Natural Capital and Ecosystem Service Mapping for the Malvern Hills AONB

Methodological approach and output specifications

June 2021

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Executive Summary

The Malvern Hills AONB Partnership commissioned this report and GIS modelling of natural capital assets and ecosystem services for the Malvern Hills AONB. The work is a contributing element to a Nature Recovery Plan which will be produced for the AONB under the commitments of the Colchester Declaration.

This report seeks to review and assess the natural capital assets of the Malvern Hills AONB and the ecosystem services that are provided by these assets. The report also acts as a technical methods document for the GIS modelling work undertaken as part of this project.

The project consists of two phases, the first of these concerns the GIS modelling work, the second, the production of this technical report. The GIS modelling work explores the role of the natural capital assets of the Malvern Hills AONB and the surrounding region in producing a series of ecosystem services. Opportunity for enhancement of these ecosystem services has also been mapped. Regarding these mapped GIS outputs, this technical report: (i) outlines the methods applied in producing the GIS outputs, (ii) presents these GIS outputs, and (iii) and offers an interpretation of these.

To map ecosystem services, we use the habitat service scoring matrix (HSSM) approach developed by Natural England and the Environmental Change Institute at the University of Oxford. This scores habitat types according to their potential to deliver different ecosystem service. These scores are then adjusted by geospatial datasets to recognise aspects of the environment – other than habitat – that contribute to the potential for a given area to deliver an ecosystem service. In considering cultural ecosystem services we have also applied our novel approach, developed as part of our Gloucestershire natural capital mapping project, which values the potential of habitats to contribute to a cultural ecosystem through the activities it can support. As part of this project, we further extended the HSSM approach by developing a technique to spatialise the role of landscape character in ecosystem services.

In summary, this project is grounded in established methods of natural capital and ecosystem service mapping and looks to move beyond and advance these methods through integrating landscape character and the historic environment.

Ecosulis would like to thank Paul Esrich at the Malvern Hills AONB Partnership for his invaluable guidance and support throughout the project, in addition to the project data team for their frequent and valuable contributions and guidance, in particular in the development of the landscape elements of the report.

1. Introduction

1.1.1. In January 2021, Ecosulis were commissioned to develop ecosystem service baseline maps for the Malvern Hills Area of Outstanding Natural Beauty and surrounding land within a 3km radius. This study area encompasses land in Worcestershire, Herefordshire, and Gloucestershire.

1.1.2. The aim of the spatial mapping exercise is to contribute towards the development of a Nature Recovery Plan for the Malvern Hills AONB. There are two main elements of this exercise:

i) Production of a suite of ecosystem service baseline and opportunity maps for the Malvern Hills AONB and a surrounding buffer area of 3 km.

ii) Integration of an analytical mapping technique recognising landscape character and the historic landscape, and how these interact with ecosystem services.

1.1.3. This technical report contains three sections. The first of these is an introduction to ecosystem services, landscape, and heritage and their relation to spatial planning. The second specifies the methodological approach taken to generate the suite of ecosystem service maps and to integrate concepts of landscape and heritage. Finally, the third section presents these maps alongside a technical specification for each.

2. Integrating Natural Capital, Ecosystem Services, and Landscape

2.1. Natural capital and ecosystem service mapping: a brief introduction

2.1.1. The concept of natural capital arose during the early 1990s (Costanza & Daly, 1992) to address shortcomings of conventional economics in relational to the environment. The UK Government's Natural Capital Committee (NCC) defines natural capital as '*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*' (NCC, 2017). 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. The core idea is that natural capital assets (habitats) can be degraded or improved, and such changes affect the 'production' of ecosystem goods and services.

2.1.2. Ecosystem services are defined by The Millennium Ecosystem Assessment (2005) as '*the benefits people obtain from ecosystems*', and they can be considered as the services which flow from natural capital assets. The Millennium Ecosystem Assessment (2005) established four broad categories of ecosystem services, namely: supporting services, provisioning services, regulating services, and cultural services. DEFRA has introduced a fifth subcategory of provisioning services entitled 'abiotic flows of nature capital' (Table 1). The latest DEFRA (2020) guidance also adopts a category of '*bundled ecosystem*' services in recognition of the fact that benefits produced from natural capital are not always easy to disaggregate into specific ecosystem services, and many supporting services are included in what they term '*reducible*' bundled services (e.g., biodiversity).

2.1.3. The 2020 DEFRA guidance has further sub-divided these categories into 18 ecosystem types with tangible examples of each service that can be mapped, measured, and assigned a value. This is based upon the Natural Ecosystems Assessment Methods of Natural Capital (2016).

Ecosystem Service Category	Description	Examples
Provisioning	Tangible outputs that can be obtained from ecosystems that meet human needs	Food & timber supply
Regulating	Ecological processes that regulate and reduce pollution and other adverse effects	Air filtration, water regulation, noise mitigation
Cultural	Environmental settings that enable cultural interaction and activity	Settings for recreation, education, tourism
Aggregated/ bundled	In practice the benefits provided by nature are not easily reducible to specific ecosystem services or can reflect a bundle of cultural or regulating services. There can be overlap with these categories.	Amenity, biodiversity, landscape, water quality, non-use values
Abiotic flows of natural capital	Flows which are not dependent upon functioning ecosystems	Minerals, oil & gas, solar, wind and tidal power

Table 1: Services provided by Natural Capital, source: Enabling a Natural Capital Approach Guidelines (Defra, 2020).

Ecosystem Service Category	Description	Examples
Supporting	These do not produce outputs for final consumption or production, but are essential for the functioning of provisioning, regulating and cultural services, which do provide outputs	Soil formation, pollination

Table 1: Services provided by Natural Capital, source: Enabling a Natural Capital Approach Guidelines (Defra, 2020).

2.1.4. The purpose of natural capital mapping is to make the benefits provided by nature explicit in decision making and different forms of spatial planning. Natural capital mapping also supports the development of market mechanisms to protect and restore nature, notably payments for ecosystem services (PES) and markets for natural capital credits (e.g., biodiversity, nitrate, and carbon) linked to new policies (such as biodiversity net gain) and to corporate Environmental & Social Governance (ESG) requirements associated with ambitions to become carbon neutral and nature positive in business operations.

2.1.5. In spatialising the distribution of natural capital assets and their associated ecosystem services (actual and potential for use in different types of spatial planning), the ecosystem service framework enables the design of market mechanisms. Notably, these mechanisms include payments for ecosystem services (PES) and markets for environmental credits. Each of these mechanisms holds potential to introduce private capital into the protection and management of natural capital assets. The conceptual components of natural capital, including links to ecosystem services are shown further in Figure 1.

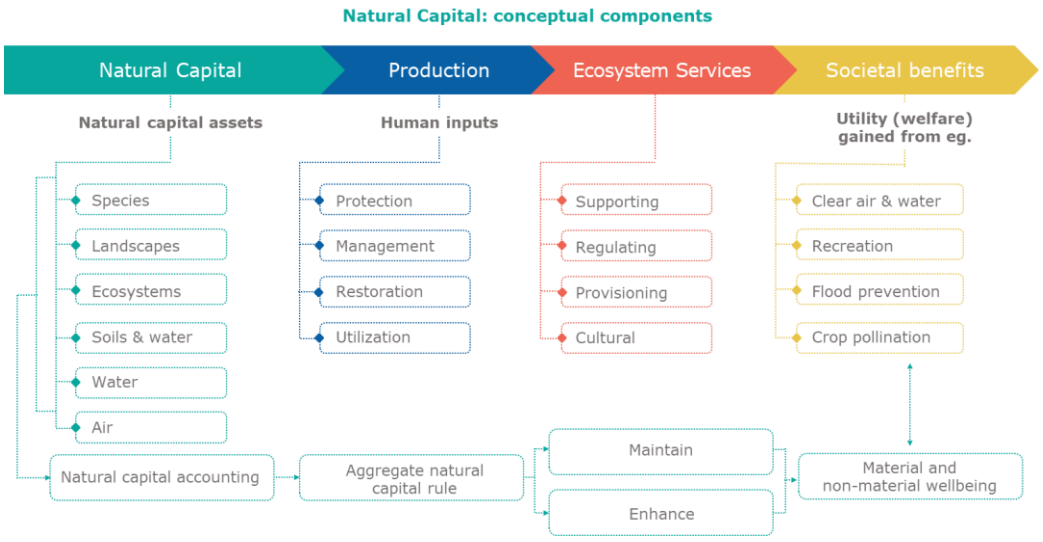

Figure 1: Conceptual components of natural capital, including ecosystem services

2.1.6. To operationalise the natural capital approach, DEFRA considers different types of habitat[1] to be synonymous with natural capital assets. There are generally two components to natural capital mapping: (a) mapping the distribution and state of natural assets (habitats) and their associated ecosystem services, and (b) identifying the potential economic and social benefits from the

[1] Habitat types were assigned according to the UK Habitats classification (eCountability, undated)

protection, restoration and/or creation of natural capital assets in strategic locations as a basis for i) more efficient delivery of public services, ii) attracting private investment, and/or iii) strategic identification of land for natural capital credit generation

2.1.7. Natural capital mapping involves the production of raster (grid cell) maps that assign a nature-related value to different areas. An advantage of the natural capital mapping approach is that all land is assigned a value describing the contribution to an ecosystem service made by natural capital asset within that cell, whereas the established polygon-based approach used for ecological network and biodiversity priority mapping leaves large areas of the map blank. Because of this, natural capital maps are better suited to master planning (which often involves modelling), attracting investment and the possibly for promoting nature recovery in agricultural settings, for example, through integration with the new Environmental Land Management Schemes (ELMS).

2.1.8. Approaches for natural capital mapping in the UK are still under development. In preparation for an earlier project in Gloucestershire (Ecosulis, 2020), we reviewed these different approaches and adopted the habitat service scoring matrix (HSSM) approach, using habitat as a proxy for natural capital assets[2]. The HSSM approach was first applied by Natural England in 2014 at a national scale and has been further developed by Oxford University's Environmental Change Institute (ECI).

2.1.9. The HSSM approach is based on a scoring matrix that assigns a score (0–10) to the potential of a habitat type to generate the list of 18 ecosystem services specified in the DEFRA guidance (ITRC, 2020). The scores enable the production of ecosystem service (natural capital) maps based on existing habitat maps. The HSSM was initially generated by expert assessment, but the ECI refined the scores based on the findings of a major systematic review of 780 scientific papers that provided evidence on links between natural capital and 13 regulating, provisioning, and cultural ecosystem services (Smith *et al.,* 2017). A second methodological innovation was the application of 'multipliers' to some ecosystem services scores in locations where other factors may influence the supply of services, such as habitat quality and spatial location.

2.1.10. The HSSM is a key component of a forthcoming Eco-metric tool that is being co-developed with DEFRA and Natural England to work alongside the DEFRA biodiversity metric to support the delivery of natural capital net gain (that links biodiversity net gain with environmental net gain). This tool is designed to provide a high-level indicator (cf. GDP) of the state of well-being benefits generated from the ecosystem services produced by natural capital stocks. It does not involve a spatial component. However, the basic logic of the Eco-metric and biodiversity metric tools is the same, and each tool offers ideas for how county-level natural capital mapping could be adapted to an index and/or investment return.

2.1.11. It was agreed with the client that the approach to natural capital and ecosystem services mapping in the Malvern Hills AONB study area would follow the HSSM model[3]. This would ensure a spatially consistent approach with the Gloucestershire natural capital mapping study (2020) which overlaps the southern part of the AONB. However, a limitation of the HSSM approach when applied to AONBs is that it does not currently account for landscape character. To address this, we worked

[2] For more information, please see Ecosulis (2020) Technical Report (DOI: 10.32071/ES.TD.011120)
[3] The HSSM model assigns a value to each habitat type, based on its potential to provide a given ecosystem service. This approach is described in detail in Section 3.1 of this report.

with the project advisory group to develop a new technique that builds from (extends) the HSSM approach. Natural capital mapping is still relatively new in the UK, and this element offers a contribution to the development of such methods.

2.1.12. More generally, cultural ecosystem services have proved the most challenging aspect of natural capital to map. In the Gloucestershire natural capital mapping study (Ecosulis, 2020), the HSSM approach was extended to develop an improved technique for spatialising cultural ecosystem services based on the suitability of habitats to support a series of value generating practices (VGPs) and the diversity of the VGPs supported by each habitat. We have provided more detail on this element of the approach in Section 3.3.

3. Methodological Approach

3.1. Methods and approach to mapping ecosystem services

3.1.1. To map ecosystem service baseline and opportunities in the Malvern Hills AONB we applied the Habitat Service Scoring Matrix (HHSM) approach developed by Smith et.al (2020). A summary of the approach is presented below and a detailed account of the methods is available in our report '*Natural capital and ecosystem service mapping for Gloucestershire: Methodological approach and output specifications*', DOI: 10.32071/ES.TD.011120) (Ecosulis, 2020).

3.1.2. The key methodological steps are shown in Figure 2. Under the HSSM natural capital mapping approach habitats are reframed as natural capital assets and act as a proxy for potential areas to produce ecosystem services. The first step in the process was to produce a habitat map for the Malvern Hills AONB and buffer area. This map was produced by Gloucestershire Wildlife Trust (2021).

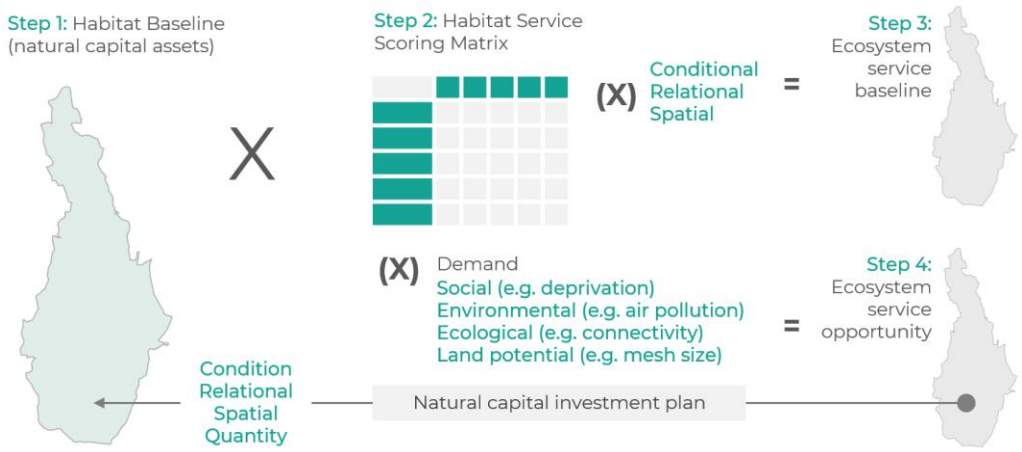

Figure 2: Methodological flow used to map ecosystem services in the Malvern Hills AONB. Adapted from Smith (2020).

3.1.3. Secondly, habitat types are assigned values through the Habitat Service Scoring Matrix, where values of 0 mean that the habitat does not produce the ecosystem service specified, 1–3 = low level of production, 4–6 = moderate level and 7–10 = high level. A Project Steering Group comprised of local specialists in landscape and heritage reviewed and adapted values from the scoring matrix previously applied in Gloucestershire. This ensured that assigned values were appropriate to the local context of the Malvern Hills AONB study area (see Annex 2).

3.1.4. The HSSM approach produces up to two outputs for each ecosystem service: baseline and opportunity maps. In the third step, ecosystem service baseline maps are produced for all ecosystem services and represent the potential of existing natural capital assets to deliver an ecosystem service. Opportunity maps are produced where ecosystem service requirement is associated with specific areas, or where potential benefits are diffuse and less localised. Baseline and opportunity maps may be adjusted using ecosystem service modifiers (Figure 2). These modifiers allow recognition of additional geospatial factors (alongside habitat) which may affect the potential of – or opportunity for – a habitat to provide an ecosystem service. For example, the ability of a habitat to provide the ecosystem service of air pollution regulation is impacted by its proximity to air pollution sources.

3.2. Integrating landscape, heritage, and ecosystem services

3.2.1. To better recognise the material elements of landscape and heritage within ecosystem service and natural capital discourse, we worked with local landscape and heritage specialists on the project steering group to devise an extension to the HSSM approach. The challenge was to score the relationship between landscape character type (LCT), habitat type, and ecosystem services. As the HSSM approach frames ecosystem service production through habitat parcels, our approach assesses the role of habitat in producing LCTs. An overview of current approaches to assessing landscape character is given in Annex 8.

3.2.2. Landscape character is defined by Tudor (2014) as 'a distinct and recognisable pattern of elements, or characteristics, in the landscape that make one landscape different from another'. Historic landscape character seeks to describe the current landscape character in recognition of the processes which have shaped it. In addition, historic landscape character is often closely linked to cultural ecosystem services but is also materially linked to all other ecosystem services through the physical assets associated with the historic environment (Fluck & Holyoak, 2017).

3.2.3. The Malvern Landscape Character Assessment lists broad habitat types that contribute to and define the landscape of the AONB. Landscape character types are defined as '*distinct types of landscape that are relatively homogeneous in character*' (Tudor, 2014).

3.2.4. The first step in our approach links LCT and habitat type. To do this, we created a scoring matrix. Each habitat was scored on a three-point scale according to the contribution it makes to each landscape character type In the Herefordshire and Worcestershire parts of the study area. This was done using LCT descriptions published by Worcestershire County Council (undated)[4]. These published descriptions provide indications of whether certain habitats are of primary, secondary or tertiary importance in each LCT. In the Gloucestershire part of the study area the Forest of Dean Landscape Character Assessment was reviewed, and professional judgement applied to establish whether habitats were of primary, secondary, or tertiary importance. In each LCT, primary habitat types were scored with a value of 2, secondary and tertiary habitat types a value of 1, and all other habitats a value of 0. These scores were then reviewed and adjusted as appropriate by local landscape and heritage specialists. This matrix is provided in Annex 3.

3.2.5. The next step was to spatially join habitat units to the landscape character type. This was necessary as the contribution of habitat to landscape character is a function of both habitat and landscape character type. Next, each habitat was assigned a score for its contribution to landscape character type. These values are presented in Annex 3.

[4] This report is available for download from: https://www.worcestershire.gov.uk/downloads/download/808/worcestershire_landscape_type_profiles

3.2.6. A visual summary of this approach is provided in Figure 3 below, where greyscale shading represents the habitat type of each habitat unit, orange shading represents LCT units, and blue shading represents habitat character values derived from both LCT and habitat type of each habitat unit.

Figure 3: illustration of the process followed to assign habitat character scores to habitat units (referred to as sub-habitat types)

3.2.7. Once classification of the character of habitats in each LCT had been reviewed, all habitat parcels within the study area were allocated both an LCT name and a score for the contribution of the habitat to the LCT. HSSM scores were then aggregated to calculate the mean HSSM score for least characteristic, moderately characteristic, and highly characteristic habitat within each LCT within the study area. These mean values were then weighted by the proportion by area of each habitat group in each LCT, to recognise that highly characteristic habitat may be dominant in one LCT, but much more confined to smaller areas in others. This process is illustrated in Figure 4, below. The Python script used to aggregate these values is provided in Annex 6. It is important to note that these values do not account for any spatial modifiers applied to the baseline, and instead take the raw HSSM values as input.

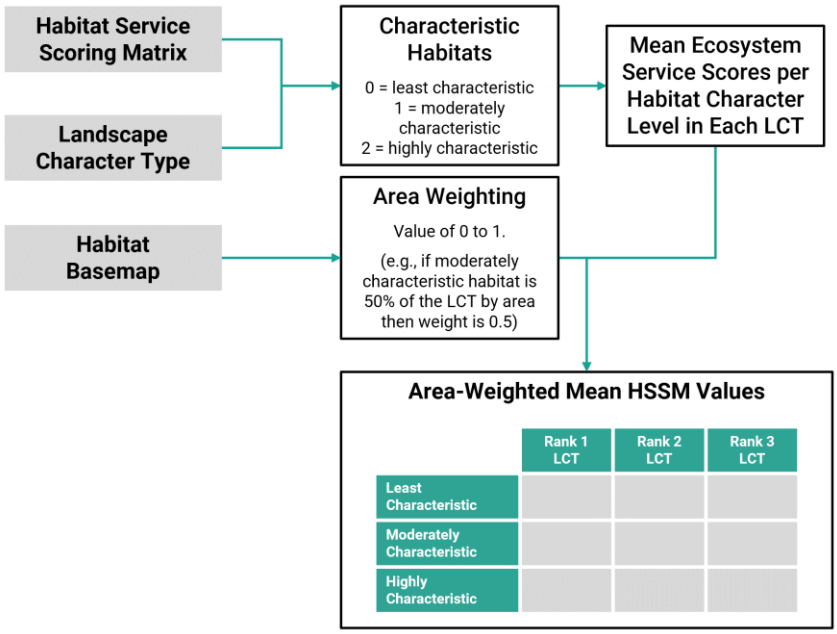

Figure 4: Methodological flow applied to integrating landscape character with ecosystem services.

3.2.8. In order to assign each habitat parcel with a LCT value, LCT data provided by Worcestershire, Herefordshire, and Forest of Dean District Councils was joined to form a single LCT dataset providing full coverage of the study area (Annex 4). Where overlapping parcels were present following the join between the datasets – a result of some LCT parcels crossing county boundaries – the geometry to retain was determined by the depth of attributes in the data. Data overlaps were resolved by taking the overlapping polygon which contained the greatest depth in its attributes. The processed LCT data was then spatially joined to habitat data, with a new attribute created to allocate a single LCT class to each habitat parcel.

3.2.9. To integrate historic landscape character (HLC) within the HSSM approach, HLC data provided by Worcestershire, Herefordshire, and Gloucestershire County Councils was used to classify areas into four categories of time depth, proposed by local historic landscape specialists (Annex 5). These categories were. (i) 1800 – present, (ii) 1540 – 1799, (iii) 410 – 1539, and (iv) pre-410. Following consultation with historic environment and heritage specialists, using these values to weight ecosystem service scores was not considered appropriate due to the implicit assumption that HLC with higher time depth are more valuable than those with less time depth. As a result, while HLC parcels with a time depth preceding 410 AD are overlaid with the sense of place outputs, these have not influenced the underlying ecosystem service provision / opportunity scores.

3.2.10. There are several limitations to note with these time depth categories. These largely result from inconsistencies between the HLC data produced to cover Worcestershire, Herefordshire, and Gloucestershire. These inconsistencies mean that HLC data in Herefordshire is more generalised then in Worcestershire and Gloucestershire. Consequently, care should be taken when comparing HLC time depth across counties. As historic landscape character is not well predicted by habitat type, HLC data was not joined to the habitat data.

3.2.11. Once spatialised, landscape character and historic landscape character data can be overlaid with ecosystem service mapping to explore the relationships between these concepts. This allows – for example – the extent to which different landscape character types contribute to the provision of different ecosystem services.

3.3. Mapping and scoring cultural ecosystem services

3.3.1. Cultural ecosystem services are not as strongly associated with habitat as other ecosystem service types, indeed Dales *et al.,* (2014) concluded that habitats are not a valid proxy for mapping the production cultural ecosystem services. The Habitat Service Scoring Matrix approach developed and applied in Oxfordshire by Smith (2020), integrated cultural ecosystem services within the HSSM. However, while adapting these values for Gloucestershire we found that input from expert review groups exhibited subjectivity and 'conservation desirability' bias.

3.3.2. In response to these challenges, we developed a novel scoring methodology based on the natural asset approach[5] (Ecosulis, 2019; Jepson *et al.*, 2017). Under this novel approach, value is

[5] For more information, please see Ecosulis (2019) Technical Brief (DOI: 10.32071/ES.TD.200519)

treated as a relational outcome[6], reflecting developments in ecosystem service theory, where cultural ecosystem services are increasingly recognised as the result of engagements between human culture and nature (Chan *et al.*, 2012). The cultural ecosystem service mapping and scoring methods applied here are fully outlined in the report produced for mapping ecosystem services in Gloucestershire (Ecosulis, 2020: Section 7).

3.3.3. In brief this method takes the following approach. Firstly, 30 value generating practices (VGPs) were defined and categorised into five broad groups based on the type of VGP (i.e., outdoor games, organised activities). Secondly, using expert judgement, these practices were scored on the contribution they make to each cultural ecosystem service. Thirdly, these scores are weighted by a Shannon Diversity Index generated for each broad VGP group to recognise the value in the variety of VGPs a habitat can support.

3.3.4. In this study, this approach has been applied to four cultural ecosystem services (i) recreation, (ii) education, (iii) sense of place, and (iv) interaction with nature.

[6] There are two types of relational ecosystem service: (i) where the service provided by an ecosystem only becomes present in relation to human culture and practices of engaging with nature, and (ii) where the habitats are producing an ecosystem service but the extent of this relates to other non-human factors. Water flow is a good example of this; it is impacted by location in a catchment, slope, proximity to other habitats of similar type.

4. Specification of Individual Ecosystem Service Layers

4.1. Introduction

4.1.1. The outputs of the mapping exercise are presented below as a series of accounts for each of 13 ecosystem services. These ecosystem services were selected to reflect the priorities of the AONB and ensure consistency with similar work undertaken in Gloucestershire. These accounts are given in a standardised structure to ensure consistency and enable key trends illustrated by the data to be readily extracted.

4.1.2. Each account comprises the following sections: (i) a definition of the ecosystem service, (ii) the methods taken to generate the ecosystem service baseline and (where relevant) opportunity datasets, (iii) a table containing a summary of the mean ecosystem service baseline values for each category of habitat character in each LCT, and (iv) a summary of the limitations and recommended future development for each of the figures. A table summarising the spatial modifier datasets and modification values is provided in Annex 1.

4.1.3. The figures in this section are printed from GIS data which have been submitted alongside this report as a series of geospatial image files (in '.tif' format).

4.1.4. To summarise ecosystem service provision in the Malvern Hills AONB, a cumulative ecosystem service baseline map was produced (Figure 5). This map was generated through the addition of the baseline layers (normalised on a scale of 0 to 10) for 12 ecosystem services. Food provision was excluded as it is considered a private ecosystem service benefit, whereas the other provisioning service (water supply) can be seen as a public benefit.

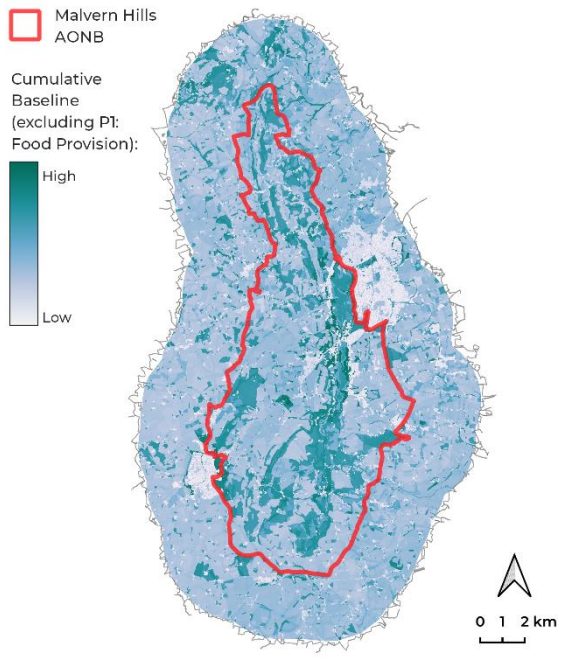

Figure 5: cumulative ecosystem service baselines for all ecosystem services, excluding Food Provision

4.2. P1: Food Provision

Ecosystem service definition

4.2.1. The ecosystem service of food provision is defined as the agricultural and horticultural production of food products via arable crops, livestock, vegetables, and fruits. This definition also includes the production of food products (i.e., berries, fungi, and game) through gathering and hunting practices. Food provision is a provisioning ecosystem service.

Baseline methods and rationale

4.2.2. The food provision ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to produce food. For example, modified grassland and arable habitats are very important for food provision and so score 10 for food provision whereas bracken only scores a 1 (the lowest value possible). A relational (i.e., spatially modified) baseline dataset was then applied to these scores to map food provision as an ecosystem service within the Malvern Hills AONB. Use of a spatial modifier was considered appropriate as the location of a given habitat was judged to be important in influencing its productivity, and therefore the production of the service.

4.2.3. The modifying dataset and values were derived from the Oxfordshire natural capital study (Smith, 2020), which applied Agricultural Land Classification (ALC) data produced by Natural England (2020a) as a modifier to the food provision ecosystem service HSSM. These identified values were based on estimated differences in productivity between each land class (Smith, 2020) and are provided in Annex 1.

Landscape Character Type analysis

4.2.4. Mean food provision baseline values were generated for highly, moderately, and least characteristic habitats for each LCT within the study area (described within Annex 4). These were then ranked to identify which LCTs made the greatest contribution to the food provision ecosystem service. Table 2 includes the three highest ranked LCTs (for food provision baseline values) for least, moderately, and highly characteristic habitat. High mean baseline values represent landscape character types where habitats of a given character value have a high mean score for the delivery of the food provision ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wet pasture meadows	1.1	Low hills and orchards	0.97	Settled farmlands on river terrace	0.97
Moderately Characteristic Habitat	Forest smallholdings & dwellings	5.15	Wooded hills	5.02	Principal settled farmlands	4.19
Highly Characteristic Habitat	Unwooded vale	6.14	Sandstone estatelands	5.19	Settled farmlands on river terrace	4.5

Table 2: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the food provision baseline

Opportunity methods and rationale

4.2.5. Food provision is an ecosystem service where demand for the service is typically diffuse and non-localised. A modifier was not applied to the opportunity layer for the food provision ecosystem service opportunity due to the absence of an appropriate dataset that can be used to assess opportunity for food provision. Therefore, data forming this layer is effectively the inverse of the food provision habitat service scoring matrix values, designed to highlight areas of high opportunity. The ALC modifier was then applied to the opportunity layer using the same modifier values as the baseline. The logic for applying the ALC modifier again is that areas of high quality soils defined by the ALC are likely to have higher potential to enhance food provision than those in lower quality soils.

Interpretation of results

4.2.6. Food provision baseline mapping (Figure 6) indicates that areas with high provision of the ecosystem service are within the area surrounding the Malvern Hills AONB and are closely associated with higher quality agricultural land (as derived from ALC data). Areas where provision of the ecosystem service is low are typically those in urban areas and the hills of the AONB. Land either side of the River Leadon near Ledbury also scores highly for the food provision baseline.

4.2.7. Food provision opportunity mapping (Figure 7) indicates that there is limited opportunity for enhancing the food provision ecosystem service in the Malvern Hills AONB, with small patches of opportunity being constrained to the surroundings north, south, and west of the AONB.

Limitations and further development

4.2.8. Habitat classification does not fully account for land management regimes, which may have a substantial impact on food production output. In this approach, the habitat service scoring matrix assumes that all habitats of a given type will contribute equally to food provision, without full consideration of food production intensity within a given habitat parcel. Future work could include an assessment of different approaches to agriculture and food production (e.g., intensive, small-scale, crops, livestock) to provide a greater understanding of the spatial distribution of food provision in the county.

4.2.9. Data indicating productivity (i.e., food production output) of land used for food production would also provide insights into the potential of natural capital assets to provide the food provision ecosystem service. Approaches to food production should be considered in the context of productivity data, to ensure impacts on other ecosystem services of these approaches are fully recognised; intensive agriculture can significantly impact water quality, for example.

4.2.10. Constraints are not included within the food provision opportunity layer and any interpretation of this figure should consider this limitation. Future work may seek to explore integrating constraints into the opportunity layer. These constraints may include urban areas, utilities, and certain designated sites.

4.2.11. Supporting documentation for ALC data states that it is not accurate enough to be used as anything other than general guidance, more accurate data should be used to indicate productivity of land (Natural England, 2020). As a result, this dataset should not be used for assessment of individual land parcels, but rather for higher-level analysis.

Figure Sheet:
P1 Food Provision

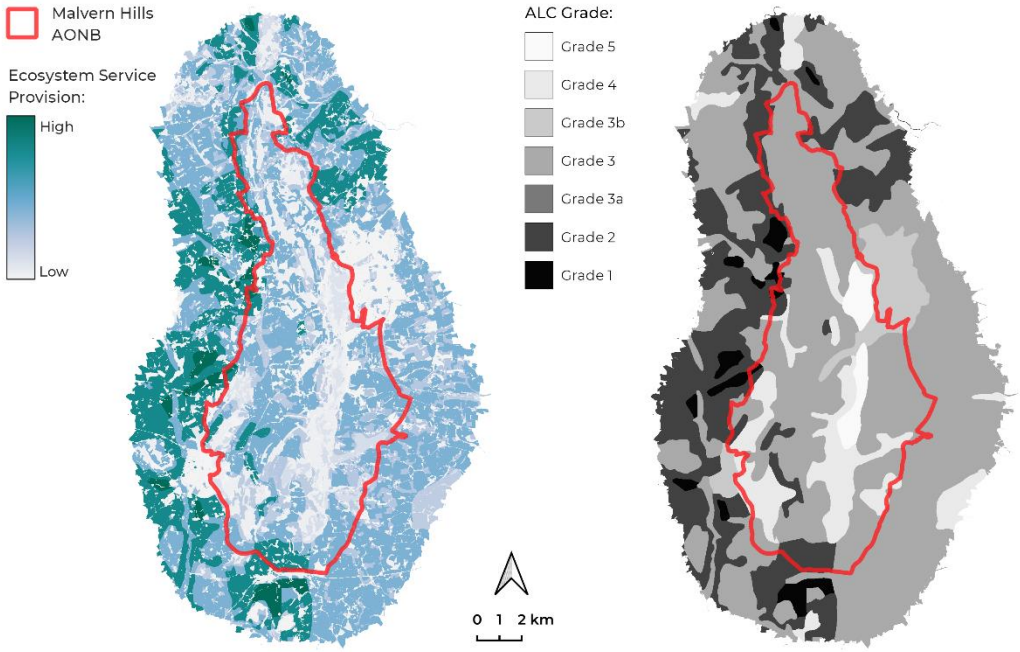

Figure 6: Food provision relational baseline (left) and ALC modifier (right)

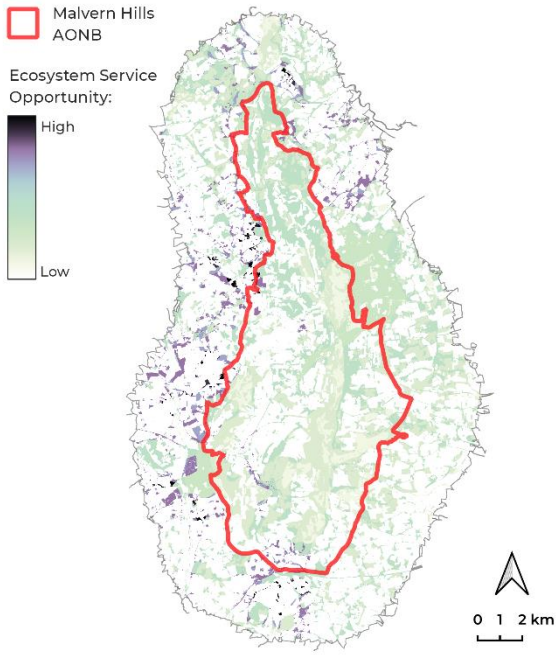

Figure 7: Food provision opportunity with ALC modifier (Figure 5, right) also applied

4.3. P2: Water Supply

Ecosystem service definition

4.3.1. The ecosystem service of water supply is defined as the extent to which surface flow and groundwater recharge are impacted by soils and vegetation through processes of run-off and filtration. Water supply is a provisioning ecosystem service.

Baseline methods and rationale

4.3.2. The water supply ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to supply water. A modification dataset was not applied to the water supply ecosystem service baseline, thereby the ecosystem service baseline reflects the raw HSSM scores (Annex 2).

Landscape Character Type analysis

4.3.3. Landscape Character Types (LCT), ranked by mean water supply baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 3. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the water supply ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the water supply ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wet pasture meadows	0.93	Low hills and orchards	0.83	Riverside meadows	0.78
Moderately Characteristic Habitat	Wooded hills	4.01	Principal settled farmlands	3.04	Forest smallholdings & dwellings	2.8
Highly Characteristic Habitat	Sandstone estatelands	4.15	Settled farmlands on river terrace	3.64	Unwooded vale	3.07

Table 3: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the water supply baseline

Opportunity methods and rationale

4.3.4. A relational (i.e., spatially modified) dataset was produced to map water supply ecosystem service opportunity within the Malvern Hills AONB. The Environment Agency's (2020a) Water Resource Availability and Abstraction Reliability Cycle 2 dataset was used as the spatial modification layer. These data are modelled and indicate the availability of additional water for abstraction for consumption (Environment Agency, 2020a). Greatest modification values were applied where water resource availability as a percentage of time – and therefore opportunity for improvement – was lowest. The logic applied here is that where availability of water for abstraction is most limited, opportunity for the ecosystem service will be greatest.

Interpretation of results

4.3.5. The ecosystem service baseline (Figure 8) indicates that water supply provision throughout the Malvern Hills AONB and surrounding area is largely uniform, with high to medium levels of

provision. Urban areas (e.g., Ledbury and Great Malvern) represent areas where provision is lowest in the AONB and surrounding area.

4.3.6. Mapped water supply opportunity (Figure 9) also shows a relatively uniform pattern across the Malvern Hills AONB and surrounding area. The key exception is Greater Malvern which has a high level of opportunity. This is due to a combination of both the urban land cover in the town (low scoring in the HSSM (Annex 2) and low water resource availability (as a percentage of time).

Limitations and further development

4.3.7. It is recognised that the ability for habitats to supply water is impacted by other factors. However, meaningful datasets that represent these factors could not be identified at the time of this study. Future work should further explore the availability of suitable modification layers to the baseline analysis to account for spatial variation of water supply production. These datasets may include climate datasets (i.e., temperature, sun exposure, precipitation) and geological datasets (i.e., porosity, and aquifer location).

Figure Sheet:
P2 Water Supply

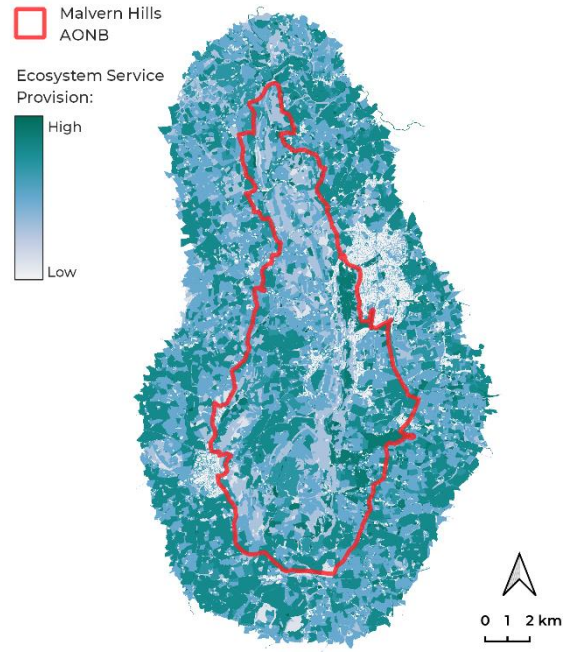

Figure 8: Water supply non-relational baseline

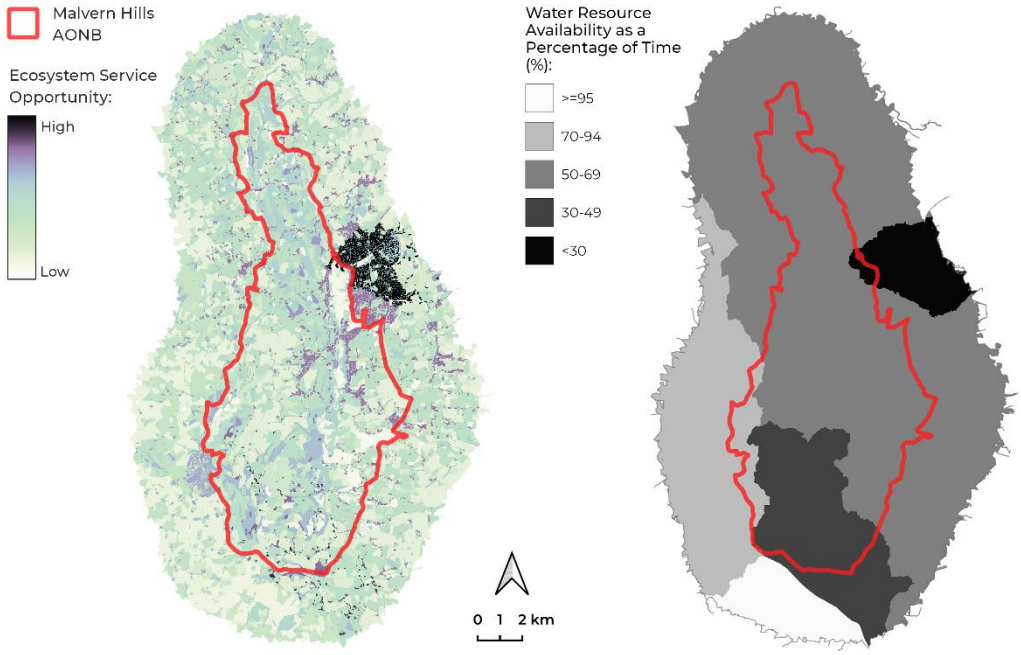

Figure 9: Water supply opportunity (left) and water resource availability modifier (right)

4.4. R1: Carbon Storage

Ecosystem service definition

4.4.1. The ecosystem service of carbon storage is defined as the quantities of carbon stored in soil and vegetation. Carbon storage is a regulating ecosystem service.

Baseline methods and rationale

4.4.2. The carbon storage ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to store carbon. Use of a modifier was considered appropriate as the HSSM values for the carbon storage ecosystem service reflect the top 30 cm of soil (Cantarello et al., 2011; Smith, 2020). To identify the contribution soils below this depth may have on the ecosystem service, National Soil Map (Cranfield University, 2021) classifications were used to identify deep soils.

4.4.3. Soil types classified as deep within the study area were 'deep clay', 'deep loam', 'deep red loam to clay', 'seasonally wet deep clay', 'seasonally wet deep loam', and 'seasonally wet deep red silty'. We were unable to obtain more detailed data on the capacity of different soil types to store carbon. Consequently, scoring values of cells where soil type was classified as deep were increased by five. A value of five was selected recognising that while these soils are likely to hold more carbon than other soil types, there is some uncertainty in the exact nature of these values. Further details on this are given in the '*Limitations and further development*' section overleaf.

Landscape Character Type analysis

4.4.4. Landscape Character Types, ranked by mean carbon storage baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 4. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the carbon storage ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the carbon storage ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.7	High hills and slopes	0.64	Settled farmlands on river terrace	0.52
Moderately Characteristic Habitat	Forest smallholdings & dwellings	1.67	Sandstone estatelands	0.89	Principal timbered farmlands	0.85
Highly Characteristic Habitat	Principal wooded hills	3.12	Wooded hills and farmlands	2.44	Unwooded vale	1.84

Table 4: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the carbon storage baseline

Opportunity methods and rationale

4.4.5. Carbon storage is an ecosystem service where requirement for the service is typically diffuse and non-localised. A non-relational opportunity layer was produced for the carbon storage ecosystem service due to the absence of an appropriate dataset that can be used to assess opportunity for carbon storage. Data forming this layer is effectively the inverse of the carbon storage baseline, designed to highlight areas of high opportunity.

4.4.6. Soil depth was included in baseline analysis to recognise soil carbon (below 30 cm depth) rather than habitat carbon storage potential. As opportunity maps are designed to illustrate the impacts of habitat change on ecosystem service provision, it was considered appropriate to remove the soil depth modifier from the opportunity layer.

Interpretation of results

4.4.7. The carbon storage baseline (Figure 10) indicates that areas of high ecosystem service provision are concentrated within the woodland of the AONB and surrounding areas, alongside areas where soils have been classified as deep. Areas of lower carbon storage provision are located within the cropland and urban areas of the study area.

4.4.8. Opportunity mapping for carbon storage (Figure 11) indicates that the areas of high opportunity are distributed throughout the study area. Highest opportunity areas are generally located in the western region of the Malvern Hills AONB and in areas to the south-west and north-east of the AONB.

Limitations and further development

4.4.9. Knowledge on wetland soil carbon storage is currently less developed than is the case for woodlands and as a result, wetlands may be underscored in the habitat service scoring matrix.

4.4.10. Soil depth – and the impact this may have on carbon storage – can vary across similar habitats and is not accounted for in the habitat service scoring matrix (Smith, 2020). Soil depth is integrated within the analysis presented here, however distinctions are not made between the capacity of different soil types to store carbon beyond the simple classification of depth. Cranfield University (2021) hold spatial data – derived from the National Soil Map – on soil organic carbon content in soils. Future work may consider these data to further explore the role of soil type in carbon storage.

4.4.11. Higher resolution soil data was obtained at both 1:25,000 and 1:50,000 scales, however, these currently do not provide full coverage of the study area and were not applied here.

Figure Sheet:
R1 Carbon Storage

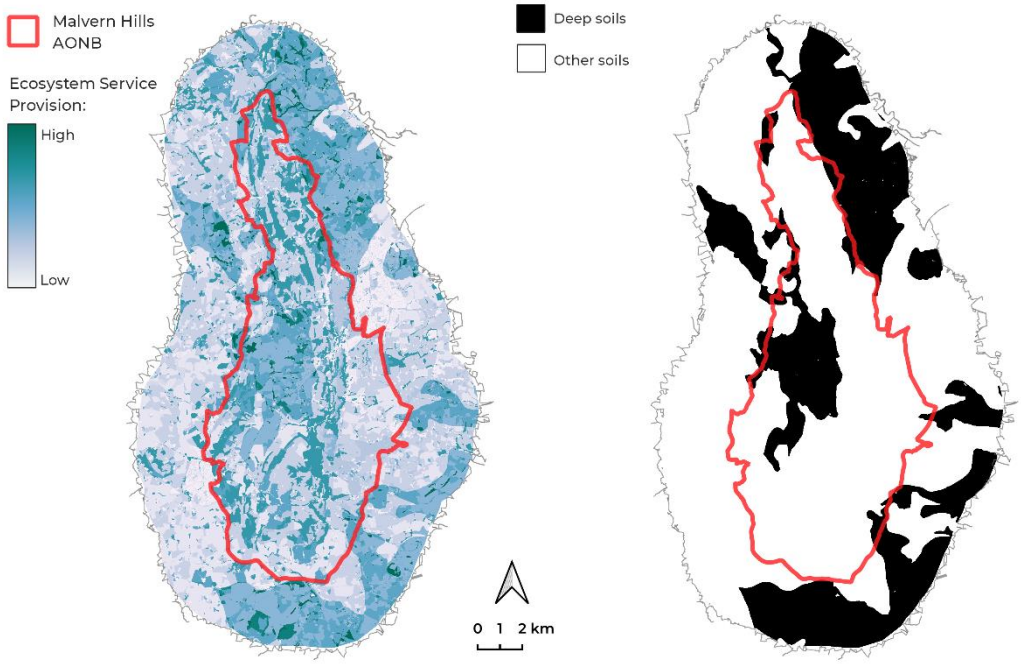

Figure 10: Carbon storage non-relational baseline (left) and soil depth modifier (right)

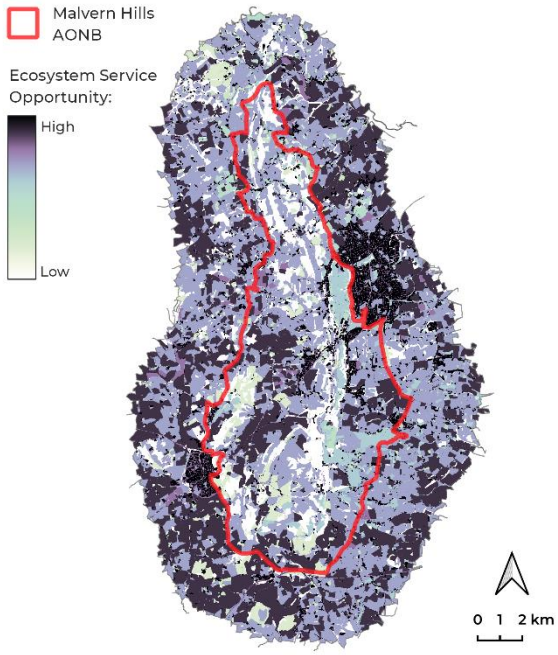

Figure 11: Carbon storage opportunity

4.5. R2: Water Flow Regulation

Ecosystem service definition

4.5.1. The ecosystem service of water flow regulation is defined as the impact of soil and vegetation on reducing surface run-off, peak flow, and flood extent and depth. Mechanisms include interception, evapotranspiration, infiltration, and physical water flow slowing. Water flow regulation is a regulating ecosystem service.

Baseline methods and rationale

4.5.2. The water flow regulation ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to regulate water flow. A spatial modifier has been applied to the water flow regulation baseline. To produce the spatial modifier, flow pathways were generated using a 2m-resolution digital surface model (DSM) derived from LiDAR data (Environment Agency, 2020b). A proximity analysis was then undertaken to score each cell within the study area on a scale of 1-10 dependent on how close to the nearest flow pathway the cell is (where 10 is closest and 1 is furthest). The logic behind using proximity to watercourses as a modifier is that cumulative surface water flow is likely to increase closer to watercourses. This proximity analysis was then applied as a modifier layer to the scores generated through the habitat service scoring matrix (HSSM), as per Annex 2.

Landscape Character Type analysis

4.5.3. Landscape Character Types, ranked by mean water flow regulation baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4) are shown in Table 5. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the water flow regulation ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the water flow regulation ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.78	Settled farmlands on river terrace	0.61	High hills and slopes	0.6
Moderately Characteristic Habitat	Forest smallholdings & dwellings	2.29	Wooded hills	2.01	Principal settled farmlands	1.73
Highly Characteristic Habitat	Principal wooded hills	2.82	Unwooded vale	2.45	Wooded hills and farmlands	2.23

Table 5: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the water flow regulation baseline

Opportunity methods and rationale

4.5.4. The water flow regulation ecosystem service opportunity was mapped using a spatial modifier layer, taking areas of flood risk as input. This model calculates areas which are upstream of areas of flood risk (identified by Environment Agency (2020c) data) and applies a modifier to increase the

score of habitats which are upstream of these areas. Modifying values are provided in Annex 1. An in-depth overview of this approach is provided in the rest of this section.

4.5.5. To produce this dataset, water flows were modelled for Severn Catchment at 250m resolution, ensuring catchment-wide impacts beyond the AONB boundary are considered. Water flow modelling produced flow pathways, flow pathway nodes, these were inputs into the QGIS model alongside the water flow regulation baseline layer,. In this model the baseline input was 'inverted' by subtracting each value from the maximum in the dataset. This identifies deficits in the current production of the ecosystem service.

4.5.6. Cost analysis was then used to calculate cumulative flood risk along flow pathways from outlet to source. This value starts at zero and is increased as the flow pathway passes through areas of flood risk. Linear flow pathways containing cumulative flood risk were converted to distinct polygons using Voronoi polygons, defined from the vertices of the flow pathways. These polygons were then dissolved and rasterised to generate the opportunity modifier layer (Annex 1).

Interpretation of results

4.5.7. The water flow regulation baseline (Figure 12) reflects the high scoring of woodland habitats within the HSSM, with these habitats being the areas of highest ecosystem service provision in the Malvern Hills AONB and surrounding area – in particular where woodlands are in close proximity to flow pathways.

Limitations and further development

4.5.8. The flow pathway proximity analysis does not account for topography and gradient, which may impact the ability of a habitat to regulate water flows. Further topographic analysis may be valuable in exploring this impact further. Modifier values for the watercourse proximity modifier layer assume that the ability of a habitat to regulate water flow increases linearly as proximity to watercourses increases. Further work should explore relevant literature to update these values to be more evidence-based and more accurately reflect this relationship.

Figure Sheet:
R2 Water Flow Regulation

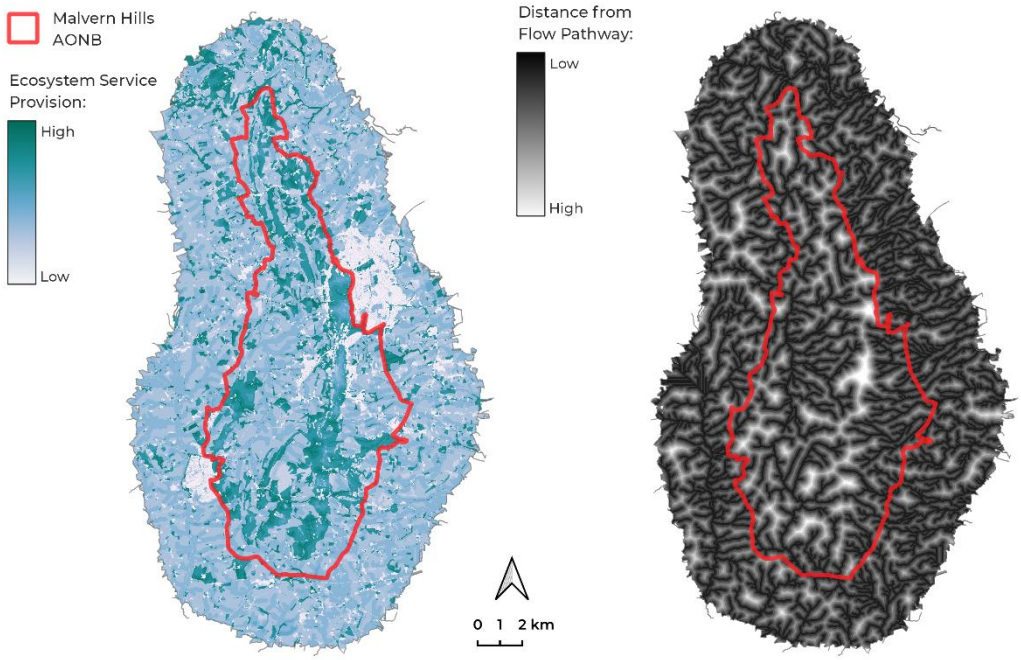

Figure 12: Water flow regulation relational baseline (left) and flow pathway modifier (right)

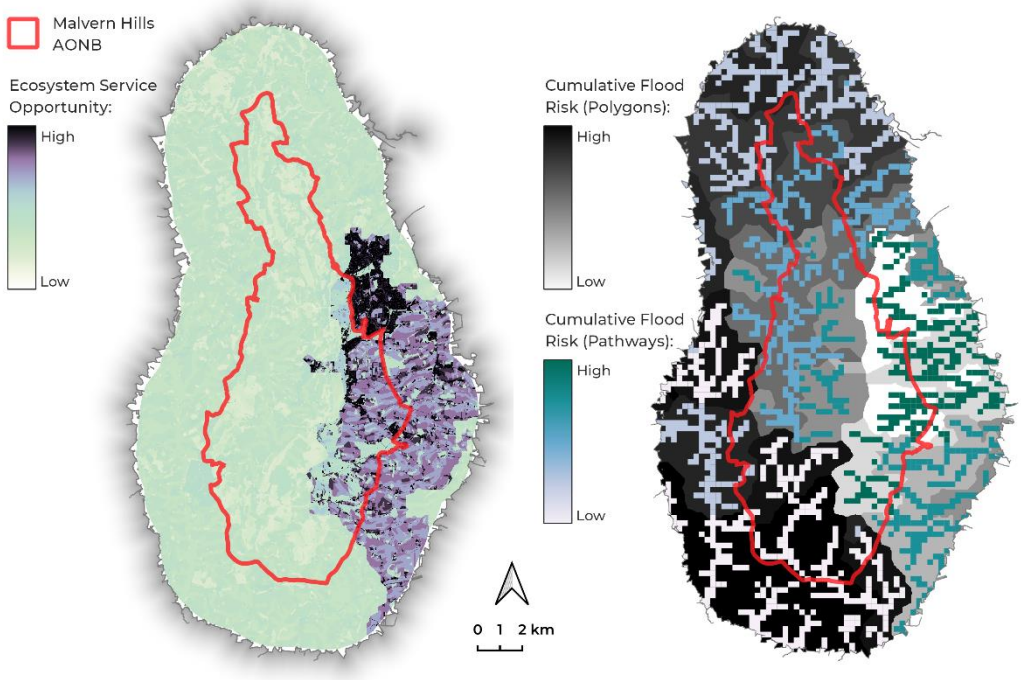

Figure 13: Water flow regulation relational opportunity (left) and cumulative flood risk modifier (right)

4.6. R3: Local Climate Regulation

Ecosystem service definition

4.6.1. The regulating ecosystem service of local climate regulation is defined as the cooling effects of vegetation and water, in particular in urban areas where these can reduce heating and cooling costs and provide areas of shade. Local climate regulation is a regulating ecosystem service.

Baseline methods and rationale

4.6.2. The local climate regulation ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to regulate the local climate. This baseline was produced using a spatial modifier. Under this modifier, non-urban cells or cells within 250 m of an urban area were scored with a value of zero. Urban and non-urban areas were identified using Ordnance Survey (2020) Open Zoomstack data.

Landscape Character Type analysis

4.6.3. Landscape Character Types, ranked by mean local climate regulation baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 6. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the local climate regulation ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the local climate regulation ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.70	High hills and slopes	0.63	Settled farmlands on river terrace	0.44
Moderately Characteristic Habitat	Forest smallholdings & dwellings	1.13	Wooded hills	1.00	Sandstone estatelands	0.92
Highly Characteristic Habitat	Principal wooded hills	3.13	Wooded hills and farmlands	2.47	Unwooded vale	1.23

Table 6: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the local climate regulation baseline

Opportunity methods and rationale

4.6.4. A non-relational opportunity layer was produced for the local climate regulation ecosystem service due to the absence of an appropriate dataset that can be used to assess opportunity for local climate regulation. Data forming this layer are effectively the inverse of the local climate regulation baseline, designed to highlight areas of high opportunity.

Interpretation of results

4.6.5. The local climate regulation baseline (Figure 14) indicates that areas of high local climate regulation provision within the Malvern Hills AONB and surrounding area is constrained to small patches of woodland. These patches are generally located adjacent to – rather than within – settlements.

4.6.6. Mapped local climate regulation opportunity (Figure 15) indicates that ecosystem service opportunity is greatest in the sealed surfaces of the major settlements in the study area. Predominantly grassland habitats surrounding these settlements also offer a high opportunity for ecosystem service provision.

Limitations and further development

4.6.7. Urban trees (and green roofs and green walls) are not well-represented in the natural capital maps and their current impact on local climate regulation may be underrepresented in the outputs. Datasets mapping these features could be a valuable inclusion into future work. Traffic data could also be used in conjunction with urban tree locations to further account for variations of localised heating within the urban environment.

4.6.8. Demand for air pollutant removal is greatest in residential areas (Smith, 2020). In recognition of this, future work should consider classifying urban areas to general categories (e.g. commercial, industrial, residential) to recognise different levels of demand for the ecosystem service within urban areas. Population density may also be used as a proxy for approaching ecosystem service demand in urban areas.

Figure Sheet:
R3 Local Climate Regulation

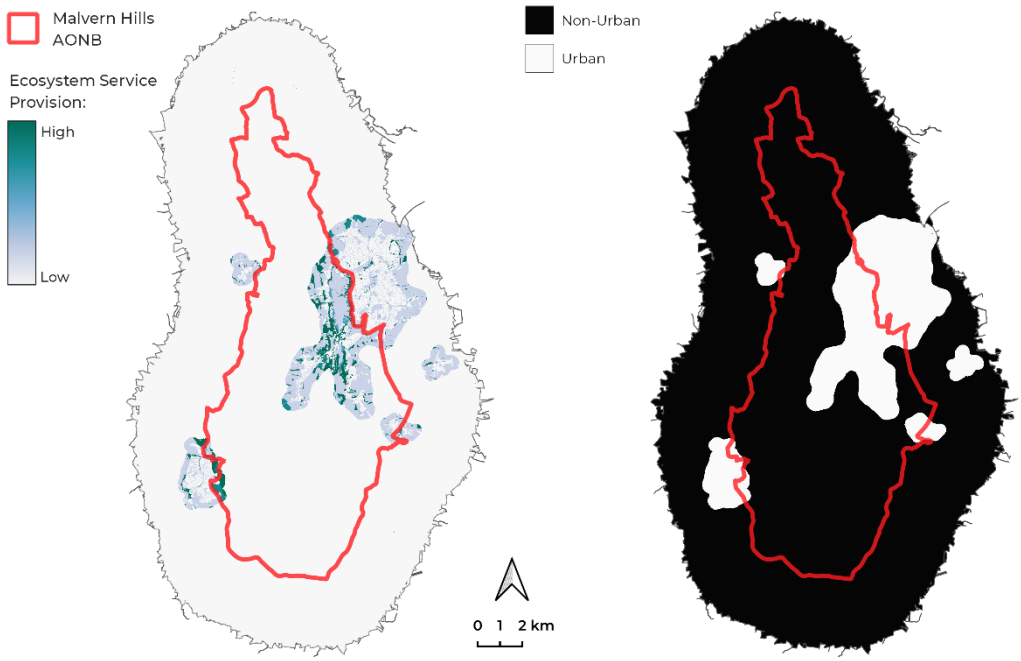

Figure 14: Local climate regulation relational baseline (left) and urban area modifier (right)

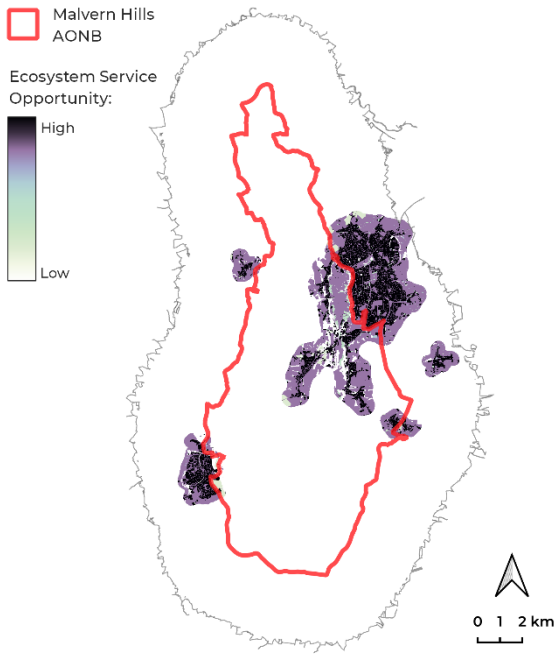

Figure 15: Local climate regulation opportunity

4.7. R4: Air Pollutant Removal

Ecosystem service definition

4.7.1. The ecosystem service of air pollutant removal is defined as the effect of vegetation on concentrations of air pollutants through mechanisms including deposition, absorption, and chemical breakdown. Air pollutant removal is a regulating ecosystem service.

Baseline methods and rationale

4.7.2. The air pollutant removal ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to remove air pollutants. During the habitat service scoring matrix process, each habitat classification was scored on its ability to remove general air pollutants, rather than focusing on individual pollutants. A spatial modifier for the ecosystem service was produced by scoring cells which fall outside of 300 m of an urban or regional or national road zero (Annex 1). The value of 300 m was selected based a Natural England (2016) report which found significantly elevated nitrogen concentrations in vegetation up to 300m from roads. Urban areas and roads were identified using Ordnance Survey (2020) Open Zoomstack data.

Landscape Character Type analysis

4.7.3. Landscape Character Types, ranked by mean air pollutant removal baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 7. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the air pollutant removal ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the air pollutant removal ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.51	High hills and slopes	0.49	Settled farmlands on river terrace	0.29
Moderately Characteristic Habitat	Sandstone estatelands	0.73	Forest smallholdings & dwellings	0.59	Wooded hills	0.5
Highly Characteristic Habitat	Principal wooded hills	2.5	Wooded hills and farmlands	1.99	Timbered plateau farmlands	0.94

Table 7: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the air pollutant removal baseline

Opportunity methods and rationale

4.7.4. A non-relational opportunity layer was produced for the air pollutant removal ecosystem service due to the absence of an appropriate dataset that can be used to assess opportunity for air pollutant removal. Data forming this layer is effectively the inverse of the air pollutant removal baseline, designed to highlight areas of high opportunity.

Interpretation of results

4.7.5. The air pollutant removal baseline (Figure 16) illustrates a similar pattern to the local climate regulation baseline, whereby woodland patches represent areas of highest ecosystem service provision. Ecosystem service provision is lowest in the sealed surfaces of settlements within and surrounding the Malvern Hills AONB.

4.7.6. Opportunity for air pollutant removal is indicated to be high throughout areas of the Malvern Hills AONB and its surroundings which fall within 300 m of urban areas and roads (Figure 17). Opportunity is highest within the sealed surfaces of settlements and lowest within the patches of woodland adjacent to roads and settlements.

Limitations and further development

4.7.7. It has been assumed that national and regional roads and urban areas are the major sources of air pollution within the Malvern Hills AONB and surrounding 3 km. However, there are likely to other sources – both point and diffuse – that have not been accounted for in this analysis. These may include nitrogen emissions from intensive stock husbandry and point source emissions from industrial sources. This data includes nitrogen critical load exceedance data which may act as a useful modifying dataset for future work.

4.7.8. Demand for air pollutant removal is greatest in residential areas (Smith, 2020) with opportunities for future work consider classifying urban areas to broad classes (e.g., commercial, industrial, residential) to recognise variations in demand for the air pollutant removal within urban areas. Population density may also be used as a proxy for this.

Figure Sheet:
R4 Air Pollutant Removal

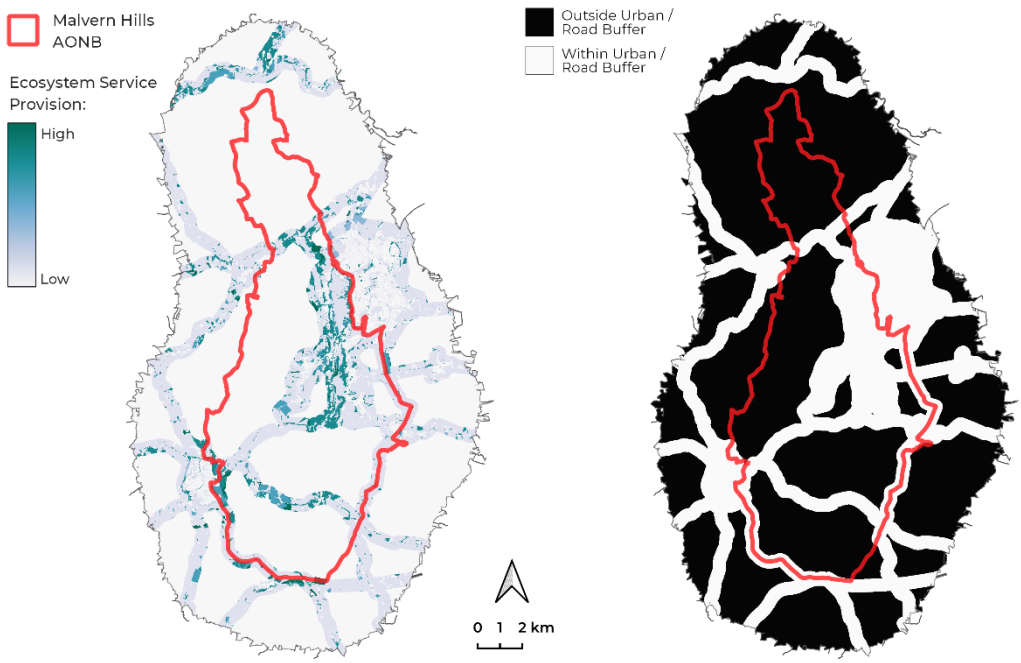

Figure 16: Air pollutant removal relational baseline (left) and urban and road modifier (right)

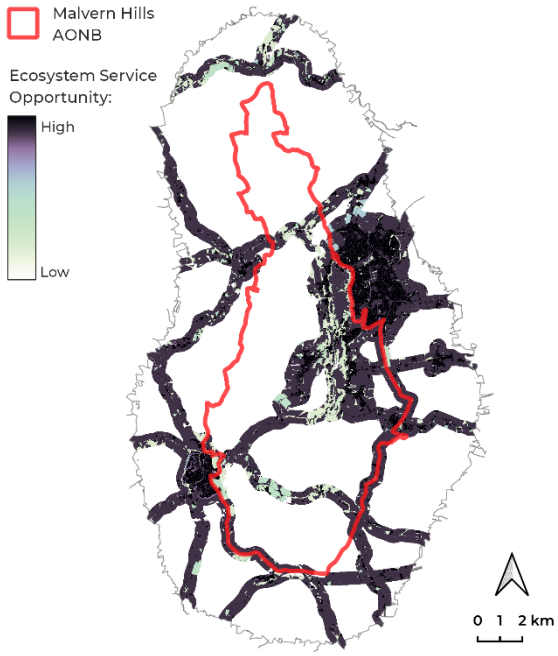

Figure 17: Air pollutant removal opportunity

4.8. B1: Biodiversity

Ecosystem service definition

4.8.1. The ecosystem service of biodiversity is defined as the ability of a habitat to support a diverse range of species, providing a variety of environmental, social, and economic benefits. These layers should be viewed in conjunction with the Malvern Hills AONB Nature Recovery Network. Biodiversity is a bundled ecosystem service.

Baseline methods and rationale

4.8.2. The biodiversity ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to support a diverse range of species. A spatial modifier was not applied to the biodiversity baseline. However, it is recommended that once the Nature Recovery Network for the study area is produced, the biodiversity ecosystem service baseline is modified using - and viewed in conjunction with - the Nature Recovery Plan. Network. The rationale for using a Nature Recovery Network is that it can identify the degree to which existing habitat is connected to core habitat patches.

Landscape Character Type analysis

4.8.3. Landscape Character Types, ranked by mean biodiversity baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 8. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the biodiversity ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the biodiversity ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.82	High hills and slopes	0.64	Riverside meadows	0.51
Moderately Characteristic Habitat	Wooded hills	2.01	Principal settled farmlands	1.50	Forest smallholdings & dwellings	1.31
Highly Characteristic Habitat	Principal wooded hills	3.15	Wooded hills and farmlands	2.42	Sandstone estatelands	2.07

Table 8: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the biodiversity baseline

Opportunity methods and rationale

4.8.4. A non-relational opportunity layer was produced for the biodiversity ecosystem service due to the absence of an existing appropriate dataset that can be used to assess opportunity for biodiversity. Data forming this layer is effectively the inverse of the biodiversity baseline, designed to highlight areas of high opportunity. A nature recovery network is currently being developed for the study area and is anticipated to model areas of high opportunity for biodiversity enhancements.

Interpretation of results

4.8.5. The biodiversity baseline (Figure 18) illustrates the provision of the ecosystem service is greatest within the Malvern Hills AONB, in particular the high-quality woodland and grassland habitats along the spine of the Malvern Hills. These areas of high provision correlate to some extent with Buglife's (2020) B-Lines[7] which also run from north to south through the AONB.

4.8.6. Mapped biodiversity opportunity throughout the Malvern Hills AONB and surrounding area (Figure 19) indicates that opportunity for enhancing provision of the ecosystem service is greatest within major settlements of the study area, alongside lower quality grassland habitats. It is important to note that though these areas are highlighted as areas of high opportunities, when planning biodiversity enhancement, areas closest to areas of current high provision, or those indicated by the region's Nature Recovery Network should be mapped.

Limitations and further development

4.8.7. The biodiversity baseline is based solely on habitat type and does not consider the assemblage of habitats or their role in species dispersal as part of an ecological network. It is understood that a Nature Recovery Network is currently in development for the study area and these layers should be updated periodically as the Nature Recovery Network is updated.

[7] Buglife's B-Lines are a network of wildlife corridors identified across the UK, designed to enable target habitat restoration and creation to support pollinator species

Figure Sheet:
B1 Biodiversity

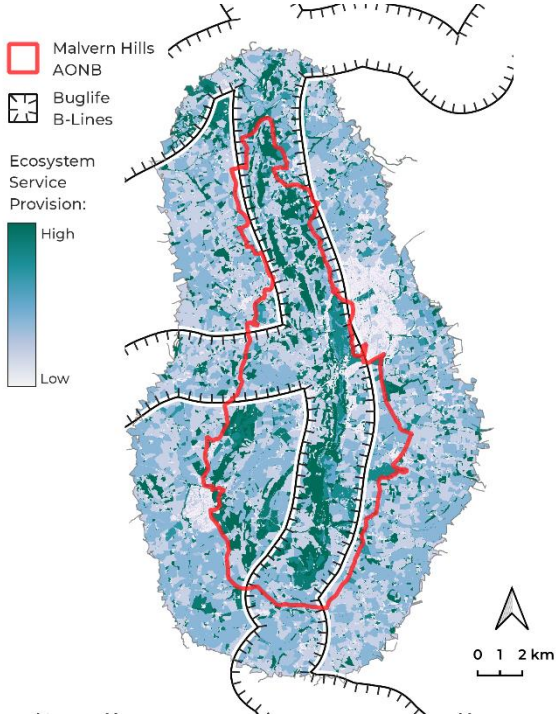

Figure 18: Biodiversity non-relational baseline

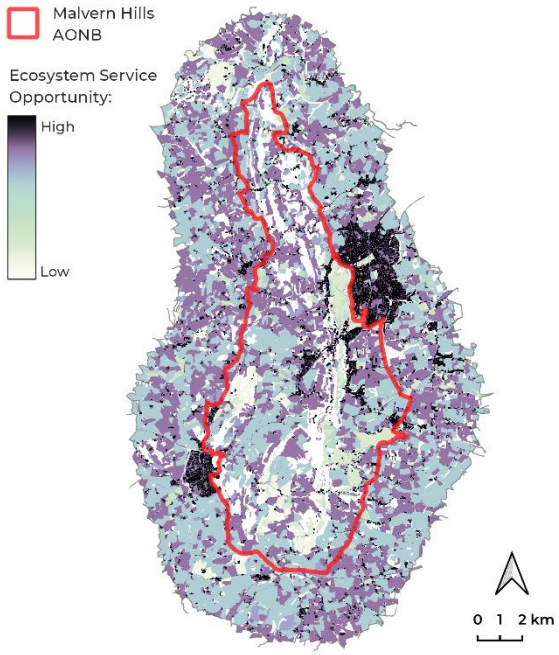

Figure 19: Biodiversity non-relational opportunity

4.9. B2: Water Quality

Ecosystem service definition

4.9.1. The ecosystem service of water quality is defined as the uptake of pollutants dissolved or suspended in water by vegetation, and the ability of vegetation to prevent pollutants reaching waterbodies through interception and filtration. Water quality is a bundled ecosystem service.

Baseline methods and rationale

4.9.2. The water quality ecosystem service baseline is based on the Habitat Service Scoring Matrix (HSSM) (Annex 2) with each habitat scored on its ability to improve water quality. A spatial modifier was not applied here. The rationale for not selecting a modification layer for the water quality baseline was (i) the absence of an appropriate available dataset that could be used as a spatial modifier for the ecosystem service and (ii) the complexity of interaction between a habitat's spatial configuration and its influence on water quality.

Landscape Character Type analysis

4.9.3. Landscape Character Types, ranked by mean water quality baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 9. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the water quality ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the water quality ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.67	High hills and slopes	0.61	Wet pasture meadows	0.48
Moderately Characteristic Habitat	Wooded hills	2.01	Principal settled farmlands	1.34	Principal timbered farmlands	1.02
Highly Characteristic Habitat	Principal wooded hills	3.13	Wooded hills and farmlands	2.4	Sandstone estatelands	2.07

Table 9: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the water quality baseline

Opportunity methods and rationale

4.9.4. A non-relational opportunity layer was produced for the water quality ecosystem service due to the absence of an existing appropriate dataset that can be used to assess opportunity for water quality. Data forming this layer is effectively the inverse of the water quality baseline, designed to highlight areas of high opportunity.

Interpretation of results

4.9.5. The biodiversity baseline (Figure 20) illustrates that areas where provision of the ecosystem service is greatest are largely located within the Malvern Hills AONB, in particular within the high-quality woodland and grassland of the AONB.

4.9.6. Provision of the ecosystem service is generally lowest within both the sealed surfaces of settlements within the study area and areas of improved grassland dispersed amongst cropland. Consequently, these are areas where opportunity exists? for enhancement of the water quality? ecosystem service (Figure 21).

Limitations and further development

4.9.7. The water quality baseline assumes habitat is the only factor in determining how a given habitat influences water quality. The reality is much more complex with factors such as land management, topography and water flow rate, and underlying geology all influencing water quality. Water Framework Directive (WFD) data whereby water bodies are assessed for their quality based on a series of indicators, may be a useful supporting dataset for this analysis.

4.9.8. Inclusion of flow accumulation modelling may also allow detailed analysis of overland flows, in turn, further analysis of the potential of a given area of land to deliver the water quality ecosystem service.

Figure Sheet:
B2 Water Quality

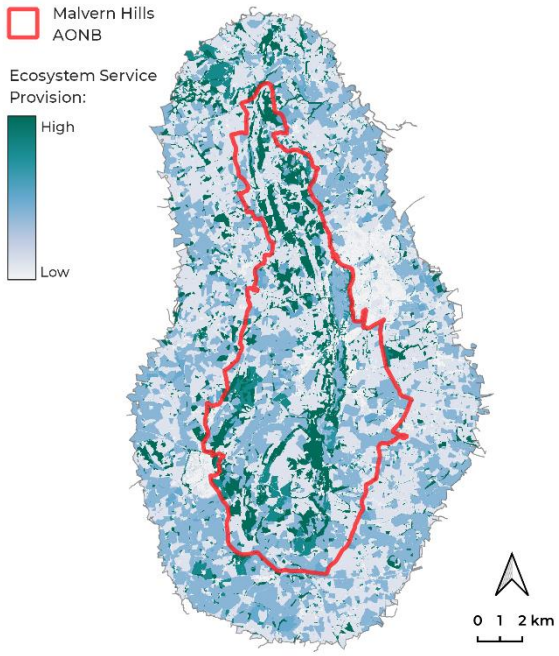

Figure 20: Water quality non-relational baseline

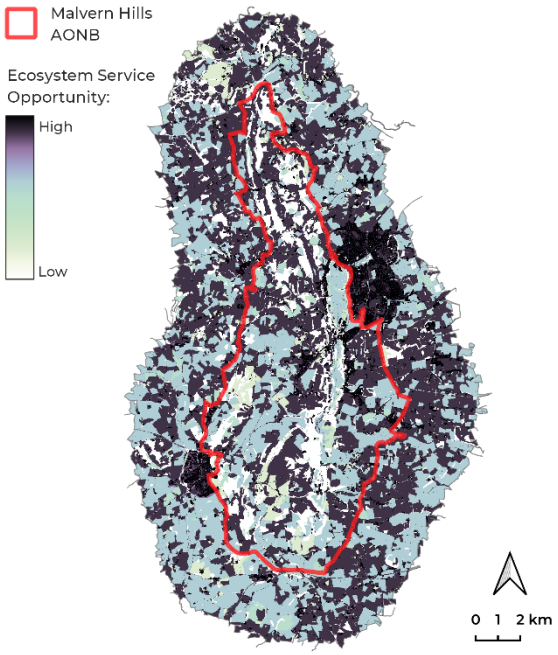

Figure 21: Water quality non-relational opportunity

4.10. B3: Soil Health

Ecosystem service definition

4.10.1. The ecosystem service of soil health is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Soil health is a bundled ecosystem service.

Baseline methods and rationale

4.10.2. A non-relational dataset was produced to map the soil health ecosystem service baseline within the Malvern Hills AONB. The rationale for not selecting a modification layer for the soil health baseline was the absence of an available dataset that could be used as a spatial modifier for the soil health ecosystem service, whilst accounting for localised variation in soils. Data describing land management practices may be a valuable additional dataset here, providing a further layer of depth into soil health analysis. As a result, the soil health baseline represents the HSSM values directly applied to the habitat basemap.

Landscape Character Type analysis

4.10.3. Landscape Character Types, ranked by mean soil health baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 10. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the soil health ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the soil health ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.73	High hills and slopes	0.66	Settled farmlands on river terrace	0.62
Moderately Characteristic Habitat	Wooded hills	2.51	Forest smallholdings & dwellings	2.29	Principal settled farmlands	2.03
Highly Characteristic Habitat	Principal wooded hills	3.14	Sandstone estatelands	2.59	Unwooded vale	2.45

Table 10: Ranked LCTs containing least, moderately, and highly characteristic habitats which make the greatest contribution to the soil health baseline

Opportunity methods and rationale

4.10.4. A non-relational opportunity layer was produced for the soil health ecosystem service due to the absence of an existing appropriate dataset that can be used to assess opportunity for soil health. Data forming this layer is effectively the inverse of the soil health baseline, designed to highlight areas of high opportunity.

Interpretation of results

4.10.5. The soil health baseline (Figure 22) indicates that the provision of the ecosystem service is high to medium throughout most of the Malvern Hills AONB and surrounding area. High-quality woodland and grassland habitats offer the greatest contribution to the soil health baseline in the area

due to the allocation of scores within the HSSM. Sealed surfaces within settlements represent the lowest scoring areas. Consequently, as no modifier has been applied in generating the opportunity layer, these areas of sealed surface also represent areas of greatest opportunity for enhancing the ecosystem service.

Limitations and further development

4.10.6. Due to limitations in available data containing soil chemistry parameters for the Malvern Hills AONB, this dataset assumes that habitat is the only determinant of soil health. Whereas soil health is dependent on a complex series of additional factors: land management regimes, topography, and climate, for example.

4.10.7. Concentrations of phosphorous in soils may provide a useful indicator of soil health that could be applied as a modifier layer, should an appropriate dataset be identified.

Figure Sheet:
B3 Soil Health

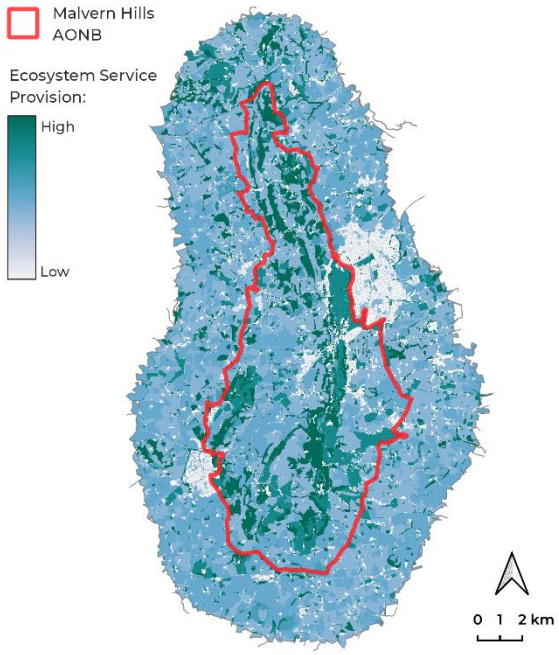

Figure 22: Soil health non-relational baseline

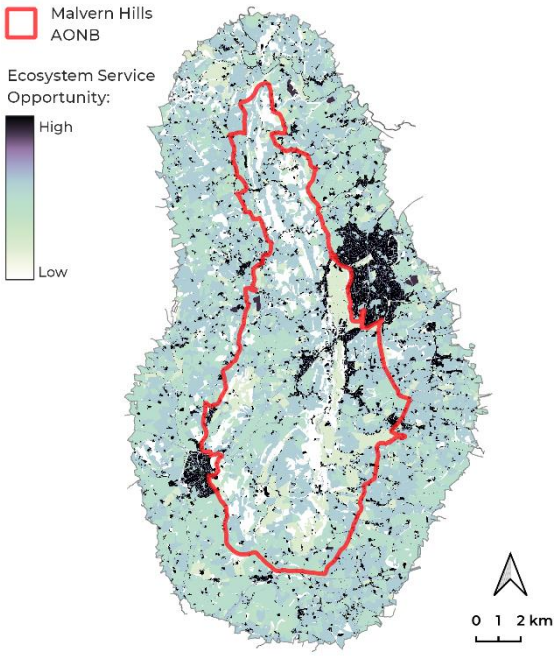

Figure 23: Soil health non-relational opportunity

4.11. C1: Recreation

Ecosystem service definition

4.11.1. The ecosystem service of recreation is defined as the 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).

Baseline methods and rationale

4.11.2. The recreation ecosystem service baseline is based on the cultural ecosystem service analysis (Section 3.3) with each habitat scored on its ability to provide recreation. A spatial modifier was applied in generating the recreation baseline. The rationale for selecting a modification layer for the baseline was in recognition that accessibility of land strongly influences the extent to which the recreation ecosystem service is captured by people. The methods detailed below were derived from the Natural Capital in Oxfordshire study (Smith, 2020), and are identical to those applied to the education ecosystem service baseline.

4.11.3. Land classed as 'open' was identified through land covered under Countryside Rights of Way Act (Natural England, 2020b), and land within the Outdoor Recreation Valuation (ORVal) dataset (Day and Smith, 2018).

4.11.4. Land classed as 'semi-restricted' was identified through applying a buffer of 50m to public rights of way within the study area. These were identified through a combination of the ORVal path data (Day and Smith, 2018), Sustrans path network data (Sustrans, 2020), and Malvern Hills AONB public right of way data (provided by Worcestershire, Herefordshire, and Gloucestershire County Councils). Community growing spaces and allotments, as well as limited access sports clubs (i.e., bowling greens, tennis courts, and other sport facilities) identified through Ordnance Survey (OS) Open Greenspace data (OS, 2020) were classed as 'semi-restricted'. Surface water was classed as 'semi-restricted' access, as it can be used for water-based recreation activities, however, has limitations to access through the requirement for equipment (e.g., for boating) or training (e.g., for swimming).

4.11.5. Land classed as 'restricted' included sports clubs where membership is more expensive (e.g., golf clubs) – these were also identified through the Open Greenspace data (OS, 2020). Restricted access land in the AONB comprises Worcestershire Golf Club. Bransford Golf Club is also located within the 2km buffer of the Malvern Hills AONB and forms an additional area of restricted-access land.

Landscape Character Type analysis

4.11.6. Landscape Character Types, ranked by mean recreation baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 11. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the recreation ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the recreation ecosystem service.

Table 11: Ranked LCTs containing moderately and highly characteristic habitats which make the greatest contribution to the recreation baseline

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.72	Settled farmlands on river terrace	0.52	High hills and slopes	0.44
Moderately Characteristic Habitat	Forest smallholdings & dwellings	2.14	Low hills and orchards	1.07	Wooded hills and farmlands	1.00
Highly Characteristic Habitat	Unwooded vale	2.45	Principal wooded hills	1.89	Settled farmlands with pastoral land use	1.82

Opportunity methods and rationale

4.11.7. To produce a relational recreation opportunity dataset, the inverse of the baseline dataset was modified by (i) index of multiple deprivation (IMD) data at the lower-layer super output area (LSOA) level and (ii) Natural England's Accessible Natural Greenspace Standard (ANGSt). The rationale for using IMD data is that in areas of high deprivation, individuals are likely to be less able to travel to access areas where the interaction with nature ecosystem service is provided. ANGSt data was applied to assess current provision of green space within the study area.

4.11.8. The weighting factor applied to the IMD dataset was calculated by dividing the decile of IMD within a given LSOA by 10 and adding this value to one to produce a range of values from 0.1 to 1.0. Deciles scored 10 for the most deprived LSOAs, and 1 for the least deprived. These deciles were calculated based on data for the whole of England to ensure the outputs are compatible on a national scale, should these methods be applied elsewhere.

4.11.9. Criteria defined by ANGSt was then used to identify areas that currently do not meet ANGSt requirements (Thompson, 2010) with these areas subsequently being weighted by population density. This data identifies deficits in current access to green space, and thus, when combined with a proxy for ability of people to access local green space, allows areas of demand for recreational green space to be identified. Here, areas of high deprivation (as per the index of multiple deprivations (IMD)) were used as a proxy for ability to travel.

4.11.10. ANGSt requirements specify that a given household should have access to one accessible natural greenspace of (i) at least 2ha within 0.3km of home, (ii) at least 20ha within 2km, (iii) at least 100ha within 5km of home, and (iv) at least 500ha within 10km (Thompson, 2010). The standards also specify a minimum of 1ha of statutory Local Nature Reserve per 1000 population, although this is not factored into this analysis.

4.11.11. Analysis of ANGSt requirements within the study area was undertaken using buffer analysis to identify areas which meet each of the distance criteria established by ANGSt. To ensure the analysis accurately represented boundary reasons, ANGSt analysis was undertaken for a 20 km

buffer of the mapped region. Modifiers values applied range from 1.0 at 0 ANGSt criteria fulfilled to 0.0 at 4 ANGSt criteria fulfilled.

Interpretation of results

4.11.12. The recreation baseline (Figure 24) indicates that provision of the ecosystem service varies most notably between semi-restricted and open-access land, with the majority of high-scoring areas being located within open-access land. These areas are mostly located along the Malvern Hills, though small patches of open-access land are also dispersed across the study area.

4.11.13. Mapped recreation opportunity (Figure 25) indicates that the ANGSt criteria assessed are met within much of the Malvern Hills AONB, in particular along the ridge of the hills (indicated by white areas of low opportunity). Settlements within the study area meet ANGSt criteria for varying degrees; Great Malvern – and to a lesser extent Ledbury – are well provisioned under the criteria, whereas opportunity is highest at the west central region and southern point of the study area.

Limitations and further development

4.11.14. Gardens were included as an additional 'private' land access category in the Oxfordshire report (as private land with a weight of 0.25), but not factored in here due to constraints in processing power. Future work may also investigate including population data to calculate the amount of Local Nature Reserves available per 1000 population. The use of IMD data assumes that the demand for interaction with nature is greatest in LSOAs where deprivation is highest. However, there are also likely to be additional factors that impact this accessibility alongside deprivation. These may include demographic and public transportation data.

Figure Sheet:
C1 Recreation

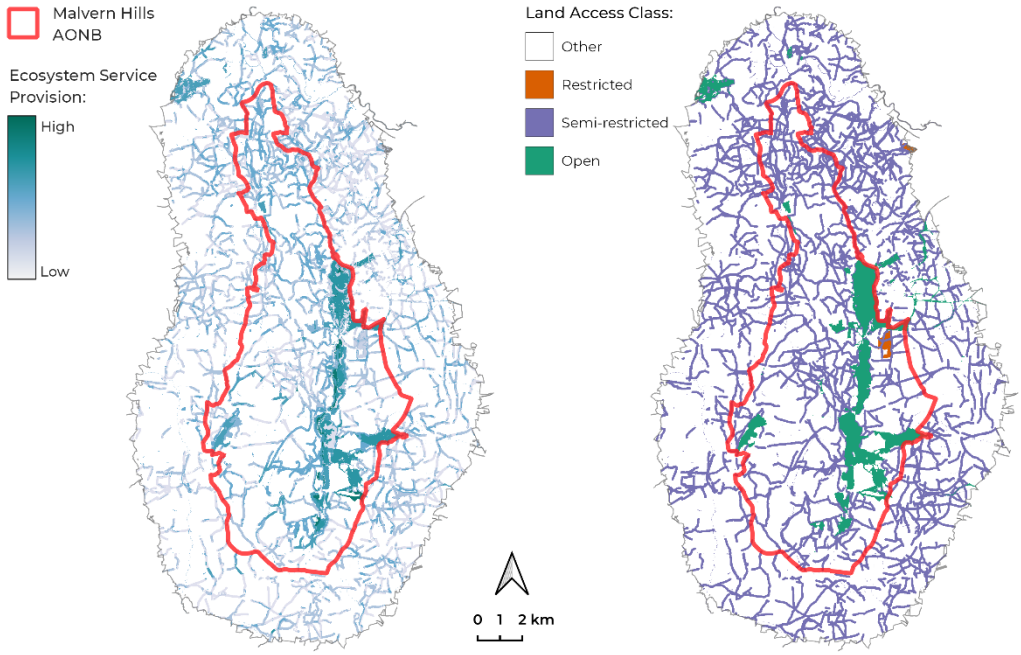

Figure 24: Recreation relational baseline (left) and land access modifier (right)

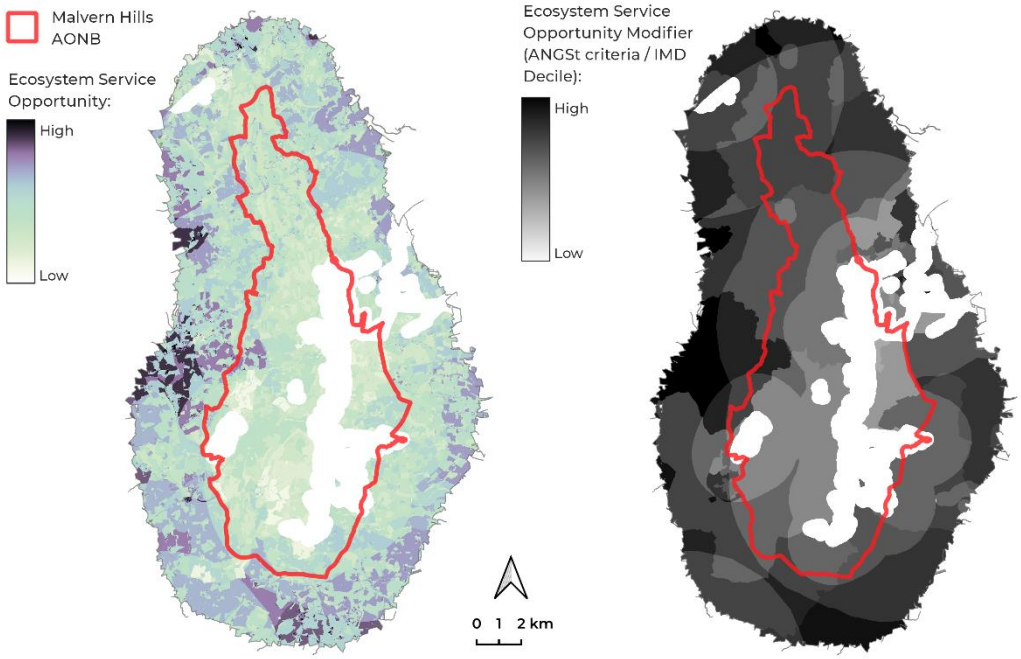

Figure 25: Recreation relational opportunity (left) and modifier (right)

4.12. C2: Education

Ecosystem service definition

4.12.1. The ecosystem service of education is defined as the provision of green and blue spaces that can provide educational benefit.

Baseline methods and rationale

4.12.2. The education ecosystem service baseline is based on the cultural ecosystem service analysis (Section 3.3) with each habitat scored on its ability to provide education. A spatial modifier was applied to the HSSM values in generation the education baseline. The rationale for selecting a modification layer for the baseline was in recognition that accessibility of land strongly influences the extent to which the recreation ecosystem service is captured by people. The methods detailed below were derived from the Natural Capital in Oxfordshire study (Smith, 2020), and are identical to those applied to the recreation ecosystem service baseline.

4.12.3. Land classed as 'open' was identified through land covered under Countryside Rights of Way Act (Natural England, 2020b), and land within the Outdoor Recreation Valuation (ORVal) dataset (Day and Smith, 2018).

4.12.4. Land classed as 'semi-restricted' was identified through applying a buffer of 50m to public rights of way within the study area. These were identified through a combination of the ORVal path data (Day and Smith, 2018), Sustrans path network data (Sustrans, 2020), and Malvern Hills AONB public right of way data (provided by Worcestershire, Herefordshire, and Gloucestershire County Councils). Community growing spaces and allotments, as well as limited access sports clubs (i.e., bowling greens, tennis courts, and other sport facilities) identified through Ordnance Survey (OS) Open Greenspace data (OS, 2020) were classed as 'semi-restricted'. Surface water was classed as 'semi-restricted' access, as it can be used for water-based recreation activities, however, has limitations to access through the requirement for equipment (e.g., for boating) or training (e.g., for swimming).

4.12.5. Land classed as 'restricted' included sports clubs where membership is more expensive (e.g., golf clubs) – these were also identified through the Open Greenspace data (OS, 2020). Restricted access land in the AONB comprises Worcestershire Golf Club. Bransford Golf Club is also located within the 2km buffer of the Malvern Hills AONB and forms an additional area of restricted-access land.

Landscape Character Type analysis

4.12.6. Landscape Character Types, ranked by mean education baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 12. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the education ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the education ecosystem service.

Table 12: Ranked LCTs containing moderately and highly characteristic habitats which make the greatest contribution to the education baseline

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.46	Settled farmlands on river terrace	0.37	High hills and slopes	0.30
Moderately Characteristic Habitat	Forest smallholdings & dwellings	1.59	Low hills and orchards	0.81	Wooded hills and farmlands	0.72
Highly Characteristic Habitat	Unwooded vale	1.84	Settled farmlands with pastoral land use	1.34	Principal wooded hills	1.26

Opportunity methods and rationale

4.12.7. To produce a relational education opportunity dataset, the inverse of the baseline dataset was modified by index of multiple deprivation (IMD) data at the lower-layer super output area (LSOA) level. The rationale for using IMD data is that in areas of high deprivation individuals are likely to be less able to travel to access areas where the interaction with nature ecosystem service is provided. The IMD modifier here is applied identically to the recreation and interaction with nature ecosystem service opportunity maps, although ANGSt standards are also included within the recreation opportunity map.

4.12.8. The weighting factor applied to the IMD dataset was calculated by dividing the decile of IMD within a given LSOA by 10 and adding this value to one to produce a range of values from 0.1 to 1.0. Deciles scored 10 for the most deprived LSOAs, and 1 for the least deprived. These deciles were calculated based on data for the whole of England to ensure the outputs are compatible on a national scale, should these methods be applied elsewhere.

Interpretation of results

4.12.9. The education baseline (Figure 26) is similar to the recreation baseline and also indicates that provision of the ecosystem service varies most notably between semi-restricted and open-access land. There are few high-scoring areas, though the highest-scoring areas are located within open-access land. These areas are mostly located along the Malvern Hills, though small areas of open-access land are also dispersed across the study area.

4.12.10. Mapped education opportunity (Figure 27) illustrates areas of highest ecosystem service opportunity are greatest where deprivation (according to IMD data) is also greatest. These areas are generally located around the margins of the Malvern Hills AONB, in particular in areas of Greater Malvern and parts of the northeast study region.

Limitations and further development

4.12.11. The use of IMD data assumes that the demand for interaction with nature is greatest in LSOAs where deprivation is highest. However, there are also likely to be additional factors that impact this accessibility alongside deprivation. These may include demographic and public transportation data.

Figure Sheet:
C2 Education

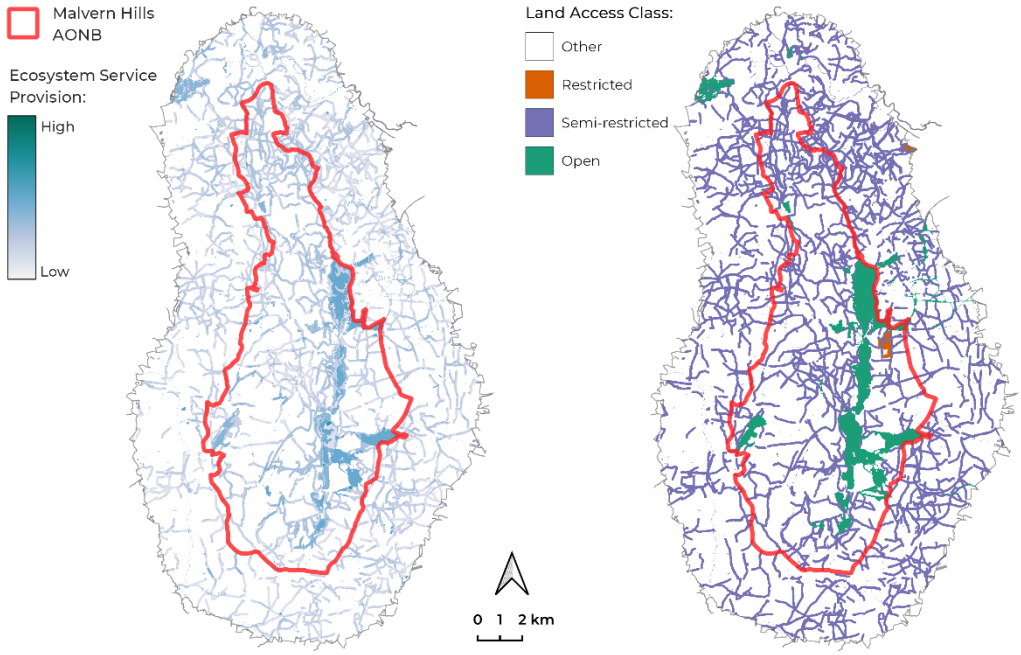

Figure 27: Education relational baseline (left) and land access modifier (right)

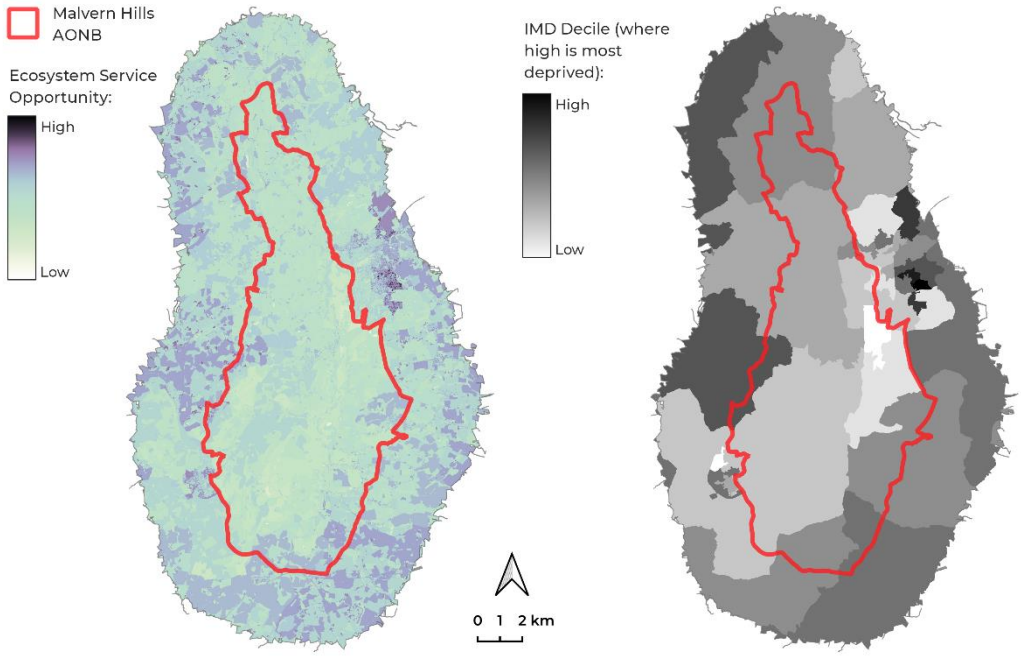

Figure 28: Education relational opportunity (left) and IMD modifier (right)

4.13. C3: Interaction with Nature

Ecosystem service definition

4.13.1. The ecosystem service of interaction with nature is defined as the provision of opportunities for formal or informal nature-related activities (e.g., birdwatching, wildlife encounters, or 'feeling connected with nature'). There is some overlap with biodiversity, but access by people can have negative impacts on some wildlife habitats. These activities exclude recreational fishing, hunting, and shooting.

Baseline methods and rationale

4.13.2. The interaction with nature ecosystem service baseline is based on the cultural ecosystem service analysis (Section 3.3) with each habitat scored on its ability to provide interaction with nature. A spatial modifier was applied to the HSSM values to map the interaction with nature ecosystem service baseline within the Malvern Hills AONB. Overlapping designated sites were used as a modifying dataset following the methods of (Smith, 2020) who states that protected areas are more likely to support a greater amount and diversity of wildlife. Some designated sites may also preserve other natural or semi-natural features of interest (i.e., geological features), and features of cultural or historical importance (i.e., scheduled monuments).

4.13.3. Designated sites included: Local Nature Reserves (LNRs), National Nature Reserves (NNRs), Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation (SACs), and local geological sites. Greater modifier values were applied where a greater number of designated sites overlapped. These values are presented in Annex 1 and derived from Smith (2020).

Landscape Character Type analysis

4.13.4. Landscape Character Types, ranked by mean interaction with nature baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 13. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the interaction with nature ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the interaction with nature ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.64	Settled farmlands on river terrace	0.42	High hills and slopes	0.42
Moderately Characteristic Habitat	Forest smallholdings & dwellings	1.62	Low hills and orchards	0.81	Wooded hills and farmlands	0.78
Highly Characteristic Habitat	Principal wooded hills	1.88	Unwooded vale	1.84	Wooded hills and farmlands	1.47

Table 13: Ranked LCTs containing moderately and highly characteristic habitats which make the greatest contribution to the interaction with nature baseline

Opportunity methods and rationale

4.13.5. To produce a relational interaction with nature opportunity dataset, the inverse of the baseline dataset was modified by index of multiple deprivation (IMD) data at the lower-layer super output area (LSOA) level. The rationale for using IMD data is that in areas of high deprivation individuals are likely to be less able to travel to access areas where the interaction with nature ecosystem service is provided. The IMD modifier here is applied identically to the recreation and education ecosystem service opportunity maps, although ANGSt standards are also included within the recreation opportunity map.

4.13.6. The weighting factor applied to the IMD dataset was calculated by dividing the decile of IMD within a given LSOA by 10 and adding this value to one to produce a range of values from 0.1 to 1.0. Deciles scored 10 for the most deprived LSOAs, and 1 for the least deprived. These deciles were calculated based on data for the whole of England to ensure the outputs are compatible on a national scale, should these methods be applied elsewhere.

Interpretation of results

4.13.7. The interaction with nature baseline (Figure 28) indicates that provision of the ecosystem service is generally greatest within the Malvern Hills AONB, in part a reflection on the number and size of designated sites within the AONB. Once again, the ridge of the Malvern Hills is visible as a higher scoring area.

4.13.8. Mapped interaction with nature opportunity (Figure 29) is similar to education opportunity and illustrates areas of highest ecosystem service opportunity are greatest where deprivation (according to IMD data) is also greatest. These areas are generally located around the margins of the Malvern Hills AONB, in particular in areas of Greater Malvern and parts of the north-east study region.

Limitations and further development

4.13.9. The use of IMD data assumes that the demand for interaction with nature is greatest in LSOAs where deprivation is highest. However, there are also likely to be additional factors that impact this accessibility alongside deprivation. These may include demographic and public transportation data.

Figure Sheet:
C3 Interaction with Nature

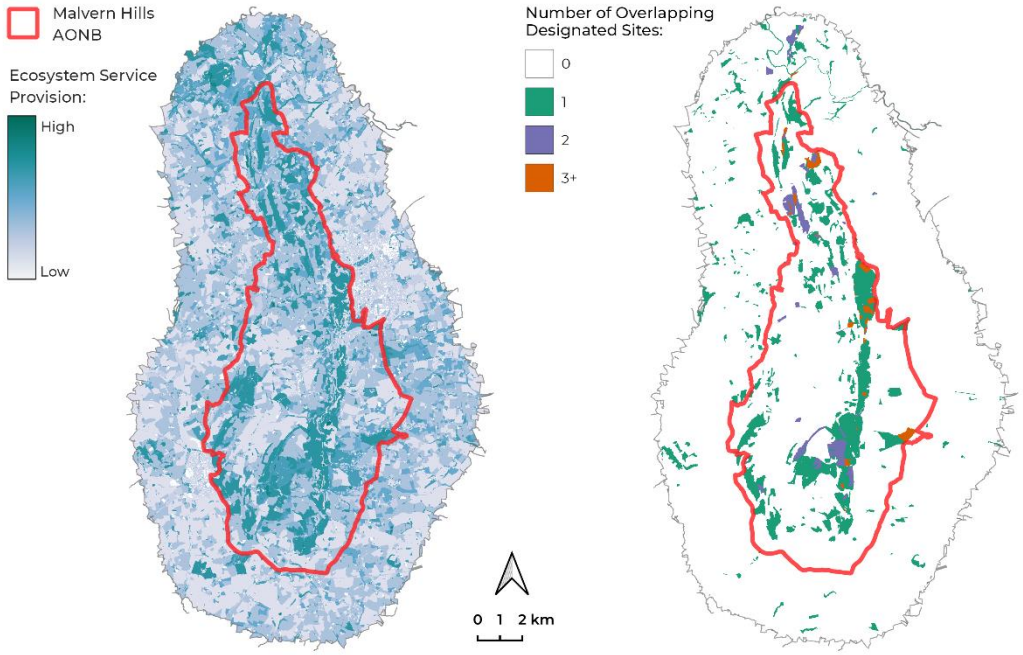

Figure 28: Interaction with Nature relational baseline (left) and designated site modifier (right)

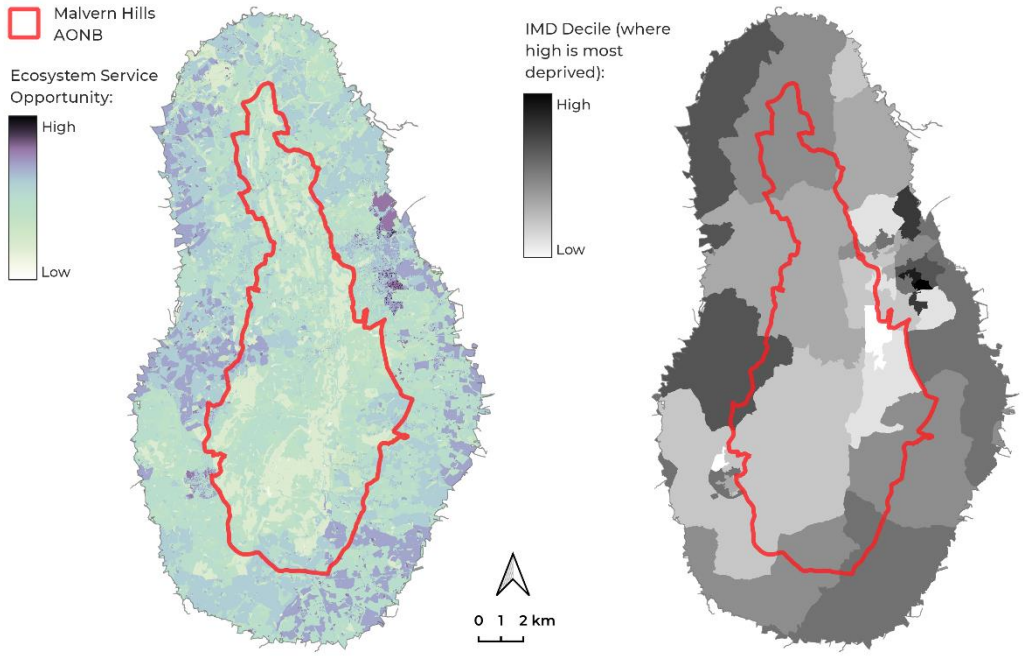

Figure 29: Interaction with Nature relational opportunity (left) and IMD modifier (right)

4.14. C4: Sense of Place

Ecosystem service definition

4.14.1. The ecosystem service of sense of place is defined as 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 or cultural events, or places important to people for spiritual or emotional reasons.

Baseline methods and rationale

4.14.2. The sense of place ecosystem service baseline is based on the cultural ecosystem service analysis (Section 3.3) with each habitat scored on its contribution to sense of place. A spatial modifier was applied to the HSSM values here. This modifier was produced by integrating historic environment record (HER) data with sense of place scores. Classification of records across HER datasets was reviewed to generate a single HER dataset from data produced by three local authorities across the Malvern Hills AONB. This allowed the three HER datasets, which vary in the types of features they include, to be filtered to only include those which are common throughout the three datasets. Feature types from county-level HER data included in the sense of place modifier were monuments and buildings. Historic parks and gardens and scheduled ancient monuments were then combined with the HER data to generate the final sense of place baseline modifier.

4.14.3. A raster dataset was then generated for the HER data, with binary values indicating presence or absence of HER entries. This dataset formed a spatial modifier for the sense of place baseline, whereby the ecosystem service HSSM score was increased by a value of two where the cell contained an HER entry.

Landscape Character Type analysis

4.14.4. Landscape Character Types, ranked by mean sense of place baseline values generated for moderately and highly characteristic habitats for each LCT within the study area (Annex 4), are shown in Table 14. The table shows the highest three ranks to identify which LCTs made the greatest contribution to the sense of place ecosystem service baseline. High mean baseline values represent LCTs where respective habitats score highly for the delivery of the sense of place ecosystem service.

	RANK					
	1		2		3	
	LCT	Mean baseline value	LCT	Mean baseline value	LCT	Mean baseline value
Least Characteristic Habitat	Wooded estatelands	0.53	Settled farmlands on river terrace	0.37	High hills and slopes	0.30
Moderately Characteristic Habitat	Forest smallholdings & dwellings	1.59	Low hills and orchards	0.81	Wooded hills and farmlands	0.74
Highly Characteristic Habitat	Unwooded vale	1.84	Settled farmlands with pastoral land use	1.34	Principal wooded hills	1.26

Table 14: Ranked LCTs containing moderately and highly characteristic habitats which make the greatest contribution to the sense of place baseline

Opportunity methods and rationale

4.14.5. A non-relational opportunity layer was produced for the sense of place ecosystem service due to the absence of an existing appropriate dataset that can be used to assess opportunity for sense of place. Data forming this layer is effectively the inverse of the sense of place baseline, designed to highlight areas of high opportunity.

Interpretation of results

4.14.6. The sense of place baseline (Figure 30) indicates that provision of the ecosystem service is relatively uniform throughout the Malvern Hills AONB and surrounding areas. There are, nonetheless, several areas that stand out as supporting a high level of ecosystem service provision. These are often associated with specific HER records, for example, Eastnor Castle, Brockhampton Park, and Hope End. Provision of the sense of place ecosystem service is typically lowest in the improved grassland habitats which surround the AONB. Consequently, these are also the areas with the highest opportunity for sense of place (Figure 31).

4.14.7. In opportunity, sense of place differs from other ecosystem services in that creating sense of place where it does not exist is highly complex, due to the interactions between cultural history and lived experiences - amongst other things – which produce sense of place. The opportunity map for sense of place has been provided as it highlights areas where provision of the sense of place ecosystem service is low.

Limitations and further development

4.14.8. Historic landscape character (HLC) has not been integrated into the sense of place ecosystem service maps, due to difficulties arising from valuing a given HLC type relative to other HLC types. Future work could explore alternative means to integrating HLC into mapping of the sense of place ecosystem service.

Figure Sheet:
C4 Sense of Place

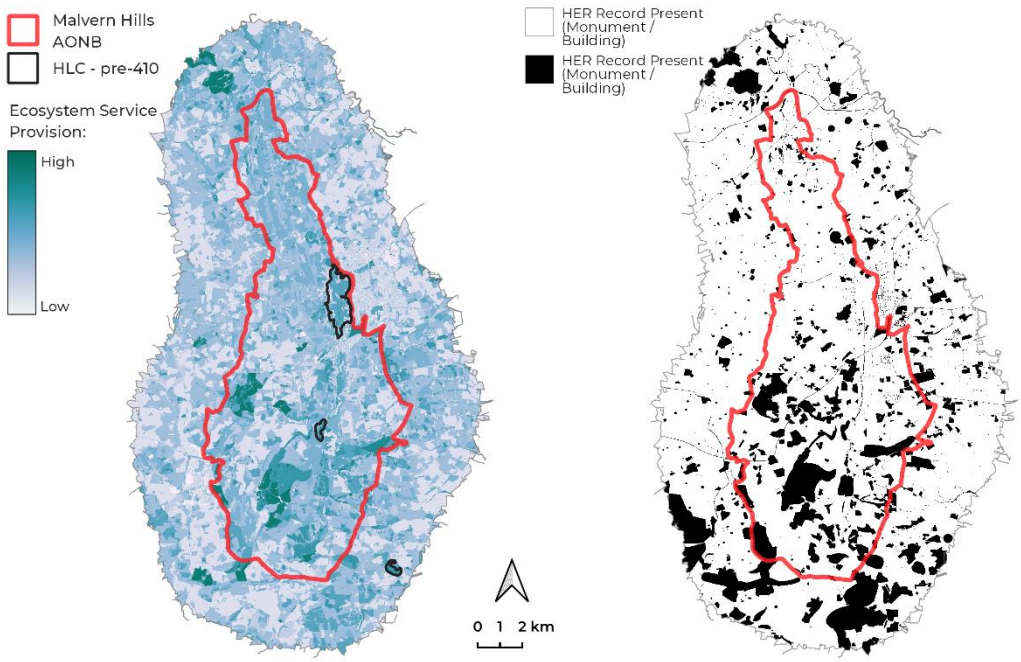

Figure 30: Sense of place relational baseline (left) and HER modifier (right)

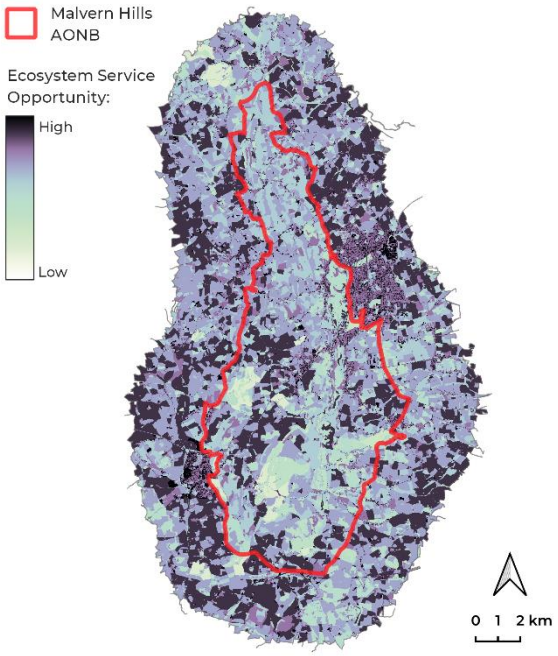

Figure 31: Sense of place non-relational opportunity

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Annex 1: Summary of ecosystem definitions and applied modifiers

<table>
<tr><th colspan="2">Ecosystem Service</th><th>Definition</th><th>Baseline Modifier</th><th>Opportunity Modifier</th></tr>
<tr><td rowspan="2">Provisioning</td><td>Food Provision</td><td>Agricultural and horticultural production of food products via arable crops, livestock, vegetables, and fruits. Production of food products (i.e., berries, fungi, and game) through hunting and gathering practices.</td><td>Agricultural Land Classification (ALC) grade (Natural England, 2020):
<table><tr><th>ALC Grade</th><th>Multiplier</th></tr><tr><td>1</td><td>3.03</td></tr><tr><td>2</td><td>2.40</td></tr><tr><td>3a</td><td>1.83</td></tr><tr><td>3</td><td>1.33</td></tr><tr><td>3b</td><td>1.00</td></tr><tr><td>4</td><td>0.67</td></tr><tr><td>5</td><td>0.50</td></tr></table></td><td>Not used.</td></tr>
<tr><td>Water Supply</td><td>The extent to which surface flow and groundwater recharge are impacted by soils and vegetation through processes of run-off and filtration.</td><td>No modifier applied.</td><td>Water resource availability as a percentage of time (Environment Agency, 2020a):
<table><tr><th>Percentage</th><th>Multiplier</th></tr><tr><td>>=95</td><td>1.20</td></tr><tr><td>70-94</td><td>1.40</td></tr><tr><td>50-69</td><td>1.60</td></tr><tr><td>30-49</td><td>1.80</td></tr><tr><td><30</td><td>2.00</td></tr></table></td></tr>
<tr><td>Cultural</td><td>Recreation</td><td>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).</td><td>Accessibility of land:
<table><tr><th>Land Access</th><th>Multiplier</th></tr><tr><td>Open</td><td>1.00</td></tr><tr><td>Semi-restricted</td><td>0.75</td></tr><tr><td>Restricted</td><td>0.50</td></tr><tr><td>Other</td><td>0.00</td></tr></table></td><td>Index of multiple deprivations (IMD):
<table><tr><th>IMD Decile</th><th>Multiplier</th></tr><tr><td>1st decile</td><td>0.1</td></tr><tr><td>2nd decile</td><td>1.2</td></tr><tr><td>3rd decile</td><td>0.3</td></tr><tr><td>4th decile</td><td>0.4</td></tr><tr><td>5th decile</td><td>0.5</td></tr><tr><td>6th decile</td><td>0.6</td></tr><tr><td>7th decile</td><td>0.7</td></tr><tr><td>8th decile</td><td>0.8</td></tr><tr><td>9th decile</td><td>0.9</td></tr><tr><td>10th decile</td><td>1.0</td></tr></table>
ANGSt criteria:
<table><tr><th>ANGSt Criteria Fulfilled</th><th>Multiplier</th></tr><tr><td>0</td><td>1.0</td></tr><tr><td>1</td><td>0.8</td></tr><tr><td>2</td><td>0.6</td></tr><tr><td>3</td><td>0.4</td></tr><tr><td>4</td><td>0.0</td></tr></table></td></tr>
</table>

<table>
<tr><th colspan="2">Ecosystem Service</th><th>Definition</th><th>Baseline Modifier</th><th>Opportunity Modifier</th></tr>
<tr><td rowspan="3"></td><td>Education</td><td>Provision of green and blue spaces that can provide educational benefit.</td><td>Accessibility of land:
<table><tr><th>Land Access</th><th>Multiplier</th></tr><tr><td>Open</td><td>1.00</td></tr><tr><td>Semi-restricted</td><td>0.75</td></tr><tr><td>Restricted</td><td>0.50</td></tr><tr><td>Other</td><td>0.00</td></tr></table></td><td>Index of multiple deprivations (IMD):
<table><tr><th>IMD Decile</th><th>Multiplier</th></tr><tr><td>1st decile</td><td>0.1</td></tr><tr><td>2nd decile</td><td>1.2</td></tr><tr><td>3rd decile</td><td>0.3</td></tr><tr><td>4th decile</td><td>0.4</td></tr><tr><td>5th decile</td><td>0.5</td></tr><tr><td>6th decile</td><td>0.6</td></tr><tr><td>7th decile</td><td>0.7</td></tr><tr><td>8th decile</td><td>0.8</td></tr><tr><td>9th decile</td><td>0.9</td></tr><tr><td>10th decile</td><td>1.0</td></tr></table></td></tr>
<tr><td>Interaction with Nature</td><td>Provision of opportunities for formal or informal nature-related activities (e.g., birdwatching, wildlife encounters, or ‘feeling connected with nature’). There is some overlap with biodiversity, but access by people can have negative impacts on some wildlife habitats. Excludes recreational fishing, hunting, shooting, intrinsic value of nature, and existence value.</td><td>Overlapping designations:
<table><tr><th>Designations</th><th>Multiplier</th></tr><tr><td>1</td><td>1.05</td></tr><tr><td>2</td><td>1.10</td></tr><tr><td>3</td><td>1.15</td></tr></table></td><td>Index of multiple deprivations (IMD):
<table><tr><th>IMD Decile</th><th>Multiplier</th></tr><tr><td>1st decile</td><td>0.1</td></tr><tr><td>2nd decile</td><td>1.2</td></tr><tr><td>3rd decile</td><td>0.3</td></tr><tr><td>4th decile</td><td>0.4</td></tr><tr><td>5th decile</td><td>0.5</td></tr><tr><td>6th decile</td><td>0.6</td></tr><tr><td>7th decile</td><td>0.7</td></tr><tr><td>8th decile</td><td>0.8</td></tr><tr><td>9th decile</td><td>0.9</td></tr><tr><td>10th decile</td><td>1.0</td></tr></table></td></tr>
<tr><td>Sense of Place</td><td>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 or cultural events, or places important to people for spiritual or emotional reasons.</td><td>Values of cells where a HER record is present have been incremented by 2.</td><td></td></tr>
<tr><td>Regulating</td><td>Carbon Storage</td><td>Quantities of carbon stored in soil and vegetation.</td><td>Soil depth:
<table><tr><th>Class</th><th>Modifier</th></tr><tr><td>‘Deep’</td><td>+5</td></tr><tr><td>Other</td><td>0</td></tr></table></td><td>Not used.</td></tr>
<tr><td></td><td>Water Flow Regulation</td><td>Impact of soil and vegetation on reducing surface run-off, peak flow, and flood extent and depth. Mechanisms include interception, evapotranspiration, infiltration, and physical water flow slowing.</td><td>Proximity to flow pathway:
<table><tr><th>Proximity to Flow Pathway</th><th>Multiplier</th></tr><tr><td>1st decile (furthest)</td><td>1.1</td></tr><tr><td>2nd decile</td><td>1.2</td></tr><tr><td>3rd decile</td><td>1.3</td></tr><tr><td>4th decile</td><td>1.4</td></tr><tr><td>5th decile</td><td>1.5</td></tr><tr><td>6th decile</td><td>1.6</td></tr></table></td><td>Cumulative flood risk (where 1 is low and 10 is high flood risk):
<table><tr><th>Cumulative Flood Risk Decile</th><th>Multiplier</th></tr><tr><td>1st decile</td><td>1.0</td></tr><tr><td>2nd decile</td><td>1.1</td></tr><tr><td>3rd decile</td><td>1.2</td></tr><tr><td>4th decile</td><td>1.3</td></tr><tr><td>5th decile</td><td>1.4</td></tr></table></td></tr>
</table>

Ecosystem Service		Definition	Baseline Modifier	Opportunity Modifier
			7th decile: 1.7 8th decile: 1.8 9th decile: 1.9 10th decile (closest): 2.0	6th decile: 1.6 7th decile: 1.8 8th decile: 2.0 9th decile: 2.2 10th decile: 2.4
	Local Climate Regulation	Cooling effects of vegetation and water, in particular in urban areas where these can reduce heating and cooling costs and provide areas of shade.	If distance from urban areas is greater than 0.25 km then habitats are scored 0, else HSSM values are used.	Not used.
	Air Pollutant Removal	Effect of vegetation on concentrations of air pollutants through mechanisms including deposition, absorption, and chemical breakdown.	If distance from national and regional roads, and urban areas is greater than 0.30 km than habitats are scored 0, else HSSM values are used.	Not used.
Bundled Benefits	Biodiversity	The ability of a habitat to support a diverse range of species, providing a variety of environmental, social, and economic benefits.	No modifier applied.	Not used.
	Water Quality	Uptake of pollutants dissolved or suspended in water by vegetation, and the ability of vegetation to prevent pollutants	No modifier applied.	Not used.
	Soil Health	The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans.	No modifier applied.	Not used.

Annex 2: Habitat Service Scoring Matrix

			PROVISIONING		CULTURAL				REGULATING				BUNDLED		
LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Food Provision	Water Supply	Recreation	Education	Interaction with Nature	Sense of Place	Carbon Storage	Water Flow Regulation	Local Climate Regulation	Air Pollutant Removal	Biodiversity	Water Quality	Soil Health
G Grassland	0021	Traditional Orchard	5	7	7	3	4	5	7	8	8	6	9	8	8
	0119	Seasonally Wet Grassland	4	9	1	2	1	2	4	9	2	1	9	5	8
	0120	Wet Grassland	3	9	2	3	2	3	4	9	2	1	10	5	8
	g	Grassland	6	7	4	6	4	5	3	3	2	1	4	1	4
	g1	Acid Grassland	6	9	5	7	5	6	4	8	2	1	8	4	8
	g1a	Lowland Dry Acid Grassland	6	8	2	9	2	2	3	8	2	1	10	4	8
	g1c	Bracken	1	8	2	2	2	2	4	8	2	1	5	5	8
	g2	Calcareous Grassland	6	9	3	5	3	4	3	8	2	1	10	4	8
	g2a	Lowland Calcareous Grassland	6	9	2	3	2	2	3	8	2	1	10	4	8
	g3	Neutral Grassland	6	9	3	5	3	4	4	8	2	1	8	4	8
	g3a	Lowland Meadows	6	9	2	3	2	2	4	8	2	1	10	4	8
	g4	Modified Grassland	10	5	3	4	3	3	3	4	2	1	2	1	4
W Woodland and Forest	0011	Broadleaved Scattered Trees	5	7	1	1	1	1	5	6	6	3	8	8	8
	0020	Wood Pasture	5	7	5	8	5	7	8	9	8	6	9	8	8
	0053	Felled Woodland	0	4	1	1	1	2	1	1	1	0	2	0	0
	w	Woodland	0	1	4	6	4	5	8	10	10	10	6	5	6
	w1	Broadleaved Mixed and Yew Woodland	1	3	4	6	4	6	10	9	10	8	10	10	10
	w1g	Other Woodland	5	7	3	5	3	4	5	6	6	3	10	8	8
	w2	Coniferous Woodland	0	1	2	4	2	3	8	5	10	10	3	5	6
	w2a	Native Pine Woodland	0	3	5	7	5	6	7	9	10	8	8	6	8
	w2c	Other Coniferous Woodland	0	1	2	4	2	3	8	10	10	10	3	5	6
H Heathland and Shrub	h	Heathland	1	8	3	4	3	3	4	7	2	4	8	7	8
	h1	Dwarf Shrub Heath	1	8	5	7	5	7	4	7	2	4	8	7	8
	h1a	Lowland Heathland	1	8	5	7	5	6	4	7	2	4	10	7	8
	h1a7	Wet Heathland with Cross-Leaved Heath	1	9	2	2	2	2	5	7	2	4	10	7	8
	h2	Hedgerows	1	4	1	1	2	2	5	8	6	8	10	7	8
	h3	Dense Scrub	1	4	1	1	1	1	6	8	6	7	5	7	8
F Wetland	f	Wetland	1	10	9	8	10	10	10	6	4	1	10	8	8
	f1	Bog	1	10	6	6	7	7	10	6	4	1	10	8	8
	f2	Fen, Marsh and Swamp	1	10	9	8	9	10	6	6	4	1	10	8	8
	f2e	Reedbeds	0	10	6	6	7	7	4	6	4	1	10	8	8

			PROVISIONING		CULTURAL				REGULATING				BUNDLED		
LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Food Provision	Water Supply	Recreation	Education	Interaction with Nature	Sense of Place	Carbon Storage	Water Flow Regulation	Local Climate Regulation	Air Pollutant Removal	Biodiversity	Water Quality	Soil Health
C Cropland	0900	Small-Scale Food Growing	7	7	1	1	1	1	3	5	2	2	8	1	1
	0920	Orchard	7	7	2	2	1	2	3	5	2	2	6	1	1
	c1	Arable and Horticulture	10	8	1	1	1	1	1	4	2	1	4	4	5
	c1a	Arable Margins	0	8	2	2	1	2	2	4	2	1	7	5	8
	c1b	Temporary Grass and Clover Leys	7	8	1	1	1	1	1	5	2	1	5	5	8
	c1c	Cereal Crops	10	7	1	1	2	2	1	2	2	1	2	1	1
	c1d	Non-Cereal Crops (e.g. Biofuel)	2	3	1	1	1	1	4	4	2	1	3	1	2
	c1e	Intensive Orchards	10	3	3	1	1	1	5	8	8	4	2	1	6
	c1f	Horticulture (e.g. Community Gardens, Allotments)	7	7	1	1	2	1	3	5	2	2	8	1	1
U Urban	0011	Scattered Trees	0	1	1	1	1	1	7	6	8	6	5	2	6
	0017	Ruderal and Tall Herb	1	8	1	1	1	1	4	8	2	1	3	5	8
	0200	Parks and Gardens	0	7	0	1	1	1	4	3	4	3	6	2	5
	0711	Natural Sports Pitches/Playground	0	7	2	3	2	2	3	3	2	1	2	2	3
	0740	Open Space/Amenity Grassland	0	7	1	1	1	1	3	3	2	1	2	2	4
	0800	Cemetaries/Churchyards	0	7	1	1	1	1	4	3	2	2	5	2	4
	1210	Other Natural Functional Green Space	0	7	3	3	2	3	3	3	2	1	4	2	3
	u	Urban	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1	Built-Up Areas and Gardens	0	0	2	2	2	2	0	0	0	0	0	0	0
	u1a	Open Mosaic Habs on Previously Developed Land	1	5	1	1	1	1	1	2	2	1	8	1	4
	u1b	Sealed Surface	0	0	0	1	0	0	0	0	0	0	0	0	0
	u1c	Artificial Unvegetated Unsealed Surface	0	4	0	0	0	0	0	1	0	0	1	1	0
	u1d	Suburban/Mosaic of Developed/Natural Surface	1	7	0	0	0	1	2	3	2	2	3	2	5
	u1e	Built Linear Features - Cyclepath And Footpath	0	5	1	1	1	2	2	2	2	1	2	1	3
	u1e	Built Linear Features - Road Verge	0	5	1	1	1	1	3	3	2	1	2	2	4
S Sparsely Vegetated Land	0073	Bare Ground	0	1	2	3	2	2	1	1	1	0	3	1	0
	0105	Quarry - Hard Rock	0	0	4	3	3	4	0	1	2	0	5	5	3
	0106	Quarry - Sand and Gravel	0	0	1	2	2	1	0	1	2	0	5	5	3
	s	Sparsely Vegetated Land	0	0	1	2	2	2	0	1	2	0	6	0	0
	s1	Inland Rock	0	0	2	3	2	2	0	0	0	0	8	0	0
	s2	Supralittoral Rock	0	0	5	5	6	6	0	1	2	0	6	7	3

			PROVISIONING		CULTURAL				REGULATING				BUNDLED		
LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Food Provision	Water Supply	Recreation	Education	Interaction with Nature	Sense of Place	Carbon Storage	Water Flow Regulation	Local Climate Regulation	Air Pollutant Removal	Biodiversity	Water Quality	Soil Health
	s3	Supralittoral Sediment	0	0	2	2	2	2	4	5	3	1	8	7	3
R Rivers and Lakes	r	Rivers and Lakes	0	10	3	5	4	4	0	1	4	0	8	1	0
	r1	Standing Open Water and Canals	0	10	6	7	7	8	1	4	4	0	8	1	0
	r2	Rivers and Streams	2	10	5	5	5	6	0	1	4	0	8	1	0
T Marine Inlets and Transitional Waters	t	Marine Inlets and Transitional Waters	0	0	2	3	2	2	0	1	2	0	6	5	1
	t1	Littoral Rock	0	0	1	1	1	1	0	1	2	0	6	7	1
	t2	Littoral Sediment	0	0	1	1	1	1	4	5	3	1	8	7	3
	t2a	Coastal Saltmarsh	4	0	1	2	2	2	10	9	4	1	10	5	5
	t2d	Intertidal Mudflats	0	5	1	2	2	1	10	5	4	1	10	7	7

Annex 3: Landscape Character Type and Characteristic Habitat Scoring Matrix

Least characteristic habitat: **0**
Moderately characteristic habitat: **1**
Highly characteristic habitat: **2**

LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land use	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
G Grassland	0021	Traditional Orchard	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	2	0	2
	0119	Seasonally Wet Grassland	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	2	0
	0120	Wet Grassland	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	2	0
	g	Grassland	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	g1	Acid Grassland	1	1	1	2	1	1	1	2	0	0	2	1	2	0	2	2	1	1	2	2
	g1a	Lowland Dry Acid Grassland	1	1	1	2	1	1	1	2	0	0	2	1	2	0	2	2	1	1	2	2
	g1c	Bracken	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	g2	Calcareous Grassland	1	1	1	0	1	1	1	2	0	0	2	1	1	0	2	2	1	1	2	2
	g2a	Lowland Calcareous Grassland	1	1	1	0	1	1	1	2	0	0	2	1	1	0	2	2	1	1	2	2
	g3	Neutral Grassland	1	1	1	0	1	1	1	2	0	0	2	1	1	0	2	2	1	2	2	2
	g3a	Lowland Meadows	1	1	1	0	1	1	1	2	0	0	2	1	1	0	2	2	1	2	2	2
	g4	Modified Grassland	1	1	1	0	1	1	0	2	0	0	2	1	0	0	2	2	1	1	2	2
W Woodland and Forest	0011	Broadleaved Scattered Trees	0	0	2	0	2	0	0	2	0	1	1	0	0	0	2	0	0	0	2	0
	0020	Wood Pasture	0	1	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
	0053	Felled Woodland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	w	Woodland	1	2	0	0	0	2	2	0	1	0	0	2	0	0	0	2	2	2	0	2
	w1	Broadleaved Mixed and Yew Woodland	1	1	0	0	0	2	2	0	1	0	0	2	0	0	0	2	2	2	0	2

Least characteristic habitat: **0**
Moderately characteristic habitat: **1**
Highly characteristic habitat: **2**

LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land use	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
	w1g	Other Woodland	1	1	0	0	0	2	2	0	1	0	0	2	0	0	0	2	2	2	0	2
	w2	Coniferous Woodland	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	2
	w2a	Native Pine Woodland	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	2
	w2c	Other Coniferous Woodland	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	0	2
H **Heathland and Shrub**	h	Heathland	0	0	0	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0
	h1	Dwarf Shrub Heath	0	0	0	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0
	h1a	Lowland Heathland	0	0	0	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0
	h1a7	Wet Heathland with Cross-Leaved Heath	0	0	0	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0
	h2	Hedgerows	2	2	2	0	2	2	2	1	2	1	2	2	2	0	0	1	2	2	2	2
	h3	Dense Scrub	0	0	1	1	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	2
F **Wetland**	f	Wetland	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	f1	Bog	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	f2	Fen, Marsh and Swamp	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
	f2e	Reedbeds	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
C **Cropland**	0900	Small-Scale Food Growing	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0
	0920	Orchard	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	2
	c1	Arable and Horticulture	1	1	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	0	1	1
	c1a	Arable Margins	1	2	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	0	1	1
	c1b	Temporary Grass and Clover Leys	1	1	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	0	1	1
	c1c	Cereal Crops	1	1	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	0	1	1
	c1d	Non-Cereal Crops (e.g. Biofuel)	1	1	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	0	1	1

Least characteristic habitat: **0**
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LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land use	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
	c1e	Intensive Orchards	1	1	0	0	1	1	0	0	2	2	0	1	0	0	0	2	1	2	0	0
	c1f	Horticulture (e.g. Community Gardens, Allotments)	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0
U Urban	0011	Scattered Trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0017	Ruderal and Tall Herb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0200	Parks and Gardens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0711	Natural Sports Pitches/Playground	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0740	Open Space/Amenity Grassland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0800	Cemetaries/Churchyards	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1210	Other Natural Functional Green Space	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u	Urban	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1	Built-Up Areas and Gardens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1a	Open Mosaic Habs on Previously Developed Land	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1b	Sealed Surface	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1c	Artificial Unvegetated Unsealed Surface	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1d	Suburban/Mosaic of Developed/Natural Surface	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1e	Built Linear Features - Cyclepath And Footpath	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	u1e	Built Linear Features - Road Verge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S Sparsely Vegetated Land	0073	Bare Ground	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0105	Quarry - Hard Rock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0106	Quarry - Sand and Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	s	Sparsely Vegetated Land	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Least characteristic habitat: **0**
Moderately characteristic habitat: **1**
Highly characteristic habitat: **2**

LEVEL 1 HABITAT	CODE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land use	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
	s1	Inland Rock	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	s2	Supralittoral Rock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	s3	Supralittoral Sediment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R Rivers and Lakes	r	Rivers and Lakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	r1	Standing Open Water and Canals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	r2	Rivers and Streams	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	1	2
T Marine Inlets and Transitional Waters	t	Marine Inlets and Transitional Waters	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	t1	Littoral Rock	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	t2	Littoral Sediment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	t2a	Coastal Saltmarsh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	t2d	Intertidal Mudflats	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

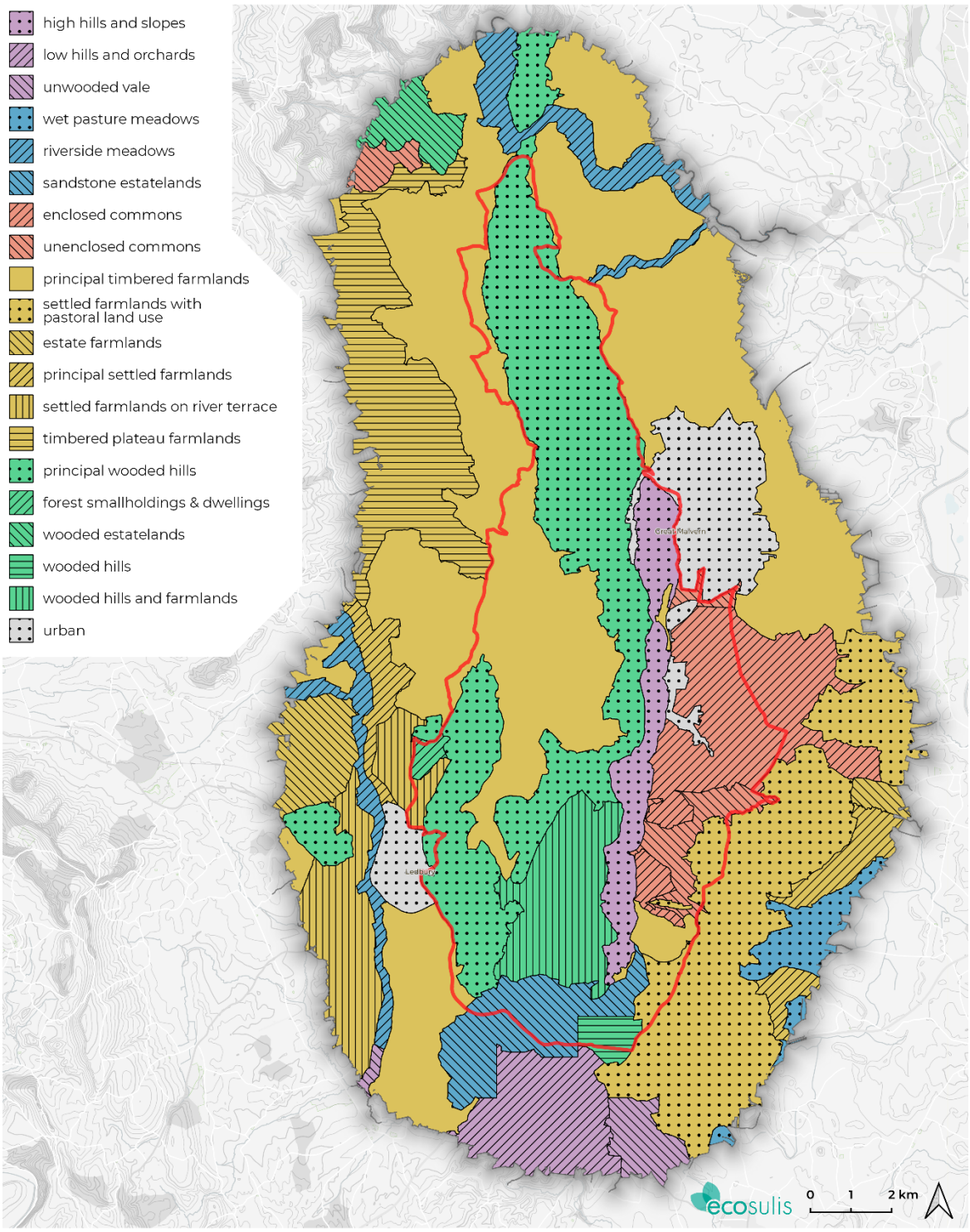
Annex 4: Landscape Character Type and Characteristic Habitats Aggregated by Ecosystem Service

ECOSYSTEM SERVICE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
P1 Food provision	Least Characteristic Habitat	0.18	0.05	0.16	0.21	0.05	0.08	0.58	0.86	0.52	0.97	0.53	0.06	0.44	0.26	1.10	0.50	0.16	0.97	0.05	0.01
	Moderately Characteristic Habitat	2.04	2.89	5.15	0.05	4.19	3.51	0.14	0.06	0.30	0.00	0.00	2.49	0.19	0.00	0.00	0.00	2.40	2.68	1.20	5.02
	Highly Characteristic Habitat	0.00	0.00	0.00	1.02	0.02	0.11	0.34	2.80	5.19	4.50	4.31	0.12	0.91	0.00	1.26	1.14	0.23	0.06	6.14	0.75
P2 Water supply	Least Characteristic Habitat	0.25	0.11	0.26	0.32	0.10	0.13	0.42	0.78	0.32	0.61	0.50	0.11	0.44	0.32	0.93	0.72	0.24	0.83	0.12	0.15
	Moderately Characteristic Habitat	1.39	1.99	2.80	0.27	3.04	2.40	0.21	0.32	0.50	0.00	0.00	1.58	0.32	0.00	0.00	0.00	1.56	1.36	0.99	4.01
	Highly Characteristic Habitat	0.00	0.07	0.00	1.46	0.04	0.25	0.97	1.61	4.15	3.64	2.58	0.35	1.35	0.00	0.72	0.78	0.72	0.19	3.07	0.52
R1 Carbon storage	Least Characteristic Habitat	0.12	0.06	0.29	0.64	0.11	0.06	0.24	0.26	0.17	0.52	0.15	0.06	0.38	0.15	0.17	0.70	0.19	0.12	0.18	0.04
	Moderately Characteristic Habitat	0.75	0.66	1.67	0.30	0.68	0.85	0.15	0.00	0.89	0.00	0.00	0.59	0.22	0.00	0.00	0.00	0.80	0.81	0.12	0.50
	Highly Characteristic Habitat	0.00	0.02	0.00	0.62	0.03	0.68	3.12	0.92	0.52	0.46	1.45	1.17	0.60	0.00	0.41	0.67	2.44	0.67	1.84	0.84
R2 Water flow regulation	Least Characteristic Habitat	0.13	0.07	0.31	0.60	0.11	0.07	0.31	0.49	0.23	0.61	0.27	0.07	0.42	0.22	0.49	0.78	0.21	0.41	0.18	0.06
	Moderately Characteristic Habitat	1.12	1.28	2.29	0.43	1.73	1.62	0.22	0.03	0.89	0.00	0.00	1.03	0.37	0.00	0.00	0.00	1.23	1.09	0.48	2.01
	Highly Characteristic Habitat	0.00	0.04	0.00	1.35	0.04	0.62	2.82	1.32	2.07	1.82	2.12	1.06	1.21	0.00	0.57	0.82	2.23	0.56	2.45	0.80
R3 Local climate regulation	Least Characteristic Habitat	0.09	0.07	0.31	0.63	0.12	0.06	0.22	0.33	0.12	0.44	0.18	0.06	0.36	0.14	0.28	0.70	0.19	0.21	0.19	0.05
	Moderately Characteristic Habitat	0.67	0.72	1.13	0.27	0.85	0.90	0.14	0.13	0.92	0.00	0.00	0.55	0.16	0.00	0.00	0.00	0.62	0.54	0.25	1.00
	Highly Characteristic Habitat	0.00	0.03	0.00	0.34	0.04	0.69	3.13	0.59	1.04	0.91	0.92	1.17	0.30	0.00	0.27	0.62	2.47	0.71	1.23	0.82

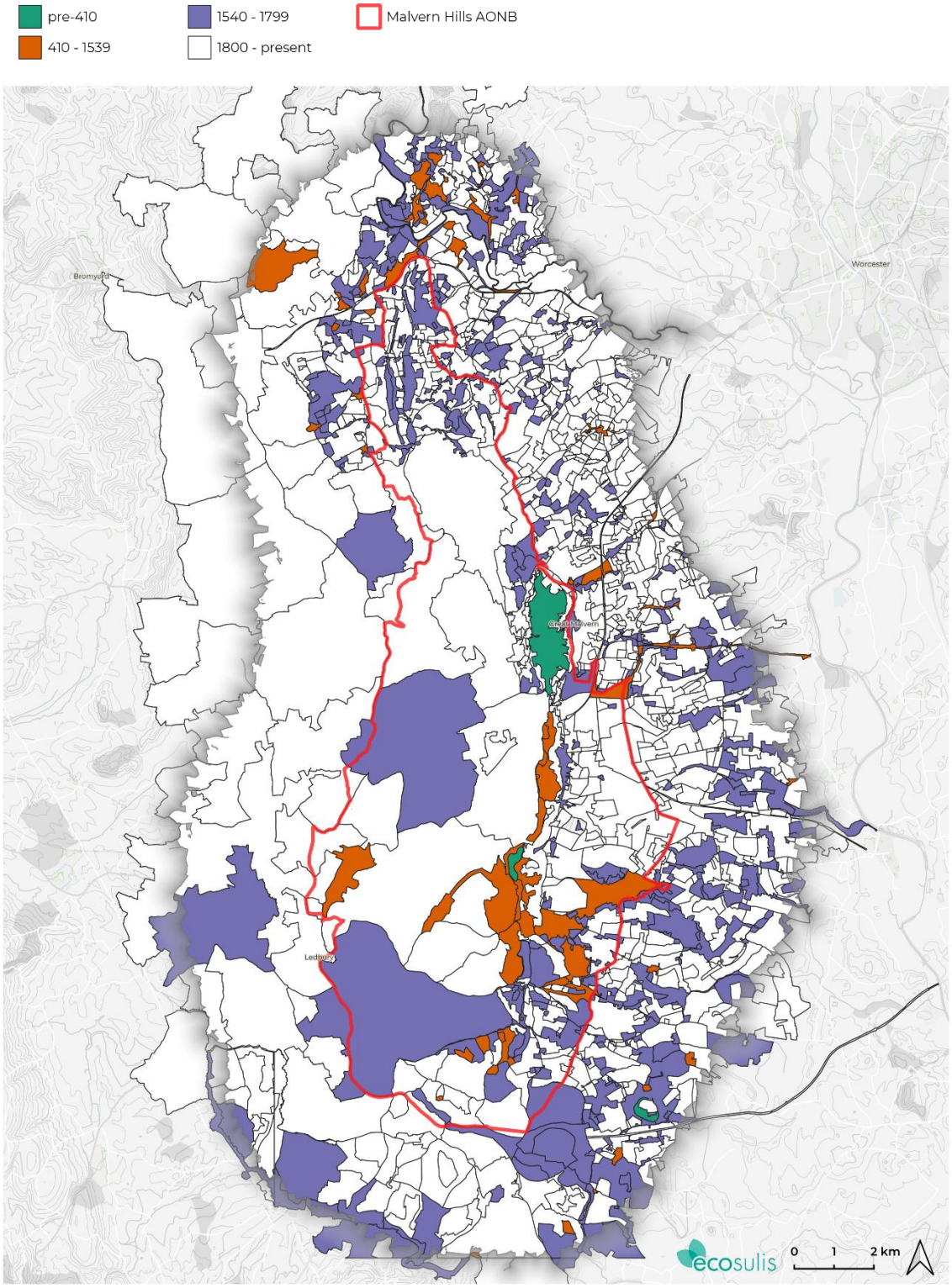
ECOSYSTEM SERVICE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
R4 Air pollutant removal	Least Characteristic Habitat	0.05	0.04	0.25	0.49	0.08	0.04	0.15	0.20	0.06	0.29	0.10	0.04	0.25	0.09	0.15	0.51	0.14	0.10	0.15	0.03
	Moderately Characteristic Habitat	0.40	0.40	0.59	0.29	0.43	0.48	0.10	0.00	0.73	0.00	0.00	0.30	0.15	0.00	0.00	0.00	0.35	0.27	0.12	0.50
	Highly Characteristic Habitat	0.00	0.02	0.00	0.17	0.02	0.53	2.50	0.29	0.52	0.46	0.46	0.94	0.15	0.00	0.13	0.43	1.99	0.61	0.61	0.65
B1 Biodiversity	Least Characteristic Habitat	0.16	0.09	0.32	0.64	0.14	0.08	0.25	0.51	0.14	0.45	0.30	0.08	0.43	0.22	0.51	0.82	0.23	0.42	0.20	0.06
	Moderately Characteristic Habitat	0.93	1.06	1.31	0.27	1.50	1.28	0.24	0.26	0.92	0.00	0.00	0.74	0.34	0.00	0.00	0.00	0.89	0.56	0.50	2.01
	Highly Characteristic Habitat	0.00	0.06	0.00	1.53	0.04	0.72	3.15	0.85	2.07	1.84	1.44	1.17	1.23	0.00	0.36	0.71	2.42	0.57	1.23	0.66
B2 Water quality	Least Characteristic Habitat	0.06	0.06	0.32	0.61	0.11	0.04	0.18	0.46	0.06	0.34	0.24	0.06	0.34	0.16	0.48	0.67	0.16	0.39	0.18	0.04
	Moderately Characteristic Habitat	0.71	0.94	0.70	0.35	1.34	1.02	0.17	0.03	0.88	0.00	0.00	0.59	0.23	0.00	0.00	0.00	0.58	0.28	0.48	2.01
	Highly Characteristic Habitat	0.00	0.05	0.00	0.68	0.04	0.70	3.13	0.40	2.07	1.83	0.67	1.17	0.61	0.00	0.18	0.62	2.40	0.61	0.61	0.63
B3 Soil health	Least Characteristic Habitat	0.15	0.08	0.36	0.66	0.13	0.08	0.34	0.59	0.23	0.62	0.34	0.08	0.46	0.25	0.61	0.73	0.20	0.51	0.19	0.08
	Moderately Characteristic Habitat	1.22	1.47	2.29	0.43	2.03	1.78	0.22	0.00	0.89	0.00	0.00	1.15	0.37	0.00	0.00	0.00	1.25	1.09	0.60	2.51
	Highly Characteristic Habitat	0.00	0.07	0.00	1.35	0.04	0.70	3.14	1.32	2.59	2.29	2.12	1.17	1.21	0.00	0.57	0.89	2.42	0.63	2.45	0.86
C1 Recreation	Least Characteristic Habitat	0.21	0.06	0.22	0.44	0.11	0.11	0.29	0.23	0.24	0.52	0.19	0.06	0.36	0.25	0.19	0.72	0.23	0.15	0.12	0.04
	Moderately Characteristic Habitat	0.80	0.72	2.14	0.07	0.80	0.90	0.10	0.16	0.63	0.00	0.00	0.72	0.14	0.00	0.00	0.00	1.00	1.07	0.13	0.50
	Highly Characteristic Habitat	0.00	0.02	0.00	0.97	0.02	0.42	1.89	1.16	0.52	0.46	1.82	0.71	1.02	0.00	0.52	0.58	1.48	0.38	2.45	0.65
C2 Education	Least Characteristic Habitat	0.14	0.04	0.14	0.30	0.07	0.07	0.21	0.18	0.17	0.37	0.14	0.04	0.25	0.17	0.16	0.46	0.15	0.13	0.08	0.03
	Moderately Characteristic Habitat	0.59	0.57	1.59	0.07	0.67	0.71	0.06	0.16	0.41	0.00	0.00	0.56	0.09	0.00	0.00	0.00	0.72	0.81	0.13	0.50
	Highly Characteristic Habitat	0.00	0.01	0.00	0.68	0.02	0.28	1.26	0.86	0.52	0.46	1.34	0.47	0.73	0.00	0.39	0.43	0.99	0.24	1.84	0.44
C3 Interaction with nature	Least Characteristic Habitat	0.17	0.05	0.20	0.42	0.10	0.09	0.24	0.22	0.18	0.42	0.17	0.05	0.32	0.20	0.18	0.64	0.20	0.14	0.11	0.05
	Moderately Characteristic Habitat	0.65	0.60	1.62	0.07	0.68	0.73	0.08	0.19	0.59	0.00	0.00	0.57	0.11	0.00	0.00	0.00	0.78	0.81	0.14	0.50
	Highly Characteristic Habitat	0.00	0.02	0.00	0.79	0.02	0.41	1.88	0.87	0.52	0.46	1.36	0.70	0.87	0.00	0.40	0.51	1.47	0.36	1.84	0.56

ECOSYSTEM SERVICE	HABITAT DESCRIPTION	Enclosed commons	Estate farmlands	Forest smallholdings & dwellings	High hills and slopes	Principal settled farmlands	Principal timbered farmlands	Principal wooded hills	Riverside meadows	Sandstone estatelands	Settled farmlands on river terrace	Settled farmlands with pastoral land	Timbered plateau farmlands	Unenclosed commons	Urban	Wet pasture meadows	Wooded estatelands	Wooded hills and farmlands	Low hills and orchards	Unwooded vale	Wooded hills
C4 Sense of place	Least Characteristic Habitat	0.14	0.04	0.14	0.30	0.07	0.07	0.21	0.18	0.17	0.37	0.14	0.04	0.25	0.18	0.16	0.53	0.16	0.13	0.08	0.02
	Moderately Characteristic Habitat	0.59	0.57	1.59	0.07	0.68	0.72	0.06	0.16	0.44	0.00	0.00	0.56	0.09	0.00	0.00	0.00	0.74	0.81	0.13	0.50
	Highly Characteristic Habitat	0.00	0.02	0.00	0.68	0.02	0.28	1.26	0.86	0.52	0.46	1.34	0.47	0.73	0.00	0.39	0.43	0.99	0.24	1.84	0.44
Total Cumulative	Least Characteristic Habitat	1.85	0.82	3.28	6.26	1.30	0.98	3.64	5.29	2.61	6.53	3.25	0.81	4.70	2.61	5.41	8.48	2.46	4.51	1.83	0.66
	Moderately Characteristic Habitat	11.86	13.87	24.87	2.94	18.62	16.9	1.89	1.50	8.99	0.00	0.00	11.43	2.78	0.00	0.00	0.00	12.92	12.18	5.27	21.57
	Highly Characteristic Habitat	0.00	0.43	0.00	11.64	0.39	6.39	28.59	13.85	22.3	19.59	21.93	10.67	10.92	0.00	6.17	8.63	22.25	5.83	27.6	8.62
	Total for all habitats	13.71	15.12	28.15	20.84	20.31	24.27	34.12	20.64	33.9	26.12	25.18	22.91	18.4	2.61	11.58	17.11	37.63	22.52	34.7	30.85

Annex 5: Landscape Character Types



Annex 6: Historic Landscape Character Time Depth



Annex 7: Landscape aggregation Python script

The Python script used to aggregate characteristic habitat scores with ecosystem service provision scores is provided below.

The input file should include a row for each habitat polygon in the study area (as per the habitat basemap). Input columns should contain UKHab primary codes ('*uk_pri*'), the area of each habitat polygon ('*area*'), the LCT which the habitat polygon is within ('*LCT*'), the habitat character score ('*habitat_character*' – see Annex 3) and finally, associated scores for each ecosystem service ('*p1*', '*p2*', '*r1*', etc.).

In summary, the script: (i) assigns broad habitat codes to each habitat parcel, (ii) calculates the area of each LCT type, (iii) joins LCT type areas to the habitat data and calculates the proportion of each broad habitat in each LCT, (iv) calculates the proportion (by area) of each level of characteristic habitat in each LCT (v) calculates mean ecosystem service scores per level of habitat character in each LCT, and (vi) weights these mean ecosystem service scores for each levels of characteristic habitat by the proportion of area these habitats cover within their respective LCT.

The script will return a .csv file containing the area-weighted mean values of ecosystem service delivery, for each category of habitat character, for each ecosystem service.

```
#import required packages
import pandas as pd


#function to assign broad habitat codes to full habitat data
def generate_broad_hab_codes(input_file):

 #loads input .csv file
 broad_habitats = pd.read_csv(input_file)

 #cleans input habitat code column
 broad_habitats['UK_pri'] = broad_habitats['UK_pri'].str.lower()

 #creates broad habitat column using first character of habitat code
 broad_habitats['broad_habitat'] = broad_habitats['UK_pri'].str.slice(0,1)

 return broad_habitats


#function to calculate lct areas
def calculate_lct_areas(input_file):

 #loads input .csv file
 lct_in = pd.read_csv(input_file)

 #calculates total area of each lct
```

```
    calculated_lct_areas = lct_in.groupby(['lct'])[['area']].sum()

    return calculated_lct_areas

#function to join total lct area to full habitat data and calculate broad
habitat areas per lct
def calculate_habitat_areas(calculated_lct_areas, broad_habitats):

    #join lct areas to full habitat data
    merged = broad_habitats.merge(calculated_lct_areas, on='lct',
        how='left',suffixes=("", "_total"))

    #calculate area of broad habitat per lct
    broad_habitat_areas = merged.groupby(['lct', 'lct_score', 'broad_habitat',
        'area_total'])[['area']].sum()

    #calculate percentage area of broad habitat per lct
    broad_habitat_areas['percent_of_total_area'] =
        broad_habitat_areas.eval('(100/area_total) * area')

    #join broad habitat areas per lct to full habitat data
    calculated_habitat_areas = broad_habitats.merge(broad_habitat_areas,
        on=['lct', 'lct_score', 'broad_habitat'], how='left',suffixes=('',
        '_total'))

    return calculated_habitat_areas


#function to calculate and apply area-based weights to mean hssm scores
def apply_weights(calculated_habitat_areas):

    #calculate mean hssm score per ecosystem service for each lct, lct score,
        and broad habitat combination
    habs_summary =
        calculated_habitat_areas[['lct','lct_score','UK_pri','broad_habitat','a
        rea','area_total','percent_of_total_area','p1','p2','r1','r2','r3','r4'
        ,'b1','b2','b3','c1','c2','c3','c4']].groupby(['lct','lct_score','broad
        _habitat']).mean().round(2)

    #function to calculate area weights for mean hssm scores for broad habitat
        groups
    habs_summary['area_weights'] =
        habs_summary.eval('percent_of_total_area/100')

    #apply weights to mean hssm scores for broad habitat groups
    weights =
        habs_summary[['p1','p2','r1','r2','r3','r4','b1','b2','b3','c1','c2','c
        3','c4']].multiply(habs_summary['area_weights'], axis='index')

    #for each lct, generate mean hssm scores for each level of habitat
        character
    weighted_landscape_scores =
        weights[['p1','p2','r1','r2','r3','r4','b1','b2','b3','c1','c2','c3','c
        4']].groupby(['lct','lct_score']).mean().round(2)

    return weighted_landscape_scores
```

```
#initialise variables
input_file = '[input file path]'
output_file = '[output file path]'

#run functions on input data
broad_habitats = generate_broad_hab_codes(input_file)
calculated_lct_areas = calculate_lct_areas(input_file)
calculated_habitat_areas = calculate_habitat_areas(calculated_lct_areas,
broad_habitats)
weighted_landscape_scores = apply_weights(calculated_habitat_areas)

#write output to file
weighted.to_csv(output_file)
```

Annex 8: Current approaches to describing landscape character

Landscape is an integral element of cultural heritage, providing valuable opportunities for people to connect with nature (Tudor, 2018). Areas of Outstanding Natural Beauty (AONBs) represent landscapes identified as being nationally important in England, Wales, and Northern Ireland. These designated landscapes are protected under the Countryside Rights of Way Act, 2000, with the intention of conserving and enhancing their natural beauty. In England, AONBs are designated by Natural England. To be designated as an AONB, a landscape must fulfil the 'natural beauty criterion' (Natural England, 2018):

i) Landscape quality: natural or built landscape is considered good quality,

ii) Scenic quality: aesthetics of features (e.g., prominent geological landforms),

iii) Relative wildness: degree of separation from the built environment (e.g., roads, residential areas)

iv) Relative tranquillity: predominance of natural soundscapes (e.g., flowing water, birdsongs),

v) Natural heritage features: presence of distinctive habitats, species, or geology, for example

vi) Cultural heritage: presence of distinctive features in the built environment (e.g., historic parkland, significant archaeology)

In England, guidance for describing landscape character is provided by Natural England through the Landscape Character Assessment (LCA) framework (Tudor, 2018). The approach explores how the configuration of distinctive features within the built and natural environments shape and produce the character of a landscape (Tudor, 2018).

Typically, LCAs will produce three spatial outputs at separate scales, each one a subset of the previous layer. In order of largest to smallest scale, these outputs are: (i) Landscape Character Type (LCT), (ii) Landscape Description Unit (LDU), and (iii) Land Cover Parcel (LCP).

Landscape Character Type - the largest scale of the three outputs - are generic and may occur anywhere in the country, provided the appropriate combinations of physical and cultural landscape attributes are present. Landscape Description Units are subsets of the LCT regions and relate to a specific location. These are characterised by variations in geology, topography, soils, tree cover character, land use and settlement pattern. Land Cover Parcels – the smallest scale of the three outputs – are a subset of LDUs and relate to local variations in landscape characteristics (e.g., historic field enclosure patterns). Landscape attributes within these parcels are wholly homogenous.

The Malvern Hills AONB Partnership have produced and published a landscape strategy to provide guidance for the management of the landscape in consideration of character, condition, and sustainability (Malvern Hills AONB Partnership, 2011). This strategy document was considered a leading example of landscape character strategy when it was published, positioning the Malvern Hills AONB at the forefront of landscape character assessment.