West of England Nature Partnership
Joining up the dots for nature

Environment SYSTEMS
evidence and insight

Ecosystem Services

Understanding nature's value in the West of England




End of project report and full technical specification

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About this report

This report provides the technical information and presents the methodology used for the creation 14 ecosystem service maps as part of the WENPs State of Environment Assessment. Accompanying this report, the West of England Nature Partnership have produced to following:

- Executive Summary report available from www.wenp.org.uk/ecosystems
- ArcGIS files for practitioners, contact info@wenp.org.uk
- Online mapping portal www.wenp.org.uk/maps
- Downloadable PDFs available www.wenp.org.uk/ecosystems

The West of England Nature Partnership

The West of England Nature Partnership (WENP) is the Local Nature Partnership for the West of England region, covering the four Unitary Authorities of Bath & North East Somerset, Bristol, North Somerset and South Gloucestershire. Working with our partners, the partnership exists to create and coordinate a plan for the restoration of the natural environment and integrate that plan into strategies for spatial planning, economic development and public health.

Environment Systems

Environment Systems are an established consultancy with a valued reputation for their recognized expertise in data analysis – specifically geoinformatics and earth observation. They conduct pioneering work in modelling and mapping of ecosystem services, using their SENCE methodology.

Introduction

The natural environment in the West of England provides a range of important ecosystem services that benefit the business, people and wildlife. However, it is a fixed and finite resource, with increasing demands being placed upon it. A range of ecosystems can be found across the rural and urban areas of the region.

Background

The West of England Nature Partnership commissioned Environment Systems Ltd to produce a series of ecosystem service maps to demonstrate the benefits the environment provides within the West of England. This is the first time this type of mapping has been done in this region and provides the vital first step in understanding the contributions the natural environment makes to our society.

A further piece of work was commissioned to analyse in detail 31 possible development sites as part of the regional planning strategy – the Joint Spatial Plan (JSP).

The Ecosystem Approach

The natural environment provides a multitude of services that support humans. These services come in a variety of forms, from the food to we eat and the air we breathe, to flood protection and medicine, nature plays an integral part in helping us survive and thrive. The benefits are collectively termed 'ecosystem services' and describe the benefits we directly, or indirectly, derive from nature.

The ecosystem approach seeks to maintain the integrity and function of ecosystems by considering the services that provide to people in decision making. The approach advocates taking an integrated approach to the way land, water and living resources are managed, and the impact this may have upon the economy, environment and culture.

The Convention on Biological Diversity (CBD) defines the ecosystem approach as:

> *'A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, and which recognises that people, with their cultural and varied social needs, are an integral part of ecosystems'.*

Within the West of England, we recognise that the natural environment is a key reason people want to live, work and play in this region. We have part of the Cotswolds, Mendip Hills and North Somerset Levels, as well as the Severn Estuary and Avon Gorge. These landscapes provide us with a range of ecosystem services that benefit our society but are often not considered in traditional financial accounting. These services are under a number of pressures and need to be properly accounted for when making decisions.

The biodiversity strategy (Defra 2011) sets out three key steps to guide the ecosystems

approach;

- **Take account of how ecosystems work**; nature connects across landscapes, so we need to consider the broad and local scales. Where habitats can connect to create larger networks, they will be more resilient to pressures.
- **Take account of services that ecosystems provide to people**; such as regulating floods and climate, breaking down waste, providing food, clean water and air, and providing cultural benefits such as recreation and tranquillity.
- **Involve people in decision making;** especially those who benefit from ecosystem services and those who manage them. This means valuing people's knowledge, helping people to participate, and giving people greater ownership and responsibility.

Ecosystem Service Mapping

Mapping provides a powerful tool to enable us to spatially visualise ecosystem services. By overlaying multiple datasets and indicators, we are able to model and grade ecosystem service provision across the West of England.

The aim of the ecosystem service mapping is to:

- Consider existing land uses in a collective and integrated way; and
- Establish a means to prioritise or guide decisions to ensure optimal land use.

Often, services provided by nature can be overlooked and undervalued, except for when they are no longer able to provide that service, often when it is too late. Ecosystem service mapping enables us to see where the land is providing functioning ecosystem services. Ecosystem service mapping also enables us to identify where the best opportunities are to enhance ecosystem service provision.

The SENCE methodology

Spatial Evidence for Natural Capital Evaluation

The SENCE methodology, developed by Environment Systems, considers 4 key factors which may affect ecosystems and their ability to provide a service:

1. The type of land cover (grassland, woodland)
2. The underlying soil and geology; (eg clay, silt)
3. The topography / slope; (eg valley, slope)
4. The type of management regime in place. (SSSI, urban, agriculture)

The SENCE approach analyses multiple datasets, by assigning difference values to different factors, it enables us to visualise where the land is providing ecosystem services.

The methodology takes into consideration possible data limitations by applying an expertise rule base, ecological knowledge and theory, and 'ground truthing' with stakeholders. The

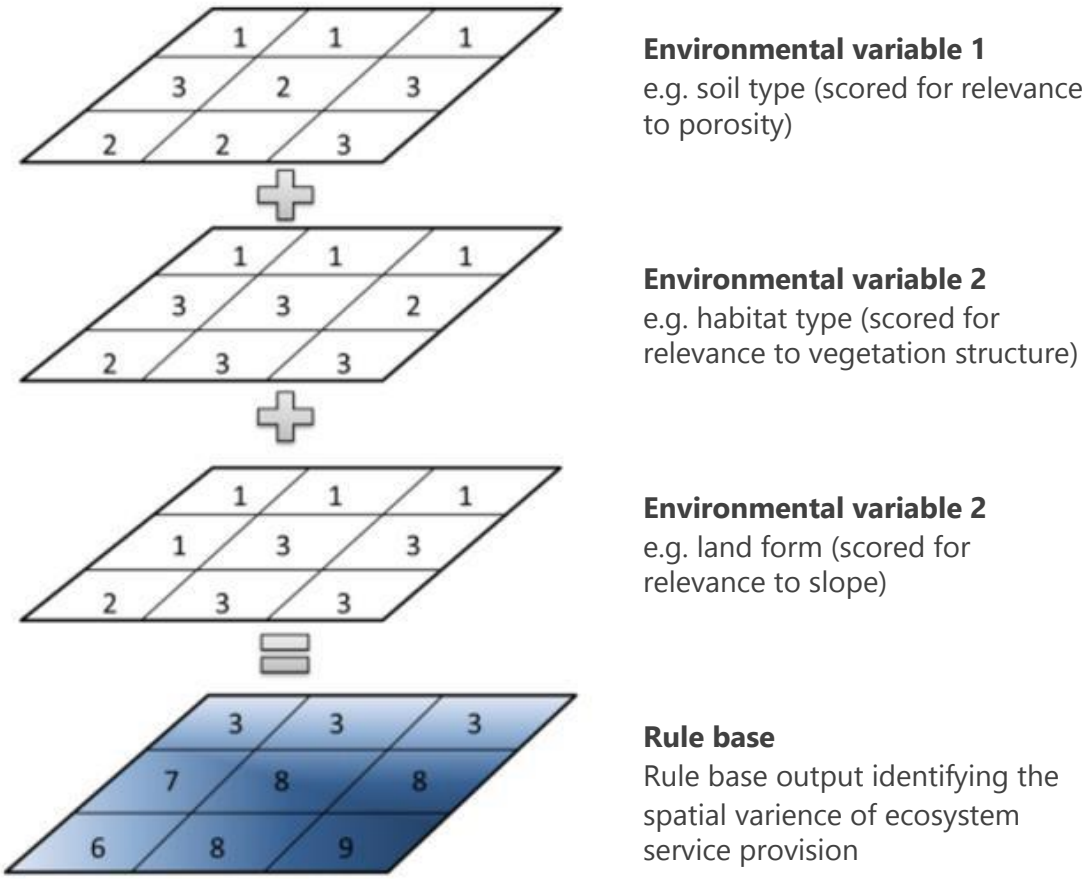
methodology takes a pragmatic approach to mapping and modelling ecosystem services, often by grading the land in terms of its ability to provide a particular service by awarding it a high, medium or low score.

Figure 1: Key factors considered under the SENCE approach

These factors are assigned a value and then each of the datasets are overlaid using a GIS technique called overlay analysis (figure 2) to highlight where the ecosystem service is being provided most. Using this technique, it is also possible to show where the land is having a negative impact upon a particular service, for example, water quality may be reduced in urban areas.

Overlay analysis is a well-established method in the GIS toolkit for bringing together datasets. It uses a technique called raster maths (fig 2), where a grid is formed for the data and each individual grid square is given a data value. For mapping the West of England, the grid was set at 5m in size to accommodate different datasets whilst maintaining consistency of mapping. The combinations of values determine the overall spatial variation of importance for the service under consideration. Some datasets (*e.g.*, high rainfall, steep slopes and shallow soils) overlap and work in combination to produce, say, a greater risk of surface water run-off together than any single dataset alone; other datasets are mutually exclusive and, logically, would not overlap (*e.g.*, different land cover types).

Where multiple datasets are used, it is sometimes necessary to weight each dataset, both to reflect its relative importance and to produce clearer mapping. Weighting was carried out by evaluating the limitations of each of the datasets, known guidance from scientific expertise from this field and following local feedback from the series of consultations that took place across the West of England.



Environmental variable 1
e.g. soil type (scored for relevance to porosity)

Environmental variable 2
e.g. habitat type (scored for relevance to vegetation structure)

Environmental variable 2
e.g. land form (scored for relevance to slope)

Rule base
Rule base output identifying the spatial varience of ecosystem service provision

Figure 2: Overlay analysis – using raster maths to assign different factors different scores using the SENCE methodology.

As well as overlay analysis, scientific knowledge and understanding about how the four factors interact was used to spatially build the ecosystem service maps for the West of England.

The Maps

The following services have been mapped across the West of England

- Woodland, grassland, and wetland networks
- Land that improves water quality
- Land that provides natural flood management
- Multiple ecosystem service provision

The multiple ecosystem service map brought all of the services together to show where the land is providing multiple services (shown in fig 3 overleaf).

For each of these maps a complementary 'opportunity' map was produced, to show the where the best opportunities existed to enhance these ecosystem services.

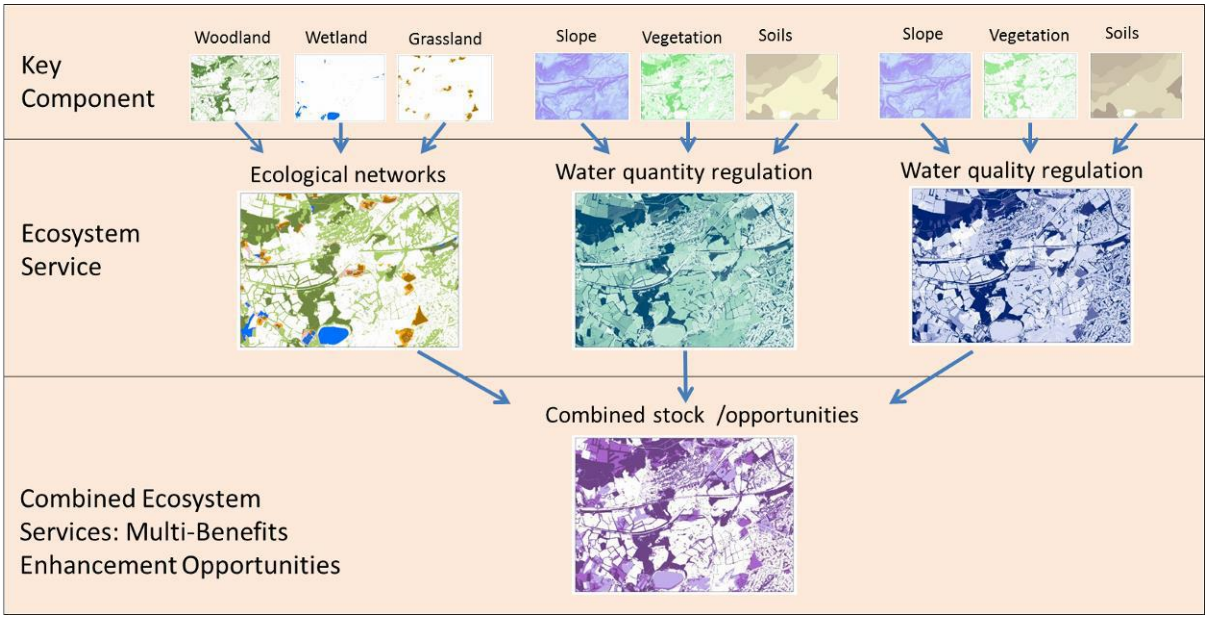


Figure 3: Methodology for producing combined ecosystem service data layers

Data acquisition and analysis

Over 200 environmental datasets were acquired as part of this project. If not used directly in the analysis, they were used for comparative reasons. The datasets came from national and local sources, including local authorities, record centres, Natural England and Environment Agency. The project also used strategic dataset including soils, geology and habitat.

The datasets ranged in scale, from national broad scale data, to local detailed scale. Where gaps were identified, modelling and proxies were used to fill the gaps. Some of the key considerations when undertaking the data review are shown in Table 1 (below)

Table 1: Consideration for data to be included in the project

Quality	Spatial coverage, topology and data projections
Suitability	Appropriateness of the information contained within the layer and how it can inform on one of the services
Availability and licensing	Data restrictions and licencing issues can prevent the data from being used
Metadata quality	Presence of metadata allows us to evaluate how the data was captured, identify limitations and assess the information provided. Datasets which were not provided with sufficient accompanying information could not be assessed and were not considered for further analysis.
The age and frequency of update	How old the dataset is affects whether it is still relevant to mapping of the service under consideration. Frequency of update also affects whether the data is suitable for use or if there is more recent data available.

Each dataset was assessed to ensure its efficacy to this project and could accurately provide the information required to make a judgement on the lands ability to provide an ecosystem service. Proxies and models were used to determine this. The methodology used to determine each datasets usability is shown below in fig 4.

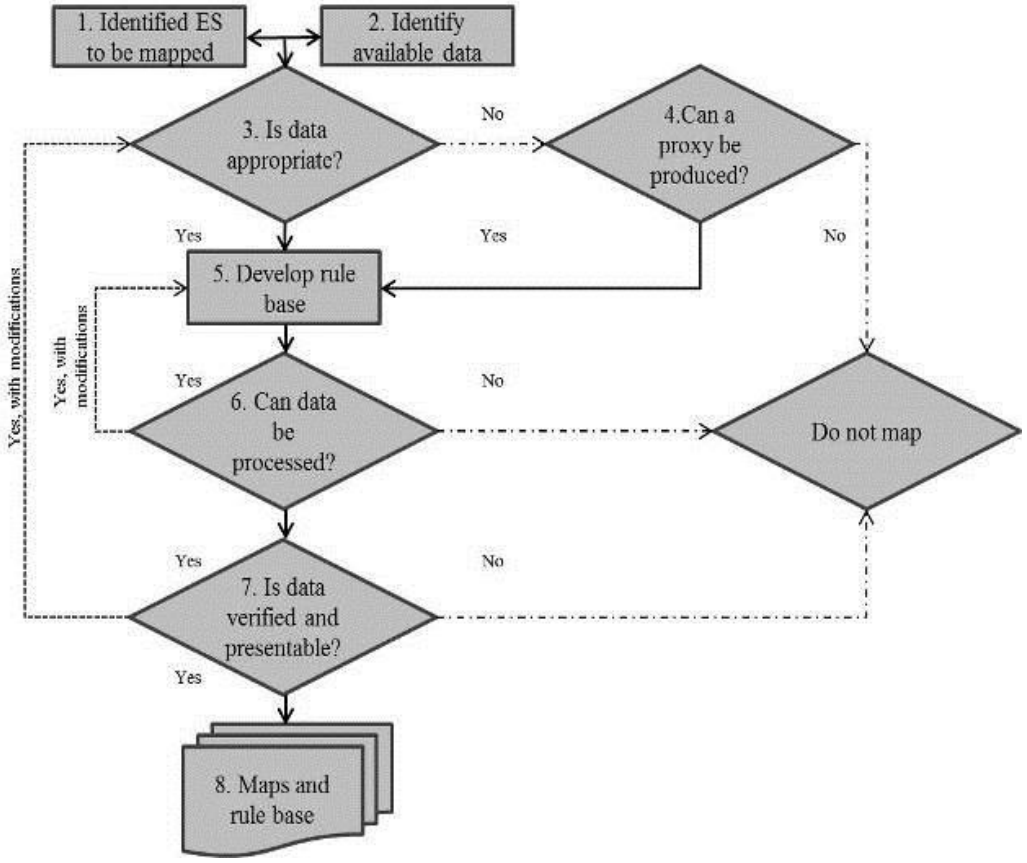


Figure 4: Summary of the method used for data collection and evaluation

To make an informed and robust judgement on a particular ecosystem, a number of datasets are required. Modelling ecosystem services require combining spatial datasets, including both point and polygon vector data and raster data, often collected at a variety of scales, collected over a number of years and containing different resolutions. By using overlay analysis we are able to bring these divergent datasets into a single model to give a coherent result.

Key factor	Datasets used	Accuracy and resolutions comments
Land cover	Phase 1 / IHS habitat layer BRERC. Good quality grasslands BRERC NE, BAP Priority Habitats National Forest Inventory Managed Woodland in the SW Ancient Woodland inventory Econet Woodland / Grassland Pond surveys.	The land cover data was created from a conflation of these surveys; they are from multiple dates and all should be assumed to be prior to 2014. (Currency would need to be assessed by field survey for any actual site development work) Some of the area has been assessed by field survey (e.g. Phase 1 /IHS surveys) and this has a resolution on the ground of between 0.1ha and 0.25ha.

	Shoreline management plans WFD Coastal waterbodies Saltmarsh species. Areas not covered by the above have been analysed from remote sensing data.	Modelled data (NFI and remote sensing analysis has a resolution of at best 0.25ha, hedgerows have only been identified where they are wider than approximately 2m)
Substrate	Natmap vector soil data – Scoring based on depth of soil, permeability and porosity of the soil, chemistry of the soil.	This dataset has a general resolution of 1:50,000 and the exact boundaries would need to be checked in the field for any site specific features.
Landform	Classification of the Digital Terrain Model (DTM) into slope and into the Agricultural Land Classification (ALC) categories. Outputs of the SCIMAP analysis giving drainage channels which could be reinstated.	The DTM for the majority of the area had a resolution of 5m in the horizontal and an accuracy of 0.5m in the vertical.
Management	Allotments, Higher level stewardship targeting maps, Ancient woodland, Woodland trust sites, Local wildlife sites, Local nature reserves, National nature reserves, Special areas of conservation, Sites of Special Scientific Interest	These data set generally have boundaries which are captured at 1:10,000.

Table 2: Datasets used for the four key factors, including comments on the accuracy and resulting resolution of these datasets

Data gaps and data certainty

A number of datasets were used in this assessment, as well as remote sensing to supplement existing habitat data. Combining, comparing and using multiple datasets enabled Environment Systems to create the most accurate portrayal of the West of England region given the available data at the time of production. However, it is worth noting the following;

- There was no hedgerow data, so remote sensing was used to identify the larger hedgerows and fill in information about scrub, grassland and arable land.
- The National Soil Map (NATMAP) was obtained under license from the National Soil Resources Institute. This dataset is the most detailed soil map available for England. However, the dataset is partially modelled from discrete sampling points taken over a 60 year period, and as such, the mapped transitions between soil types may not precisely reflect the gradients in soil properties on the ground and should be viewed as indicative only.
- Field based data collection depends on the training and skill of the ecologist collecting the records, the conditions on the particular day they were collecting.
- Many of the habitat datasets were found to be over 15 years old and therefore their accuracy cannot be guaranteed, or indeed, the land use may well have changed oved this period, particularly outside of the designated sites where less monitoring occurs.

- The datasets used as part of this assessment come in a variety of scale, and therefore caution should be applied when interpreting the ecosystem service maps at more detailed scales. Anomalies in data can occur for a number of reasons: the course scale of the original data, or changes in the conditions since the time of the data capture.
- Data gathered using remote sensing, such as the National Forest Inventory can be of high quality, especially when multiple images are used and quality assurance procedures are in place. The infill procedure used in conjunction with this was only captured at one point in the year, therefore can be viewed as moderate in accuracy.
- Using remote sensing to identify hedgerows and scrub features is good, but features such as grassland and bracken will be less accurate using this method, as they rely on assessing imagery at specified times of the year.

For the reasons given above, any land-use decisions based on ecosystem service maps should be supported by ground-based validations checks and other supporting evidence prior to implementation.

Ecosystem services are fluid and rarely have fixed boundaries and, therefore, do not neatly fit within a single spatial scale. Mapping ecosystem services is a constantly evolving area. Where further data becomes available, the mapping models can be re-run and updated. Remote sensing is a very useful tool to infill information where there is a lack of good quality data. It is also a very useful tool for identifying land use changes over a period of time.

The maps were created using data from pre 2015 and as accurate as can be at the time of print. The information on the maps is provided for identification purposes only. No warranty as to accuracy is given or implied. WENP cannot be held responsible for any inaccuracies, but if you do spot any please let us know at info@wenp.org.uk

Data accuracy descriptions

Dataset	Classes used	Accuracy
West of England area	Remote sensing analysis	Due to constraints at the time of acquisition the analysis was run on only one image therefore a Low/Moderate certainly is assigned to this data. Certainty could be increased by re-running the analysis following the release of Sentinel data in 2015.
National Forest Inventory	NOT Category = Non woodland IFT_IOA = Assumed woodland	Accuracy good for all classes used as extensive QA is done on this remote sensing product that uses multiple imagery.
BERC Priority habitat	Priority habitat: • Lowland calcareous grassland • Lowland dry acid grassland • Lowland meadows • Purple moor grass and rush pasture	Accuracy depends on age of the dataset and any possible land use change or management since data capture. Accuracy could be enhanced by monitoring / change assessment
Nt_35_phase1_natural	Phase_1_Co = • AG • CG • MG • NG • SAG SCG • SNG	Accuracy depends on age and possible land use change. Accuracy could be enhanced by monitoring / change assessment
Nt_33_good quality grasslands BRERC	Where Habitat NOT = *Blank*	Accuracy depends on age and land use change Accuracy could be enhanced by monitoring / change assessment
Grazing marshes		Accuracy enhanced by comparison with other data to model where arable /more intensive cropping would occur to identify the ditches and semi-natural grasslands.
Agri-options grassland network score	OPTCODE_1 = EK4 HC10 HC15 HC16 HC20 HC21 HC7 HC8 HC10 HK6 HK7 HQ1 OHK3 OK2 OK3	Accuracy good, as current and field based survey based on agri-environment payment
Water 5m		OS MasterMap accuracy excellent
Road 5m		OS MasterMap accuracy excellent
Build 5m		OS MasterMap accuracy excellent

Table 3. Detailed description of data used and accuracy assigned.

The maps

Two types of ecosystem service maps were produced.

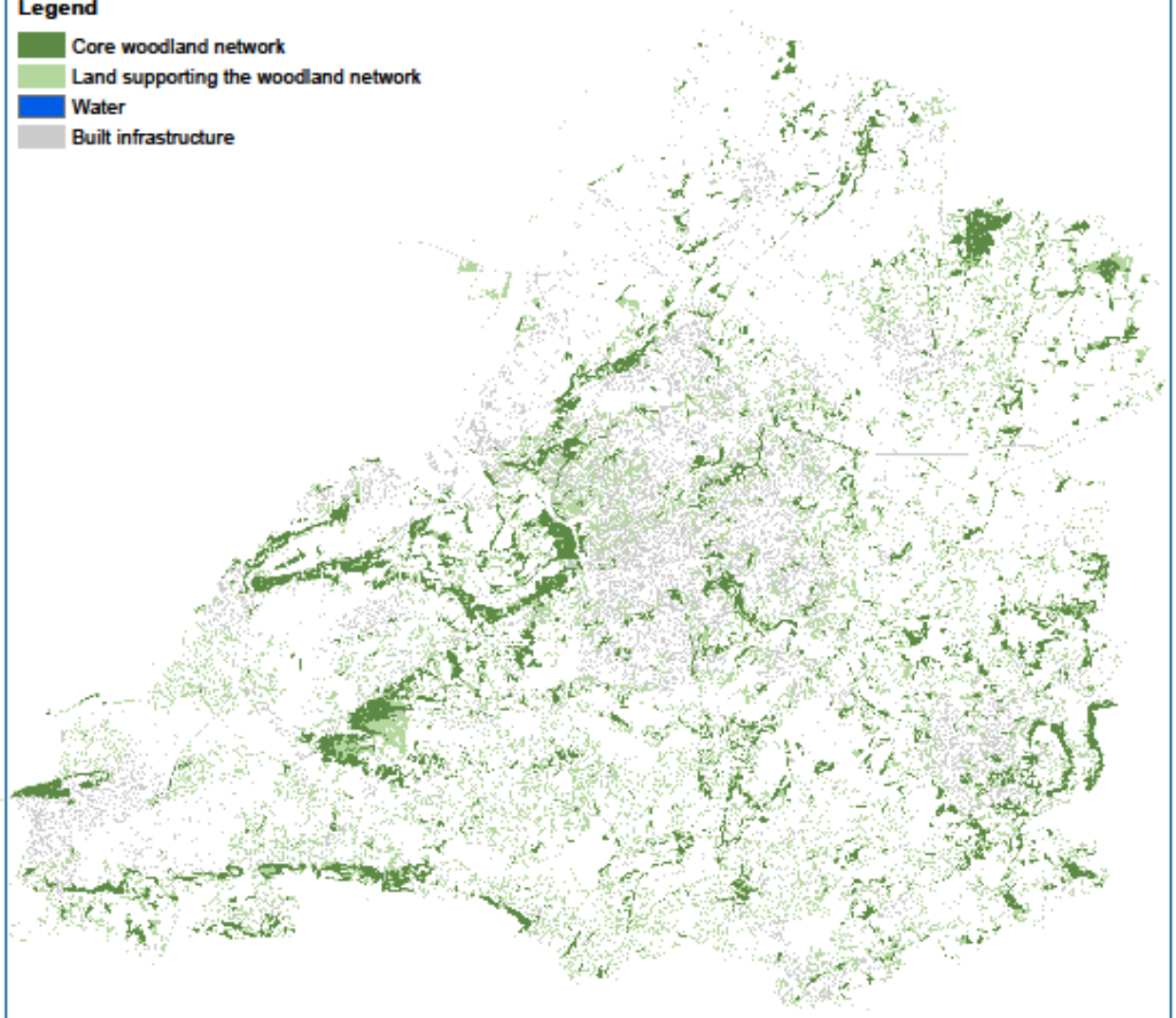
- Stock maps (shown in blue): These show the **Natural Capital Assets** in the West of England
- Opportunity maps (shown in green): highlight areas where actions can be undertaken to enhance the environment.

The layers produced as part of this phase of work are shown below in Table 4.

Table 4: Map layers produced

#	Map ID	Title
Ecological networks		
1	Woodland Network	Woodland in the west of England
2	Opportunity Map – Woodland	Opportunities to strengthen the woodland network
3	Grassland Network	The best species-rich areas of grassland
4	Opportunity Map – Grassland	Opportunities to strengthen the grassland network
5	Wetland Network	Wetlands in the West of England
6	Opportunity Map – Wetland	Opportunities to strengthen the wetland network
7	Combined Ecological Networks	The woodland, grassland and wetland networks combined
8	Opportunity Map – Combined Ecological Networks	Opportunities to strengthen ecological networks in the West of England
Ecosystem services		
9	Water Quality	Land that improves the quality of water
10	Opportunity Map – Water quality	Areas that could be enhanced to improve water quality
11	Water Quantity	Land that provides natural flood management
12	Opportunity map – Water quantity	Areas with opportunities to provide natural flood defences
13	Multiple Ecosystem Services	Combining ecosystem services in the West of England
14	Opportunity Map – Multiple Ecosystem Services	Opportunities to deliver multiple ecosystem services in the West of England

Map #1: Woodland Network
Woodland in the West of England



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ECOSYSTEM SERVICE ASSESSMENT

The woodland network
The woodland network includes the best areas of woodland and the land that strengthens the network by helping connect areas of woodland, enabling species to move between the areas.

What does the map show?
The 'core' woodland network is shown in dark green.
This core area of broadleaved woodland is made up of areas greater than 2 hectares. This core network is supported by smaller patches of woodland, thick hedges and areas of scrub (shown in pale green), which provide vital corridors and refuge areas that enable species to move across the land.

Why is this ecosystem important?
Woodland provides a multitude of beneficial services, it is an important habitats for a variety of species, slows water, stores carbon and offers recreation opportunities.

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Kilometres

Map #1: Woodland Network

Woodland in the West of England.

The woodland network includes the best areas of woodland and the land that strengthens the network by helping connect areas of woodland, enabling species to move between the areas.

What does the map show?

The 'core' woodland network is shown in dark green. This core area of broadleaved woodland is made up of areas greater than 2 hectares. A lot of the woodland follows steeper ground, and overlies limestone, such as Leigh woods.
This core network is supported by smaller patches of woodland, thick hedges and areas of scrub (shown in pale green), which provide vital corridors and refuge areas that enable species to move across the land.

Why is this ecosystem important?

Woodland provides a multitude of beneficial services, it is an important habitats for a variety of species; it helps with the regulation of water quality and quantity; stores carbon and offers recreation opportunities.

How was the map created?

Ecological networks	Ecosystem service type
Woodland	Regulation and maintenance Provisioning Cultural

The value of a habitat parcel for biodiversity resilience can be assessed by considering:

Size – The size habitat must be sufficient so that it is resilient to edge effects and invasive species, as well as being able to withstand future environmental changes, such as climate change.

Vulnerability – vulnerability and speed to change, eg calcareous grassland can scrub over without management.

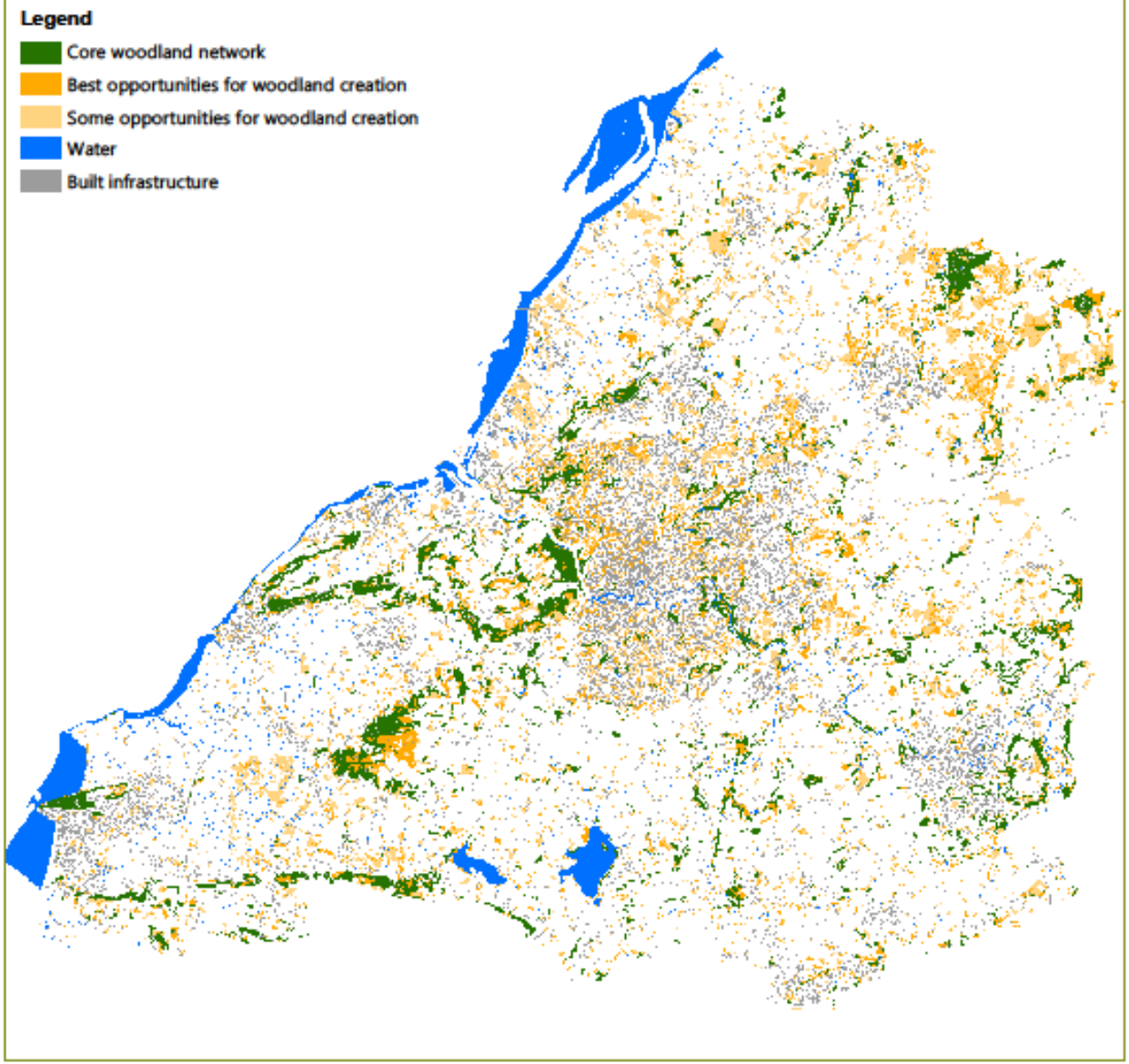
Connectivity – Habitats which are well connected are less likely to suffer edge effects. Fragmented patches (depending on size) can only support smaller population and are therefore less resilient to stochastic events and impacts.

For this layer, important woodland habitats have been included scored by their size and type, with added points awarded to areas that fall within a networks.

Influencing factors	Example attributes	Permeability
Resilience – patch size and vulnerability	Woodland >2ha Woodland <2ha	Core Associated (permeable)
Location within the landscape – surrounding vegetation types	Semi-natural habitat with the network Semi-natural habitat outside the network	Core Associated

Ecosystem Map #2: Opportunity Map - Woodland

Opportunities to strengthen the woodland network



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ECOSYSTEM SERVICE ASSESSMENT

Opportunities - the woodland network
This opportunity map shows where the best opportunities for woodland creation are in order to expand and strengthen the woodland network.

What does the map show?
The map shows the existing core woodland areas in dark green. It shows where the best opportunities are to create woodland within the network, and the opportunities outside of the network. Woodland creation will be most effective if the soil and habitat conditions are right.The areas with the greatest opportunity fall in close proximity to the existing networks, in particular areas that can help buffer and connect woodlands that have been designated for their ecological importance, and help reduce fragmentation. These are likely to establish far quicker than areas outside of the network.

Why is this ecosystem important?
Creating a coherent woodland network will increase the resilience of services woodlands can provide such as; carbon storage, water storage, recreation and wildlife habitat. It will also ensure woodlands are resilient to future pressures such as climate change. Biodiversity and ecosystem benefits are higher where expansion helps strengthen habitat networks.

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Map #2: Opportunity Woodland Network

Opportunities to strengthen to woodland network

This opportunity map shows where the best opportunities for woodland creation are in order to expand and strengthen the woodland network.

What does the map show?

The map shows the existing core woodland areas in dark green. It shows where the best opportunities are to create woodland within the network (in dark orange), and the opportunities that exist outside of the network (in light orange). Woodland creation will be most effective if the soil and habitat conditions are right. The areas with the greatest opportunity fall in close proximity to the existing network, in particular areas that can help buffer and connect woodlands that have been designated for their ecological importance, further reducing fragmentation and degradation of these important sites. These areas are likely to establish far quicker than areas outside of the network.

Why is this ecosystem important?

Creating a coherent and resilient woodland network will increase the ability for woodlands to continue providing ecosystem services such as carbon storage, water storage, recreation and wildlife habitat. It will also ensure woodlands are more resilient to future pressures such as climate change. Biodiversity and ecosystem benefits are greater where expansion helps strengthen natural networks.

How was the map created?

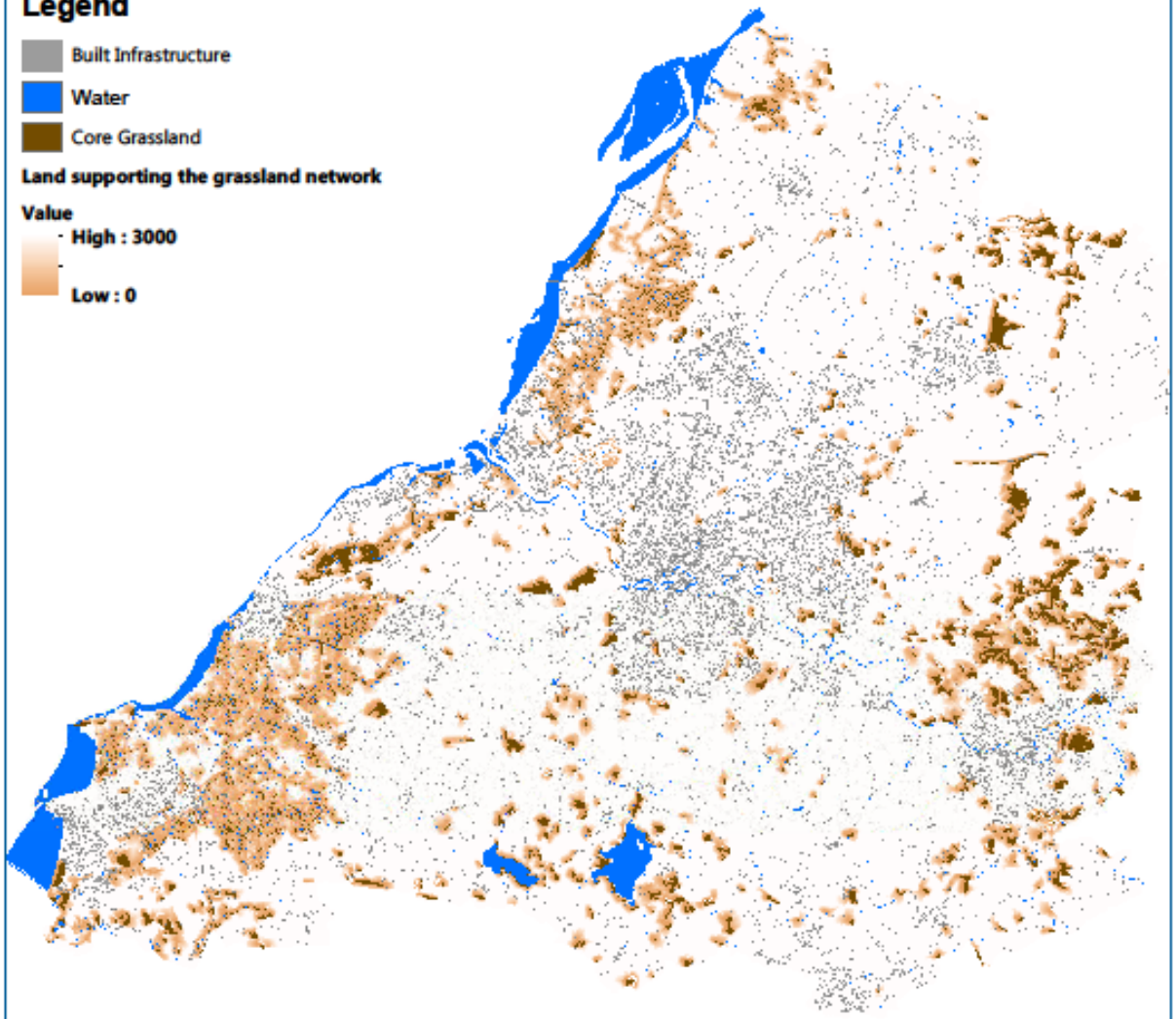
The maps considered the status of existing protected sites (SAC, SPA, SSSI, NNR, LNR, LWS & SNCIs) and where action adjacent to these areas would be more likely to provide further resilience and contribute to the sites favourable conservation status, through increased buffering and improving functionality of the network. It is possible to restore or recreate woodland outside of the network but this re-establishment will be slower, take more effort, and have less resilience to future pressures, than those areas inside the network.

A rule base determines the best place for woodland creation, looking at current land use, soil, slope, geology and position within the landscape to work out the most appropriate location. Suggested locations should not be suggested where there are existing habitats, for example on species-rich grassland.

A full ground survey should be undertaken to assess suitability of opportunity before any decisions are made.

Map #3: Grassland Network

The best species-rich areas of grassland



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The Grassland Network
This map shows the best or 'core' areas of wildflower-rich meadows and the land that support these areas.

What does the map show?
The brown areas show the 'core' areas of grassland. These are areas greater than 0.5ha which are the most species and flower rich areas in the region. The orange areas show the land that supports the core areas and enable species to move from one core area to another, helping make coherent and resilient networks.

Why is this ecosystem important?
Grassland is particularly important for maintaining pollinator species which are crucial for many food crops.

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Map #3: Grassland Network

The best species-rich areas of grassland

This map shows the best or 'core' areas of species-rich grassland and the land that support these areas.

What does the map show?

The brown areas show the 'core' areas of grassland, primarily within agricultural areas, except for the notable exceptions of the Clifton Downs. These are areas greater than 0.5ha which are the most species and flower rich areas in the region. The orange areas show the land that supports the core areas and enable species to move from one core area to another, helping make coherent and resilient networks. The most permeable parts of the grassland network can be found north of Bath and around the Chew Valley. Large areas of Coastal and Floodplain Grazing Marsh can also be found around the North Somerset Levels and Moors and adjacent to the Severn Estuary.

Why is this ecosystem important?

Grassland is particularly important for maintaining pollinator species which are crucial for many food crops. Currently 22% of the core grassland network is protected under some sort of conservation designation, though most of these are local wildlife sites to SNCIs.

How was the map created?

Ecological networks **Grassland**	**Ecosystem service type**
	Regulation and maintenance Provisioning Cultural

The value of a specific habitat can be assessed by considering:

Size – The size habitat must be sufficient so that it is resilient to edge effects and invasive species, as well as being able to withstand future environmental changes, such as climate change.

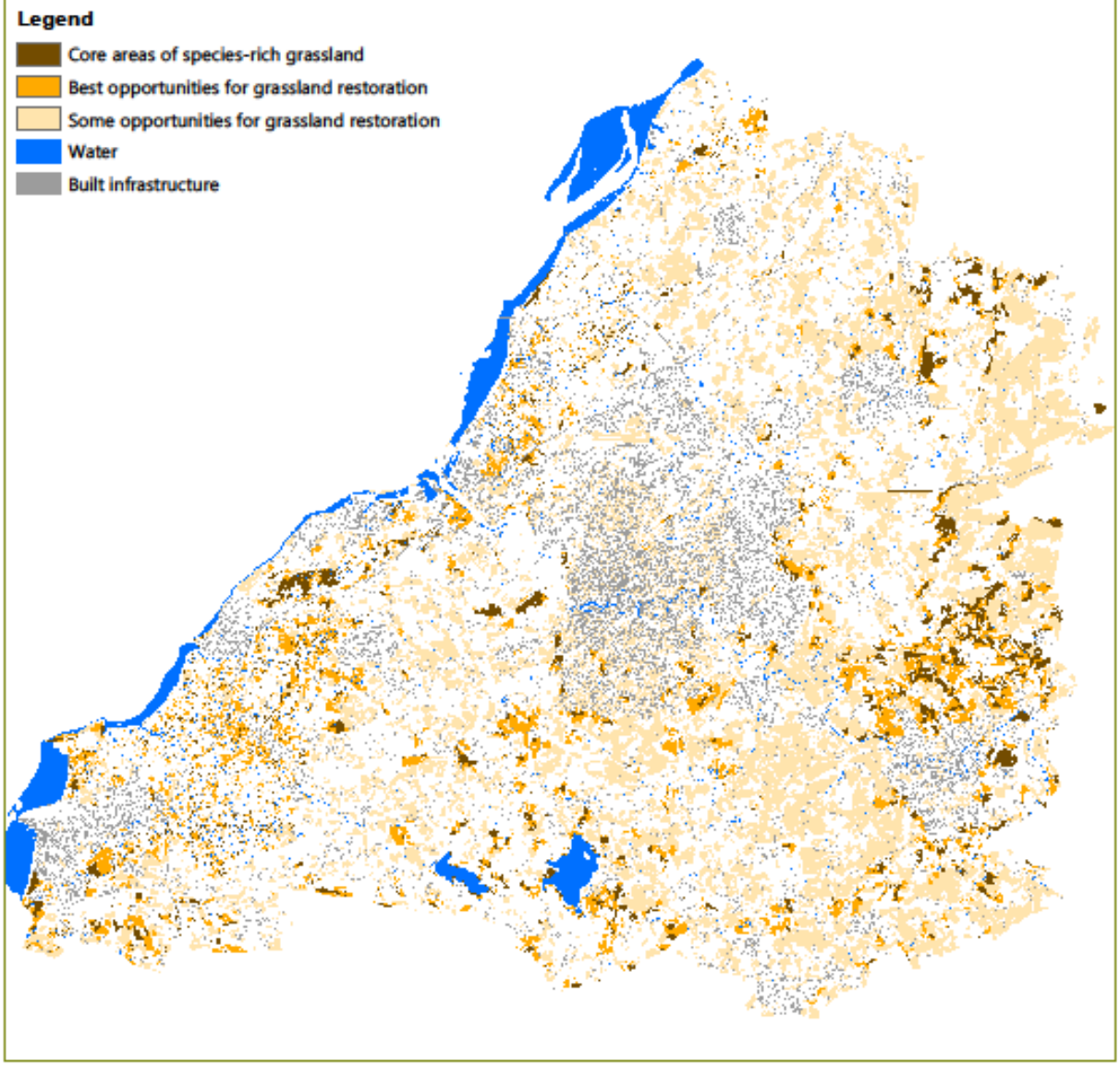
Vulnerability – vulnerability and speed to change, eg calcareous grassland can quickly scrub over without management.

Connectivity – habitats which are well connected are less likely to suffer edge effects. Fragmented patches (depending on size) can only support smaller population and are therefore less resilient to stochastic events and impacts.

For this layer, important grassland habitats have been included scored by their size and type, with added points awarded to areas that fall within a networks.

Influencing factors	**Example attributes**	**Permeability**
Resilience – patch size and vulnerability	grasssland >0.25ha grassland <0.25ha	Core Associated (permeable)
Location within the landscape – surrounding vegetation types	Semi-natural habitat with the network Semi-natural habitat outside the network	Core Associated

Map #4: Opportunity Map - Grassland
Opportunities to strengthen the grassland network



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Opportunities to stregthen the grassland network
This map shows where the best opportunities exist to restore and recreate good quality grassland and flower-rich meadows.

What does the map show?
It shows where the opportunities to restore or recreate grassland are greatest and will help strengthen the network (shown in dark orange). The lighter areas highlight where restoration is possible, but outside of the network.

Why is this ecosystem important?
Wildflower-rich grassland is particularly important for maintaining pollinator species which are crucial for many of our food crops. Establishment will be more effective if it forms part of the network, this is because the connectivity between core areas is stronger and species can move more easily between them.

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Ecosystem Map #4: Opportunity Map – grassland

Opportunities to strengthen the grassland network

This map shows where the best opportunities exist to restore and recreate good quality grassland and flower-rich meadows.

What does the map show?

It shows where the opportunities to restore or recreate grassland are greatest and will help strengthen the network (shown in dark orange). The lighter areas highlight where restoration is possible, but outside of the core network (in light orange).

Why is this ecosystem important?

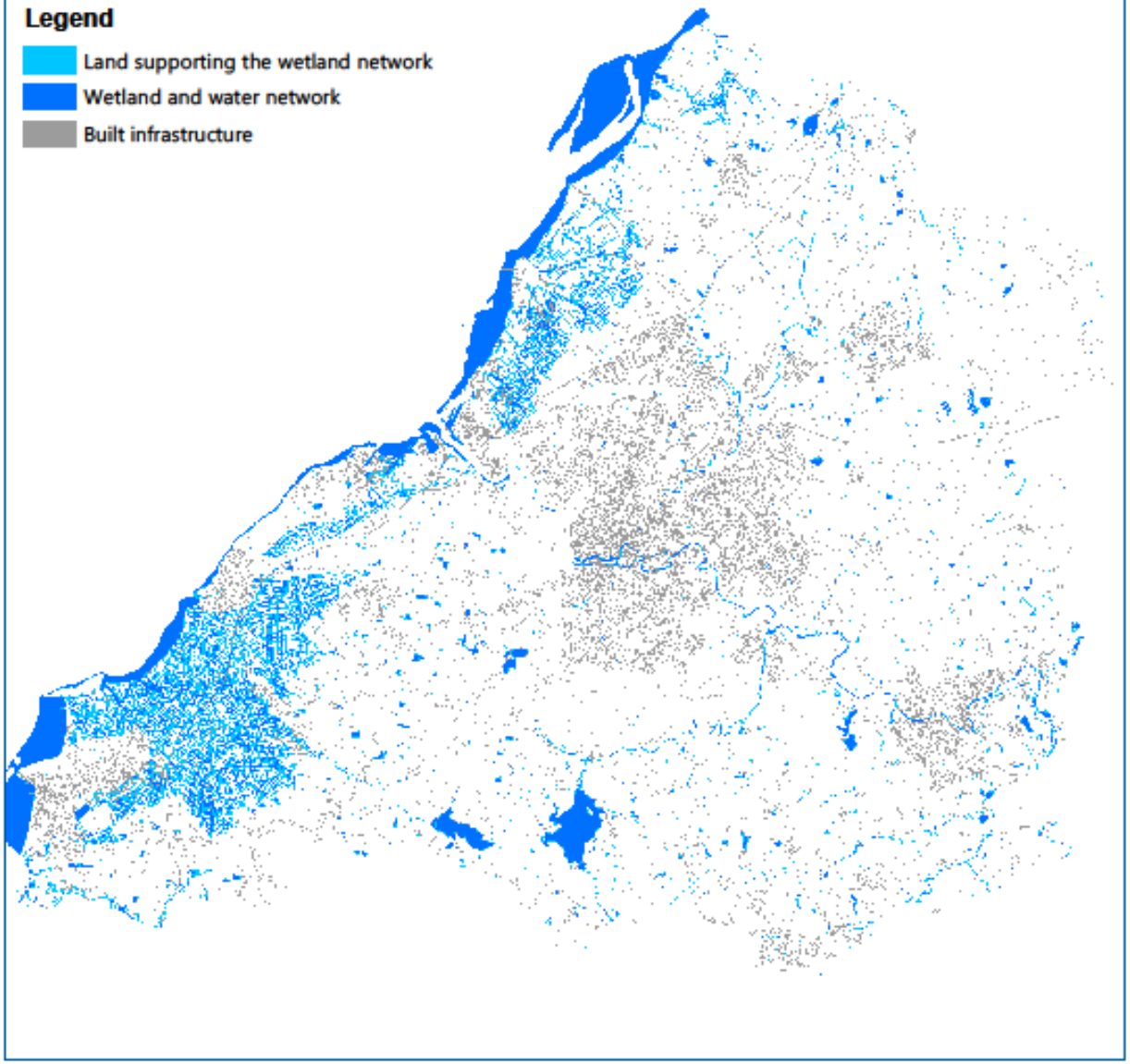
Species-rich grassland is particularly important for maintaining pollinator species which are crucial for many of our food crops. Establishment will be more effective if it forms part of the network, this is because the connectivity between core areas is stronger and species can move more easily between them.

How was the map created?

Using the core grassland network map, it is possible to identify the best locations to re-connect fragmented networks. The map shows the locations that are the most suitable for restoration, considering the proximity to core habitat and ecotones; and where edge effects can benefit the movement of species. Focusing on the areas that fall within the network will help build resilience to future pressures and help with establishment. It is possible to recreate good quality grassland outside of the networks, but establishment may take longer in these areas.

Ecosystem Map #5: Wetland Network

Wetlands in the West of England



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The wetland network
This map shows the water and wetland network in the West of England. Wetlands are described as land that is saturated with water, either permanently or seasonally.

What does the map show?
The wetland and water system is shown in dark blue. This includes the extensive artificial ditch and rhyne system that lies adjacent to the Severn Estuary. The map also shows the land that supports this network is paler blue.

Why is this ecosystem important?
Wetlands are an important habitat due to the range of ecosystem services they provide; they help purify water, control flooding, store carbon and help with shoreline stability. They are also home to a range of important aquatic plant and animal species.

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Map #5: Wetland Network

Wetlands in the West of England

This map shows the water and wetland network in the West of England, including brackish and freshwater systems and varying hydrological regimes. Wetlands are described as land that is saturated with water, either permanently or seasonally.

What does the map show?

The wetland and water system is shown in dark blue and the land that supports this network is shown in pale blue. Included within the wetland network is the extensive artificial ditch and rhyne drainage system in the low lying land that lies adjacent to the Severn Estuary, the intertidal coastal habitats, such as mudflats and saltmarsh alongside the Bristol Channel and freshwater lakes and surrounding land, such as the Chew Valley Lake.

Why is this ecosystem important?

Wetlands are an important habitat due to the range of ecosystem services they provide; they help purify water, control flooding, store carbon and help with shoreline stability. They are also home to a range of important aquatic plant and animal species.

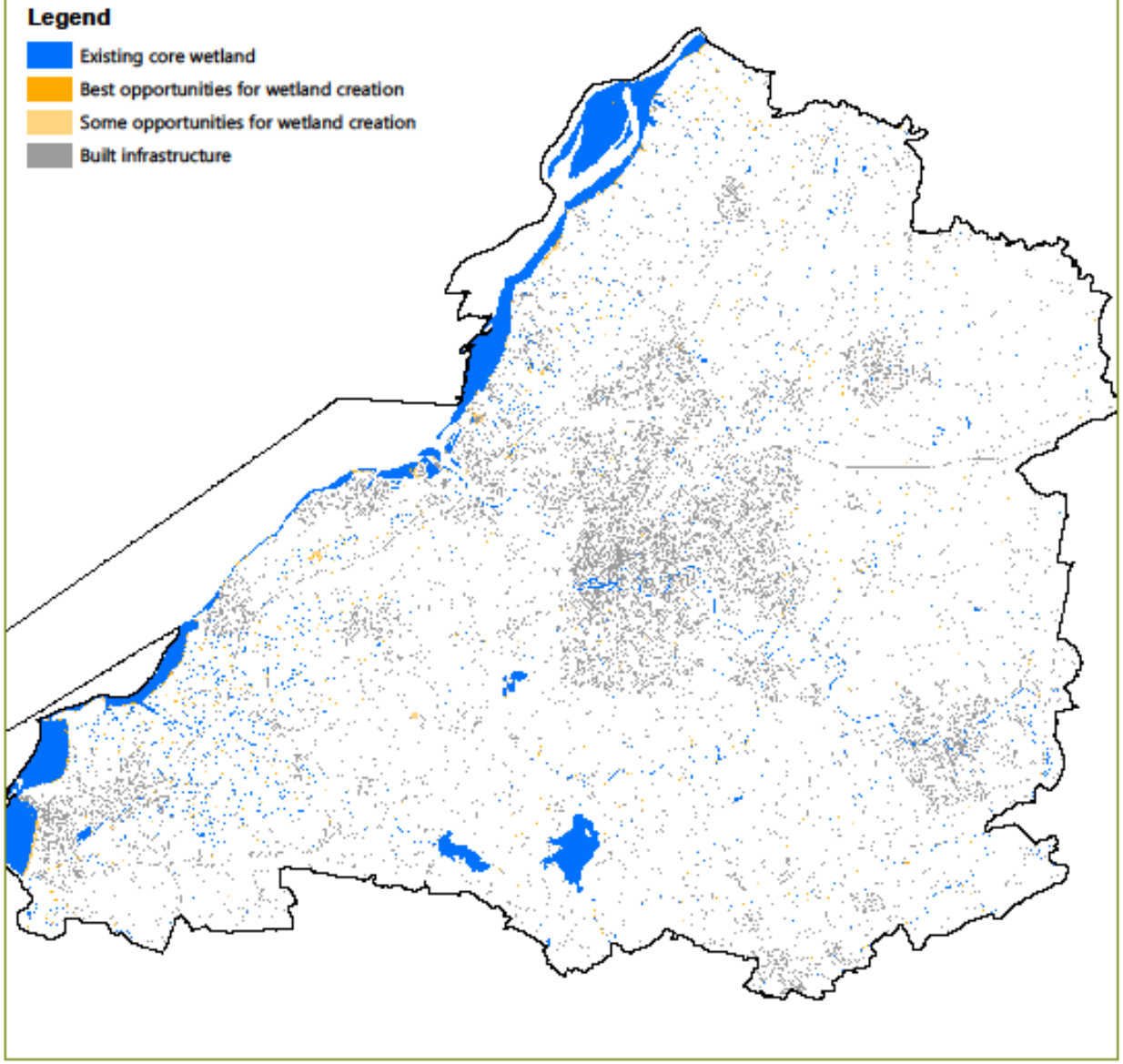
How was the map created?

The map was created using a number of data sources and remote sensing. The core wetland network was defined as areas of greater than 0.5 hectares, and the supporting land due to its permeability to wetland species. Agricultural and urban provide relatively poor support to wetland networks, the best areas are those that have multiple water channels, such as in North Somerset.

The total area of core water and wetland network is 100km^2, of which 79% is designated for its ecological importance (international, national and local conservation designations).

Ecosystem Map #6: Opportunity Map - Wetland

Opportunities to strengthen the Wetland Network



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Opportunities to strengthen the Wetland Network
This map shows where the best opportunities exist for wetland creation.

What does the map show?
Wetlands can only be created where the conditions and hydrology are correct. By combining land drainage route modelling, proximity to core wetland habitats and network information, it is possible to determine where wetlands could be effectively created.

Why is this ecosystem important?
Wetlands provide a number of vital ecosystem services, enhancing the wetland network will help improve resilience to future pressures, such as climate change, flooding and water quality issues. Wetlands also provide an important habitat for wildlife, especially birds who use them over winter.

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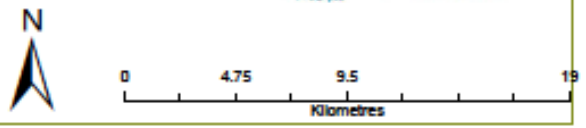


Map #6: Opportunity Map - Wetland

Opportunities to strengthen the Wetland Network

This map shows where the best opportunities exist for wetland creation.

What does the map show?

Wetlands can only be created where the conditions and hydrology are correct. By using land drainage route modelling, and looking at other features such as proximity to core wetland habitats, slope, soil and network information, it is possible to determine where wetlands could be effectively created.

Why is this ecosystem important?

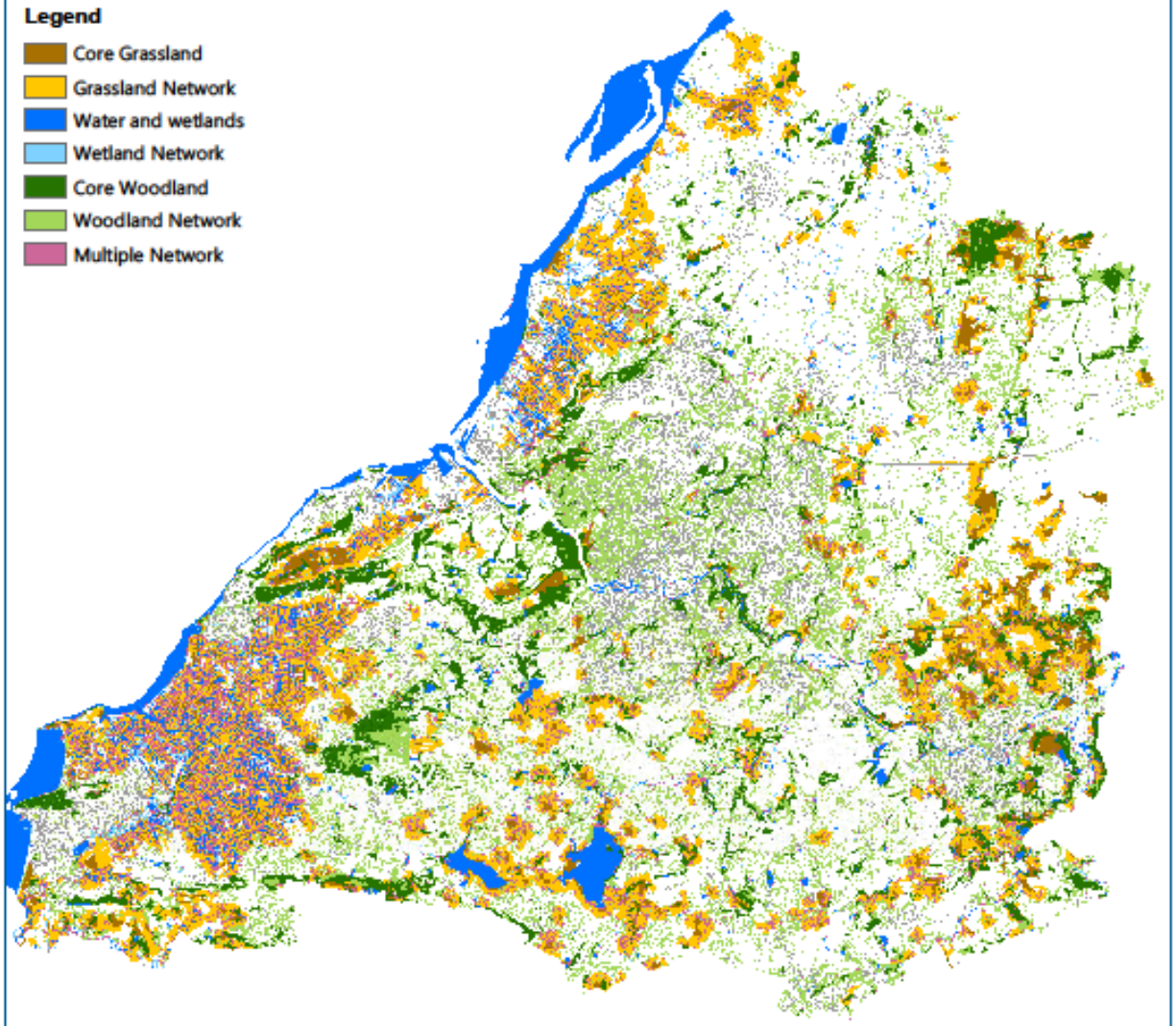
Wetlands provide a number of vital ecosystem services, enhancing the wetland network will help improve resilience to future pressures, such as climate change, flooding and water quality issues. Wetlands also provide an important habitat for wildlife, especially birds who use them over winter.

How was the map created?

The map looked at where the best places to recreate or restore wetlands areas. It analysed soil type, underlying geology and slope, alongside land drainage route modelling and water flow paths. The land was scored based in its permeability to wetland species.

Ecosystem Map #7. Combined Ecological Networks

The grassland, wetland and woodland networks combined



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Combined Ecological Network
The grassland, wetland and woodland networks have been combined to show the ecological networks across the region. 40% of the West of England region is part of a network.

What does the map show?
The maps shows the core areas of grassland, wetland and woodland, and the land that supports these networks, enabling them to function. It also shows where there are areas of land that are providing multiple functions, in pink.

Why are these ecosystems important?
Species often require a range of habitats to help them survive, landscapes which have a mosaic of habitats tend to be more biodiverse.

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Map #7: Combined Ecological Networks

The woodland, grassland, and wetland networks combined

The grassland, wetland and woodland networks have been combined to show the ecological networks across the region. The networks include areas of natural and semi-natural habitats that are close enough together that species can easily move from one area to another, ensuring they can get what they need from the habitat and genetic diversity is maintained. 40% of the West of England region is part of a network.

What does the map show?

The maps shows the core areas of grassland, wetland and woodland, and the land that supports these networks, enabling them to function. It also shows where there are areas of land that comprise of multiple habitats in pink.

Why are these ecosystems important?

Species often require a range of habitats to help them survive, landscapes which have a mosaic of habitats tend to be more biodiverse. Networks are essential for food, migration, seed dispersal, pollination and genetic diversity. However they do not take into account exact species requirements.

Amount of land in each network

Ecological network	Core area (km^2)	Whole network (km^2)	Percentage of WoE
Woodland	90	282	19%
Grassland	50	193	13%
Wetland	100	119	8%

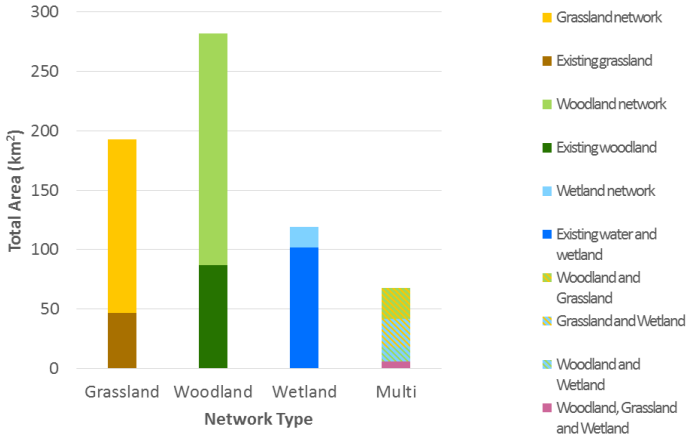
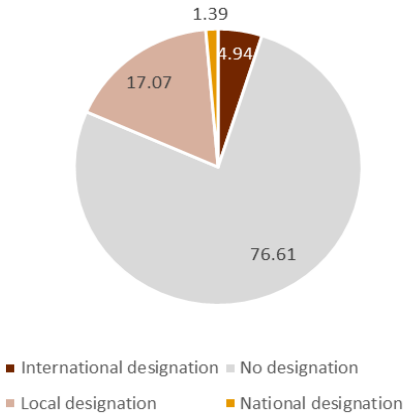


Fig 1: total area (km2) of core and supporting habitats contributing to the ecological networks.

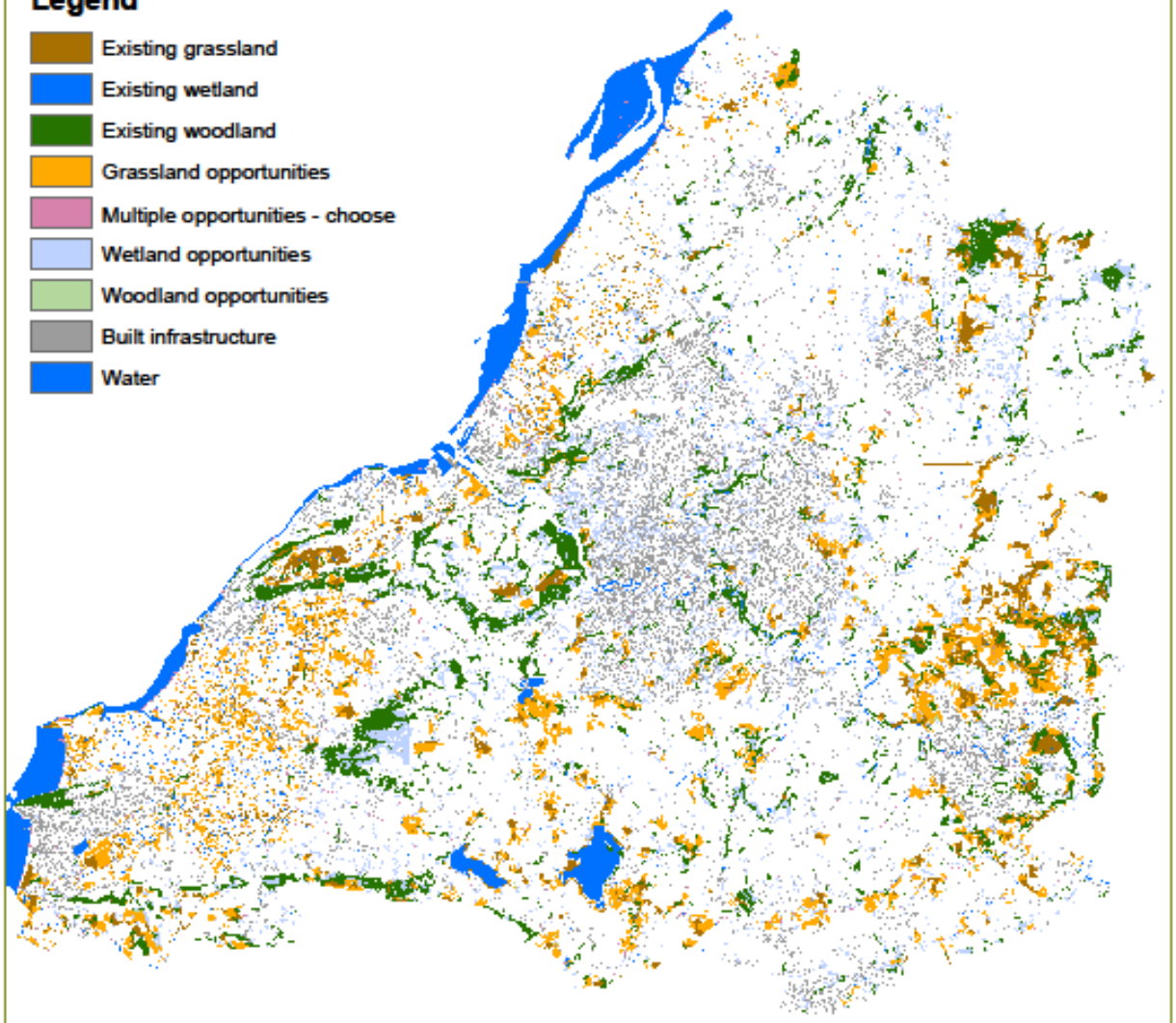
Protection

Much of core areas of habitat are currently protected by statutory conservation designation (international, national or local), and in some cases parts of the associated network is protected. By combining the networks we can see that 76.6% of the ecological networks are currently not protected by any form of conservation designation (figure 2).



Ecosystem Map #8: Opportunity Map - Combined Ecological Network

Opportunities to strengthen Ecological Networks in the West of England



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Opportunities - Combined Ecological Network

It is possible to combine the opportunity layers and show where the'best' opportunities exist for habitat creation. This map shows the existing 'core' networks.

What does the map show?

The map shows the 'core' areas of the woodland, grassland and wetland network and where the best opportunities exist to further strengthen these networks across the West of England. The wetland, woodland, and grassland opportunity layers have been combined to show opportunity locations for each habitat, as well as where there are multiple opportunities.

Why are these ecosystems important?

Habitat creation will be most effective if it is within an existing network and if the conditions are right. The data also considered proximity to designated and protected sites, where action nearby would contribute to achieving favourable status through increased buffering. Re-establishment will be more effective in these areas, further increasing the habitats ability to deliver multiple ecosystem services.

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Map #8: Opportunity Map – Combined Ecological Networks

Opportunities to strengthen ecological networks in the West of England

It is possible to combine the opportunity layers and show where the 'best' opportunities exist for habitat creation. This map shows the 'best' opportunities for habitat creation.

What does the map show?

The map shows the 'core' areas of the woodland, grassland and wetland network and where the best opportunities exist to further strengthen these networks across the West of England. The wetland, woodland, and grassland opportunity layers have been combined to show opportunity locations for each habitat, as well as where there are multiple opportunities.

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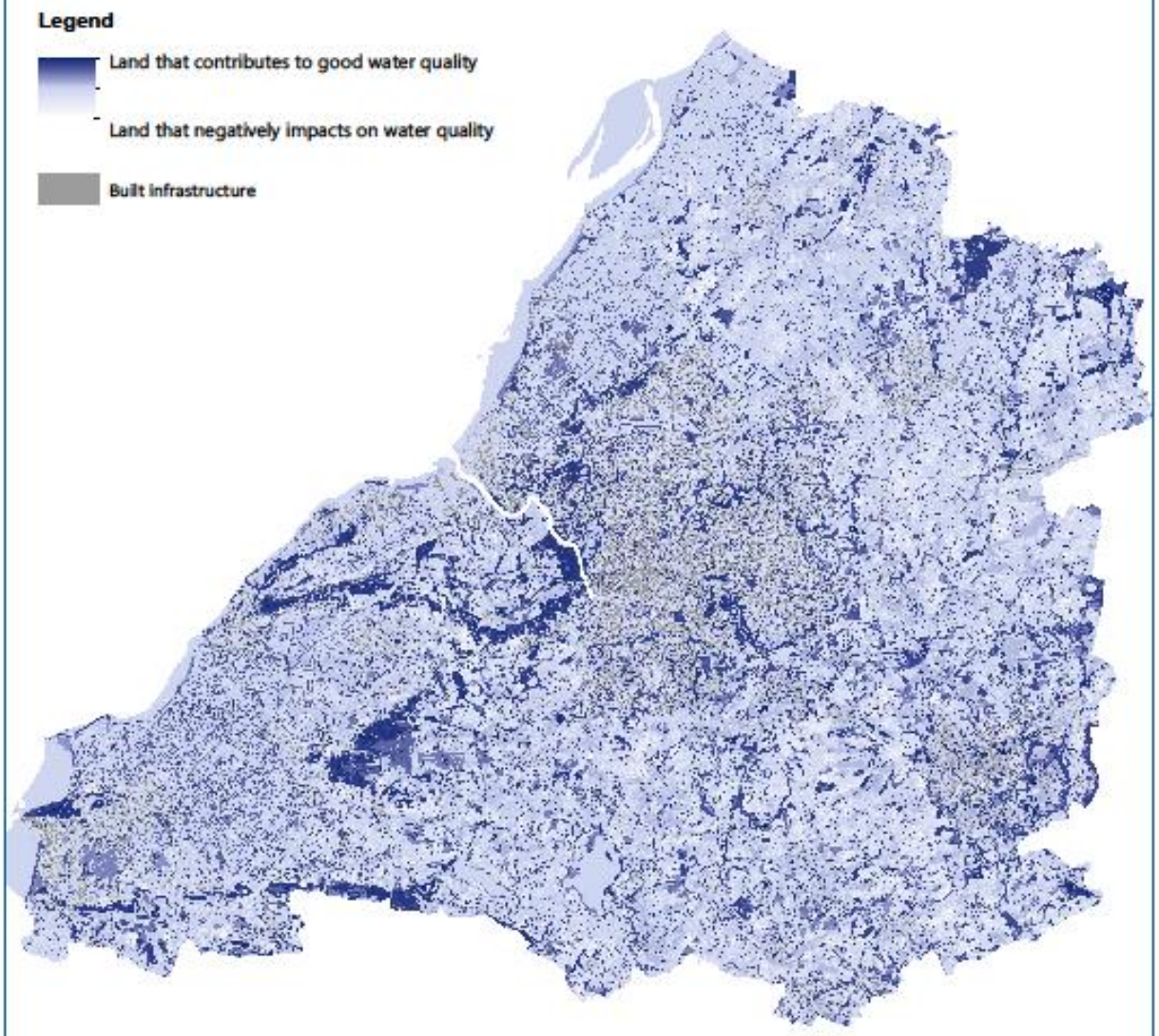
Habitat creation will be most effective if it is within an existing network and if the conditions are right. The data also considered proximity to designated and protected sites, where action nearby would contribute to achieving favourable status through increased buffering. Re-establishment will be more effective in these areas, further increasing the habitats ability to deliver multiple ecosystem services.

How were the maps created?

The soil and habitat conditions were analysed to identify the areas where re-establishment would be most effective. A 'least cost' model was applied which assessed functional connectivity and potential dispersal areas within the landscape to score areas on their permeability to each habitat.

Ecosystem Map #9: Water Quality
Land that improves the quality of water



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Water quality:
This map shows the impact the natural environment has on water quality.

What does the map show?
The darkest colours represent the land that is positively contributing to the quaity of water. This tends to be land that overlies chalk or where there is the presence of broadleaved woodland or wetlands, as both of these habitats are good at removing impurities. The lighter colours show where the land use is having a negative impact on water quality, such as in urban areas, or where farming methods result in chemicals and other impurities entering the water environment.

Why is this ecosystem service important?
Clean water is essential for life. Managing ecosystems to mprove water quality can reduce treatment costs and minimise pollution.

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Map #9: Water quality

Land that improves the quality of water

This map shows the impact the natural environment has on water quality.

What does the map show?

The darkest colours represent the land that is positively contributing to the quality of water. This tends to be land that overlies chalk or where there is the presence of broadleaved woodland or wetlands, as both of these habitats are good at removing impurities.

The lighter colours show where the land use is having a negative impact on water quality, such as in urban areas, or where farming methods result in chemicals and other impurities entering the water environment, such as when animals have access to streams and rivers, compacting the banks so that sediment enters the water. 21% of land in the West of England has a high ability to improve the quality of water, as shown below in figure 3.

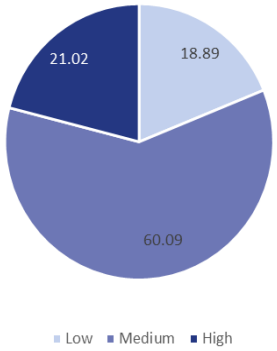


Fig 3: Percentage contribution to water quality; grouped into 'low' 'medium' high'

Why is this ecosystem service important?

Clean water is essential for life. Managing ecosystems to improve water quality can reduce treatment costs and minimise pollution.

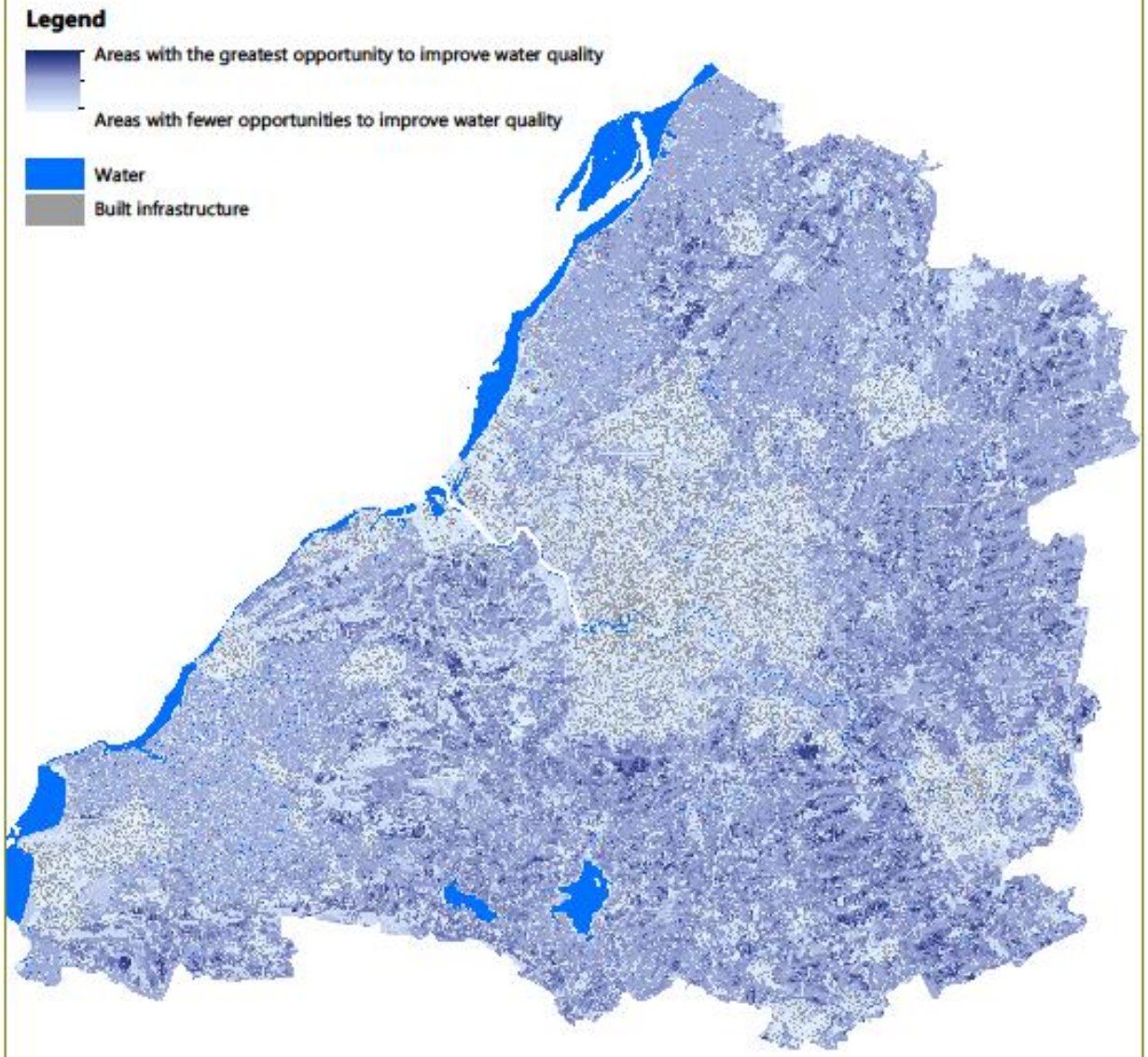
How was the map created?

The maps was created by analysing soil type, landform, hydrology and vegetation. Sediment risk was also modelled using SCIMAP, to model where diffuse pollution is likely to be originating from. Habitat type was also analysed as shown below;

Water quality regulation		Ecosystem Service Type: Regulating
Water quality can be affected by: **Soil** – water is stored in soil following rain and either releases it into the water system or adds it to the overall ground water table. Some soil types filter water, whilst others are suspecded within water, reducing its quality. **Slope** – steep slopes shed water more rapidly that shallow slopes. On steeper slopes more sediment is removed from the land. **Habitat** – can influence the quality of water, largely due to the structure of the vegetation, but sometimes to do with the type and species of vegetation and their ability to assist with water purification.		
Influencing Factors	Example attributes	Indicative scoring
Habitat	Woodland Hedge Bog Arable	moderate/high moderate moderate / low low / negative
Filtration effect of the substrate	Brown earths Peaty soils	moderate/high low
Slope is linked to flow rate	Steep slopes	negative

Map #10: Opportunity Map - Water Quality

Areas that could be enhanced to improve water quality



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ECOSYSTEM SERVICE ASSESSMENT

Opportunities for improved water quality

Certain types of land management will have a negative impact on the quality of water because they allow pollutants to enter the water environment, such as intensively farmed land and urban areas. Where these areas exist, it is possible to make changes to how the land is managed to help improve overall water quality.

What does the map show?

The map was created by looking at the soil type, slope, hydrology and habitat and analysing where the best opportunities exist. The darker areas show where it might be possible to modify the land use to help improve water quality. The areas that present the most opportunities to improve water quality tend to be in the rural areas, on steep slopes with shallow soils. Those with fewer opportunities are areas that are already providing that service, such as areas with dense and well established vegetation, or areas that are unlikely to change, such as urban areas.

Why is this ecosystem service important?

Water companies are responsible for cleaning water, which can be costly and is energy intensive. Investment into natural systems upstream can reduce the costs for water companies and provide additional benefits for wildlife

Bristol Avon Catchment

The rivers and waterways in the West of England are part of a wider catchment known as the Bristol Avon Catchment. The Bristol Avon Catchment comprises an area of 2810km² and drains parts of Gloucestershire, Wiltshire and Somerset.

Visit www.bristolavoncatchment.co.uk

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Map #10: Opportunity Map – Water Quality

Areas that could be enhanced to improve water quality

Certain types of land management will have a negative impact on the quality of water because they allow pollutants to enter the water environment, such as intensively farmed land and urban areas. Where these areas exist, it is possible to make changes to how the land is managed to help improve overall water quality.

What does the map show?

The map was created by looking at the soil type, slope, hydrology and habitat and analysing where the best opportunities exist to enhance the land for water quality purposes. The darker areas show where it might be possible to modify the land use to help improve water quality. The areas that present the most opportunities to improve water quality tend to be in the rural areas, on steep slopes with shallow soils. Those with fewer opportunities are areas that are already providing that service, such as areas with dense and well established vegetation, or areas that are unlikely to change, such as urban areas.

Why is this ecosystem service important?

Water companies are responsible for cleaning water, which can be costly and is energy intensive. Investment into natural systems upstream can reduce the costs for water companies and provide additional benefits for wildlife. Improving water quality will require multiple landowners working together to create an integrated strategy.

How was the map created?

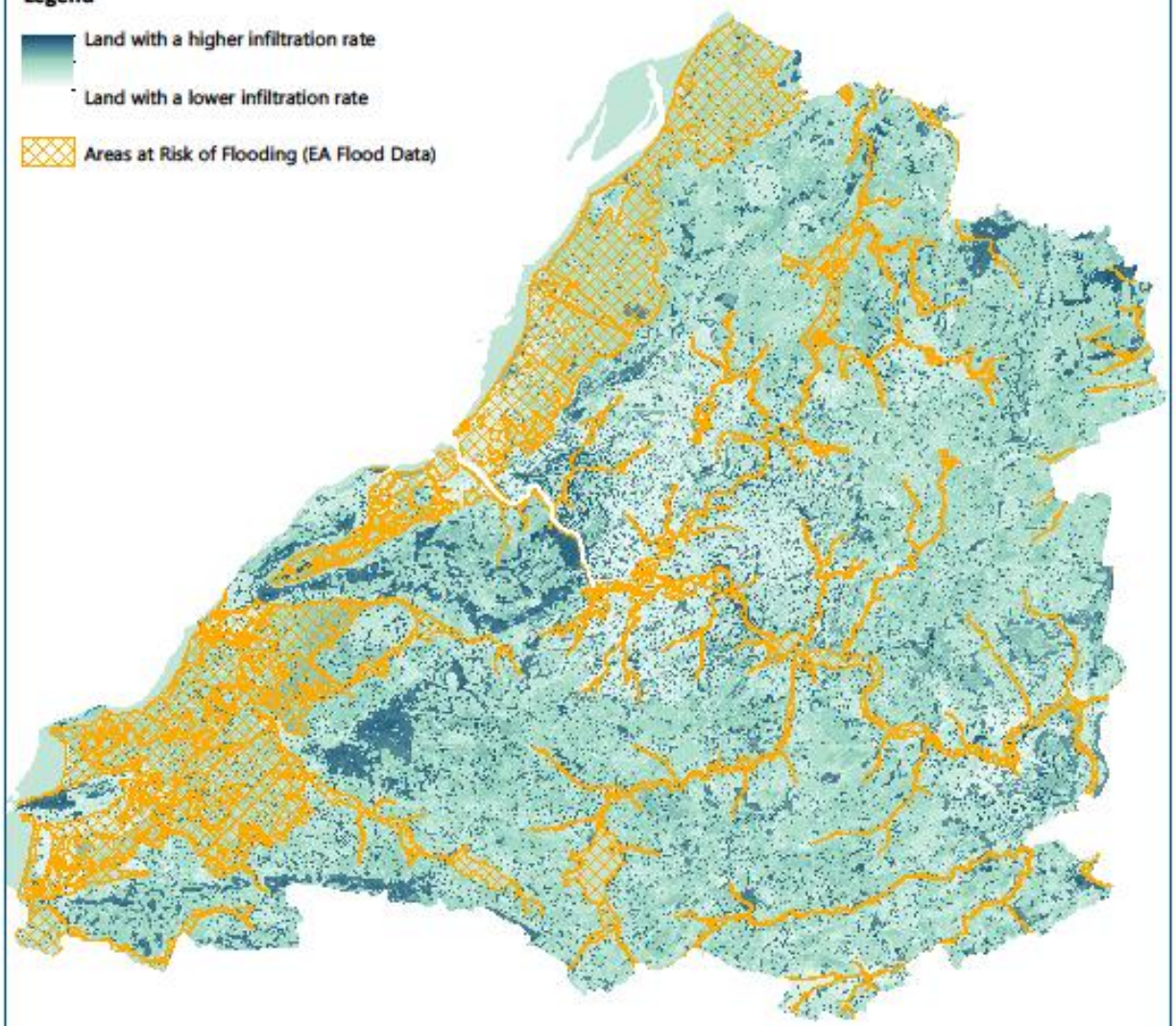
The areas with the greatest opportunities can be found in agricultural areas, where there is steep slopes and shallow soils. The habitats and land management regimes were assessed to show where modifications would result in better water quality. Areas with the best opportunities are located in the headwaters of the catchments. These areas tend to be dispersed across the catchment.

Bristol Avon Catchment

The rivers and waterways in the West of England are part of a wider catchment known as the Bristol Avon Catchment. The Bristol Avon Catchment comprises an area of 2810km² and drains parts of Gloucestershire, Wiltshire and Somerset. The catchment partnership have mapped the whole of the catchment and developed a series of maps which look at water quality issues at a catchment scale.

Visit www.bristolavoncatchment.co.uk

Map #11: Water Quantity
Land that provides natural flood management



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ECOSYSTEM SERVICE ASSESSMENT

Water quantity

This map shows where the environment is slowing the movement of water, by temporarily storing it following rain. When water is not stored in the soil it runs over the land. This is known as overland flow or runoff and can cause flooding when it has nowhere to go.

What does the map show?

The darker colours represent areas that have higher infiltration rates and therefore help slow the movement of water. The infiltration rate describes the speed water enters the soil and its ability to hold that water. The structure of the vegetation, the soil type, underlying geology, gradient of the slope and the land managed all contribute to an areas infiltration rate.
The lighter colours have a lower infiltration rate, meaning that rainfall isn't absorbed as well and the water can run over the surface.
The orange hatching shows the areas that the Environment Agency have identified as being at risk of flooding.

Why is this ecosystem service important?

Flooding is a major hazard in the UK and is set to increase in frequency due to climatic changes. Flooding is very costly as it causes untold damage to people's homes and businesses. Careful investment in the natural environment can help increase resilience to flooding, whilst also being beneficial for wildlife.

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Kilometres

Map #11: Water quantity

Land that provides natural flood management

This map shows where the environment is slowing the movement of water, by temporarily storing it following rain and helping reduce flood risk. When water is not stored in the soil it runs over the land. This is known as overland flow or runoff and can cause flooding when it has nowhere to go.

What does the map show?

The darker colours represent areas that have higher infiltration rates and therefore help slow the movement of water. The infiltration rate describes the speed water enters the soil and its ability to hold that water. The structure of the vegetation, the soil type, underlying geology, gradient of the slope and the land managed all contribute to an areas infiltration rate.

15% of the land within the West of England plays a 'high' role in slowing water and helping to prevent flooding, shown below in figure 5.

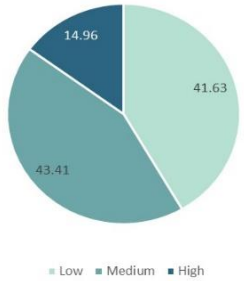


Figure 5: Percentage contribution of area to Natural Flood Management; grouping into 'low', 'medium', and 'high'.

The lighter colours have a lower infiltration rate, meaning that rainfall isn't absorbed as well and the water can run over the surface. The orange hatching shows the areas that the Environment Agency have identified as being at risk of flooding.

Why is this ecosystem service important?

Flooding is a major hazard in the UK and is set to increase in frequency due to climatic changes. Flooding is very costly as it causes untold damage to people's homes and businesses. Careful investment in the natural environment can help increase resilience to flooding, whilst also being beneficial for wildlife.

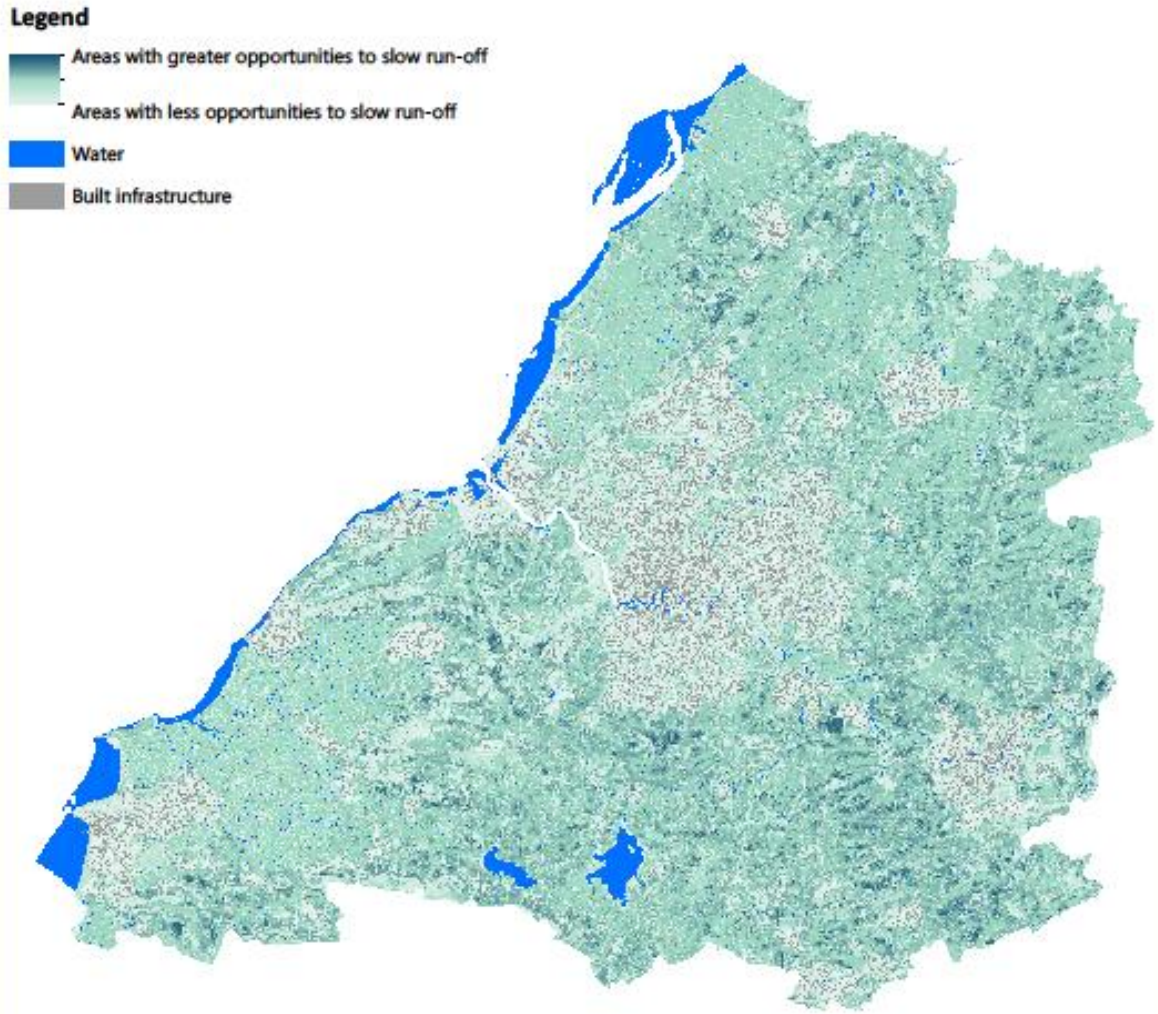
How was the map created?

Factors affecting what happens to rain when it hits the ground (vegetation, soil types, slope) were spatially assessed, to show where the land was slowing the movement of water before it enters into the rivers. The map was created by analysing the vegetation, type, slope, soil and geology, alongside the Environment Agency flood risk areas.

Water quantity		**Ecosystem Service Type:** Regulating
Water quantity is regulated by a number of factors. Climate and amount of rain are very important, but once the rain reaches the ground, where the water goes and how it is channeled also makes a difference. **Soil** – the ability of soil to hold water depends on its texture, depth and organic matter content. **Landscape** – where the soil is in the landscape also makes a difference, for example on a steep or shallow slope. **Habitat** – water storage is linked to vegetation structure and its ability to intercept rain.		
Influencing Factors	**Example attributes**	**Indicative scoring**
Habitat	Woodland Hedge Bog Arable	high moderate low negative
Filtration effect of the substrate	Brown earths Peaty soils Clay soils	Moderate high low
Slope is linked to flow rate	Steep slopes	negative

Map #12: Opportunity Map: Water Quantity

Areas with opportunities to provide Natural Flood Defences



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Opportunities for natural flood defences
The map shows where the best places exists to modify the land so that it can store water for longer following rainfall. Slowing the movement of water across the land, can reduce surface run-off and the risk of flooding.

What does the map show?
The darker areas show where the opportunities are greatest to modify the land so it can absorb and store water more effectively. Areas that have greater opportunities include steep slopes with short vegetation.
The lighter areas have fewer opportunities, and any changes in their management would have limited impact on their ability to store water.

Please note, the areas that are currently providing natural flood management are shown as having low opportunities, as they are already providing this ecosystem service.

Why is this ecosystem service important?
Manmade flood defences can be overwhelmed depending on the amount and frequency of rain. To increase our resilience against flood it is often necessary to employ a range of flood defence schemes that look at the natural and mad made solutions.

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Map #12: Opportunity Map – Water Quantity

Areas with opportunities to provide natural flood defences

The map shows where the best places exists to modify the land so that it can store water for longer following rainfall. Slowing the movement of water across the land, can reduce surface run-off and the risk of flooding.

What does the map show?

The darker areas show where the opportunities are greatest to modify the land so it can absorb and store water more effectively. Areas that have greater opportunities include steep slopes with short vegetation. Features which slow water down include vegetation with high structural diversity, such as trees with different layers of branches, a dense understory and ground flora. Ancient woodland has a greater capacity to store water as it is often found on deep soil. The underlying geology can also affect the amount of war

The lighter areas have fewer opportunities, and any changes in their management would have limited impact on their ability to store water. Please note, the areas that are currently providing natural flood management are shown as having low opportunities, as they are already providing this ecosystem service.

Why is this ecosystem service important?

Manmade flood defences can be overwhelmed depending on the amount and frequency of rain. To increase our resilience against flood it is often necessary to employ a range of flood defence schemes that look at the natural and mad made solutions.

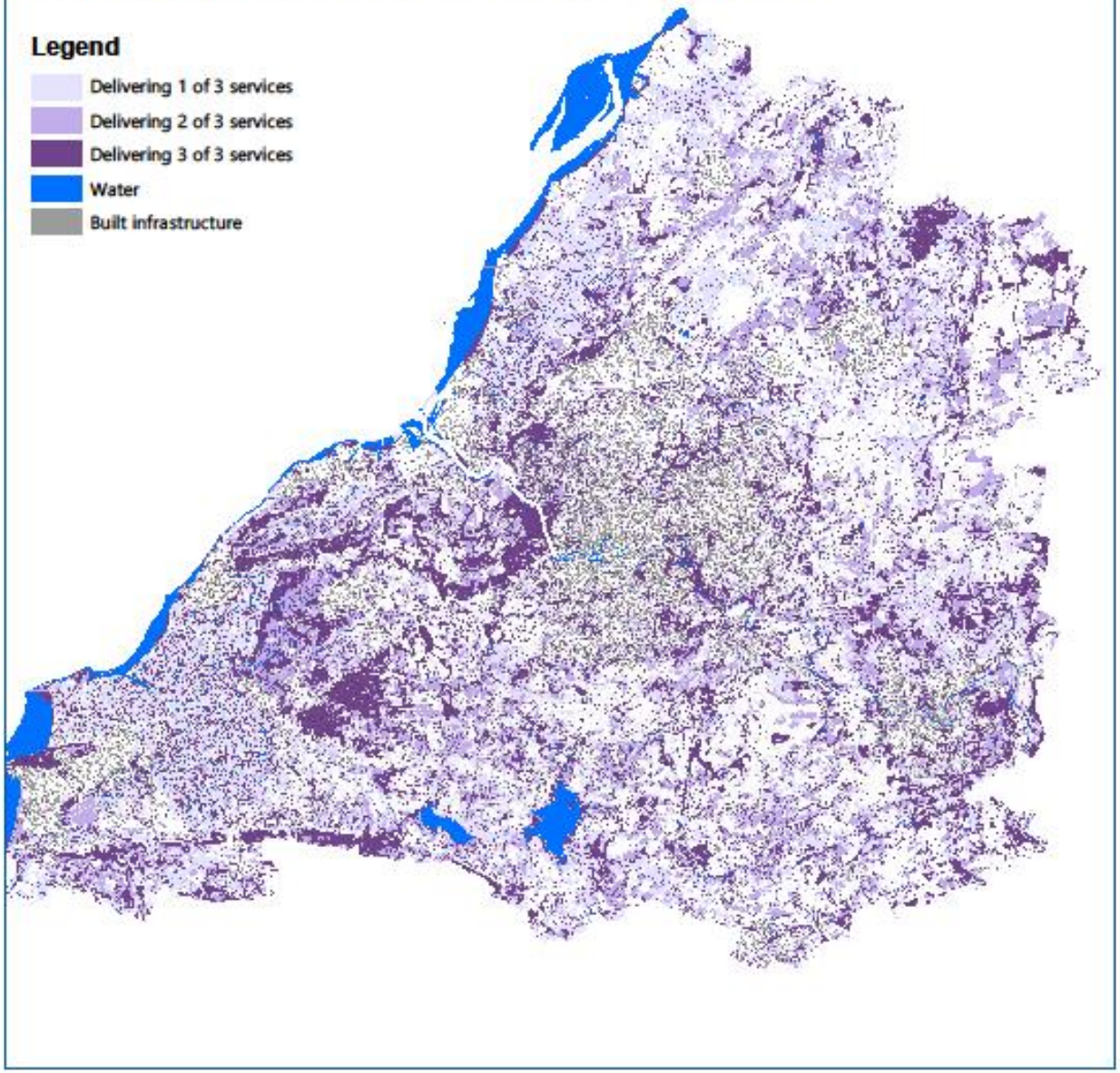
How was the map created?

The map was created by analysing the different features which can affect how water is absorbed into the land. Features which slow water down

Water include vegetation with high structural diversity, such as trees with different layers of branches, a dense understory and ground flora. Ancient woodland has a greater capacity to store water as it is often found on deep soil. The underlying geology can also affect the amount of water that is absorbed, for example limestone is porous and will help hold water.

Ecosystem Map #13: Multiple Ecosystem Services

Combining ecosystem services in the West of England



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JOINT ECOSYSTEM SERVICE ASSESSMENT

Multiple Ecosystem Services
Many areas of land in the West of England is providing more than one ecosystem service. This map has combined the services mapped to create a multiple ecosystem service map.

What does the map show?
Different ecosystem services have been overlaid to show where the land is delivering multiple ecosystem service provision. It shows the areas that contribute to good water quality, areas that are providing natural flood defences and areas that are part of an ecological network. The darker the colour indicates where multiple services are being provided.

Why are these ecosystems important?
Areas that are providing multiple services are helping improve the regions overall resilience. The darker areas are the most ecologically important areas that should be protected to ensure they can continue providing multiple services.

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Map #13: Multiple Ecosystem Services

Combining ecosystem services in the West of England

Many areas of land in the West of England is providing more than one ecosystem service. This map has combined the services mapped (water quality, water quantity, and core areas of the networks) to create a multiple ecosystem service map.

What does the map show?

Different ecosystem services have been overlaid to show where the land is delivering multiple ecosystem service provision. It shows the areas that contribute to good water quality, areas that are providing natural flood defences and the core areas of the ecological networks. The darker the colour indicates where multiple services are being provided. 21% of the West of England is delivering 3 ecosystem services simultaneously, as shown in fig 6.

Why are these ecosystems important?

Areas that are providing multiple services are helping improve the regions overall resilience. The darker areas are the most ecologically important areas that should be protected to ensure they can continue providing multiple services.

How was the map created?

The map combined the following layers:

1. The 'core' areas of woodland, grassland, and wetland network.
2. The areas the contribute most to good water quality
3. The areas with the highest infiltration rates (water quantity)

This identified where in certain areas, multiple ecosystems were being delivered, and either 1, 2 or 3 services were being delivered simultaneously.

For example part of the core woodland network, will also be helping improve water quality and depending on where it is, may also be helping to prevent flooding by temporarily storing water following rainfall.

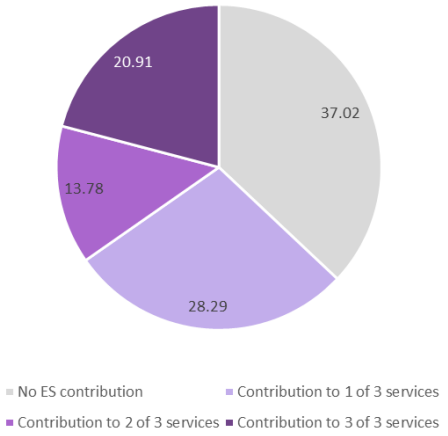
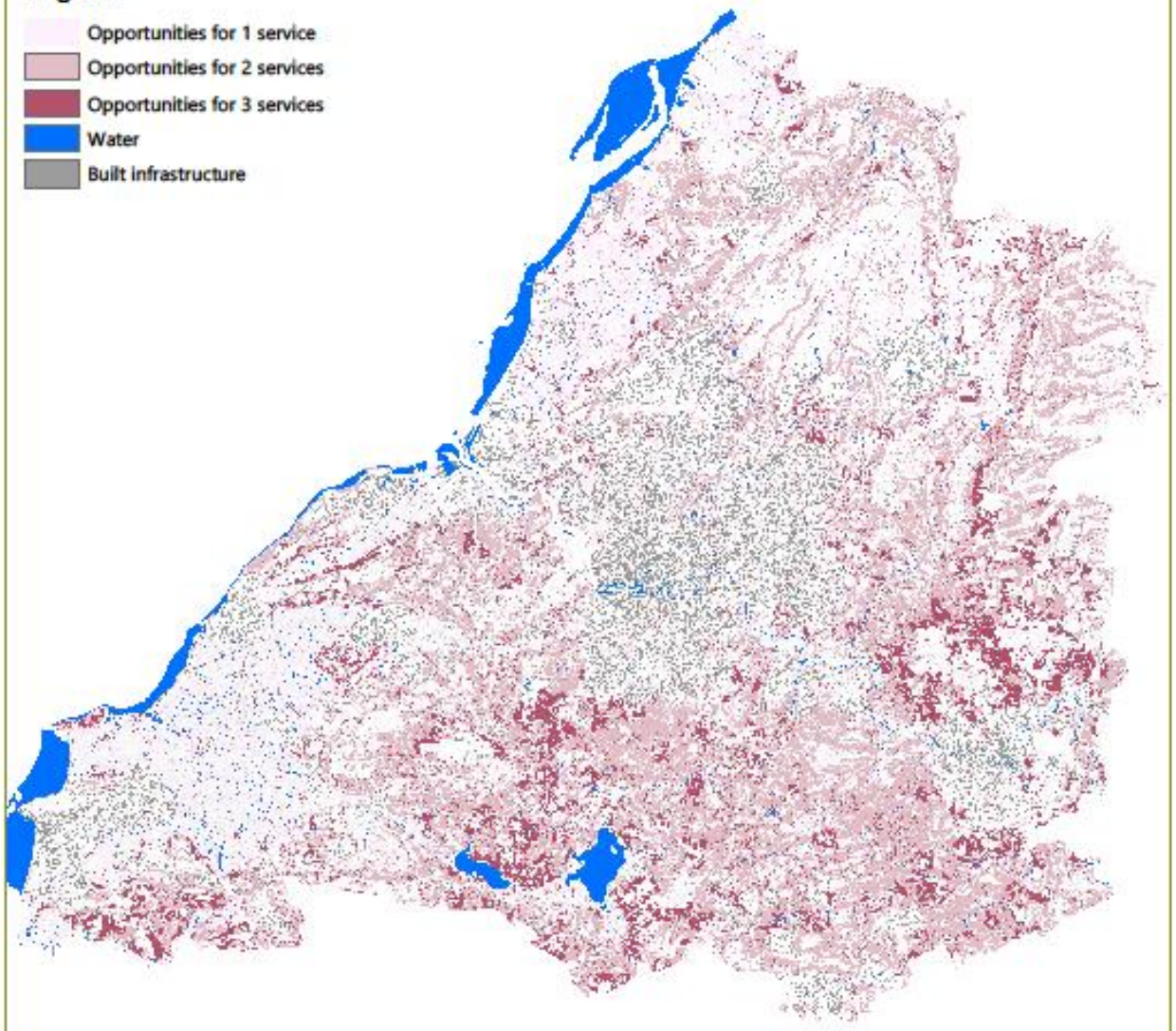


Fig 6. Percentage of land in the West of England that is delivering multiple ecosystem services.

Opportunity Map #14: Multiple Ecosystem Services

Opportunities to deliver multiple ecosystem services in the West of England



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JOINT ECOSYSTEM SERVICE ASSESSMENT

Multiple Ecosystem Services

This map shows where there exists opportunities to restore habitats to provide multiple ecosystem services.

What does the map show?

Different areas can be enhanced in a variety of methods resulting in provision of a number of different ecosystem services.

The lightest shade of pink shows where it is possible to deliver 1 ecosystem service, the middle shade of pink shows where 2 can be delivered and the darkest shade shows where enhancement would result in the delivery of 3 ecosystem services. 7% of the land in the West of England could be modified to deliver 3 ecosystem services simultaneously.

The map was created by overlaying the areas with the greatest opportunities to deliver the ecosystem services that were mapped, namely the areas that contribute to good water quality, areas that are providing natural flood defences and areas that are part of an ecological network.

Why are these ecosystems important?

Investing in ecosystem service provision can provide multiple direct and indirect benefits. If an area can deliver multiple benefits, it will be good value for money and provide added benefits for people and nature.

SENCE

Avon

Environment Systems

N

0 4.75 9.5 19

Kilometres

Map #14: Opportunity Map – Multiple Ecosystem Services

Opportunities to deliver multiple ecosystem services in the West of England.

This map shows where there exists opportunities to restore habitats to provide multiple ecosystem services.

What does the map show?

Different areas can be enhanced in a variety of methods resulting in provision of a number of different ecosystem services. The lightest shade of pink shows where it is possible to deliver 1 ecosystem service, the middle shade of pink shows where 2 can be delivered and the darkest shade shows services simultaneously. The map was created by overlaying the areas with mapped, namely the areas that contribute to good water quality, areas that are providing natural flood defences and areas that are part of an ecological network.

Why are these ecosystems important?

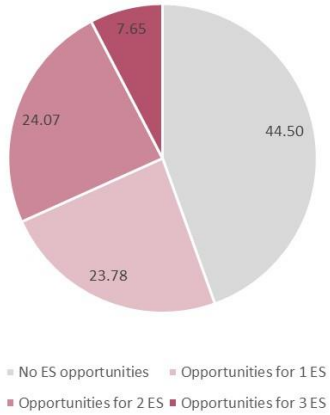
Investing in ecosystem service provision can provide multiple direct and indirect benefits. If an area can deliver multiple benefits, it will be good value for money and provide added benefits for people and nature. As well as resilience against future threats such as climate change.

How was the map created?

The map was created by overlaying the following information from the opportunity maps:

1. The 'best' opportunity areas to create woodland, grassland, or wetland
2. The areas with the greatest opportunity to improve water quality
3. The areas with the greatest opportunities to slow run-off.

By combining this information it is possible to show where there are opportunities to enhance the land to provide one, two, or three ecosystem



services simultaneously. The analysis revealed that 7% of the land in the West of England could be modified to deliver 3 ecosystems (shown in fig 7), focusing on these areas would not only make good economic sense, it will help strengthen the region's reliance and provide multiple benefits for all.

Fig 7. Percentage of West of England that could be enhanced to deliver one, two, or three ecosystem services simultaneously.

West of England Nature Partnership

Joining up the dots for nature

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