Principles of the Environmental Benefits from Nature (EBN tool) approach - Beta Version

enabling wider benefits for people and nature from habitat change

First published 07 July 2021

Natural England Joint Publication JP038

www.gov.uk/natural-england

NATURAL ENGLAND

Natural England Joint Publication JP038

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Published 7th July 2021

ISBN: 978-1-78354-758-6

Project details

This report should be cited as:

SMITH, A.C[A]., BAKER, J.[B], BERRY, P.M.[A], BUTTERWORTH, T.[C], CHAPMAN, A.[E], HARLE, T. [E], HEAVER, M.[F], HÖLZINGER, O.[C], HOWARD, B[G]., NORTON, L.R.[H], RICE, P. [E], SCOTT, A. [I], THOMPSON, A [E]., WARBURTON, C [E]. AND WEBB, J [E]. Principles of the Environmental Benefits from Nature (EBN tool) approach (Beta Version, July 2021).

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This report can be downloaded from the Natural England Access to Evidence Catalogue: **http://publications.naturalengland.org.uk/** . For information on Natural England publications contact the Natural England Enquiry Service on 0300 060 3900 or e-mail **enquiries@naturalengland.org.uk**.

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Expert reviewers and consultees

We are grateful to the attendees of the Phase 1 and 2 and 4 stakeholder meetings and webinars, the Defra group workshop attendees, the pilot projects in Phases 2 and 4, the many expert reviewers, consultees and information providers listed below, the UKHab working group, and fpcr (Sam Arthur and team), who thoroughly tested the tool and guidance during Phase 4 and provided many useful suggestions.

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Kath Baldock, University of Bristol
John Boardman, University of Oxford
Chris Bolton, Natural England
Tom Breeze, Reading University
Mark Broadmeadow, Forestry Commission
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Foreword

The last 15 months have made us all more aware than ever of the benefits that Nature brings and its importance in the built environment. Fully recognising these benefits in decision-making as we build back better can help achieve better, greener, places to live that are both Nature-positive and climate resilient, while addressing local community needs such as health and wellbeing.

Such benefits are often intuitive but can often be hard to quantify. Trees can help store carbon, provide valuable shade, and, when positioned appropriately, help reduce flooding and buffer noise and air pollution. Other diverse habitats can also bring a range benefits and provide food, pollination, recreation opportunities and pest control as well as aesthetic value and contribute to our sense of place. However, as these benefits are often hard to measure, consideration of these services can be piecemeal or overlooked.

Our work over recent years on the biodiversity metric has shown what is possible. It has shown how a common means of measurement can be embedded into decision making to help achieve net gains in biodiversity from development, improving the environment, while also providing greater certainty for developers on environmental needs.

The voluntary Environmental Benefits from Nature tool will continue this journey of innovation, building on Biodiversity Metric 3.0 to indicate how changes to habitats can affect the services provided by Nature and the benefits to people. Using the metric outputs alongside wider environmental information, it highlights the associated ecosystem service losses and gains from development and how these would vary under different biodiversity net gain options. The ambition is that it helps identify and enable multi-functional approaches and achieve ‘win-win’ opportunities for people and Nature.

Restoring Nature is one of the most important things we can do for the long-term health and prosperity of people, wildlife and our economy. It is a goal that is being brought closer by government policy, the commitment of industry and the passion of everyone working for the natural environment. Using the EBN tool can support Government’s 25 Year Environment Plan commitment to expand net gain approaches to include wider Natural Capital benefits. It can also help facilitate the kind of holistic decision-making we will need to ensure that thriving Nature drives the green recovery of this country.

With this release of the Beta version of the tool, you are invited to explore how it can help you deliver wider benefits through planned development work, and to take part in our evaluation. Together we can determine the next steps for both the tool itself and our work in this exciting area.

Tony Juniper CBE, Chair of Natural England

Executive summary

The Environmental Benefits from Nature Tool (EBN tool)[1] is a voluntary decision-support tool that has been developed to work alongside Biodiversity Net Gain (BNG) and enable wider benefits for people and nature from habitat change. It has been developed by Natural England and the University of Oxford in partnership with Defra, the Forestry Commission and the Environment Agency to support Government's 25 Year Environment Plan commitment to *expand net gain approaches to include wider Natural Capital benefits such as flood protection, recreation and improved water and air quality.* It is designed to be used at a variety of scales and settings to help achieve improved environmental outcomes through better consideration of the services that nature provides. Potential users include environmental consultants, house builders and infrastructure developers, local authorities working on Green Infrastructure, providers of off-site biodiversity units, and other habitat-led projects looking to consider wider benefits. The tool is suitable for use at all stages of project delivery, from initial scoping to optioneering, application and post application assessment.

The EBN tool is expected to be of particular interest to those seeking to align projects with Environmental Net Gain commitments and explore ways to achieve more from their planned BNG delivery. The tool provides a common and consistent means of considering the direct impact of land use change across the full range of services that nature delivers. It focusses on ecosystem services[2] such as recreation, air and water quality regulation, and climate benefits such as cooling and shading and carbon storage. The tool indicates relative change in ecosystem service provision associated with habitat change and is intended to 'start a conversation' around wider benefits to people and enable better consideration of losses and gains in ecosystem services from development.

The tool has been independently tested and extensively piloted over a four-year period with a range of input from industry, academia and Government to ensure a robust product for publication. It is now at its Beta release stage and Natural England will be evaluating its use over the coming year to evaluate its effectiveness. This will determine where it works best and how it should be best applied and guide next steps for the project.

While suitable for a range of applications, the EBN tool should not be used alone, but instead used alongside – and in addition to – a suite of established approaches, in particular BNG, but also including Environmental Impact Assessments (where required)

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[1] The EBN Tool was known as the 'Eco-metric' throughout its development phase from 2017 to 2021.

[2] Ecosystems Services - The components of nature that are directly and indirectly enjoyed, consumed, or used in order to maintain or enhance human well-being.

and detailed impact assessments, such as on flood risk or air quality. It does not replace or undermine existing legal or policy protections and should be used in accordance with the established mitigation hierarchy of avoid damage, minimise damage, restore or rehabilitate damaged habitats, and only compensate through offsetting as a last resort.

The EBN tool takes a biodiversity-led approach and recognises that healthy, diverse and resilient ecosystems are essential to underpin the long-term delivery of multiple ecosystem services. It is designed to be used in conjunction with the Biodiversity Metric and – when used together with this, and other appropriate tools – can help to highlight wider service gains from proposed environmental work. It can also help enable better consideration and delivery of these benefits to: maximise gains and minimise losses, through better project design; support the business case for investment, by linking multiple objectives and make the impacts of land-use change decisions more transparent to stakeholders.

The wider benefits for people and nature identified through EBN tool are intended to add to, rather than compete with, the primary driver of BNG. Following good practice principles is crucial in ensuring that the approach will be applied correctly – and this will reduce the risk of perverse outcomes. This document presents good practice principles for use. It provides an overview of how the tool works and explains its limitations. A separate User Guide provides step by step instructions on how to use the tool, and a Data Catalogue describes how to collect all the condition and spatial indicators needed to run the tool.

Contents

1. Introduction

1.1 Why apply the Environmental Benefits from Nature tool?

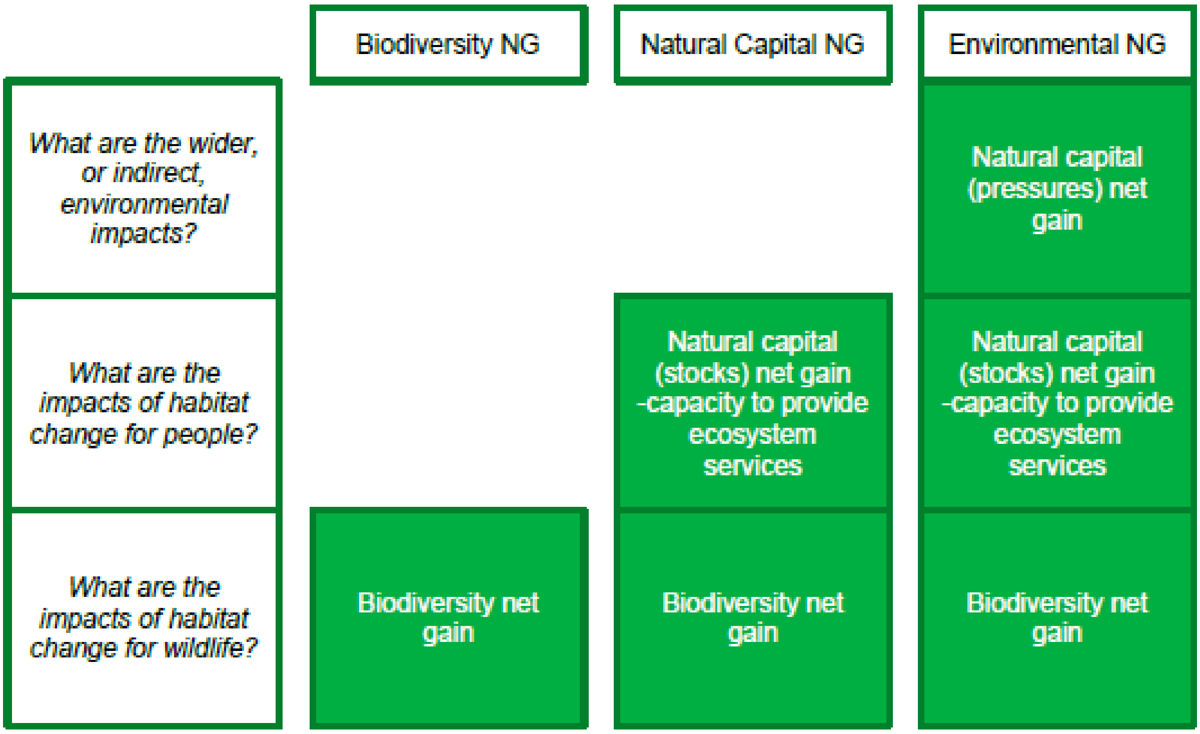
The 25 Year Environment Plan (25 YEP) (HM Government, 2018) sets out the Government's ambition for this generation to leave the environment in a better state than we found it. Achieving this goal is anticipated to require a positive contribution from the development sector. This can be measured at the project level through the concept of 'environmental net gains' referred to through this document as ENG. The 25 YEP states that government will embed an ENG principle for development, including for housing and infrastructure[3]. Government policy in this area is currently under development, but broadly speaking such gains can be described as follows:

Environmental net gains are considered to be: outcomes where a development has resulted in measurable net improvements to the quantity, quality, and/or distribution of locally prioritised natural capital assets and the supply of associated ecosystem services and benefits (above and beyond biodiversity net gain); and reductions in pressures on those assets.

This concept is illustrated in the potential framework for ENG (Figure 1). This shows how ENG incorporates gains in biodiversity and natural capital stocks (soil, water, rocks and all living things), and action to improve resource efficiency that reduces wider pressures on natural capital such as pollution.

[3] "expanding the net gain approaches used for biodiversity to include wider natural capital benefits, such as flood protection, recreation and improved water and air quality".

Figure 1: Relationships between biodiversity net gain and environmental net gains (Defra, 2018)



The EBN tool can help users looking to build on an existing biodiversity net gain assessment to begin to assess direct impacts on natural capital benefits, by measuring and enabling improvements to ecosystem services flowing from associated natural capital assets (in this case habitats). It can also highlight positive contributions that habitats can make to addressing indirect environmental impacts, for example as strategically placed barriers to reduce future pressures, such as sources of pollution.

Beyond new development the tool can also help users consider or illustrate similar wider gains through their projects. For example, broadening use to include improvements to existing Green Infrastructure or other environmental assets.

The strength of the EBN tool is that it enables the user to explore the impacts of land use change projects on a wide range of ecosystem services, going beyond the capabilities of current environmental impact assessments. It can be used to raise awareness of how the location and condition of habitats can affect their ability to deliver different ecosystem services. It also provides a way of assessing the broad range of environmental goods and services provided by biodiversity net gain at a scoping level, using a consistent scoring system.

Principles of the EBN tool approach

1.2 What does the EBN tool measure?

The EBN tool supports ENG by focussing on the middle layer of the emerging conceptual framework – assessing the impact of land-use change on ecosystem service provision resulting from biodiversity net gain (see Figure 2). It will highlight potential individual service gains and losses associated with proposed works and indicate where provision of these services is likely to be greater than, or less than, the baseline it replaces – along with the relative size of the change. It is therefore useful as a transparent and consistent means of highlighting wider benefits of proposed works to potential decision makers or funders. Where pressures such as noise, air or water pollution have been identified, the tool can also help identify and 'design-in' nature-based provisions that can help address them, often offering multiple benefits. The tool in its current form is focused on the direct impact of development on ecosystem services, so under the above ENG Framework the EBN tool will not tell you where you have achieved ENG and ***Environmental Net Gains cannot be claimed following its use***. This is because policy in this area is still developing and the tool only considers direct impact on natural capital stocks within the existing potential framework (see red box below).

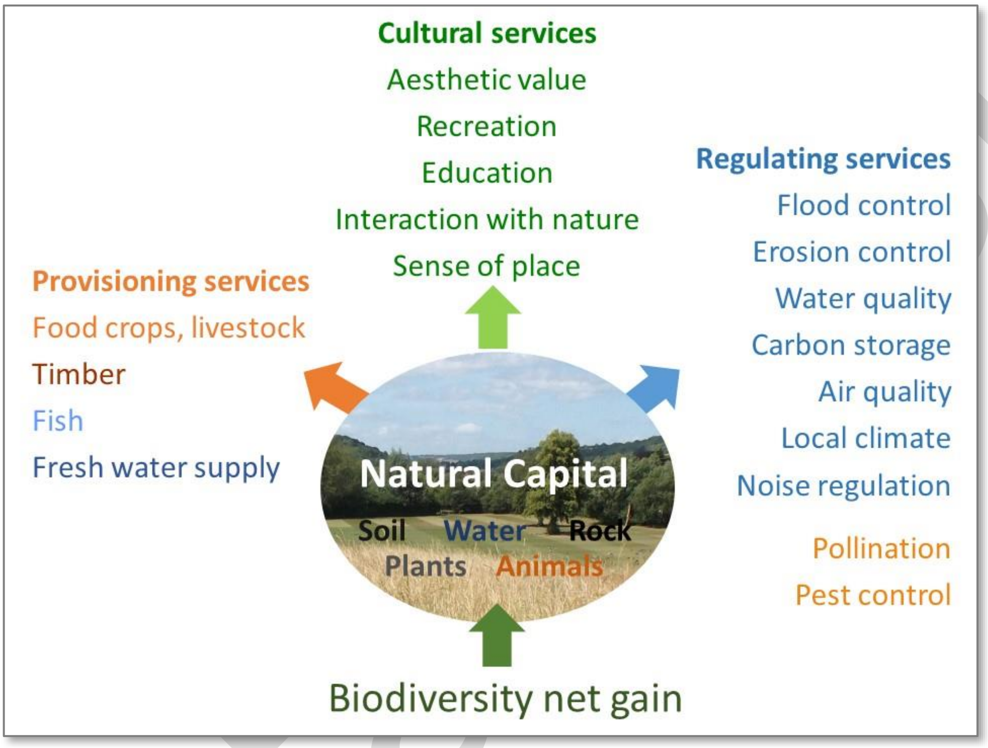
Figure 2: The potential for ENG in development (Defra, 2018). The distinctions made in this table are not clear cut in theoretical or academic terms but are helpful to illustrate the potential scope for ENG in development. Examples of what might be measured in practice are likely to vary for marine development, and for non-development application of net gain. The role of the EBN tool is highlighted in red.

			Examples of what might be measured in practice
Environmental net gain	**Natural capital stocks:** natural assets including biodiversity assets such as terrestrial and aquatic habitats or species diversity which underpin the asset's capacity to deliver ecosystem services.	**Biodiversity**: habitats and the wildlife species they support	Wildlife habitats (as measured by the Biodiversity Metric)
			Protected species' habitats / populations
		Ecosystem services: the capacity of habitats, and the wildlife they support, to provide wider ecosystem and cultural services	Water quality regulation
			Air quality regulation
			Places for recreation
			Carbon storage and sequestration
			Flood water regulation
			Wildlife for enjoyment and appreciation
	Natural capital pressures: direct and indirect pressures on national and international natural capital stocks		Energy efficiency
			Water efficiency
			Transport efficiency
			Construction materials and processes
			Light and noise pollution
			Recreation impacts on protected sites

1.3 What are the links with Biodiversity Net Gain?

The EBN tool is biodiversity-led and recognises that healthy, diverse and resilient ecosystems are essential to underpin the long-term delivery of multiple ecosystem services (Figure 3).

Figure 3: Biodiversity net gain can have wider benefits for natural capital and ecosystem services



The EBN tool is designed to be used in conjunction with the Biodiversity Metric. Gains in biodiversity are expected to act as the primary driver. Other benefits, identified through EBN tool, are intended to add to, rather than compete with, BNG considerations to offer benefits for both people and nature. These should be delivered through the established mitigation hierarchy: avoid damage, minimise damage, restore or rehabilitate damaged habitats, and only compensate through offsetting as a last resort.

Within this hierarchy there are often different ways of achieving biodiversity net gain, for example when choosing what type of habitats to create or restore and where to position them, offering flexibility in its application and design. The EBN tool allows users to explore such opportunities to enable the delivery of wider natural capital benefits.

Such benefits can often be optimised by considering multiple objectives, for example siting new woodland in an optimum location for flood protection or air quality regulation, improving public access for recreation, creating flower-rich grassland to benefit pollinators, providing green roofs for cooling, and planting the right tree species with maximum potential for carbon storage.

Principles of the EBN tool approach

1.4 What does it do, and what does it not do?

The design principles of the EBN tool were to create a tool that was:

1. **Simple** and easy to use, using freely available data and/or data gathered as part of Phase 1 or equivalent surveys
2. **As scientifically robust as possible**, using best available evidence
3. Able to incorporate the impact of **ecosystem condition and quality** and **spatial location** on ecosystem service (ES) supply.

The approach mirrors the Biodiversity Metric's methodology, by applying a matrix of scores for different habitats and ecosystem services which are modified by factors reflecting habitat condition, spatial location, delivery risk, and time for new habitats to reach maturity (see Section 3).

The EBN tool provides an **exploratory scoping tool** that covers a wide range of ecosystem services. It provides a consistent approach for scoring 18 ecosystem services that flow from natural capital assets, enabling the impacts of land-use change that achieves biodiversity net gain to be assessed relatively quickly at a broad level. Its strength is that it allows the user to explore the impacts of land use change projects on a very wide range of ecosystem services, going beyond the capabilities of current environmental impact assessments. The EBN tool uses a relative scoring system based on nominal scores from 0 to 10. It does **not** measure ecosystem services in biophysical or monetary units (such as tonnes of carbon stored, tonnes of wheat produced, cubic metres of avoided floodwater runoff or number of recreational visits made to a site). Other ecosystem modelling tools and assessment methods exist for this purpose but have their own limitations (see Defra's ENCA website for more information on different tools).

The EBN tool does **not** replace statutory requirements, such as the requirement for an Environmental Impact Assessment. It should be used alongside other planning information and more detailed assessments if appropriate (see Section 2).

The rapid assessment of a wide range of ecosystem services is a key asset of the tool. Other ecosystem service assessment tools or methods that focus on a smaller range of ecosystem services can provide more specific evaluation, but often focus only on services that are more readily evaluated in monetary terms. If these are used in isolation, there is a risk that decisions could adversely affect other services omitted from the assessment, especially cultural services (other than recreation, which is often included). The EBN tool therefore provides a broader approach to help ensure that the full range of services is taken into account in decision-making.

1.5 How can the tool be used and what are the benefits?

By measuring gains or losses in ecosystem services, the EBN tool can help to improve the design of projects that deliver biodiversity net gain in order to deliver wider environmental benefits from nature for people. It has been designed primarily to assess the impact of land use change for an individual development project. For example, it could be applied to:

1. Compare alternative options for site design (habitats, spatial configuration) at the pre-application, masterplanning, feasibility or early or detailed design stages.

2. Assess the impact of land use change (e.g. changes to habitat type or condition) at any stage of a project lifecycle.

The tool is designed to help environmental consultants, house builders and infrastructure developers, local authorities working on Green Infrastructure, providers of off-site biodiversity units, and other habitat-led projects looking to consider wider benefits to:

1. Improve the design of biodiversity net gain projects so that they deliver multiple benefits for nature and people
2. Strengthen the business case for investment in biodiversity net gain by demonstrating the wider benefits that it can generate, beyond biodiversity enhancement
3. Increase transparency in decision-making on biodiversity net gain, by allowing evaluation of losses and gains of different ecosystem services.

It can offer the following benefits to key audiences:

Developers and their consultants and contractors: When a development project achieves biodiversity net gain, the wider environmental and social benefits generated can smooth the planning process, deliver more appealing places to live and work, and enhance the company's reputation and 'licence to operate' within the community. Understanding and demonstrating the wider natural capital benefits generated through biodiversity net gain, which are not recognised by standard environmental assessments, can strengthen the business case and help increase the benefits from investing in improved habitats for biodiversity.

Development management and policy planners: Understanding and assessing the wider environmental and societal benefits of biodiversity net gain can help planners, businesses and communities to tailor biodiversity net gain projects so that they also deliver local and national priorities for investment in natural capital. Considering ecosystem services alongside the Biodiversity Metric can inform decision-making on the design and location of habitats for biodiversity net gain to generate the best outcomes for nature and people in a transparent way.

It has been designed as a project-based tool, though we have also tested the use of the EBN tool at a larger (county or district) scale, e.g. for assessing the relative natural capital impacts of different locations for woodland creation or housing site allocations. When used in this way, there is typically less information available on habitat type before and after change and for the habitat condition and spatial multipliers, meaning that extensive assumptions have to be made. Simplifications are also necessary in order to use the tool at this wider geographic scale, so that only a limited selection of habitat condition and spatial multipliers can be used. However, it can still provide a useful tool at this scale to encourage consideration of the potential impact of land use change on ecosystem service delivery. Defra's ENCA website has more information on other approaches or tools that can help natural capital and ecosystem service decision making at this scale.

Principles of the EBN tool approach

2. Good practice principles

The EBN tool is founded on four good practice principles, described in the following sections. Users should demonstrate that these principles have been applied.

- **Make biodiversity net gain the primary driver**
- **Apply the mitigation hierarchy**
- **Use as a decision-support tool alongside other impact assessments and evidence, and always sense check**
- **Avoid adding together scores for individual ecosystem services**

2.1 Make biodiversity net gain the primary driver

The EBN tool is based on the principle that healthy and diverse ecosystems underpin the long-term delivery of the ecosystem services on which we all depend. Therefore, the core principle of the approach is that development should achieve biodiversity net gain. Once this has been demonstrated using an approved Biodiversity Metric, such as Biodiversity Metric 3.0, the EBN tool can be used to help explore opportunities to deliver wider natural capital benefits and minimise any negative impacts. Biodiversity net gain cannot be lost in order to deliver gains in ecosystem services. If there are different options for delivering biodiversity net gain then the EBN tool can be used to assess which options provide the intended biodiversity net gain (primary goal) and also maximise ecosystem services (secondary goal). However, the design of a biodiversity compensation site should be based first and foremost on the biodiversity net gain good practice principles, and never only to maximise EBN tool scores for ecosystem services.

2.2 Apply the mitigation hierarchy

Both the Biodiversity Metric and the EBN tool should be firmly embedded within the mitigation hierarchy, as specified in the UK's biodiversity net gain good practice principles and associated guidance (CIEEM, CIRIA and IEMA 2016; Baker et al., 2019):

1) avoid damage,
2) minimise damage,
3) restore or rehabilitate damaged habitats, and
4) only compensate any residual damage through offsetting as a last resort.

As well as following the mitigation hierarchy, users of the EBN tool should follow all the good practice principles of biodiversity net gain (CIEEM, CIRIA and IEMA, 2016), especially to avoid any perverse outcomes. 'Biodiversity net gain: a practical guide' provides invaluable detailed advice and case study examples on how to implement the good practice principles for biodiversity net gain throughout the project life cycle (Baker et al. 2019).

2.3 Use as a decision-support tool alongside other impact assessments & evidence, and sense check

The EBN tool should be used as a decision-support tool, alongside other tools such as a full Environmental Impact Assessment (EIA), where required, and other procedures for detailed assessment of important services such as flood protection. Decisions should not be based on the EBN tool alone: it should be used as part of a suite of approaches. It does not replace the use of other decision-support tools required as part of the planning process, although there can be benefits in aligning these assessments so that data collected can be used to inform the EBN tool.

High quality design principles such as 'the right tree in the right place' should be followed, as well as the relevant statutory guidance in the NPPF, and industry good practice including on biodiversity net gain (CIEEM, CIRIA and IEMA 2016; Baker et al 2019). Newly created habitats should be designed and sited to take account of future resilience to climate change and other environmental change (including tree diseases etc.). There should also be long-term monitoring of newly created or restored habitats to demonstrate the achievement of biodiversity net gain.

As with any other tool or model, **you must 'sense check' the EBN tool outputs**. The tool highlights the impact of habitat types, condition, and location on delivery of different services, to help users reach more informed and transparent decisions on how to maximise ecosystem service provision under biodiversity net gain. Users should take account of all available supporting knowledge, evidence and expertise, including local stakeholders and community voices, as they develop a narrative around the EBN tool outputs that fits with other sources of information.

2.4 Avoid adding together scores for different ecosystem services

The EBN tool highlights impacts across a wide range of ecosystem services. This is important because if the focus is only on a few services, there can be perverse outcomes for other services. It is likely that the EBN tool will highlight opportunities for particular habitats to deliver multiple services, but it could also identify trade-offs, e.g. between provisioning services (food, timber) and regulating or cultural services.

The results are presented as arrows that indicate the direction and magnitude of change for each ecosystem service (see Section 4). For transparency, the underlying scores can be viewed on the calculation sheets. However, the scores for different services should not be added together into a single total value because:

1. The scores for different services are not directly comparable because they are not in common units. It is fairly meaningless to add a "unit" of air quality regulation to a "unit" of recreation or carbon storage. A score of 10 for one ecosystem service may have a lower societal value than a score of 5 for another ecosystem service if it contributes less value to human wellbeing.

2. The scores do not represent actual biophysical values, only relative rankings between different habitats for delivering each service.
3. Adding may obscure large gains or losses in individual ecosystem services.
4. Adding scores together risks double counting, for services that may partially overlap (e.g. aesthetic value and 'sense of place').

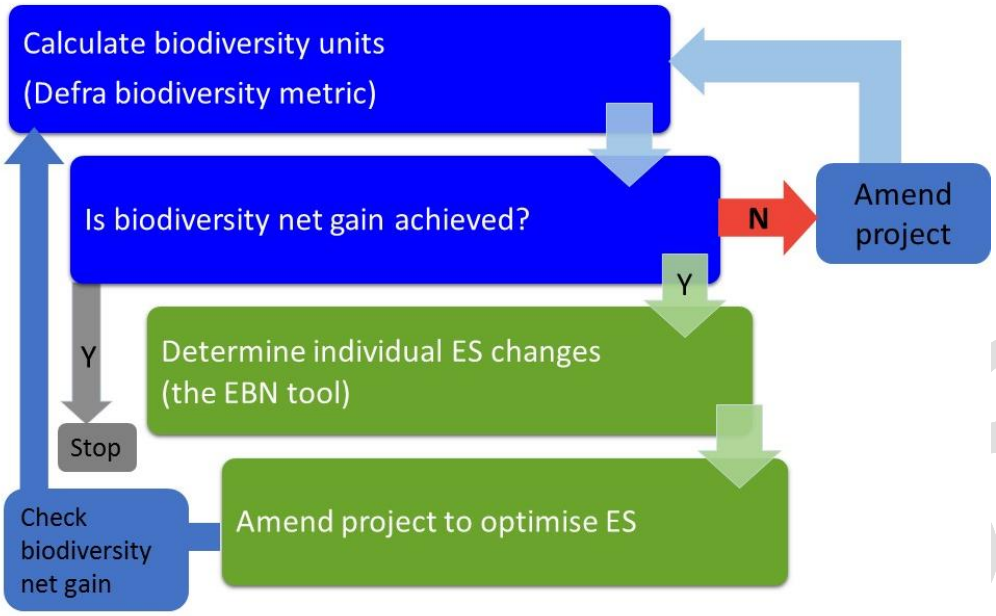
3. Background to how the EBN tool works

This section explains the background to how the EBN tool works. It is useful to have a general understanding of how the tool operates when considering results and improvements. The overall approach is described first, and then the following sections describe the individual components of the tool: habitat classifications, ecosystem service classifications, scores, condition indicators, spatial factors, time lag factors and delivery risk factors. See the separate User Guide for step by step instructions on how to use the spreadsheet tool. The full technical report of tool development to date is being finalised and will be published separately.

3.1 The overall approach

The EBN tool is designed to be used together with a biodiversity net gain assessment (Figure 4). Biodiversity net gain is the primary driver. One way to use the tool is to design a project to deliver biodiversity net gain and calculate the EBN tool scores for this project design. This will show either losses or gains in different ecosystem services, and the project can be amended to reduce losses and increase gains. If the changes are likely to affect the Biodiversity Metric results, the biodiversity and wider net gain assessment should be updated to ensure that biodiversity net gain is achieved in line with good practice guidance.

Figure 4: Applying the EBN tool, showing how biodiversity net gain is the primary driver



Another way is to apply the EBN tool at the same time as the Biodiversity Metric, so that the EBN tool informs the design of a biodiversity net gain project from the start. For example this could highlight the importance of certain habitats for both their biodiversity value and ecosystem service provision, and help to identify areas within the development site to create or enhance habitats that maximise ecosystem service provision for people affected by habitat loss for the development.

The EBN tool mirrors the approach of the Biodiversity Metric. This multiplies habitat area by a habitat distinctiveness score, a condition factor, a spatial location factor, and (for newly created or restored habitats) factors to reflect the time taken for habitats to reach target condition, and the delivery risk (risk that the habitat will not be created or restored successfully).

The Biodiversity Metric

Baseline (before habitat change):

Biodiversity units = Habitat area x Distinctiveness x Condition x Spatial factors

Post-development or intervention:

Biodiversity units = Habitat area x Distinctiveness x Condition x Spatial factors x Time to target condition x Delivery risk

For the EBN tool, the habitat distinctiveness score is replaced by a set of ecosystem service scores, reflecting the ability of the habitat type to deliver each of the 18 ecosystem services. The condition and spatial indicators and time-to-reach-target-condition factors are also specific to each ecosystem service because, for example, good condition for flood protection is not necessarily the same as good condition for food production.

Principles of the EBN tool approach

The EBN tool

Baseline (before habitat change):

ES1 = Habitat area x Score x Condition x Spatial factors

ES2 = Habitat area x Score x Condition x Spatial factors

ES3 = Habitat area x Score x Condition x Spatial factors

ES4 = Habitat area x Score x Condition x Spatial factors

Post-development or intervention:

ES1 = Habitat area x Score x Condition x Spatial factors x Time to target condition x Delivery risk

ES2 = Habitat area x Score x Condition x Spatial factors x Time to target condition x Delivery risk

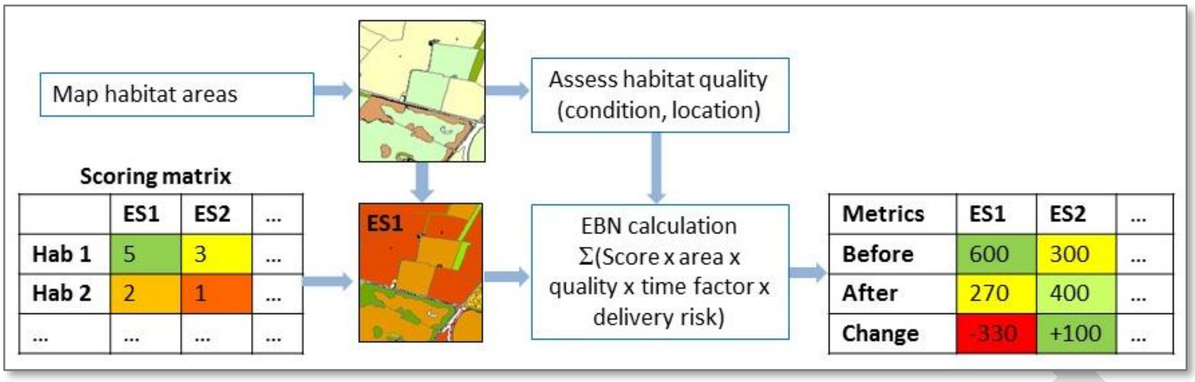
ES3 = Habitat area x Score x Condition x Spatial factors x Time to target condition x Delivery risk

ES4 = Habitat area x Score x Condition x Spatial factors x Time to target condition x Delivery risk

For the Biodiversity Metric, the scores for all habitats on the site are added together to give total biodiversity units. For the EBN tool, this is done separately for each ecosystem service, first for the 'baseline' habitats before the proposed change, and then for the post-development habitats. The assessment should cover both on-site change in habitats from the proposed development or management plan, and any associated off-site change in habitats from compensation and net gain activities. The net gain or loss in each ecosystem service is simply the difference between the baseline and post-development scores (Figure 5). When losses and gains in habitats are in different locations (whether within or outside the development boundary) they may not benefit the same communities or species as the habitats that are lost. The EBN tool does not show this; it is for the user to identify such issues and design biodiversity net gain in accordance with good practice for both biodiversity (CIEEM, CIRIA, IEMA, 2016) and people (Bull et al, 2018).

Positive scores indicate that a net gain in a particular service has been achieved and negative scores indicate a net loss. This is indicated by the arrows in the results overview table. If some services show a net loss, this should prompt efforts to amend the biodiversity net gain design in order to deliver net gain where possible, whilst recognising that some trade-offs may occur.

Figure 5: How the EBN tool works



3.2 Habitat / land-use classification

Users can enter habitat types using either UKHab, Phase 1 or Biodiversity Metric habitat classifications, and the EBN tool will automatically translate these to a simplified set of 'eco-metric' habitats (named after an earlier name used for this tool). This includes both semi-natural habitats and urban habitats including the built environment, urban green infrastructure (GI) and Sustainable Drainage Systems (SuDS) features. The eco-metric habitat list aims to distinguish between different habitats that provide noticeably different levels of ecosystem services.

The habitat list is based largely on Level 3 of the UKHab system for rural habitats, and UKHab secondary codes for urban habitats. It is compatible with the habitat classification used by the Biodiversity Metric 3.0. Following feedback, we added some 'higher level' habitats such as 'semi-natural grassland' for situations where further detail is lacking, as well as a generic 'suburban mosaic' habitat (see below). This resulted in 72 habitats (see Table 1) which each have a row in the matrix of ecosystem service scores.

Although users should enter separate habitat types for suburban areas (e.g. sealed surfaces and buildings, private gardens and amenity grassland), the 'suburban mosaic' habitat is a broad habitat type for when detailed information is not yet gathered, such as for high level assessments at large scales, or where detailed site design is not yet started. Details of the composition of the suburban mosaic are entered on the 'Project details' sheet of the tool. A default composition is provided, but users can change these percentages to match their own schemes (see User Guide). The EBN tool scores for the suburban mosaic habitat type are then derived from combining the scores for the component habitats in the appropriate proportions. However, if the split between habitat types is known then the individual habitats should be entered separately.

Table 1: Habitats included in the EBN tool. Colours indicate broad habitats (woodland dark green, semi-natural grassland bright green, farmland orange, mountain and heath purple, freshwater and wetland light blue, coastal and marine mid blue, green infrastructure grey-green, hard surfaces grey). Italicised habitats are sub-habitats under a top-level classification (e.g. five types of 'semi-natural grassland').

Broadleaved, mixed and yew semi-natural woodland
Broadleaved, mixed and yew plantation
Native pine woodlands
Coniferous plantation
Wood pasture and parkland with scattered trees
Traditional orchards
Dense scrub
Hedgerows
Hedgerow with trees
Felled woodland
Tall herb and fern
Ephemeral / short perennial
Bracken
Semi-natural grassland
Acid grassland
Calcareous grassland
Neutral grassland
Calaminarian grasslands
Poor semi-improved grassland
Improved grassland
Arable fields, horticulture and temporary grass
Arable field margins
Woody biofuel crops
Intensive orchards
Bog
Dwarf shrub heath
Inland rock
Freshwater
Standing open water
Canals
Running water
Fen, marsh and swamp
Lowland fens
Purple moor grass and rush pastures
Upland flushes, fens and swamps
Aquatic marginal vegetation
Reedbeds
Other swamps

Coastal rock
Biogenic reefs
Coastal saltmarsh
Coastal lagoons
Seagrass beds
Vegetated dunes and shingle
Beach and bare sand
Other littoral sediment
Sealed surface and buildings
Artificial unvegetated, unsealed surface
Bare ground
Garden
Vegetated garden
Unvegetated garden
Open mosaic habitats on previously developed land
Parks and gardens
Footpath / cycle path - green
Green bridge
Amenity grassland
Road island / verge
Natural sports pitch, recreation ground or playground
Cemeteries and churchyards
Allotments, city farm, community garden
Intensive green roof
Green wall
Brown roof or extensive green roof
Tree
SuDS retention pond
SuDS detention basin
Bioswale
Rain garden
Introduced shrub
Flower bed
Suburban/ mosaic of developed/ natural surface

3.3 Ecosystem service classification

It is important to cover a broad range of services because if key services are omitted, the EBN tool could trigger poorly informed decisions that have unintended adverse impacts on the missing services. Four provisioning services, nine regulating services and five cultural services are assessed (Table 3), in order to cover all those that could be important to stakeholders in the context of a typical UK development project in either a rural or urban setting. Services that are less relevant for the typical UK development context have been omitted. These include hydropower and provision of medicinal products.

The classification is broadly compatible with CICES (Common International Classification of Ecosystem Services, https://cices.eu), but the terminology has been modified for easier use by non-specialists.

The cultural services can be mapped to the framework used in the UK National Ecosystem Assessment. This considers cultural services to be provided by the interaction of places ('environmental settings') such as parks and woodlands etc., which correspond to the eco-metric habitats, and activities ('cultural practices') such as playing and exercising. The services give rise to three categories of benefits: experiences, capabilities and identities (Church et al., 2014). A similar framework has been adopted by IPBES (Intergovernmental Panel on Biodiversity and Ecosystem Services), which uses three non-material (cultural) services: learning and inspiration, physical and psychological experiences and supporting identities. Although there is some overlap (for example all five services can provide health benefits, which are classed under 'capabilities'), the five cultural services used in the EBN tool can be broadly mapped to the three categories of benefit as shown in Table 2.

Table 2: Links between cultural services in the EBN tool and those in UK National Ecosystem Assessment and IPBES

EBN tool	UK NEA	IPBES
Recreation and leisure Interaction with nature Aesthetic value	**Experiences** (e.g. tranquillity, inspiration, escape, discovery)	Physical and psychological experiences
Education and knowledge	**Capabilities** (e.g. knowledge, health, dexterity)	Learning and inspiration
Sense of place	**Identities** (e.g. belonging, sense of place, rootedness, spirituality)	Supporting identities

Table 3: Ecosystem services included in the EBN tool

Provisioning	**Food production**	Arable crops, horticulture, livestock, orchards, allotments, urban food, wild food (e.g. gathering berries or mushrooms).
	Wood production	Timber, wood production for paper, woody biofuel crops, coppice wood or wood waste used for biofuel.
	Fish production	Aquaculture, commercial fishing, recreational fishing (recreational fishing is also a cultural service, but the habitat conditions match those for fish production).
	Water supply	Impact of soil and vegetation on rainwater runoff and infiltration, and thus on groundwater recharge or surface water flow.
Regulating	**Flood regulation**	Reduction of surface runoff, peak flow, flood extent and flood depth through canopy interception, evapotranspiration, soil infiltration and physical slowing of water flow.
	Erosion protection	The ability of vegetation to stabilise soil against erosion and mass wastage by protecting the soil from the erosive power of rainfall and overland flow, trapping sediment, and binding soil particles together with roots.
	Water quality regulation	Direct uptake of pollutants by terrestrial or aquatic vegetation; interception of overland flow and trapping / filtration of pollutants and sediment by vegetation before it reaches watercourses; breakdown of pollutants into harmless forms e.g. by denitrifying bacteria that convert nitrates into nitrogen gas. Also, infiltration into the ground, allowing pollutants to be filtered out by the soil and preventing pollution of watercourses – though pollutants could enter groundwater supplies.
	Carbon storage	Carbon stored in vegetation and soil. For a typical development (with complete loss of habitats and often major soil disturbance), this is more relevant than carbon sequestered annually. However, peatland restoration is an exception (see Box 1). The 'time to reach target condition' reflects the time taken for a new habitat to reach a typical carbon sequestration rate for a mature habitat.

	Air quality regulation	Air pollution impacts on health, climate and biodiversity. Vegetation can affect pollutant concentrations through dispersion and remove pollutants by deposition. Fine particles ($PM_{2.5}$) are particularly damaging for human health. The right vegetation in the right place can remove particulates, sulphur dioxide, ozone and nitrogen oxides.
	Local climate regulation	Shade, shelter and cooling effect of vegetation and water, especially urban trees close to buildings, green roofs and green walls, which can reduce heating and cooling costs, or trees in urban parks which can provide shade on hot days.
	Noise reduction	Attenuation of noise by vegetation.
	Pollination	Pollination of crops (and wild plants, supporting other ES) by wild insects (mainly bees and hoverflies). Excludes pollination by managed honeybees.
	Pest control	Predation of crop or tree pests by invertebrates (e.g. beetles, spiders, wasps), birds and bats.
Cultural	**Recreation**	Provision of green and blue spaces that can be used for any recreational activity, e.g. walking, cycling, running, picnicking, camping, boating, playing or just relaxing.
	Aesthetic value	Provision of attractive views, beautiful surroundings, and pleasing, calming, or inspiring sights, sounds and smells of nature.
	Education and knowledge	Opportunities for formal education (e.g. school trips), scientific research, local knowledge and informal learning (e.g. from information boards or experiences).
	Interaction with nature	Provision of opportunities for formal or informal nature-related activities, e.g. bird watching, botany, random encounters with wildlife, or feeling ‘connected with nature’. There is some overlap with biodiversity, but access by people can have negative impacts on some wildlife habitats. Excludes recreational fishing; hunting / shooting (not covered); the intrinsic value of nature (covered by the Biodiversity Metric); existence value (from just knowing that nature exists).
	Sense of place	The aspects of a place that make it special and distinctive – this could include locally characteristic species, habitats, landscapes, or features; places related to historic and cultural events, or places important to people for spiritual or emotional reasons.

Box 1. Carbon storage and carbon sequestration

Carbon storage is the total amount of organic carbon stored in soil and vegetation. Carbon sequestration is the amount of carbon absorbed from the atmosphere per year, as vegetation grows through photosynthesis and soil organic carbon increases through the incorporation and decomposition of organic matter such as leaf litter and fine roots. Carbon storage and sequestration are two facets of the same process, as carbon storage is simply the sum of all carbon sequestration over time (minus any emissions).

For most types of habitat change we expect the direction and magnitude of changes in carbon storage and carbon sequestration to be very similar. For example, planting a new woodland will result in an increase in both carbon storage and sequestration, while destroying a woodland will result in a large loss of both stored carbon and future sequestered carbon. Therefore, for simplicity, we report only carbon storage in the EBN tool.

However this is not the case for peat, which has an exceptionally high level of carbon storage, but where sequestration can range from a small annual increase for peat in good condition to a large annual emission of carbon for degraded or cultivated peat, such as on moorland that has been drained or burnt, or on lowland fens that have been drained for agriculture. Restoration of degraded peat, either from moorland or arable land, is therefore expected to result in a switch from carbon emissions to carbon sequestration but without a major short-term impact on carbon storage. This type of restoration will play a vital role in meeting climate mitigation targets. We have therefore added a flag to the results page to notify the user of the potential difference in results between carbon sequestration and carbon storage in projects that involve peat.

3.4 Scores

The core of the EBN tool is a matrix of scores reflecting the ability of different types of habitat or land cover (rows) to deliver different ecosystem services (columns). The score sheet of the EBN tool are accessible from the Technical User Menu.

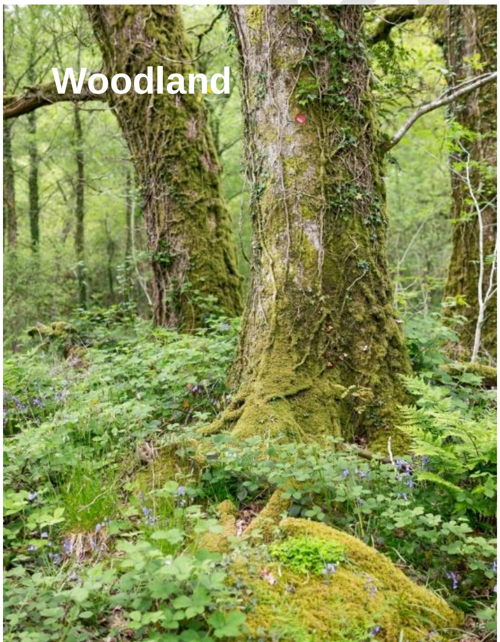
The scores were derived from an extensive review of a range of over 30 existing tools and data sources as part of Phase 1 of the EBN tool development, supplemented by a literature review of over 700 papers (Smith et al., 2017). The scores were further reviewed by a range of experts in different ecosystem services and habitats in a series of expert workshops and consultations as part of Phase 2. Note that these scores are still under review and may be further refined as new data sources emerge.

Although most scores are simply rankings of the level of services delivered by different habitats, in some cases (carbon storage and air quality regulation) they are set to be proportional to biophysical evidence (tonnes of carbon stored per hectare, and deposition of air pollutants).

3.5 Habitat condition indicators and spatial factors

The matrix of scores reflects the performance of a 'typical' habitat. Multipliers are then applied based on 40 indicators of habitat condition and spatial location. These indicators reflect how a habitat differs to the expected condition. For example, Figure 6 (top) shows two examples of amenity grassland. The top of the picture shows grassland in very poor condition for most services (except certain types of recreation such as football), whereas the bottom shows grassland in better condition that would generate a more diverse range of ecosystem services. Grassland with dense vegetation and many flowering plants will provide better water quality regulation, pollination and aesthetic value than over-grazed or over-mown grassland with compacted soil, limited species diversity and bare patches. Similarly, woodland with larger trees and complex understorey vegetation will provide more carbon storage and better flood protection than woodland with smaller trees and short ground cover (Figure 6, bottom).

Figure 6: Two different examples of amenity grassland (top) and woodland (bottom) with very different condition.

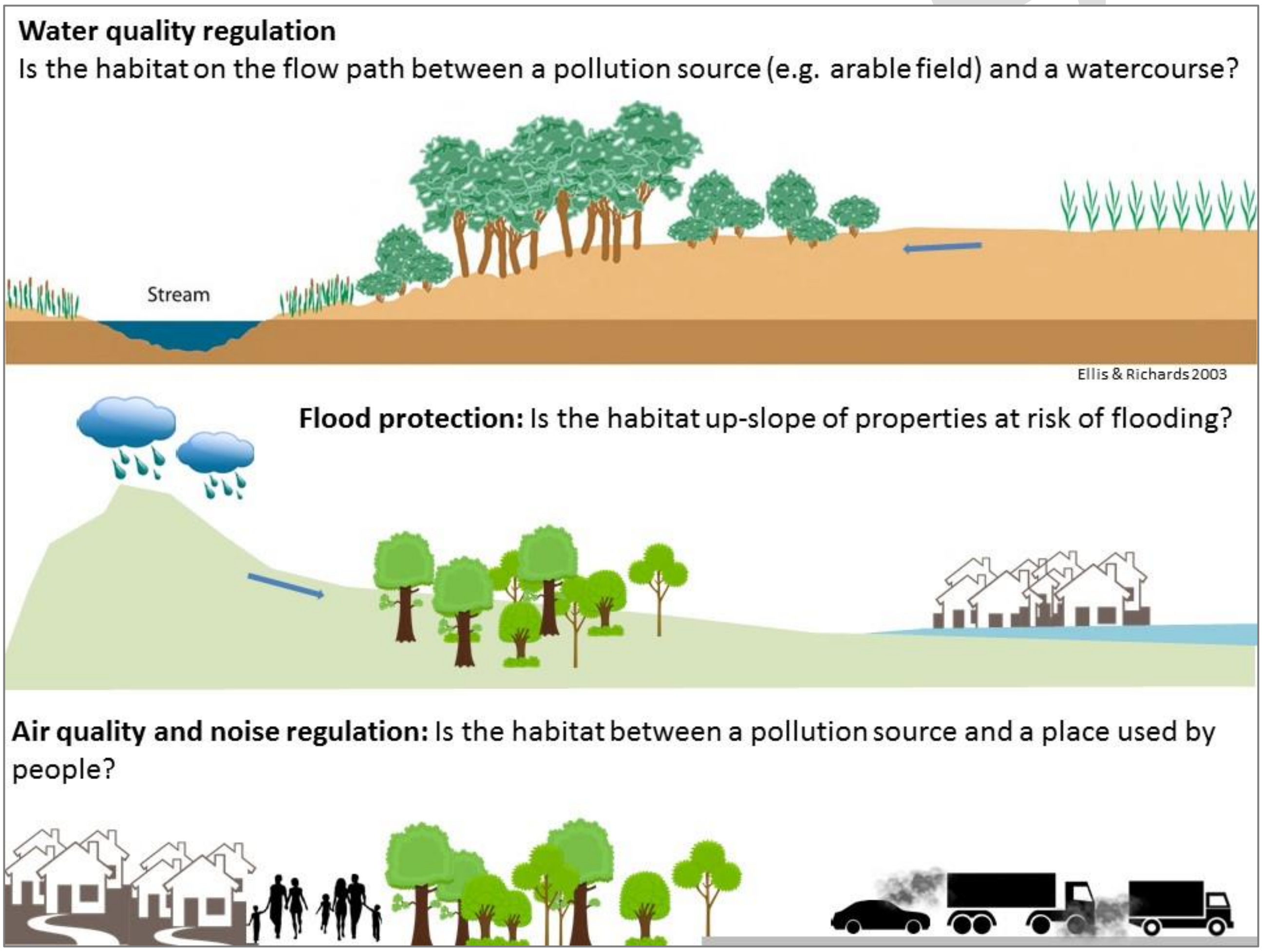


Large trees; complex ground cover; high structural diversity

Small trees; short grass; low structural diversity

Spatial factors also influence the provision of many ecosystem services. For example, vegetation can only deliver the service of water quality regulation if it is positioned between a pollution source (e.g. an arable field) and a receptor (e.g. a stream). Similarly, woodland upstream of a flood zone will be more important for flood protection than woodland where there are no properties downstream at risk of flooding, and trees or hedges are better for limiting noise and air pollution if they are between a busy road and a place used by people (Figure 7).

Figure 7: Examples of the importance of spatial factors (habitat position and spatial configuration)



The condition indicators affect the supply of ecosystem services, whereas many of the spatial factors reflect the demand for the services. The demand indicators could be considered as indicators of the priority or weight that could be placed on each service. However, to keep the tool simple for users, the demand indicators only take account of whether or not the habitat is capable of providing a benefit for people, not the number of beneficiaries (except for a basic indicator of population density applied to the services of recreation and education, and some consideration of flood management priority in one of the flood protection demand indicators). Also, some people might benefit whereas others might lose ecosystem services, especially if habitats are cleared at the development site and compensated for in a different location. The EBN tool does not reflect these issues but they should be taken into account in decision-making (see section 4.4 and Bull et al, 2018).

For certain ecosystem services, linear habitats may have a higher impact than is indicated by their area on the ground. This includes rivers and streams for fish production and cultural services, hedgerows for cultural services, and footpaths for recreation. The Biodiversity Metric accounts for rivers and hedgerows separately to non-linear habitats, as they are high value habitats that must be replaced on a like-for-like basis. In the EBN tool, linear habitats are included alongside other habitats for many services (such as carbon storage), but we apply a multiplier to indicate their greater value for certain services.

Table 4 summarises the main habitat condition and spatial factors that can be applied for each ecosystem service. It shows which information can be obtained from freely available online sources such as Defra's MAGIC website, and which is to be collected via a site survey. Data requirements for the EBN tool have been harmonised with the survey data needed for the Biodiversity Metric 3.0, and that which will be collected for an Environmental Impact Assessment (EIA) for larger developments. However, some indicators, such as tree size, are additional. Data collection for the EBN tool can easily be integrated within the procedure for a Phase 1 habitat survey. Full details of how to determine values for all the indicators are provided in the Data Catalogue.

Table 4: Condition indicators and spatial factors applied for each service (See Data Catalogue for full details)

Blue = demand; Green = supply; Brown = position or spatial configuration

Ecosystem Service	Condition indicators and spatial factors	Source
Food provision	Agricultural Land Class	MAGIC
Fish production	WFD (Water Framework Directive) overall ecological and chemical status	Catchment Data Explorer (Environment Agency (EA))
	Barriers to fish passage	Site assessment
	Naturalness of water body	Site assessment
	Linear habitat multiplier	Applies to all running water
Timber production	None (Usually grown on low grade land and can cope with steep slopes, low temperatures, high rainfall and high altitudes).	
Water supply	Surface water availability in the catchment	Catchment Abstraction Management Status (EA)
	Groundwater availability in the catchment	WFD groundwater quantitative status (EA)
	Soil drainage	LANDIS
	Soil compaction	Site assessment

Ecosystem Service	Condition indicators and spatial factors	Source
Flood regulation	Ability of habitats to mitigate flood risk: Maximum of three indicators (= Natural Flood Management priority (1st of 3 flood demand indicators); Woodland for flood risk (2nd of 3 flood demand indicators; WWNP target zone. (3rd of 3 flood demand indicators)).	Online maps (Environment Agency and MAGIC)
	Canopy cover (%)	Site assessment
	Soil compaction	Site assessment
	Extent of tall or tussocky grasses Extent of shrub layer	Site assessment
	Water body naturalness	Site assessment
Erosion protection	Slope	UK Soil observatory
	Rainfall	Met Office website
	Soil erodibility	NSRI (not free)
	Ground cover (%)	Site assessment
	Extent of tall or tussocky grasses Extent of shrub layer	Site assessment
	Peat quality (actively forming or degraded)	Site assessment
	Soil management	Local knowledge
	Position for erosion prevention (Yes, No or Partial): is the habitat positioned below or within an area susceptible to erosion?	Site assessment / maps
Water quality regulation	Is the habitat in a water quality management area?	Catchment Data Explorer (Environment Agency)
	Ground cover (%)	Site assessment
	Extent of tall or tussocky grasses	Site assessment
	Peat quality (actively forming or degraded)	Site assessment
	Soil management	Local knowledge
	Soil compaction	Site assessment
	Water body naturalness	Site assessment
	Position for water quality regulation: is the habitat located on the flow path between a pollution source (arable field or road) and a water course?	Site assessment or maps
Carbon storage	Tree size	Site assessment
	Canopy cover	Site assessment
	Peat quality (actively forming or degraded)	Site assessment
Air quality regulation	Canopy cover	Site assessment
	Air pollution barrier: does the habitat provide a barrier between a pollution source and people?	Site assessment
Local climate	Tree size	Site assessment
	Canopy cover	Site assessment
	Shading ability: does the habitat provide shade for a building or area used by people?	Site assessment

Ecosystem Service	Condition indicators and spatial factors	Source
Noise reduction	Noise barrier: does the habitat form a noise barrier between a busy road and people?	Site assessment
Pollination	Flower abundance and diversity	Site assessment
	Presence of invertebrate nesting sites (dead wood, tree cavities, dry earth)	Site assessment
Pest control	Presence of invertebrate nesting sites (dead wood, tree cavities, dry earth)	Site assessment
Recreation	Population density in local area	CAVAT website
	Public access (Y/N)	Local knowledge
	Special recreational value	MAGIC
	Linear habitat multiplier	Applies to paths, running water, hedges
Aesthetic value	Flower abundance and diversity	Site assessment
	Tree size	Site assessment
	Landscape diversity / habitat mosaic: number of different semi-natural habitats on site	Site map
	Water body naturalness	Site assessment
	Linear habitat multiplier	Applies to running water, hedges
Education	Population density in local area	CAVAT website
	Educational use	Local knowledge
	Nature designation	MAGIC
	Cultural designation	MAGIC; local authority
	Managed for nature	Local knowledge
	Linear habitat multiplier	Applies to running water, hedges
Interaction with nature	Public access	Local knowledge
	Extent of tall or tussocky grasses Extent of shrub layer	Site assessment
	Tree size	Site assessment
	Flower abundance and diversity	Site assessment
	Presence of invertebrate nesting sites (dead wood, tree cavities, dry earth)	Site assessment
	Nature designation	MAGIC
	Ancient habitat	MAGIC
	Managed for nature	Local knowledge
	Resources for local species	Site assessment and local knowledge
	Fish barriers	Site assessment
	Water body naturalness	Site assessment
	Linear habitat multiplier	Applies to running water, hedges
Sense of place	Tree size	Site assessment
	Nature designation	MAGIC

Principles of the EBN tool approach

Ecosystem Service	Condition indicators and spatial factors	Source
	Cultural designation	MAGIC; local authority
	Ancient habitat	MAGIC
	Managed for nature	Local knowledge
	Resources for local species	Site assessment and local knowledge
	Local distinctiveness / special value to the local community	Local authority; local knowledge
	Water body naturalness	Site assessment
	Linear habitat multiplier	Applies to running water, hedges

Although it is relatively easy to list the main condition and spatial factors that are important for each service, it is harder to translate these into multiplier values. Where possible, biophysical data is used to inform the multipliers (e.g. for the influence of tree size on carbon storage). However, most of the multipliers are based on expert opinion. The rationale for multiplier selection is presented in the Data Catalogue.

3.6 Time for habitat to reach target condition, and delivery risk

Newly created or restored habitats will typically take some time to reach their full potential to deliver ecosystem services. This time lag will vary depending on the habitat and the ecosystem service in question. This can be reflected in a 'time to reach target condition' multiplier.

The Biodiversity Metric uses a discount rate of 3.5% to calculate the present value of a habitat delivered at the 'time to target condition', compared to the value if the habitat was delivered today. The discount rate reflects society's preference for 'habitats now' rather than 'habitats later'. However, user feedback from pilot testing led us to adopting a simpler approach in the EBN tool. It displays the change from the baseline score at three points in time: 1, 10 and 30 years after the land use change. For newly created habitats, the change in score takes account of the starting habitat. For example, if a woodland is created on improved grassland, the tool calculates the gradual increase in score from the grassland score to the woodland score over the time it takes for the woodland to grow to its target condition.

There is a risk that habitats may not be successfully created or restored, which is expressed as a separate 'delivery risk' factor. The EBN tool uses similar delivery risk factors to Biodiversity Metric 3.0 for habitat creation. The delivery risk factors are slightly different, however, because pilot tests showed that using exactly the same factors as the Biodiversity Metric caused perverse outcomes for some services. For example, semi-natural habitat creation would score less than creation of managed habitats such as amenity grassland. Therefore, we use a simplified set of factors: all semi-natural habitats have a delivery risk of two-thirds (0.667), and all managed habitats have a risk of 1.0 (i.e. zero risk). The Biodiversity Metric applies high risk factors because it aims to ensure adequate compensation for any lost areas of semi-natural habitat. The EBN tool is applied together with the Biodiversity Metric and therefore this compensation should already be guaranteed by achievement of BNG. We aim to gather further feedback on this issue during Beta testing.

We do not apply a delivery risk factor for habitat restoration / enhancement because enhancement is considered to be relatively low risk for ecosystem service delivery, though there could be a higher risk of not achieving target condition for biodiversity.

The time lag and delivery risk factors are only applied to habitats that are newly created, restored or enhanced as part of the land-use change proposal being assessed. They are not applied to existing habitats, even if existing habitats are not yet at full potential (e.g. young woodland). Differences in ecosystem service delivery for young habitats can be captured through condition indicators such as tree size.

The Biodiversity Metric excludes irreplaceable habitats (e.g. ancient woodlands) because they cannot be offset as part of biodiversity net gain. Irreplaceable habitats should not be destroyed. The EBN tool currently includes ancient habitats, flagged with a specific indicator, in order to make their value more visible to decision-makers. An error check warns if any ancient habitats are not retained or enhanced.

4. Using the results

This section explains how the results from the tool can be used and key considerations for interpretation and incorporation in project design.

The EBN results show which services are estimated to have gains and which have losses (Figure 8). Where there are losses, the user can experiment with altering the type, condition, or spatial location of habitats to see if losses can be reduced or turned into gains, working within the good practice principles for biodiversity net gain. Following changes of this type, the Biodiversity Metric calculation should be updated to check that the project still produces a biodiversity net gain in line with good practice guidance.

Figure 8: Example results from the EBN tool

Potential impacts of on-site and off-site habitat change at three time points (not cumulative): Whole area

Select area of interest: Whole area	1 year	10 year	30 year	Confidence	Interpretation (Expand / Collapse)
Food production	↓	↓	↓	🟠	The results 30 years after development indicate a large decrease in the potential for food production.
Wood production	→	→	↗	🟠	
Fish production	→	→	→	🟠	
Water supply	↘	↘	↘	🔴	The results 30 years after development indicate a decrease in the ecosystem service of water supply. If
Flood regulation	↘	↘	↗	🔴	
Erosion protection	→	↗	↗	🔴	
Water quality regulation	↗	↗	↗	🔴	
Carbon storage	↘	↘	→	🟠	
Air quality regulation	↘	→	↗	🟠	
Cooling and shading	↘	→	↗	🟠	
Noise reduction	↗	↗	↗	🟠	
Pollination	↘	↗	↗	🔴	
Pest control	↘	→	↗	🔴	
Recreation	↑	↑	↑	🔴	
Aesthetic value	↘	↗	↗	🔴	
Education	↗	↗	↗	🔴	
Interaction with nature	↗	↗	↗	🔴	
Sense of place	↘	→	↗	🔴	

The results reveal opportunities to deliver multiple benefits, but also trade-offs between different services. For example, planting new woodland on arable land could provide benefits for carbon storage, aesthetic value, flood protection and air quality regulation, but there will be a loss in food provision. The EBN tool makes these trade-offs explicit, so that local stakeholders can consider their priorities and act accordingly.

The outputs should not be presented in isolation, but as part of a narrative that explains the reasons for the changes in ecosystem service delivery and provides the local context. There should always be a 'sense check' to make sure that the EBN tool outputs are logical and consistent with other assessments. Users may wish to examine the interpretation charts and the underlying calculations (links are provided from the main results sheet) to understand the reasons behind the changes in EBN tool scores before and after the development and associated biodiversity net gain activities.

4.1 Consideration of stakeholder needs and priorities

The EBN tool should be applied as part of an inclusive, participatory process with local stakeholders. Both local priorities for ecosystem services and national priorities such as food production or carbon storage should be considered. Although it is unlikely that gains in all ecosystem services can be achieved, the EBN tool can be used to make gains and losses visible, so that decision-making is consistent, transparent and thorough. It could be applied as part of a process of Multi-Criteria Decision Analysis (MCDA).

4.2 Consideration of design

There are many sources of existing guidance on how to improve different aspects of project design in order to enhance the delivery of natural capital, green infrastructure and biodiversity. The National Design Guide[4] illustrates how well-designed places that are beautiful, enduring and successful can be achieved in practice, and sets out the ten characteristics of good design. The accompanying National Model Design Code[5] provides detailed guidance on the production of design codes, guides and policies to promote successful design, expanding on the ten characteristics of good design. Natural England is currently developing a National Framework of Green Infrastructure Standards which aims to enhance the quantity, quality and functionality of green infrastructure. Guidance on designing effective green infrastructure will be integral to this work. The EBN tool should be used alongside these and other industry good practice design guidance and can provide a consistent approach to capturing the multi-functional benefits of green infrastructure.

4.3 Consideration of landscape-level impacts

When using EBN tool outputs to inform decisions, users should consider how appropriate it is to create or restore different types of habitat in a specific location, taking into account landscape, townscape and historic character, as well as cumulative impacts and the balance between habitat types across the region. For example, if the tool predicts large ecosystem service gains from creating woodland or grassland, there would still be a need to maintain a mix of habitat types appropriate to the character of the area, rather than focusing purely on the type that gives the largest scores. The aim should be to create an appropriate mix of habitat types and habitat mosaics appropriate to the context, ideally linking to local nature recovery strategies and networks, green infrastructure strategies and landscape character assessments.

4.4 Consideration of caveats and limitations

All tools and approaches have their own limitations and it is good practice to be transparent about these because it helps ensure good application. The following caveats and limitations are intended to provide transparency and help users correctly use the tool.

1.The EBN tool uses habitat extent, condition and location as proxies for ecosystem service delivery

The EBN tool uses changes in habitat extent, condition and location as proxies for changes in the ecosystem services that flow from these habitats. It does not take into

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962113/National_design_guide.pdf

[5] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/957205/National_Model_Design_Code.pdf

account, for example, topography or hydrological factors, so it is not a substitute for a detailed assessment such as a flood risk model. However, it can identify the role of woodland in intercepting rainfall and thus reducing flood risk, and it assigns high flood protection scores to SuDS features such as bioswales, retention ponds, detention basins or raingardens.

2.The EBN tool does not consider impacts beyond ecosystem service provision or impacts on different groups of beneficiaries.

As the EBN tool focuses only on the impacts of habitat change on ecosystem services, it does not provide a detailed assessment of factors such as environmental justice and community impact. It can help users to apply international good practice principles on the 'people' aspects of biodiversity net gain (Bull et al, 2018), although it does not associate losses and gains in ecosystem services with individual groups of people. For example, it might show an overall increase in recreational benefits but it would not show that residents living near a development site lost a local green space and lived too far from the biodiversity offset site to benefit from it. The user should take this into account, applying the EBN tool appropriately and in-line with good practice including Bull et al, 2018.

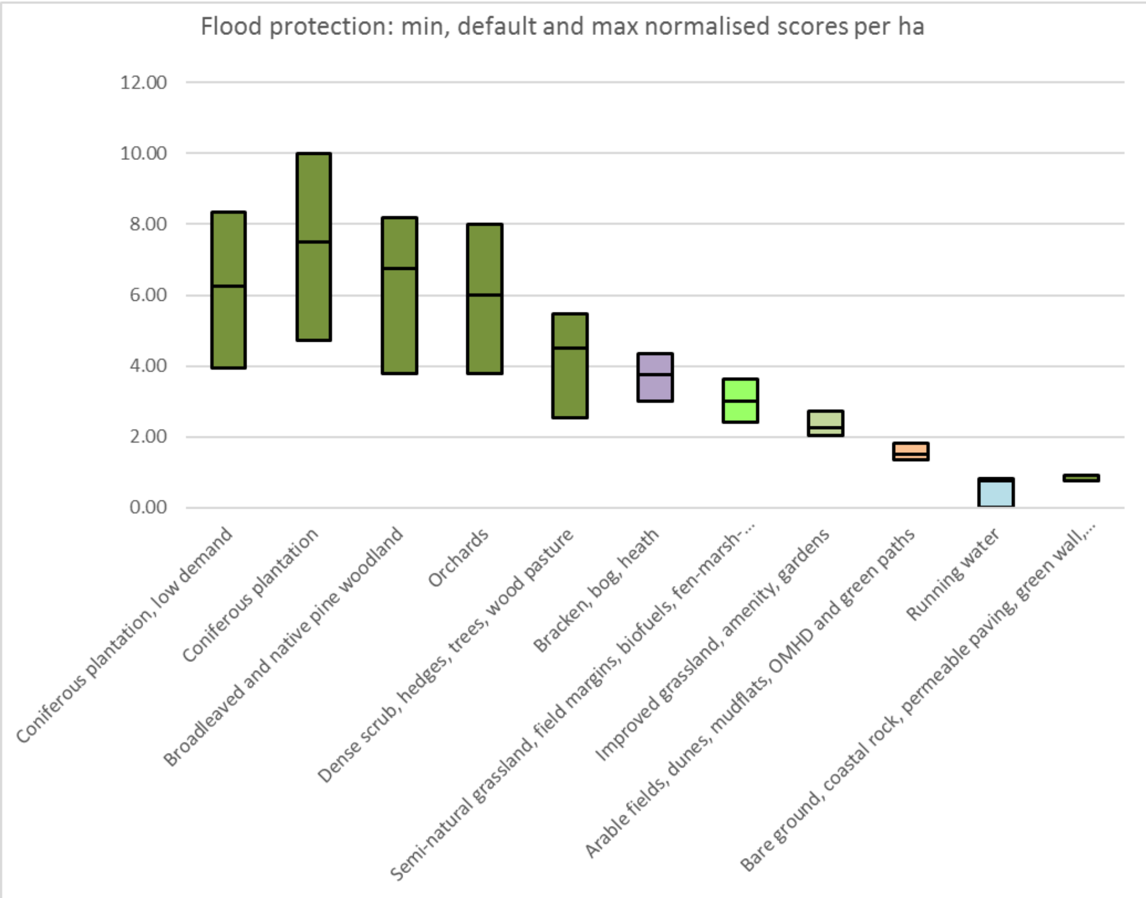
3.Confidence ratings for the EBN tool scores and multipliers vary

The tool is based on best available evidence. Since this evidence is partial and variable between ecosystem services, and relationships between habitat land use change and ecosystem service provision are complex, the results indicate relative confidence levels for transparency. What this means (as seen in Figure 8) is that where an ecosystem service has an amber rating there is more evidence available to calibrate the range of scores across habitats and multipliers than where it is red. This emphasises the need to sense-check the results in line with the good practice outlined in this document.

The EBN tool scores have been derived from an extensive review of published evidence and a series of expert consultations (see Section 3). The scoring matrix is robust in comparison with similar score-based approaches, but there is still considerable reliance on expert knowledge and professional judgement. In particular, confidence is lower for the cultural services, because the value of these services is rooted partly in the subjective opinion and personal preference of different users, which can vary widely. Even where evidence is available, often this does not cover all habitat types and the researchers have filled these gaps based on their own judgement, typically by defining scores in relation to comparable habitat types for which evidence was available.

Assigning values to the multipliers for condition and spatial factors is even more challenging. We have restricted the combined impact of the multipliers to realistic upper and lower bounds, such that, for example, the adjusted flood storage score for 'best condition' grassland does not exceed the score for 'worst condition' woodland (Figure 9). The scores and multipliers will continue to be refined in response to wider testing and evaluation and user feedback.

Figure 9: Example of sensitivity test comparing the impact of condition and spatial multipliers for the ecosystem service of flood protection



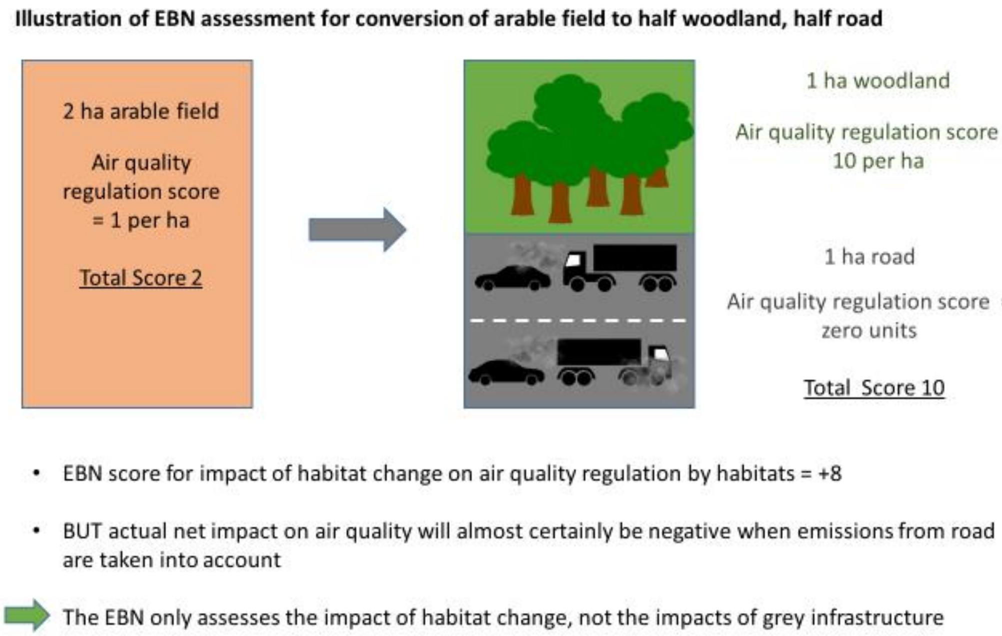
4.The EBN tool results are not cumulative and do not account for the cumulative impact of losses over the time periods shown

As stated above the results table (Figure 8) the potential impacts shown at the three different time periods are not cumulative. This means that where losses have occurred (for example, as shown by downward arrows at year 1 and 10) these are not considered with in the results for year 30. The results simply compare delivery at each of the time periods with service provision from the baseline.

5.The EBN tool assesses losses or gains of ecosystem services related to habitat change, not the wider environmental impacts and pressures caused by 'grey' infrastructure

The EBN tool only captures the impacts of habitat change on ecosystem services. It captures the role that vegetation plays in reducing air pollution and noise, but not non-ecosystem impacts of the development as a whole, such as noise and air pollution from traffic. For example, if half of a field is converted to woodland and the other half to a road, the EBN tool will show a net improvement in the capacity of natural habitats on the site to regulate air quality, due to the change from arable to woodland on half of the site. This reflects the ecosystem services impact. However, the overall net impact of the whole development on air quality is likely to be negative when emissions from the road are also taken into account. Such non-ecosystem service impacts are subject to statutory and planning requirements, usually informed by an Environmental Impact Assessment. In order to achieve ENG under the potential framework the development would also need to demonstrate a net overall reduction in total emissions, e.g. through stringent vehicle emissions regulations combined with some sort of offsetting investment (Figure 10).

Figure 10: Example showing that the EBN tool assesses only the impacts of habitat change, not other impacts of development (simplified example with no multipliers for condition and spatial factors or time to reach target condition)



5. Evaluating Use

The EBN tool has been released as a Beta Test version. A survey is available to allow users to provide feedback to Natural England. Users are encouraged to take part to help Natural England determine next steps for the EBN tool.

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ISBN 978-1-78354-758-6

Catalogue code: JP038