Ecosystem Service Map Explorer (ESME): applications and limitations

Chief Scientist's Group report

March 2026

NCEA | Natural Capital and Ecosystem Assessment

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

Published by:

Environment Agency
Horizon House, Deanery Road,
Bristol BS1 5AH

www.gov.uk/environment-agency

Further copies of this report are available from our publications catalogue: www.gov.uk/government/publications or our National Customer Contact Centre: 03708 506 506

Email: research@environment-agency.gov.uk

Project Team:

Environment Agency
Alice Crouch, Chris Cooper, Rachel Goodwin, Sarah Rustage, Emma Warner, Jed Nicholson and Ruth Jones

Natural Capital Solutions
Jim Rouquette, Valentina Zini, Chris Osborne and Malori Richards

River Restoration Centre
Marc Naura and Josh Anthony

Keywords: Natural Capital and Ecosystem Assessment, natural capital, ecosystem services, condition, rivers, mapping, ESME, indicators.

Research contractor:

Natural Capital Solutions, Towcester, Northamptonshire, NN12 8AX. +44 (0)7790 105375

River Restoration Centre, Cranfield, Bedfordshire, MK43 0AL. +44 (0)1234 752979

Environment Agency's Project Lead: Alice Crouch

Project number: F/2526/0344

Citation: Environment Agency (2026) Ecosystem Service Map Explorer (ESME): applications and limitations. Environment Agency, Bristol

Acknowledgements

The Riverine Natural Capital Condition and Ecosystem Service Mapping project is funded by the UK Government through Department for Environment, Food & Rural Affairs (Defra) Natural Capital and Ecosystem Assessment programme (NCEA). The NCEA programme is Defra's largest research and development programme; surveying England's land, freshwater, and coastal ecosystems to produce a baseline assessment of our natural assets.

The project team would like to thank all contributors to this report, particularly to stakeholder workshop and User Story participants, many of whom also filled in the polls and questionnaires which have been used to improve the outputs. We would also like to thank subject matter experts in Water, Nature, Flood, Research, Social Science, Data and Natural Capital teams across the Environment Agency, and the Natural Capital team in Natural England, for their methodology and review contributions. Thank you also to Tash Senior (Esri) for ArcGIS Online Experience Builder advice, and Alison Smith (University of Oxford, Environmental Change Institute), who provided expert external review.

Research at the Environment Agency

Scientific research and analysis underpins everything the Environment Agency does. It helps us to understand and manage the environment effectively. Our own experts work with leading scientific organisations, universities and other parts of the Defra group to bring the best knowledge to bear on the environmental problems that we face now and in the future. Our scientific work is published as summaries and reports, freely available to all.

This report is the result of research commissioned by the Environment Agency's Chief Scientist's Group.

You can find out more about our current science programmes at https://www.gov.uk/government/organisations/environment-agency/about/research

If you have any comments or questions about this report or the Environment Agency's other scientific work, please contact research@environment-agency.gov.uk.

Dr Robert Bradburne
Chief Scientist

Contents

1. Background

The Ecosystem Service Map Explorer (ESME) was created through the Riverine Natural Capital Condition and Ecosystem Service Mapping project. It is a first of its kind open and transparent tool. It uses evidence on the condition of the water environment to model and map ecosystem service capacity (i.e. the potential to provide key ecosystem services). In doing so, ESME can advance the environmental sector's ability to map and understand natural capital.

The tool currently covers natural and modified freshwater rivers across England. The data can be explored at 3 spatial scales (from broad to fine scale): management catchment, river water body and river reach (stretches of river).

You can use this tool to view the underlying natural asset condition indicators and relative ecosystem service capacity in your area of interest, in map and chart form. Ten ecosystem services are currently included:

- Provisioning services (Water supply),
- Regulating services (Water quality regulation; Water flow regulation; Habitat and species population maintenance),
- Cultural services (Aesthetic and amenity experience; Recreation; Physical / mental health and wellbeing; Education and investigation; Spiritual, cultural and religious experiences; and Intrinsic value of nature).

You can export the results to use in analysis, stakeholder engagement, business cases or project planning. ESME provides a snapshot in time using the most suitable national evidence available in 2025. It should be considered a starting point for understanding ecosystem service capacity in a place, and interpretation should be supplemented with local data and knowledge. It is important to understand limitations and confidence in results and scale which are outlined below.

A prior Environment Agency review of user needs in relation to natural capital geospatial evidence identified a need for national natural capital condition and ecosystem service mapping as suitable evidence was considered limited, particularly in the freshwater environment. A deeper understanding of user needs has been captured throughout the project and has shaped the outputs. An assessment of other ecosystem service mapping tools available (see Project Report for the full assessment) revealed the need for a tool that focusses on rivers and one that integrates both habitat and river condition to more accurately capture changes in ecosystem service capacity. A further need is for a tool that provides ready to use and user-friendly mapped outputs, rather than requiring the user to carry out modelling, and one that does so at a fine spatial scale. ESME has been designed to meet these needs.

This short report outlines potential uses and applications of ESME (Section 2), the relationship with the Water Framework Directive (Section 3), and briefly outlines the most suitable scale of mapping to use for different ecosystem services (Section 4). It then outlines the level of confidence in the outputs (Section 5) before listing a series of limitations and caveats that users should be aware of when using ESME (Section 6). Annex 1 details potential scales suitable for different users and uses, and Annex 2 provides broad summaries of the benefits potentially provided by different ecosystem services. Further information can be found in the main Project Report or the Methodology Report, which are published alongside ESME. Ecosystem service descriptions are provided in Appendix A of the Project Report and within ESME.

ESME is currently being released as a Beta version, and we welcome all feedback, which can be sent to NaturalCapital@environment-agency.gov.uk.

ESME can be accessed using this link.

2. Uses and applications

Throughout the project, information has been gathered on potential uses, applications, and user needs of the ESME tool. During the main mapping phase, additional information was collected through user workshops and a user testing questionnaire. Further information on the process that we followed is provided in the main ESME Project Report.

The Environment Agency project team also conducted a series of internal interviews ('user stories') with potential user groups of ESME to collect more information on the **anticipated use** of ESME. These uses are summarised in Box 1. Items are listed in order of the number of times they were mentioned by user groups, from most mentioned to least mentioned.

Box 1: anticipated use of mapping (ordered by number of times mentioned)

- identify investment opportunities
- improve evidence baseline
- spatial prioritisation of interventions
- communication/engagement of environmental issues and opportunities with partners or stakeholders
- identify risks/pressures/impacts on ecosystem services
- identify benefits/beneficiaries
- share evidence and outputs with partners/stakeholders
- develop projects to improve condition of assets and ecosystem services
- inform strategic partnership vision
- tracking change to ecosystem service provision over time
- influence national and local policy

There are clearly a wide range of potential uses, with the top three (identify investment opportunities, improve evidence baseline, and spatial prioritisation) all being identified by over 70% of the groups interviewed.

As well as the general uses listed above, a range of more **specific potential applications** that align with other schemes have been identified. Some of the main ones are:

- support a national natural capital baseline assessment
- target river restoration and promote landscape scale management of rivers
- inform Biodiversity Net Gain (BNG) offsetting
- help prioritise Natural Flood Management (NFM) delivery
- provide evidence to support Local Nature Recovery Strategy (LNRS) actions and delivery
- inform landscape delivery schemes such as the Landscape Recovery Scheme

- align with Flood and Coastal Risk Management (FCRM), Natural Flood Management (NFM) and nature-based solutions projects to enhance ecosystems and biodiversity, leading to better integration
- assessing BNG and natural capital on water companies' water resources and drought management plans
- prioritising data collection and monitoring to target evidence gaps

The diagram below (Figure 1) shows each stage in the Environment Planning and Delivery (EPD) Cycle (widely used in environmental projects), and the percentage of user group responses that believed the ESME tool would have a use for that particular stage.

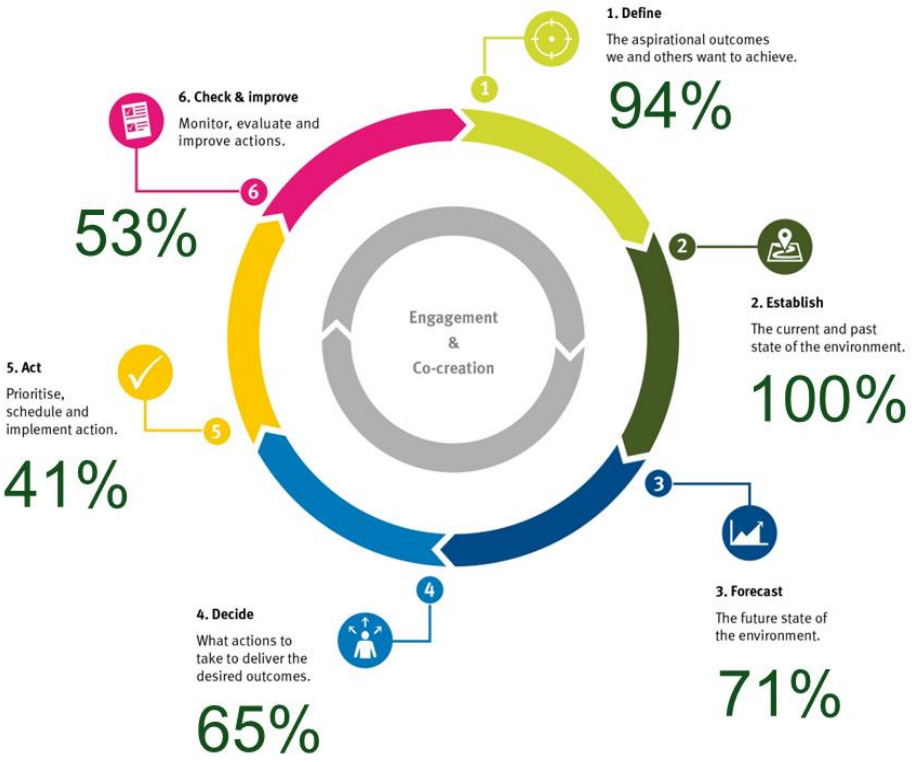

Figure 1: Most common uses for ESME outputs by Environment Planning and Delivery cycle stage, according to User Story responses.

Two case studies showing the use of an earlier version of ESME to support Environment Agency projects have been developed (note the number of case studies is being expanded over time). Summaries of these use cases are available on the ESME homepage:

- ESME Use Case – Mordon and Preston Carrs
- ESME Use Case – Haugh Head Ford

ESME through the project life cycle

Some projects will be able to use ESME through the entire EPD cycle – from strategic visioning, to acting and checking the delivered outcomes against those planned at the start. Other projects may only use ESME for part of the project development or delivery. For example:

Define

A project that is designed to provide strategic steer for the delivery of local projects to improve riverine bankside habitat might use ESME to understand the most applicable ecosystem services for setting a strategic vision as part of 'Define' ('we want to improve riverine habitats - habitats and population maintenance ecosystem service - by improving the hydrological connectivity and sinuosity of rivers in our area - Water flow regulation ecosystem service).

ESME could also help with communication of the current ecosystem service baseline with partners and stakeholders.

Establish and Forecast

The ecosystem service indicator score, and specific condition indicators, could be used to set the current ecosystem service provision baseline as part of 'Establish'.

At this stage, it is also possible to start exploring other ecosystem services in the project area that could be considered for improvement at the same time as the primary improvement. For example, re-meandering and reconnecting the river with its flood plain may provide flood mitigation, while additional riverside access may help improve the recreational use of a river.

ESME could also be used to 'Forecast' change to the relevant ecosystem services based on actions identified as required from local information on pressures and risks. See section 2.1 for more information on using ESME to plan interventions.

Decide and Act

The above stages, and specific local information, could be used to 'Decide' the actions required and to enable ('Act') these to be funded and delivered by helping:

- identify local stakeholders
- identify local beneficiaries
- identify other potential ecosystem service improvements
- identify additional funding opportunities

Check & Improve

Once the project has been completed, ESME could be used to track changes to ecosystem services, over a medium-long term period, against the original baseline. Please see section 2.2 for more information on using ESME to examine trends over time.

2.1 Using ESME to plan interventions

There is interest from users in understanding the sensitivity of the ecosystem service scores to change; which indicators are driving scores, which should be targeted first to enable the score to improve, and how much change would be required to shift a score into a better category. This can be used to help identify interventions to bring about a change and how to use reporting based on ESME to incentivise the delivery of those actions.

The most influential indicators for each ecosystem service, and therefore the ones that would likely be best to target to drive an improvement in score, are shown in Table 1. We also indicate whether changes to these indicators are realistically actionable by Environment Agency teams or local partners, in other words how easy they may be to change through targeted interventions.

This information would need to be considered in the wider context of the opportunities and constraints in a place; and also whether there are trade-offs between ecosystem services.

Table 1: The most influential indicator(s) for each ecosystem service, which will have the greatest effect on the overall score, and whether these indicators are realistically actionable by Environment Agency teams or local partners.
H = high (possible to change), M = medium (more difficult, but could be changed), L = low (difficult to change).

Ecosystem service	Most influential indicator(s)	Actionable
Aesthetic and amenity experiences	R1 - River Habitat Quality	H
Water quality regulation	R3 - Riparian Quality Index	H
Habitat and species population maintenance	R1 - River Habitat Quality	H
Physical / mental health and wellbeing	R13 - Recreational hotspots R12 - Local access	M M
Recreation	R13 - Recreational hotspots R12 - Local access	M M
Intrinsic value of nature	R15 - Community Conservation Index	M
Spiritual, cultural and religious experiences	R18 - Heritage features R1 - River Habitat Quality	L H
Education and investigation	R30 - Scientific interest	L
Water supply	R26 - Surface water abstraction amount R27 Abstraction sustainability	L M
Water flow regulation	R5 - Lateral connectivity R6 - Vertical connectivity	H H

Re-naturalising reaches would be the most significant intervention to half of the ecosystem services. This would involve works to reduce or remove the impacts of culverts, bridges, outfalls and deflectors, bank and bed reinforcement, bank and bed resectioning, berms and embankments, weirs, dams and sluices, as well as enhancing the complexity, naturalness and continuity of the riparian zone (the bank and a 5m buffer). These types of intervention are realistically actionable by Environment Agency teams and project partners. Improving access to rivers would be key to enhancing the delivery of two further ecosystem services. Changing these aspects is likely to be more difficult, as it may require significant funding, but is still possible. The remaining ecosystem services would require a range of different interventions to improve capacity, many of which are either moderate or difficult to change. Further detail is provided in Section 9.2 of the Project Report.

2.2 Examining trends over time and updating ESME

Frequency of update is a balance between funding, user desires, data updates, and access to new and improved data sources.

ESME reports a 2025 baseline assessment of condition and ecosystem service capacity based on data from 2013 to 2025 (tranquillity dates from 2007), which was the most suitable national evidence available in 2025. It is hoped that if the assessment is repeated in the future, it will be possible to create a time series to examine change over time. Many of the indicators have been scaled using quintiles and if the same break points are used in subsequent years, it will be possible to determine categories of scoring in relation to the 2025 ESME reporting baseline.

Currently, ESME uses WFD classification data used as the statutory basis for the Cycle 3 River Basin Management Plans, collected over the period of 2013 to 2018, with data published in 2019. Some classification data was additionally published in 2022, but this data was less comprehensive and not entirely compatible and so was not used. Other data (e.g. data derived from RHS, species data) were also used with a start date of 2013 to match the WFD data, although a number of data sets used in ESME are more recent, so there may be a slight temporal mismatch. More details are provided in the methodology report.

WFD classifications are being re-run across 2025 to 2026 to use in the Cycle 4 River Basin Management Plans (due to be published in 2027). The Environment Agency will assess the impact of updated classification data on ESME once the new classification data is available and plan when best to incorporate it into updated ESME outputs. At that stage, if an update is made, the cut-off (oldest date) used for other data sources, especially RHS and species data, could also be updated to 2019 so that data aligns better temporally and a moving reporting window is established. From late 2025 the Environment Agency also started to release national River Surveillance Network (RSN) and Small Streams Network (SSN) Analysis Ready Data collected through the NCEA programme. The Environment Agency is currently exploring the feasibility of integrating this data with ESME data to enable ecosystem

service reporting at different scales and this work could also inform the next ESME update.

After an initial update to capture WFD Cycle 4 data, national NCEA data if appropriate, and to address any issues with the Beta version, a **full update would be most relevant over a 3-6 year cycle**, with an interim update every 3 years and a full update to fit with the WFD reporting cycle occurring every 6 years. Further information on updating is provided in the Project Report.

3. Relationship with the Water Framework Directive

ESME presents a different picture of the water environment to classifications under the Water Framework Directive (WFD).

WFD ecological classifications reflect the ecological status of water bodies — a general measure of their ecological health and intactness. These classifications are based on biological, physico-chemical and hydromorphological parameters and are assessed against reference conditions, meaning they provide an absolute measure of how close a water body is to its natural or undisturbed state.

ESME reflects relative ecosystem service capacity - the potential of a natural asset to provide ecosystem services, based on a variety of environmental and socio-economic indicators. A water body may have different levels of capacity for different ecosystem services. For example, a water body may have high capacity for Recreation ecosystem service (e.g., riverside walks), but low capacity for Habitat and Species Population Maintenance ecosystem service (e.g., healthy fish populations). ESME also uses a relative approach to reflect capacity, with many indicators using national quintiles, so that a “very high capacity” score represents the top 20% of rivers in England and a “very low capacity” score represents the bottom 20%.

In short, WFD classifications provide an absolute measure of ecological health, whereas ESME combines that same information with additional datasets to give a service-specific perspective - showing how ecological condition supports the delivery of individual ecosystem services. ESME is complementary to WFD classifications and enriches the evidence available for environmental planning and delivery.

4. Which scale of mapping should I use?

Consideration of scale is an important factor when using ESME. Results are available at three different scales: river reaches (fine scale), WFD waterbodies (medium scale), and WFD management catchments (broad scale). More information on which scale to use and the importance of scale for different ecosystem services is provided in the main Project Report (Section 9.3 and 9.4) but is summarised here and in Table 2 in the next section:

ESME is best used at reach and waterbody scales for the majority of purposes, with the best scales for each ecosystem service indicated in Table 2 and summarised below:

- **Reach scale** provides the most detailed results and is best for assessing many of the cultural services, especially, Aesthetic and amenity experiences, Recreation, and Physical / mental health and wellbeing. But it should be noted that not all data sets and indicators could be assessed at that level of detail so there may be a false sense of accuracy, or missing data in some cases, especially for the regulating services, and spurious levels of variation in some indicators that are recorded at reach scale.
- **Waterbody scale** provides a good compromise between providing enough detail to make the results useful and not giving a false sense of accuracy. The results are broadly similar to those reported at reach scale, but with some of the potentially spurious variation removed. It is a particularly good scale for assessing the results of the regulating services and some of the cultural services such as Intrinsic value of nature, and Education and investigation. It also matches the scale used in other reporting published by the Environment Agency, such as for WFD.
- **Management catchment scale** is considered much less useful operationally as most results are broad averages, removing much of the variation and nuance in the outputs. But user feedback indicates it may be useful for strategic reporting, comparing broad patterns across regions, and it provides some additional useful information for Water supply.

For more information on the potential scales suitable for different users and uses, please see Annex 1.

5. Level of confidence in the outputs

Table 2 (below) reports the overall confidence in and limitations / caveats of the predicted ecosystem services that have been mapped, using a RAG rating:

- red identifies services that had little to no data available for mapping and were therefore left out (no confidence).
- amber indicates services that require more indicators because some aspects of condition have not been mapped (low confidence).
- yellow is for those services that have been predicted using the appropriate condition indicators, but the indicators would benefit from improvement or it would be difficult to improve these models further, but some uncertainties or gaps remain (moderate confidence).
- green highlighted boxes identify those services which have been mapped using the best data available to map the service and most aspects of condition have been captured (high confidence).

Note that there are no red or amber boxes in the table below, although earlier iterations of the mapping (and this table) did include these colours.

All ecosystem services are now assessed to be yellow or green, indicating that we have at least moderate confidence in all the ecosystem service outputs. The main reasons for some ecosystem services achieving yellow rather than green status is summarised in the “Limitations and caveats” column in the table. Further details about confidence can be found in Section 10.1 of the main Project Report and there is more on limitations and caveats in the next section.

Table 2: RAG rating showing overall confidence in the outputs for each ecosystem service mapped in ESME, the scale considered best for examining the outputs, and notes on limitations and caveats. The confidence of ecosystem service scores varies according to availability and/or certainty of the data covering aspects of condition. This is derived using expert judgement.
Red = no confidence; Amber = low confidence; Yellow = moderate confidence; Green = high confidence.
Best scale: R = reach, W = WFD waterbody, C = WFD management catchment, () = suitable scale but may not be optimum.

Overall confidence	Best scale	Limitations and caveats
Aesthetic and amenity experiences	R, W	Does not pick up very fine scale changes in tranquillity and this dataset is old (2007). Does not consider impact on house prices.
Education and investigation	W	No comprehensive data available on school / educational visits to watersides.
Intrinsic value of nature	(R), W	High confidence in decision tree and key factors, but data on iconic species and INNS is severely limited due to licencing restrictions on relevant data.
Habitat and species population maintenance	R, (W)	Decision tree constructed in a different way. Unlike other ecosystem services, final map is closer to an absolute score, rather than a relative score of ecosystem service capacity.
Physical / mental health and wellbeing	R, (W)	Data on local swimming spots and continuous discharges could be further improved. Does not pick up very fine scale changes in tranquillity and this dataset is old (2007).
Recreation	R, (W)	Considered to work well. Data on local swimming spots and continuous discharges could be further improved. **This map does not necessarily indicate that the river is suitable for immersive watersports.**
Spiritual, cultural and religious experiences	R, W	Some identified heritage features are not directly relevant to the river. Sense of place / history is very broad and may have nothing to do with the river. Difficult to capture all aspects of this ecosystem service.
Water flow regulation	W	Considers how natural processes of rivers regulate both peak flows (flood) and low flows (drought) so difficult to map the ecosystem service.

Overall confidence	Best scale	Limitations and caveats
		This map is not suitable for assessing flood or drought risk. Data/proxies for baseflow contribution (groundwater input) could be further improved. **This ecosystem service should not be conflated with regulation of flows and levels by man-made structures.**
Water quality regulation	W	Concerned with the regulation of water quality, not water quality itself. Difficult to map as data on the former is lacking and we have to rely on proxy indicators. **This ecosystem service should not be conflated with regulation of water quality by permitting**.
Water supply (drinking/ agriculture/ industry)	W, C	Does not consider groundwater abstraction. Abstraction in one waterbody likely to be influenced by upstream abstractions and water level management. **This map is not suitable to support water abstraction permit applications.**

6. Limitations and caveats

ESME is a Beta release innovation product, so it should be used with care. We welcome feedback as it is tested more widely. **Feedback can be sent to** NaturalCapital@environment-agency.gov.uk. It is considerably improved compared to the prototypes demonstrated in earlier phases of the project, but there are still limitations to be aware of. This section brings together and repeats limitations presented in the accompanying Methodology and Project Reports.

6.1 General limitations

- This is a desk-based mapping tool based partially on national scale datasets, so spatial accuracy is not always high or coverage comprehensive for all indicators. While ESME can inform the uses listed above, **decisions ultimately need to be considered alongside data and evidence collected on the ground and local knowledge**. ESME does not provide the function to make user adjustments to results - however, users could export ESME data and adjust it to reflect more detailed local data or knowledge in their own GIS systems if they had need of this, and provide feedback to us to improve our methodologies in the longer term. Note that a significant amount of work has gone into understanding underlying assumptions, so users should be aware of this if developing their own approach.
- ESME reports a 2025 baseline assessment of condition and ecosystem service capacity based on data from 2013 to 2025 (tranquillity dates from 2007), which was the most suitable national evidence available in 2025. The WFD data used in ESME dates from the period 2013-2019 (forming the statutory basis of Cycle 3 River Basin Management Plans), so it is important to bear in mind that there may have been changes since that time. More recent comprehensive classification data for the Cycle 4 River Basin Management Plan, expected in 2027, is not yet available. A number of other data sets used in ESME are more recent, so there may be a slight temporal mismatch.
- In several indicators, quintiles have been used to determine the range of condition scores, which provide relative scores across England, meaning that a proportion of sites will always score well or badly. It was not possible to assign absolute scores for many indicators, although some indicators are based on absolute scores. The tool therefore uses a mix of scoring approaches (full details provided in the Methodology report). Overall, it should be seen more as providing **relative ecosystem service scores**.
- The indicators are not all strictly “condition” or “capacity” indicators, with some indicators of demand, flow, ecological pressure, and vulnerability, but **in all cases used as a proxy of condition and ecosystem service capacity.**

- The indicators used within ESME were developed at the finest spatial scale suitable for each dataset, which was nearly always either reach or waterbody scale. These were then extrapolated or averaged to other scales. This means that in some cases reach scale values are the same across a waterbody. It also means that catchment scale results are always simply an average (normally a weighted average) of results at finer scales so will be more likely to present intermediate values (see Section 4 for more details).
- Although the focus is on delivery of ecosystem services based on the condition of natural capital assets, it is inevitable that there is some overlap with built assets, especially around public access, which is a requirement to deliver some of the cultural services. It is not possible or desirable to disentangle these different types of asset.
- The mapping of ecosystem services and indicators cannot be linked directly to monetary value as most of the indicators used could not be valued directly. Methods for monetary valuation are much more limited and are poorly developed for riverine systems. The potential benefits provided by ecosystem services to people, society, organisations and business are included as high level supporting narrative in ESME. A more comprehensive narrative on the potential benefits provided by different ecosystem services is provided in Annex 2. To learn more about the Environment Agency's work on natural capital benefits and valuation please contact NaturalCapital@environment-agency.gov.uk, as we have other products that may support you.
- Specific data for artificial rivers was unavailable. We were unable to secure expert canal knowledge and evidence. Therefore, **artificial watercourses / waterbodies are not currently included in the tool**, although could be included in the future.
- Although Defra colleagues were consulted as part of the project's expert panel their opinions do not represent Defra official stance.

6.2 Ecosystem services limitations

There are limited data sets available or limitations within data sets for some ecosystem services. In particular:

- The **Aesthetic and amenity experiences** ecosystem service captures broad scale patterns but cannot pick up fine scale difference, such as a tranquil or attractive stretch of river in an otherwise heavily industrialised or urbanised area. It also does not consider the impact of rivers on property prices. There may be overriding contextual factors that might impact significantly the realisation of this ecosystem service (as opposed to the potential ecosystem service). For example, there may be limitations to visibility of the location, planning restrictions on property development or business activities, localised antisocial behaviour etc., which aren't being captured by our indicators.

- For **Education and investigation**, there are no comprehensive data available on school / educational visits to watersides. The pupils access indicator is therefore based simply on the proximity of schools to accessible watersides, assessing how many pupils potentially have access to the river. This provides only a very crude approximation of the potential of each river for educational visits.
- **Habitat and species population maintenance** does not capture historical/heritage landscape features (where there may be relic, protected, heritage infrastructure that supports wildlife and provides unique habitat such as old millstreams and redundant wharf backwaters), or artificially created waterways that provide a unique habitat and support species, such as overwintering migrant birds. These features, on the contrary, would potentially score low on naturalness, connectivity, hydromorphological pressures, etc.
- The **Intrinsic value of nature** ecosystem service is missing an important element of the social context that leads to people having an attachment to a place beyond the ecological framing of the presence/absence of particular species. Furthermore, some data from the National Biodiversity Network Atlas is open under the Open Government Licence (OGL), but much is not. We have only used OGL data to maintain openness of the outputs, but this does mean that the data that we are able to show is partial.
- For the **Recreation** ecosystem service, a caveat that needs to be considered for the realisation of, as opposed to the capacity for this ecosystem service, is that the majority of visits will be bankside (next to the water), rather than in or on the water. It is important to remember this only applies to publicly accessible rivers (i.e. statutory navigations) and the majority of rivers in England are not statutory navigations which means the 'in' and 'on the water' activities are severely restricted by the riparian owner (e.g. bankside Public Rights of Ways are much reduced). In this tool we also ignore the seasonality to recreation that is more pronounced for the 'on' and 'in the water' categories and that there are often de facto closures at certain times of the year. Data on local swimming spots and continuous discharges could be further improved. The Recreation ecosystem service map shows the potential for the provision of this ecosystem service and does not necessarily indicate that the river is suitable for immersive watersports. For advice on swimming in rivers, lakes or coastal waters, please see this guidance on how to swim healthy: www.gov.uk/government/publications/swim-healthy-leaflet.
- The **Physical/mental health and wellbeing** ecosystem service does not pick up very fine scale changes in tranquillity. It could also benefit from improved data on local swimming spots and continuous discharges. The most potentially confusing indicator within it is health deprivation by access. This is a culturally specific indicator, as it reflects the increased value that the service provides depending on the people it benefits. Hence the highest scoring areas

are those where there is high deprivation but also access to a river as these populations will most benefit from that service.

- The **Spiritual, cultural and religious experiences** mapping does not consider the full range of spiritual/cultural/religious experiences facilitated by rivers. It would be very difficult to capture all the reasons why a place has particular spiritual or religious meaning or value.
- The **Water quality regulation** service is affected by fine scale anthropogenic factors significantly influencing this service which aren't being captured here. However, this is not considered a major limitation as we are assessing water quality regulation not water quality itself. This makes it quite difficult to map as data on the natural regulation of water quality is lacking and we have to rely on proxy indicators. This ecosystem service should not be conflated with regulation of water quality by permitting.
- The **Water supply** ecosystem service does not currently consider groundwater abstraction (as we have initially focused on the ecosystem service capacity of rivers). It is also noted that abstraction in one waterbody is likely to be influenced by upstream abstractions and water level management. For this reason, we have calculated the catchment scale indicator of surface water abstraction amount in a different way to the other indicators in ESME. We sum the total abstraction volume across the catchment as a whole, rather than taking a weighted average, as this will provide a more realistic picture at catchment scale. However, this does mean that the pattern of results at this scale looks quite different from the results at waterbody scale. Note that the Water supply ecosystem service map is not suitable to support water abstraction permit applications. The relevant abstraction licensing strategy documents available on GOV.UK give more detail on how the Environment Agency manages abstraction within each catchment.
- The **Water flow regulation** ecosystem service considers how natural processes of rivers regulate both peak flows (flood) and low flows (drought) and as such it is relatively difficult to map as a river could be potentially good at mitigating floods but poor in drought conditions, or vice versa, although a number of natural processes can help with both aspects. Results should, however, be interpreted with that in mind. Data/proxies for baseflow contribution (groundwater input) could be further improved. This ecosystem service should not be conflated with regulation of flows and levels by man-made structures. This map is not suitable for assessing flood or drought risk.

6.3 Indicators limitations

- The indicators are not all strictly 'condition' indicators, with some being indicators of pressure, usage, vulnerability (and so on), but in all cases used as a proxy of condition and ecosystem service capacity. A fuller description of

types of indicators and how they are used within ESME is provided in the Methodology Report.

- The indicators use a mix of data sets that have been collected at different times and scales, and for different purposes, so outputs should be seen as providing a relative picture of condition.
- Most species data is not available openly, so indicators that rely on this are limited, especially R16 Iconic species and R17 Invasive non-native species.
- R14 the recreational hotspots indicator used in Physical / mental health and wellbeing, and Recreation, does not fully capture all the important aspects that characterise a 'hotspot'. In particular, if a hotspot has car parking, charging points, cycle access, toilets, cafes, etc this will potentially attract more visitors, and this is not currently accounted for. These are not aspects of natural capital directly, but they do have a significant impact on access to and use of natural capital. They are significant contextual modifiers but, as of yet, we haven't been able to distinguish whether car parks that are adjacent to rivers exist mostly for visitors to the river, or for other reasons (e.g., a shop might have a car park that happens to be close to the river). Another contextual factor is the proximity of one hotspot to any others. If there's only one within 'average' travel distance then it will be a greater focal point than if there are more in-range hotspots per capita.
- The accessible watersides sub-indicator (used in R12 and R13) is created purely by the proximity of the water edge to publicly accessible green infrastructure and/or a Public Right of Way. Circumstances on the ground might mean that some sections marked as likely to be accessible are in fact not. The identification of waterside as accessible is thus indicative and not definite. There are also instances where paths along rivers are not being picked up by this data set.
- The use of WFD data within R11 and R19 water quality indicators comes with caveats. Some reaches may have poor biological status for reasons not related to water quality (e.g., presence of a barrier to fish migration).
- The water quality indicator used in the Recreation and Physical/mental health and wellbeing ecosystem services could be improved with respect to immersive watersports by using continuous discharge data.
- R17 Invasive non-native species are being treated equally, and this is arguably too crude an approach given the range of impact produced by these species. The quality of the data precludes a more nuanced approach.
- For R23 Pupils access, educational and investigation activities may be more likely to take place at designated reserves, protected sites, research stations, etc. rather than nearest publicly accessible waterbody. Distance travelled will then depend on school level - e.g. primary schools may well be visiting local

rivers (unless lucky enough to have a reserve nearby), whereas secondary schools will be more likely to travel further distances and visit specific sites. The data we currently have doesn't allow us to set different distances based on school level. It also makes the major assumption that having an accessible waterside within a certain distance of a school will mean that it is more likely to be visited for educational purposes.

- The data used for R26 Surface water abstraction amount is provided at river waterbody scale, hence all reaches within the waterbody are given the same score. Furthermore (and as noted above), abstraction in one waterbody is likely to be influenced by upstream abstractions and water level management. For this reason, we have calculated the catchment scale indicator of surface water abstraction amount in a different way to the other indicators in ESME. We sum the total abstraction volume across the catchment as a whole, rather than taking a weighted average, as this will provide a more realistic picture at catchment scale. This does mean that the pattern of results looks different when comparing the river waterbody map to the catchment map.
- Some indicators had missing values which were addressed by averaging the value of adjacent reaches or, if this was not available, by assigning the weighted-average (by reach length) calculated across the river water body. We applied this to R3 Riparian quality index, R6 Vertical connectivity, HMS bank and bed resectioning sub-score (D24e) and HMS berms and embankment sub-score (D24f) used in R5 lateral connectivity. These values are flagged with an asterisk symbol ("*") in ESME to allow users to identify data that has been inferred and needs to be used with caution.
- R1 River Habitat Quality Index and R5 Lateral connectivity use some modelled data for a small proportion of data points. Using modelled input data within indicators for building ecosystem service models is necessary where empirical observations are unavailable. Modelled inputs introduce several limitations that affect the reliability of the outputs. All models simplify reality and reflect assumptions about ecological processes. When modelled inputs are used within indicators, these assumptions become embedded within the ecosystem service framework biasing the final outcome. However, this impact is likely to be small.
- It is important to highlight that aggregating our results to river water bodies and catchments scales presents challenges particularly with indicators such as R2 Litter index, R16 Iconic species, R17 Invasive non-native species, for which we couldn't use a weighted-average approach as for the rest of the indicators, as these are based on presence-absence data. The use of these indicators at waterbody and catchment scale should therefore be interpreted with caution. These data sets are sparse, and a negative result does not mean that litter, or a particular species, do not occur there, simply that it has not been recorded in an open data set that we can use. More information on

the approach for scaling indicators up is contained in the indicator description and in the Methodology Report.

6.4 River reaches limitations

- The river reaches derived for ESME were based on a network of points every 500m along the UKCEH rivers network. This means that 500m intervals is the limit of resolution for the reaches and hence the accuracy of applying break points. This is particularly a limitation when dealing with lakes and reservoirs.
- The UKCEH rivers network were then snapped to the Open Rivers Network (ORN). Due to the difference between the UKCEH and ORN networks, some points may have snapped incorrectly, making data association difficult. This was a particular issue around confluence points and around loops and braids.
- Due to simplification of the WFD boundary shapefiles, there are sections where the river network passes through the same WFD boundary multiple times, particularly where a river network runs close and parallel to a boundary. In some cases, this artificially created break points where there was not a true change in waterbody area, although stretches below 1km have been corrected.
- Not all parameters identified in the workshop for river condition and segmentation are addressed by the method used. Further work could look to implement more variables within the analysis.

6.5 Licensing limitations

Some of the datasets used within ESME are not open access (see below for details). The Environment Agency have express permission to use these to derive open ESME outputs. As a result, all users can view and use the mapped condition indicators and resulting ecosystem service layers without restriction.

- As part of R1 River Habitat Quality Index, the Channel Resectioning Index and Hydromorphological Impact Assessment Index used are not open access but can be used by the Environment Agency to produce reach and water body level statistics that can be made publicly available.
- These hydromorphologicial indices make use of UKCEH river network 500m points and attributes, UKCEH LCM2000 1km dataset, and UKCEH Integrated Hydrological Units, all of which were used with permission from UKCEH.
- R7 Tranquillity uses licensed data, but we are able to use it in ESME, with the data owner’s permission, as we are extracting information from it, not displaying the original data.
- As part of R12 Local access, the proportion of people within each Local Authority area that access rivers and watersides has been extracted from the People and Nature Survey (PANS) under licence from Natural England.

- R14 Recreational hotspots and R16 Iconic species use the Environment Agency survey of freshwater angling which is published openly but the underlying data was used with permission from the Environment Agency.
- R26 Surface abstraction amount uses Environment Agency WRGIS data which is not published openly but which was used with permission from the Environment Agency to derive open outputs as the attributes required are not sensitive.
- The Open River Network segmentation process used to derive the reaches used within ESME used the UKCEH Land Cover Map 2020 10m raster dataset, with permission from UKCEH.

6.6 ESME tool platform limitations.

- ArcGIS Online's Experience Builder application platform mostly conforms with accessibility standards and guidelines and ESME was subject to an accessibility audit. Many of the accessibility issues were resolved where it was technically feasible to do so, or workarounds identified. However, a few of the issues identified could not be resolved as they are caused directly by the Experience Builder platform. This included inconsistencies with keyboard focus ordering and the inability to view ESME with JavaScript disabled. A roadmap of accessibility improvements has been identified for implementation as technology allows. Full details can be found in the accessibility statement in ESME.
- The ESME tool uses triggers to link elements together, such as the select widget updating multiple map widgets. It was discovered that triggers would break when data within the maps was adjusted. As a result, certain functionality was not included in the tool (such as enabling a user selection at one scale to automatically be selected at other scales), due to concerns over future maintenance of the tool and its functions. This concern was further compounded as there is limited ability to organise and name triggers within Experience Builder making them very difficult to manage.
- It is not possible to print a 'report-like' output from the ESME tool. To achieve this, a separate ESRI application, known as Report Builder, or equivalent application, is required. This functionality may be added in the future. You can however print a basic map or a screenshot of an ecosystem service chart graphic alongside a map (note you may need to adjust your browser zoom settings to fit your graph to the screen window if you have a small screen size).
- Datasets with large and/or complex geometries cannot be shown at the default zoom scale of the maps, due to their impact on performance. It was anticipated that this could be resolved by using a hybrid approach of tiles and features layers; however, at the time of this project, the combining of tile and feature layers (known as Vector Tile Layers in the ESRI platform) was not available. This can be solved by the user zooming in on a more specific area

of the map and only affects some of the reference datasets in ESME (not the ESME data itself), including: Saltmarsh Zonation, Sites of Special Scientific Interest Units, and Priority River Habitat.

Annex 1: Suitable spatial scales for different uses and users of ESME

The table below provides an indication of the suggested suitable ESME spatial scales for different high level uses and users. For more information on how to use EMSE, please refer to the User Guide.

Table 3. High level example uses and users of ESME and potential suitability of ESME scale outputs

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
Improved strategic evidence baseline	• Strategic Environment Agency teams • Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Universities • Other environmental Non-Governmental Organisations (eNGOs) • Consultants	X		

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
Improved tactical evidence baseline	• Strategic Environment Agency teams • Operational Environment Agency teams • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Universities • Other environmental Non-Governmental Organisations (eNGOs) • Consultants		X	X
Communication and engagement with partners or stakeholders	• Strategic Environment Agency teams • Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Universities • Other environmental Non-Governmental Organisations (eNGOs)	X	X	X

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
Strategic vision	• Strategic Environment Agency teams • Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Universities • Other environmental Non-Governmental Organisations (eNGOs) • Consultants	X	X	X
National policy and development	• Strategic Environment Agency teams • Defra • Water companies • Other Government departments	X		
Local policy development	• Operational Environment Agency teams • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities		X	X

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
	• Risk Management Authorities • Other Government departments • Other local environmental Non-Governmental Organisations (eNGOs)			
Spatial prioritisation of work	• Strategic Environment Agency teams • Operational Environment Agency teams • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Other environmental Non-Governmental Organisations (eNGOs) • Consultants		X	X
Identify investment opportunities	• Strategic Environment Agency teams • Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities		X	X

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
	• Other Government departments • Universities • Other environmental Non-Governmental Organisations (eNGOs). • Nature Markets			
Develop projects	• Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities • Other Government departments • Other environmental Non-Governmental Organisations (eNGOs). • Consultants		X	X
Identify benefits and/or beneficiaries	• Operational Environment Agency teams • Defra • Water companies • Rivers Trusts • Catchment Partnerships • Local and combined Planning Authorities • Risk Management Authorities		X	X

Potential Use (e.g.)	Potential user groups (e.g.)	Suitable spatial scale		
		Catchments	River Water Body	Reaches
	• Other Government departments • Other environmental Non-Governmental Organisations (eNGOs) • Consultants • Universities			

Annex 2: Natural capital benefits

The narratives below provide broad summaries of the potential benefits from different ecosystem services and are not specific to river assets. The narratives are drawn from work currently underway at the Environment Agency to produce a detailed analysis of the benefits from ecosystem services. For more information, please contact NaturalCapital@environment-agency.gov.uk.

1. Water quality regulation

Plants, animals, microorganisms, and geology all combine to clean water by diluting, filtering and breaking down pollution, and in turn **people** and **nature** benefit from this service as clean water is essential for all life.

This service provides **people** with clean water to drink and, where access is allowed, cleaner lakes, rivers and beaches to enjoy safely. For **society**, it helps more people stay active and able to work and reduces costs of providing healthcare. The benefits of this service are likely to be positive for **policy areas** such as public health, biodiversity and conservation, water management and land use planning as well as marine and coastal planning.

For **businesses**, cleaner water reduces the cost of additional treatment, helps meet regulations and standards, and supports good customer relations.

This ecosystem service is **closely linked to other services** especially water supply and water flow regulation, and the service itself supports many other services.

2. Water supply (drinking/agriculture/industry)

Water naturally collects into rivers, lakes and groundwaters which supply us with water to drink, for rearing livestock and growing crops, and for energy generation, cooling and other uses.

People and **nature** benefit from this service as water is fundamental for all life and good health. An affordable, reliable water supply is a vital resource for **society**, it helps more people stay active and able to work and reduces costs of providing healthcare. This service is important to public **policy areas** including water security and resource management, as well as public health, biodiversity and conservation, land use planning, energy security and marine and coastal planning.

For **businesses** such as water companies, the natural supply of water supports sustainable supply to meet consumer demand, and for other businesses a reliable supply of water helps ensure productivity and profitability.

This ecosystem service is **closely linked to other services** especially water quality regulation, water flow regulation, and renewable energy, and the service itself supports many other services.

3. Water flow regulation

The natural environment protects **people** and **nature** against storm surges, floods and drought, with habitats, soils and geology combining to slow, retain or divert water flows. For example, sand dunes and saltmarsh can play a role in protecting against coastal storm surges, while woodlands, wetlands and other habitats might help intercept and hold back runoff from rainstorms, and groundwaters can help sustain water flows in rivers during periods of drought.

Nature benefits from regulated water flows because reliable water levels and flows are essential for many habitats and species to survive and flourish. Note, some species and habitats are adapted to flourish in response to extreme changes (e.g. plants that establish in newly deposited silt after flooding).

People benefit in terms of reduced risk to life and property (such as homes and cars) from flooding or drought, and from longer periods of time when water levels and flows in lakes and rivers are suitable for swimming, angling or water sports.

For **society**, this service helps to reduce the risk of damage to public infrastructure such as transport networks, and for **businesses** it additionally helps continuity by reducing the risk to premises and operations. Public **policy areas** including flood risk planning, marine and coastal planning, water security and resource management, as well as biodiversity and conservation, land use planning, and energy security are all likely to benefit from this service.

This ecosystem service is **closely linked to other services** especially water quality regulation, water flow regulation, and renewable energy, and the service itself supports many other services.

4. Recreation

Nature provides places for recreation; climate, landscapes, plants and wildlife combine to lend themselves to all types of outdoor recreation (provided access is allowed). For example, coastal beaches may provide places for swimming and sunbathing, rivers and lakes for boating and angling, whilst woodlands, wetlands and other habitats for walking and observing wildlife.

Recreation improves and maintains **people**'s wellbeing including both physical and mental health. It may also create a bond with a place that improves their sense of belonging or identity. For **society**, maintaining wellbeing reduces the costs of providing healthcare. As a result, the benefits of nature-based recreation are likely to be positive in many **policy areas** such as public health, biodiversity and conservation, water management and land use planning as well as marine and coastal planning.

For **businesses**, improved wellbeing of staff may benefit productivity, and some specific sectors, such as hospitality, may gain increased trade by being located near a recreational site.

This ecosystem service is **closely linked to** other cultural services (particularly education or investigation, volunteering, spiritual, cultural or religious experiences, aesthetic or amenity experiences, and physical or mental health or wellbeing), whilst the service itself is dependent on many other services such as water quality regulation and habitat or population maintenance.

5. Education or investigation

Plants and wildlife, habitats, landscapes and geology provide places and materials for study and teaching. For example, coastal sand dunes can provide places for studying erosion, rivers and lakes for studying the impacts of pollutants on wildlife, or woodland fungi might provide subject material for learning about the decay of timber.

Nature benefits from this service when the knowledge gained is applied to maintain or improve the natural environment.

Education and investigation increase **people**'s knowledge and skills, and for **society**, the knowledge gained improves our collective scientific understanding, whilst opportunities to learn in outdoor places potentially broadens participation in education. The benefits of this service are likely to support **policy areas** such as biodiversity and conservation strategies, biosecurity, water strategies, flood risk and land use planning, as well as marine, transitional and coastal water strategies.

For **businesses**, the application of knowledge and insight gained from nature may benefit process and product design.

This ecosystem service is **closely linked to** other cultural services such as recreation, volunteering, spiritual, cultural or religious experiences, aesthetic or amenity experiences, and physical or mental health or wellbeing, and the service itself supports many other services such as intrinsic value of nature, genetic resources, renewable energy, and pest or disease regulation.

6. Spiritual, cultural or religious experiences

Plants, wildlife, habitats and landscapes can inspire or provide places for spiritual or religious experiences which can build strong personal connections with the natural environment.

A sense of connection with nature may help a **person**'s wellbeing, including physical and mental health, and improve their sense of belonging.

For **society**, better overall wellbeing may help people remain active and able to work and reduce the cost of providing healthcare. And, if people within a community share similar experiences of nature, this may help strengthen community cohesion (e.g. if

an iconic beauty spot comes under pressure from pollution and people then act together to protect or maintain it). This service is likely to positively benefit many **policy areas** such as public health, biodiversity and conservation, water management and land use planning as well as marine and coastal planning.

For **businesses** and **organisations**, inspiration from nature can help with new ideas and solutions, and sectors like hospitality may attract more trade by being located near places of spiritual or cultural importance.

This ecosystem service is **closely linked to** other cultural ecosystem services, such as recreation, aesthetic or amenity experiences, physical or mental health or wellbeing, intrinsic value of nature, education or investigation, and volunteering, and the service itself is dependent on other services such as water quality regulation and habitat or population maintenance.

7. Aesthetic or amenity experiences

Plants, wildlife, habitats and landscapes provide places that **people** want to visit, or where they want to live or work because of the natural beauty.

Being in a place of natural beauty may improve a **person**'s wellbeing, including their physical and mental health, and their sense of belonging. In desirable places to live, people's homes may be worth more.

For **society**, better overall wellbeing may help people remain active and able to work and reduce the cost of providing healthcare. And, if people within a community share a similar appreciation of nature, this may help strengthen community cohesion (e.g. if a local beauty spot comes under pressure from pollution and people then act together to protect or maintain it). This service is likely to positively benefit many **policy areas** such as public health, biodiversity and conservation strategies, land use planning, water environment strategies, and flood risk planning.

For **businesses** and **organisations**, the wellbeing benefits of this service may improve productivity, whilst specific sectors such as hospitality may attract more trade by being located near places of spiritual or cultural importance.

This ecosystem service is **closely linked to** other cultural ecosystem services, such as recreation, spiritual, cultural or religious experiences, physical or mental health or wellbeing, intrinsic value of nature, education or investigation, and volunteering, and the service itself is dependent on other services such as water quality regulation and habitat or population maintenance.

8. Physical or mental health or wellbeing

Plants, wildlife, habitats and landscapes provide places that **people** visit because it makes them feel good, and whether participating in physical or more gentle activities, this may help their wellbeing, including their physical and mental health.

For **society**, better wellbeing helps people remain active and able to work and reduce the cost of providing healthcare. As a result, the benefits of this service are likely to positively benefit many **policy areas** such as public health, biodiversity and conservation strategies, land use planning, water environment strategies, and flood risk planning.

For **businesses** and **organisations**, wellbeing benefits may improve productivity, reduce days lost to illness, and improve staff retention.

This ecosystem service is **closely linked to** other cultural ecosystem services such as recreation, spiritual, cultural or religious experiences, aesthetic or amenity experiences, intrinsic value of nature, education or investigation, and volunteering, and the service itself is dependent on other services such as water quality regulation and habitat or population maintenance.

9. Habitat or species population maintenance

Plants, wildlife, habitats, landscapes and climate provide places that are essential for biodiversity to thrive. Such places include breeding sites, nursery habitats, feeding grounds and places of shelter or natural corridors that connect between these places.

This service enables species in **nature** to complete their life cycles and establish sustainable populations.

For **people**, **society** and **organisations**, this service underpins all services and benefits from nature, as a result this service positively benefits many **policy areas**, particularly biodiversity and conservation strategies and biosecurity.

This ecosystem service is **closely linked to** supporting ecosystem services such as pollination or seed dispersal, and the service itself supports many other services such as wild produce, genetic resources, pest or disease regulation, intrinsic value of nature, recreation, education or investigation, aesthetic or amenity experiences, spiritual, cultural or religious experiences, physical or mental health or wellbeing, water quality regulation, water flow regulation, physical or mental health or wellbeing, and global and local atmospheric regulation.

10. Intrinsic value of nature

Plants, wildlife, habitats or landscapes can be appreciated and enjoyed without visiting them. This might relate to the existence of nature generally or to a specific place (e.g. coral reefs) or species, even a specific individual (e.g. a veteran tree).

Simply ‘knowing that nature is there’ may improve or maintain a **person**’s wellbeing including their physical and mental health and sense of belonging.

For **society** better wellbeing helps people remain active and able to work and reduce the cost of providing healthcare. And, if people share a common appreciation of

nature, this may help strengthen community cohesion (e.g. if a remote island habitat comes under pressure from pollution and people then act together to fund its protection or maintenance). As a result, the benefits of this service are likely to positively benefit many **policy areas** such as public health, biodiversity and conservation strategies, land use planning, water environment strategies, and flood risk planning.

For **businesses** and **organisations**, wellbeing benefits may improve productivity by reducing days lost to illness and improving staff retention.

The benefits of this ecosystem service are **closely linked to** other cultural ecosystem services such as spiritual, cultural or religious experiences, aesthetic or amenity experiences, and physical or mental health and wellbeing, and the service itself is dependent on other services such as water quality regulation and habitat or population maintenance.

Would you like to find out more about us or your environment?

Then call us on

03708 506 506 (Monday to Friday, 8am to 6pm)

Email: enquiries@environment-agency.gov.uk

Or visit our website

https://www.gov.uk/environment-agency

Incident hotline

0800 807060 (24 hours)

Floodline

0345 988 1188 (24 hours)

Find out about call charges (https://www.gov.uk/call-charges)

Environment first

Are you viewing this onscreen? Please consider the environment and only print if absolutely necessary. If you are reading a paper copy, please don't forget to reuse and recycle.