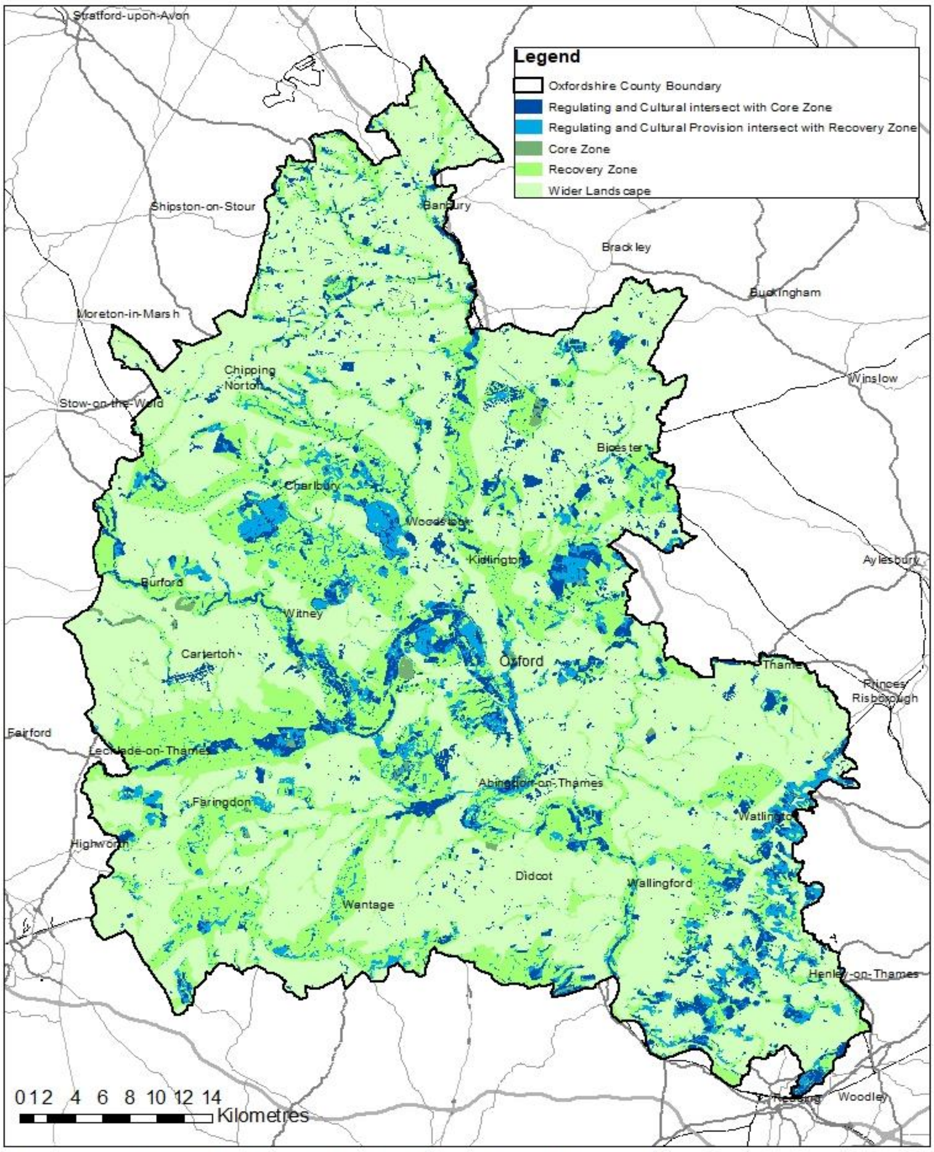

Figure 28 Overlaps between areas scoring highly for regulating and cultural services (blue) and Nature Recovery Networks (green)

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[2] https://www.wildoxfordshire.org.uk/biodiversity/draft-map-of-oxfordshires-nature-recovery-network/

Figure 29 shows a closer view of the area around Oxford, showing the high-scoring areas for regulating and cultural ecosystem services (blue) that intersect the NRNs (green). This highlights hotspots such as the seminatural grasslands south and east of Bicester, the Otmoor area, Blenheim Park near Woodstock, and green infrastructure networks along the river valleys.

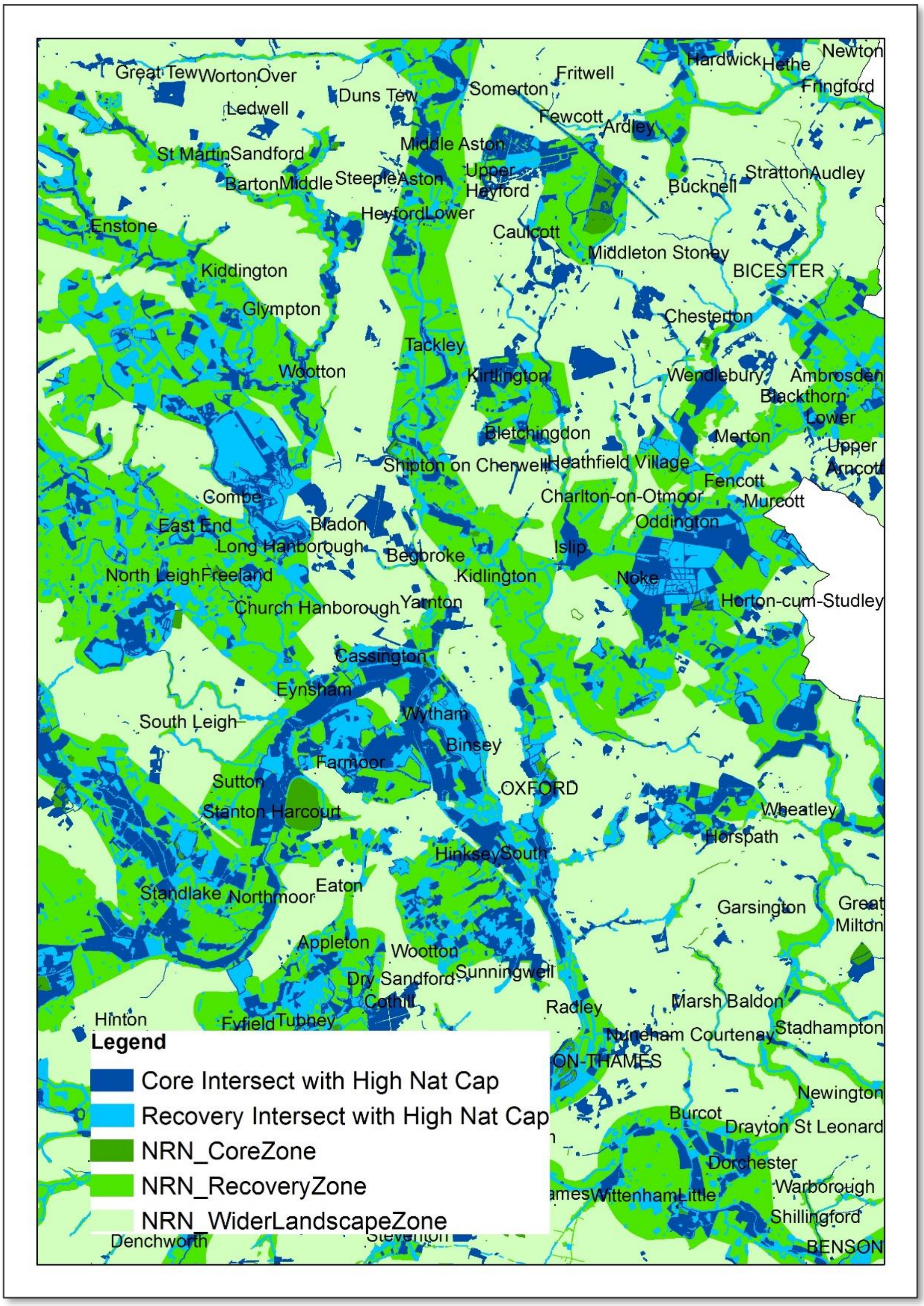

Figure 29. Closer view of overlaps between high-scoring natural capital areas and Nature Recovery Networks

7.4 Identifying low value areas where there may be opportunities to enhance natural capital

Figure 30 shows areas that score 2.5 or less for all services. These areas could be suitable for habitat enhancement, perhaps as part of Nature Recovery Networks. Further identification of suitable areas for enhancement would be facilitated by the extension of this approach to map the demand for services, in order to identify gaps between supply and demand (see 'Next steps').

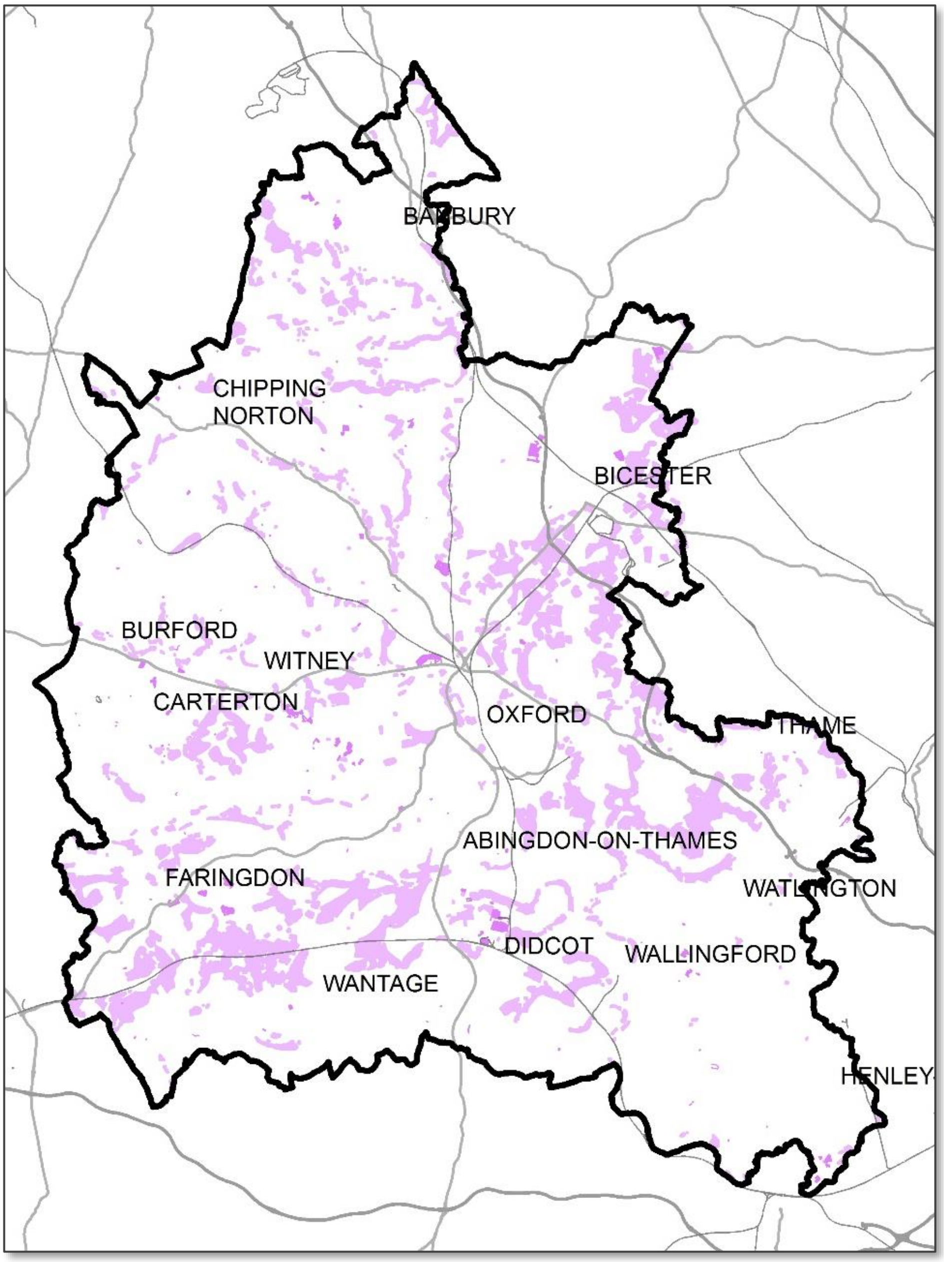

Figure 30: Low scoring areas, suitable for habitat enhancement

8 Next steps

This mapping approach has now been extended to the wider Oxford-Cambridge Arc, to help integrate Oxfordshire's plan with those of neighbouring areas (with funding from the University of Oxford's MISTRAL project and the Environment Agency's Local Natural Capital Plan for the Arc).

There are a number of opportunities to improve and extend the natural capital mapping exercise:

- Gathering further feedback from stakeholders, following the improvements made in response to comments at the June 2019 workshop.
- Gathering and incorporating information on:
    - District Wildlife Sites or their equivalent;
    - Countryside Stewardship schemes, to inform multipliers for interaction with nature, pollination, pest control, flood protection, water quality regulation, erosion protection and carbon storage;
    - Carbon stored in soil;
    - SSSI condition.
- Assessing demand for ecosystem services, so that gaps between supply and demand can be identified to guide future investment planning. This will require spatial analysis of where the demand for the service is located.
- Assessing the difference between alternative spatial strategy scenarios. Some preliminary work has taken place on this, but the results were dominated by the very different footprint areas of the spatial options, which will not reflect their actual impacts on the ground (assuming that the number of houses is the same in each scenario).

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Appendix 1: Matrix of ecosystem service scores for each habitat type

Habitat	Food production	Wood production	Fish provsion	Water supply	Flood regulation	Erosion protection	Water quality regulation	Carbon storage	Air quality regulation	Cooling and shading	Noise reduction	Pollination	Pest Control	Recreation	Aesthetic value	Education	Interaction with Nature	Sense of Place	Biodiversity
Broadleaved, mixed and yew semi-natural woodland	1	6	0	3	9	10	10	10	7	10	8	7	8	10	10	10	10	10	8
Broadleaved, mixed and yew plantation	0	8	0	2	9	8	8	9	7	10	8	6	6	10	10	6	7	8	5
Native pine woodlands	0	0	0	3	9	8	6	7	8	10	10	6	8	10	10	10	10	10	8
Coniferous plantation	0	10	0	1	10	6	5	8	10	10	10	2	6	10	6	6	4	6	2
Wood pasture and parkland with scattered trees	5	2	0	7	6	8	6	5	3	6	4	9	8	10	10	8	8	10	10
Traditional orchards	5	1	0	7	8	8	5	5	4	8	4	9	8	8	10	8	7	10	8
Dense scrub	1	2	0	4	6	8	5	6	7	6	6	9	10	8	8	6	8	6	5
Hedgerows	1	1	0	4	6	8	5	5	7	6	6	9	10	8	10	8	10	10	10
Hedgerow with trees	1	2	0	4	7	9	5	7	8	7	7	10	10	8	10	10	10	10	10
Felled woodland	0	0	0	4	1	0	1	2	0	1	1	1	3	5	1	1	1	1	2
Tall herb and fern	1	0	0	8	5	8	5	4	1	2	1	8	10	8	10	6	8	4	3
Ephemeral / short perennial	1	0	0	5	3	4	3	2	1	2	1	8	10	10	8	6	8	4	3
Bracken	1	0	0	8	5	8	5	4	1	2	1	6	8	8	6	4	6	2	5
Semi-natural grassland	6	0	0	9	4	8	4	4	1	2	1	9	8	10	10	10	10	10	8
Acid grassland	6	0	0	9	4	8	4	4	1	2	1	7	8	10	10	10	10	10	8
Calcareous grassland	6	0	0	9	4	8	4	3	1	2	1	10	8	10	10	10	10	10	8
Neutral grassland	6	0	0	9	4	8	4	4	1	2	1	9	8	10	10	10	10	10	8
Calaminarian grasslands	1	0	0	5	3	4	3	2	1	2	1	8	10	10	8	10	10	10	
Poor semi-improved grassland	8	0	0	8	3.5	6	2.5	3.5	1	2	1	5.5	5.5	10	7	6	6	7	5
Improved grassland	10	0	0	7	3	4	1	3	1	2	1	2	3	10	4	2	2	4	2
Arable fields, horticulture and temporary grass	10	0	0	7	2	1	0	2	1	2	1	2	2	6	2	2	1	2	2
Arable field margins	0	0	0	8	4	6	5	2	1	2	1	8	8	10	8	6	6	4	6
Woody biofuel crops	0	10	0	3	4	2	1	4	1	2	1	2	4	6	2	2	1	2	5

Habitat	Food production	Wood production	Fish provsion	Water supply	Flood regulation	Erosion protection	Water quality regulation	Carbon storage	Air quality regulation	Cooling and shading	Noise reduction	Pollination	Pest Control	Recreation	Aesthetic value	Education	Interaction with Nature	Sense of Place	Biodiversity
Intensive orchards	10	1	0	3	8	6	1	5	4	8	4	6	4	6	8	2	1	2	2
Bog	1	0	0	10	5	8	7	10	1	4	1	4	3	8	8	10	10	10	10
Dwarf shrub heath	1	0	0	8	5	8	5	4	1	2	1	10	9	10	10	8	10	10	8
Inland rock	0	0	0	0	0	0	0	0	0	0	0	0	0	8	10	10	6	10	8
Freshwater	0	0	10	10	1	0	1	1	0	4	0	1	2	10	10	10	10	10	8
Standing open water and canals	0	0	10	10	4	0	1	1	0	4	0	1	2	10	10	10	10	10	8
Running water	0	0	10	10	1	0	1	0	0	4	0	1	2	10	10	10	10	10	8
Fen, marsh and swamp	1	0	0	10	4	8	7	6	1	4	1	4	3	6	10	10	10	10	8
Lowland fens	1	0	0	10	4	8	7	6	1	4	1	4	3	6	10	10	10	10	10
Purple moor grass and rush pastures	4	0	0	9	4	8	7	4	1	2	1	4	6	10	10	8	10	10	10
Upland flushes, fens and swamps	1	0	0	10	4	8	7	6	1	4	1	4	3	6	10	10	10	10	8
Aquatic marginal vegetation	0	0	10	10	4	8	7	2	1	4	1	6	8	6	10	10	10	10	5
Reedbeds	0	0	10	10	4	8	7	4	1	4	1	2	3	6	10	10	10	10	8
Other swamps	1	0	0	10	4	8	7	4	1	4	1	4	3	6	10	8	10	10	5
Coastal rock	0	0	0	0	8	10	2	0	0	0	0	0	3	10	10	10	10	10	8
Biogenic reefs	0	0	10	0	8	10	6	4	0	0	0	0	3	10	10	10	10	10	
Coastal saltmarsh	4	0	10	0	6	8	6	4	1	4	1	3	3	6	10	10	10	10	10
Coastal lagoons	0	0	10	0	4	0	1	1	0	4	0	1	2	10	10	10	10	10	
Seagrass beds	0	0	10	0	4	10	10	4	0	0	0	0	3	10	10	10	10	10	
Vegetated dunes and shingle	1	0	0	2	5	8	1	1	0	1	1	9	3	10	10	8	8	10	8
Beach and bare sand	0	0	0	2	5	6	0	0	0	0	0	0	2	10	10	8	6	10	2
Other littoral sediment	0	0	0	0	2	6	0	1	0	2	1	0	0	6	6	8	8	10	8
Sealed surface and buildings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Artificial unvegetated, unsealed surface	0	0	0	4	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Bare ground	0	0	0	4	1	0	1	1	0	1	0	1	1	6	0	0	0	0	1

Habitat	Food production	Wood production	Fish provsion	Water supply	Flood regulation	Erosion protection	Water quality regulation	Carbon storage	Air quality regulation	Cooling and shading	Noise reduction	Pollination	Pest Control	Recreation	Aesthetic value	Education	Interaction with Nature	Sense of Place	Biodiversity
Garden	0.5	0	0	3	2	2	1	1	1	1	1	3	2	10	2	2	2	2	2
Vegetated garden	1	0	0	7	3	5	2	2	2	2	2	6	4	10	6	4	4	4	3
Unvegetated garden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Open mosaic habitats on previously developed land	0	0	0	5	2	4	1	2	1	2	1	6	6	10	6	8	6	4	8
Parks and gardens	0	0	0	7	3	5	2	4	3	4	2	6	8	10	8	6	6	6	5
Footpath / cycle path - green	0	0	0	5	2	3	1	2	1	2	1	4	4	10	6	2	4	6	2
Green bridge	0	0	0	5	2	1	1	1	1	2	1	2	2	10	6	6	8	8	10
Amenity grassland	0	0	0	7	3	4	2	3	1	2	1	2	2	10	5	2	2	2	2
Road island / verge	0	0	0	5	3	4	2	3	1	2	1	2	2	6	5	2	2	2	2
Natural sports facility, recreation ground or playground	0	0	0	7	3	3	2	3	1	2	1	2	2	10	2	2	2	4	2
Cemeteries and churchyards	0	0	0	7	3	4	2	4	2	2	1	6	4	6	6	2	4	8	5
Allotments, city farm, community garden	7	0	0	7	2	1	1	3	2	2	2	8	4	10	5	6	4	10	5
Intensive green roof	0	0	0	0	3	1	1	2	1	6	1	6	4	6	5	4	2	6	3
Green wall	0	0	0	0	1	1	1	1	4	6	2	6	4	0	6	4	2	6	2
Brown roof or extensive green roof	0	0	0	0	1	1	1	1	1	2	1	7	8	6	4	4	4	6	5
Tree	0	1	0	1	6	6	2	7	6	8	4	7	8	8	10	8	8	10	5
SuDS retention pond	0	0	0	10	10	4	6	3	1	3	1	3	3	10	6	3	3	3	4
SuDS detention basin	0	0	5	10	10	0	1	4	0	4	0	3	3	10	8	7	7	7	3
Bioswale	0	0	0	5	5	2	2	2	1	4	1	5	4	8	8	4	6	4	3
Rain garden	0	0	0	10	5	2	7	2	1	4	1	6	6	6	10	6	8	6	3
Introduced shrub	0	1	0	4	5	6	4	4	4	6	6	6	6	8	8	2	4	4	2
Flower bed	0	0	0	7	2	2	1	2	1	2	1	6	6	8	10	2	6	4	5
Suburban/ mosaic of developed/ natural surface	0.2	0	0	1.4	0.6	1	0.4	0.4	0.4	0.4	0.4	0	0.8	2	1.2	0.8	0.8	0.8	0.6

Appendix 2: Stakeholder workshop report

Natural Capital Mapping in Oxfordshire

Monday 17th June 2019 12.30-4.30 pm

Gottman Room, Oxford University Centre for the Environment, South Parks Road, Oxford OX1 3QY

Context

This workshop was organised by Alison Smith, a senior research associate at the Environmental Change Institute, as part of an Oxford Policy Exchange Network (OPEN) fellowship. OPEN is a new scheme funded by the Higher Education Innovation Fund to help the University of Oxford translate research into policy and practice. Alison is working with Oxfordshire County Council, with support from Cherwell District Council, developing evidence on natural capital to feed into development of the Oxfordshire Plan to 2050. She has developed some draft natural capital maps using a simple land-use scoring system (see the advance information document for a summary of the approach) and the aim of the workshop was to seek feedback from relevant stakeholders.

Agenda

12.30	**Lunch**
12.50	Welcome and introductions
13.00	Presentation on the mapping approach – Alison Smith
13.30	Q&A
13.45	Examination and small group discussion of draft natural capital maps
14.30	Plenary discussion - feedback on draft maps
15.00	**Tea and Coffee**
15.15	Update on the OP2050 (Andrew Thomson, Oxfordshire County Council)
15.30	Update on Nature Recovery Networks (Dan Carpenter, TVERC)
15.40	The way forward – could the maps feed into OP2050, Local Plan updates, nature recovery networks?
16.30	**Finish**

Key feedback

The matrix of scores. Development of the scores in the matrix has taken place in a series of projects over the last five years. Sources include the outputs from a stakeholder workshop in Warwickshire, a systematic literature review of 780 papers, a comparison of over 30 different tools, and a series of expert consultations as part of Natural England's eco-metric project. Although most of the scores are indicative rankings, scores for two services (carbon storage and air quality regulation) are proportional to observed or modelled data. Scores for the cultural ecosystem services are partly subjective, and although multiple sources have been used there is still disagreement between sources reflecting differing personal opinions (e.g. on the aesthetic value of a bog). Interestingly, the workshop attendees did not query any of the scores in the matrix, instead focusing on issues concerning the presentation of the maps.

Individual maps for ecosystem services. Maps for individual ecosystem services were generally felt to be clear and easy to understand. However the underlying land use maps could benefit from additional ground-truthing and bringing in extra information to adjust the scores. Suggestions included:

- **Adding Biodiversity Action Plan habitat designations** rather than just relying on Phase 1 habitat survey classifications. For example, Stratton Audley Quarry is mapped as a quarry under Phase 1, so is shown as having a very low score, but it is a local wildlife site and classed as Open Mosaic Habitats on Previously Developed Land under BAP.

- **Funding TVERC to do further ground truthing of the Phase 1 maps,** which are currently mainly derived from aerial photos.

Averaging the scores. Because all the regulating and cultural services show very similar patterns, the 'overall' natural capital map displayed an average score for all these services. This is not technically correct because the scores are not in comparable units. Although this approach was adopted in order to simplify the results, feedback was that participants would prefer to look at the individual services, or small groups of similar services.

Presentation of the maps. There was much discussion on the presentation of the overall maps of natural capital. Many attendees found the combination of the food provision map with the average score for regulating and cultural services problematic. For example, it was not clear which of the high-scoring (dark green) areas were scoring highly for food provision, and which were scoring highly for the combined (average) cultural and regulating services.

Interpreting the maps. The maps identified 'low natural capital' areas (those scoring less than 2.5 out of 10 for both food provision and the average of all regulating and cultural services) in purple. These areas could be interpreted both as areas where development would cause less natural capital loss, and as areas where there is a high potential to improve delivery of ecosystem services through habitat enhancement. Feedback confirmed that the first of these options was somewhat problematic, as there are many other factors that need to be taken into account when identifying areas for development, such as landscape impacts and transport links.

Potential uses of the maps. The maps were felt to be potentially useful for:

- Providing an evidence base on where natural capital is located in Oxfordshire, to inform OP2050 and potentially Local Plan updates.
- Identifying 'high natural capital areas' that should be avoided if possible during development, or mitigated through enhancing natural capital elsewhere.
- Identifying 'low natural capital' areas that could be enhanced, potentially through being incorporated into nature recovery networks.
- As a starting point for further work to assess demand for natural capital, gaps between supply and demand, and opportunities for improvement (as proposed by TVERC).

Attendees

Janice	Bamsey	West Oxfordshire District Council
Jenny	Barker	Cherwell District Council
Ann	Berkeley	Evenlode Catchment Partnership
Pam	Berry	ECI
Venina	Bland	Oxfordshire County Council
Haidrun	Breith	Oxfordshire County Council
Dan	Carpenter	TVERC
Roselle	Chapman	Wild Oxfordshire
Christina	Cherry	Cherwell District Council
Neil	Clennell	Wychwood Project
Mark	Connelly	Cotswolds AONB
Kath	Daly	Chilterns AONB
Melanie	Dodd	Cotswold District Council
Andy	Fairbairn	BBOWT
Jonathan	Fleming	Environment Agency
Vicky	Fletcher	Oxfordshire County Council
Louise	Fox	Oxfordshire County Council

Richard	Harding	CPRE
Mai	Jarvis	Oxford City Council
Dominic	Lamb	South and Vale District Councils
Ceri	Lewis	Natural England
Sue	Marchand	Cherwell District Council
Beccy	Micklem	Natural England
Nick	Mottram	Oxfordshire County Council
Oliver	Murray	Publica
Kate	Prudden	BBOWT
Sue	Roberts	South Oxfordshire District Council
David	Rogers	Professor of ecology (retired)
Alison	Smith	University of Oxford
Charlie	Stratford	CEH
Andrew	Thomson	Oxfordshire County Council
Colin	Wilkinson	RSPB

Apologies

Jeremy	Biggs	FWHT
Scott	Brown	TOE
Daryl	Buck	Environment Agency
Camilla	Burrow	TVERC
Georgia	Craig	NFU
Fiona	Danks	TOE
Veronica	James	Environment Agency
Lewis	Knight	Bioregional
Nicole	Lazarus	Bioregional
Stuart	Malaure	Environment Agency
Paul	Orsi	Sylva
Chris	Parker	Earth Trust
Richard	Pearce	Forestry Commission
Dawn	Pettis	Oxfordshire County Council
Mike	Pollard	RSPB
Sam	Riley	Forestry Commission
Graham	Scholey	Environment Agency
Jayne	Manley	Earth Trust