Department for Environment Food & Rural Affairs

Biodiversity Terrestrial and Freshwater Targets

Detailed Evidence report

Date: 28th April 2022

We are the Department for Environment, Food and Rural Affairs. We're responsible for improving and protecting the environment, growing the green economy, sustaining thriving rural communities and supporting our world-class food, farming and fishing industries. We work closely with our 33 agencies and arm's length bodies on our ambition to make our air purer, our water cleaner, our land greener and our food more sustainable. Our mission is to restore and enhance the environment for the next generation, and to leave the environment in a better state than we found it.

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Statement of Interests

Conflicts of interest

All conflicts of interest were identified either through existing terms of reference for expert groups or through contractual arrangements.

Statement of transparency

This report outlines evidence used to support decisions on the proposed terrestrial and freshwater biodiversity targets. It is recognised that gaps remain in the evidence base, and the assumptions and caveats associated with the analysis are stated in the report. Where expert opinion has been used it is clearly stated.

A range of experts contributed to the production of this evidence. In engaging experts, we sought to bring in a range of expertise reflecting the breadth of the proposed targets.

The report provides proposed indicators, which will be peer reviewed prior to use.

Changing status of evidence and policy

The evidence in this document was developed over a two-year period. As such, the analysis undertaken drew on the most relevant evidence available and made assumptions on policy development that were considered most appropriate at that time. It is recognised that this is a constantly evolving picture and that some evidence and assumptions may no longer reflect the most up to date picture. We have endeavoured to make this clear in the document, but readers should be aware that the analysis was undertaken mostly in 2020 and 2021.

Delivery of the chosen targets will require further evidence undertaken with that purpose.

Introduction

This government has committed to leave the environment in a better state than we found it, which is embodied by the historic target to halt nature's decline by 2030. We want to see nature conserved and enhanced for the good of our ecosystems and the species within them, and for the benefits that they deliver to society, including our economic prosperity and maintaining life support systems. This includes tackling climate change, reducing flood risk, providing recreational opportunities, and improving wellbeing.

Much of England's wildlife-rich habitat has been lost over the last century, and whilst progress has been made in recent decades many habitats are in poor condition and still declining. There has been widespread species loss. The main drivers of biodiversity decline are habitat loss and land use change, pollution, invasive species, unsustainable use of our resources, and climate change.

As acknowledged in the 25 Year Environment Plan, recovering wildlife will require more habitat; in better condition; over larger areas that are more closely connected, in line with the Lawton principles (1). The Environment Act 2021 targets will demonstrate our commitment to these aims and act as a regulatory lever to ensure action is taken. In addition, targets will provide a vital function in communicating progress, raising awareness and encouraging collaboration and investment in nature conservation and monitoring (2).

This document sets out the process and evidence that has been used to support decisions on the target proposals, including the proposed target areas, indicators and target level. This document is technical, focussing on the expert opinion and analysis that has been undertaken. It should be noted that due to the evidence being developed over an extended period of time and the policy continuing to evolve, not all of the evidence presented allows for a direct link to the proposed targets. Alongside the evidence, stakeholder engagement and consultation will support decisions on the final target. This document is intended for those who want to understand the scientific evidence base underpinning the proposals for the biodiversity targets. The economic analysis is set out in detail in the accompanying biodiversity targets Environment Act Impact Assessment (IA) but a high-level summary is provided in the Value for Money section of this report. This document does not set out the delivery plan for the targets, which will be a separate and significant piece of work as part of the Environmental Improvement Plan.

Approach to target development

The Environment Act 2021 mandates that at least one long-term biodiversity target must be set in addition to a target relating to the abundance of species for 2030. Four possible target areas were explored initially: Species Abundance, Species Extinction Risk, Wider Habitats and Protected Sites. As we are currently proposing ideas to reform our site protections to better enable the delivery of our nature goals through the Nature Recovery

Green Paper, the decision was made not to propose a protected sites target at this time; however, maintaining and improving our protected sites will remain critical, including to our delivery plan for other targets.

The three proposed target areas - Species Abundance, Species Extinction Risk, Wider Habitat - are covered in this evidence pack. This Section provides an overview of the process.

Process and timescale

As set out in the Targets Public Consultation Paper[1] four steps are being applied to systematically develop targets:

- Step 1: Setting the scope of targets
- Step 2: Developing fully evidenced targets
- Step 3: Public consultation on target proposals
- Step 4: Drafting target legislation

The evidence in this proposal summarised work undertaken under steps one and two, which will support steps three and four.

Criteria for target development

The process of setting international biodiversity goals and targets, e.g. through the Convention for Biological Diversity (CBD), sets a framework and, in addition to scientific literature, provides lessons to inform legally-binding biodiversity targets for England. Setting domestic targets presents the opportunity to make the most of the UK's biodiversity data.

The Annex to the target consultation includes the criteria and principles that have been applied in developing targets. These criteria have been further developed below to consider biodiversity targets specifically, drawing on the scientific literature and best practice for global biodiversity targets.

Biodiversity targets should:

1. Be SMART (specific, measurable, ambitious, realistic and time-bound)- failure to demonstrate sufficient progress towards international environmental and biodiversity goals has been attributed to the complexity and lack of clarity in the

[1] https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/supporting_documents/Environment Targets Public Consultation.pdf

wording (5). The literature demonstrates the link between SMART-ness and progress in delivering global Aichi targets (2,6). For a target to be considered measurable, we need either have or be in the process of developing a relevant indicator based on routinely collected data (7).

2. Draw upon the best available data and evidence- The UK has well established programmes for collecting data on habitats and species. There are still gaps, but we will make use of as much scientifically robust data as possible.
3. Be England focussed- Biodiversity is a devolved issue, and the power to set targets created by the Environment Act 2021 is for England only, therefore targets will be also.
4. Track something of real-world ecological significance- In line with the 25 Year Environment Plan outcome indicator framework, targets will aim to be outcome- rather than action-based.
5. Have an existing baseline with a trend- to support predicting future change in the trend. This will support setting achievable targets.
6. Be responsive to changes over the timescale of the target- The purpose of the long-term targets is to demonstrate progress over a 15-year period as a minimum. There should be confidence that measurable change will occur over this timescale. Areas where significant time lags occur between action and a change in status or condition will not be suitable for targets.
7. Be politically relevant and of public interest- Targets should be aligned to both domestic and international commitments, and meaningful to wider public interest in biodiversity.

Meeting all these criteria for a complex area such as biodiversity is a challenge, and the choice of targets will need to balance the various requirements.

Indicator choice and development

The 25 Year Environment Plan Outcome Indicator Framework[2] was developed as a comprehensive set of indicators to capture environmental change as it relates to the goals in the 25 Year Environment Plan. Through consultation with stakeholders, a suite of 7 indicators were developed in relation to goals for Thriving Plants and Wildlife although there are also synergies with other indicator suites within the framework. These indicators are not exhaustive but provide a high-level overview of change over the timescale of the plan. Five of the indicators are ‘headline’ indicators that are useful for communicating change.

[2] Measuring environmental change: outcome indicator framework for the 25 Year Environment Plan (publishing.service.gov.uk)

The proposed targets relate to the headline indicators in the 25 Year Environment Plan. As several of the indicators are still in development and use for legally-binding targets was not an initial purpose of the indicators, we have reviewed and considered alternatives.

Table 1: Indicators developed for the Thriving Plants and Wildlife goal within the 25 Year Environment Plan Outcome Indicator Framework

Indicator	Description	Status
D1	Quantity, quality and connectivity of habitats	In development
D2	Extent and condition of protected sites – land, water and sea	In development. Interim indicator available and published
D3	Area of woodland in England	Published
D4	Relative abundance and/or distribution of widespread species	Developed, not yet published
D5	Conservation status of our native species	In development
D6	Abundance and distribution of priority species in England	Published
D7	Species supporting ecosystem functions	In development, interim indicator available

Further details on the indicators proposed to measure change in response to policy interventions can be found in the sections below for each proposed target.

Biodiversity Target Advisory Group (BTAG)

Expert groups have helped to inform target development. They have provided bespoke guidance on evidence processes and best available evidence. The Biodiversity Target Advisory Group was established in September 2020 and as of January 2022, has met nine times. Members have been brought together to represent a balance of independent, relevant expertise. Details of the terms of reference, membership and meeting minutes are published[3].

Core attendees include four Scientific Advisory Committee members plus two further members with marine and freshwater expertise. The group has provided a useful steer and advice on the overall evidence approach and specific analysis related to the development of potential targets. Members of the group have also contributed to questionnaires and workshops to explore necessary actions for the individual targets as well as providing feedback on the approach and development of trajectories for each target.

Notional targets

Notional targets were used to support development of the evidence base for targets. The notional targets were developed in 2020/21 and were, as their name suggests, notional. The notional targets were used to test what was considered feasible and understand the level of intervention that would be required to reach different outcomes, in this way the notional targets did not constrain or dictate the level at which a target could be set. In developing the notional targets, a spread of target levels was used in order to not pre-judge the eventual target level. The notional targets were used to explore policy options as discussed in the next section. This means that it is not possible to draw a direct link between the scenarios considered under the notional targets and the proposed targets. However, the evidence developed around notional targets has informed the evidence base and assessment of the most appropriate targets to propose.

The approach to Scenario Analysis

To inform target recommendations, evidence on desirability, feasibility and viability was sought from experts and stakeholders. Participants included individuals from Defra, Natural England, UK Centre for Ecology and Hydrology, JNCC, Environment Agency and Forestry Commission as well as academics. We assessed feasibility for each notional target through a questionnaire and workshop. The outputs defined the most important actions that could be considered to both achieve a target and contribute towards nature recovery. The actions were placed into one of five scenarios based upon the resource and nature of the action. These groups of potential actions were then used as far as possible to assess potential change in the indicator over time under different scenarios, and subsequently guide the development of targets. The evidence touched on desirability,

[3] Biodiversity Target Advisory Group at: https://www.gov.uk/government/organisations/science-advisory-council/about/our-governance#sub-groups

however, desirability extends beyond evidence and included wider stakeholder engagement.

Questionnaire & Workshop

For each of the biodiversity target areas a questionnaire and expert workshop were used to assess feasibility and identify actions critical to delivering each notional target within a given timeframe. To note, at the time of the workshop the timeframe was set at 15 years as this is the minimum length of time a target can cover as set out in the Environment Act 2021. However, as the options were considered further this was later extended to 20 years to align with the end date of the 25 Year Environment Plan. For the remainder of the document, workshop and questionnaire results relate to 15-year timeframe (2037), while trajectories extend for 20 years to 2042.

The questionnaire asked participants to:

- Rate the feasibility of delivering each notional target within a 15-year timescale;
- Suggest a more realistic timescale to delivery, where delivery in 15 years was not deemed feasible (if known);
- Rate a list of critical actions to deliver the relevant notional target;
- Rate whether the actions required significant changes to support delivery of the notional target;
- Identify additional actions that would be required to deliver the notional targets; and
- Rate their confidence in their answers.

The outputs from the questionnaire were presented in an interactive white board (MURAL board) at the workshop. Participants discussed and reviewed the criticality and sufficiency of the actions listed in the questionnaire.

For wider habitats a second workshop was conducted within Natural England only. The aim of this workshop was to again consider feasibility of the three levels of ambition for the notional target as well as address what habitat types would be counted under the action-based target.

The outputs from the questionnaire and workshops were used to produce an initial high-level summary of key actions required for each notional target to inform further analysis on the feasibility and viability of targets and to support the development of trajectories.

Scenarios

One of the key outputs of the workshops was the categorisation of actions into different broad high-level potential scenarios, described below. In total, five scenarios encompass the actions highlighted during the workshop. All but one of these (Scenario 5), have trajectories modelled against them where the data allows.

While the scenarios allow a way to test ambitions and understand what actions are necessary for different target levels, each target area used different methodologies to produce trajectories; this is due to the nature and availability of data. The purpose of the scenarios was to allow some differentiation in the level of improvement that could be achieved with different levels of action. The scenarios also allowed some consistency between the target analysis, so that we may draw some conclusions on how suites of action may influence the different targets.

See below for a description and rationale for each of the scenarios.

Scenario 1:

This scenario extrapolated existing trends where possible.

Scenario 2:

This scenario includes the actions that form the bedrock of action for biodiversity. These are the top actions identified by experts across all the targets areas and for which government has a relatively high level of control to influence and implement (e.g. mechanisms exist or are in the process of being developed). This “action scenario” represents an increase in scale of the actions that have happened under Biodiversity 2020.

Includes: creation of new habitats, restoration of existing habitats, management and onsite actions aimed at improving the condition of protected sites

Scenario 3:

This scenario includes the actions under “Scenario 2” plus the additional actions that will have significant positive impact on the ability of our basic actions to deliver positive outcomes. These generally formed some of the medium to high importance actions in the workshops. They are also actions that are identified in action plans for species and protected sites. Implementation of these actions should either allow positive outcomes for a greater number of sites/species or increase the rate of improvement. These actions are limited to those for which funding is the main limiting factor and few if any trade-offs exist.

Includes: research, partnership, spatial planning, targeted action for species.

Scenario 4:

This scenario includes all actions under the two previous scenarios as well as actions identified as critical or important to the delivery of our targets, but which require more than just additional funding. This scenario requires action taken in sectors/policy areas for which government has less influence or control and/or may have trade-offs or cultural barriers that may limit their implementation or effectiveness.

Includes: actions for water quality, planning, any changes to legislation.

Scenario 5

The actions included here are the more speculative actions that were identified through the workshops for which limited evidence or understanding exists. These actions will be difficult to fully describe or quantify, but for which there was consistent, if low, confidence that they would support target delivery- especially higher levels of ambition. *This scenario could not be modelled due to a lack of data.*

Includes: rewilding and other high-level changes to how land and environmental policies are implemented and wider cultural changes, e.g. changes to diets.

The fact that Scenario 5 is not modelled does not mean that some of these actions will not be considered or included in how targets are delivered. For example, successional and scrub habitats, often associated with rewilding approaches, are included in our definition of wildlife-rich habitats (see Annex 1).

Factors considered in proposing a target

This document sets out the evidence base as it relates to the proposed targets set out in the consultation document, covering the below factors. This is drawn from the wider evidence process summarised here. The following will be taken into account when making a final target recommendation:

- Desirability (level of ambition) for a target according to stakeholders, experts and government.
- Feasibility based on the notional target levels, according to stakeholders, expert and government evidence and policy leads.
- Expert opinion on timescales for delivery of the notional target ambition levels.
- Trajectories and confidence intervals (where applicable).

Target: Wider Habitats

Summary

Proposed target: To create or restore in excess of 500,000 hectares of a range of wildlife-rich habitat outside protected sites by 2042, compared to 2022 levels.

The following section summarises the evidence and analysis explored to inform the development of a wider habitats target. Key points covered in this section of the evidence report are:

- Habitat loss and fragmentation is identified internationally as one of the five main drivers of biodiversity decline. New or improved habitat is critical for the recovery of biodiversity.
- Due to data limitations, setting an 'outcome-based' target for wider habitats which would report on habitat condition as well as extent is not feasible. An action-based target has been proposed.
- We do not currently have the mechanisms to effectively measure habitat loss. The Natural Capital and Ecosystem Assessment (NCEA) should help us to improve monitoring of habitat loss in future.
- The proposed target to create or restore in excess of 500,000 hectares of a range of wildlife-rich habitat outside protected sites by 2042 would represent an increase compared to Scenario 1, which estimated, based on 2011-2019 data, that 331,900 ha would be delivered.
- Around 48% of workshop participants were medium, high or fully confident that creating or restoring 500,000 hectares was achievable by 2037; the proposed target would cover a slightly longer period to 2042, to align with the 25 Year Environment Plan.
- Analysis completed by Natural England indicated that the target ambition is feasible given the current and forthcoming initiatives contributing to habitat creation and restoration.

Introduction

Habitat loss and fragmentation is identified internationally as one of the five main drivers of biodiversity decline. Much of England's wildlife-rich habitat (wetlands, woodlands, heathlands, uplands, grasslands, and coastal habitats) has been lost over the last century. While losses have slowed, many natural and semi-natural habitats are in poor condition and facing ongoing degradation from past land use and continuing/increasing pressures (e.g., agricultural intensification, grazing, poor water quality, air quality and climate change).

Protected Sites contain some of the best examples of habitat types and species and government has committed to improving their extent and condition in the 25 Year Environment Plan. To build on this, a target on wider habitats would drive action to improve the wider countryside, thereby allowing a wider range of species to spread and thrive. Creating and improving wildlife-rich sites will also buffer and have positive impacts on Protected Site features. Furthermore, such a target will underpin the delivery of the proposed species targets. Restored ecosystems and habitat networks can help species recover and thrive, as well as adapt to climate change and move to more favourable climates through habitat corridors.

Healthy ecosystems and habitats also trap and store carbon, contributing to achieving Net Zero. A target focused on habitat creation would be complementary to the Government's 30 by 30 commitment to protect 30% of UK land and sea by 2030 and support the development of a Nature Recovery Network. Delivering this target can provide opportunities for people to connect with and enjoy nature across the country, and obtain health benefits from that interaction, in different locations and environments. Habitats are stocks of natural capital which provide flows of benefits to people. Habitats in good condition with their full complement of biodiversity, are more resilient and provide more services for people. Investing in improving the extent and condition of our habitats is not only positive for nature, but also for society and the economy (8).

Given most of the semi-natural terrestrial and freshwater habitat in England lies outside SSSIs (SSSIs cover 8% of England; some 60% of priority habitat recorded on the national inventories is outside of this network), 47% of estuarine and coastal waters and the habitats within them lie outside of marine protected areas, and the 25 Year Environment Plan goal of creating or restoring 500,000 ha of habitat outside of protected sites, it is desirable to have a statutory wider habitats target. Such a target would support the Government response to the Dasgupta Review (8) by 'delivering a 'nature positive' future, in which we leave the environment in a better state than we found it.

Data Availability

Habitats of 'principal importance' for the conservation of biological diversity in England are recorded under section 41 of the Natural Environment and Rural Communities Act 2006. Priority habitats are a focus for conservation action in England. However, there is currently no consistent or comprehensive approach to monitoring to enable a robust assessment of the current extent or condition of semi-natural habitat outside of SSSIs.

The CEH Landcover Map 2015 identifies 2.3 million ha of land in England most likely to be semi-natural habitat, with a possible further 1 million ha of additional habitat of some wildlife value (within other land use categories classed as either grassland, arable, forestry, urban and sub-urban). Of the 3.3 million ha of habitat of potential wildlife value, 2 million ha are recorded within the priority habitats inventory (1.87 million reported in 2013[4]) (15% of England). The total priority habitats resource in England is made up of deciduous woodland (39%); wetland habitats (29%); heathlands (16%), grasslands (7%) and coastal habitats (7%). Rarer habitats such as traditional orchards and limestone pavements together make up 1% of the total resource.

Assessing the condition of wider habitats in England

We explored the possibility of developing an 'outcome-based' target for wider habitats which could report on habitat condition as well as extent. Reporting on the status of habitats outside of the protected site network depends upon the availability of data and evaluation of existing datasets. There are a variety of datasets that provide information on habitats.

Despite all these different evidence sources, limitations to the available habitat data beyond Protected Sites remain at the current time. Further development is needed to systematically assess positive and negative changes in the quantity, quality and connectivity of habitats for 25 Year Environment Plan indicator D1. For instance, much of the data are old or inconsistent, of inadequate predictive power, or provides partial coverage. Many of the satellite-derived mapping tools are still in development. These gaps mean we do not have what is required to be able to describe wider habitat status or predict change as a result of policy interventions. Furthermore, the current evidence is dispersed and not in a form that allows it to be managed and accessed in a single platform to enable integrated outcomes. Licensing and product conditions add further challenges to data analysis.

An updated approach to collect, collate, manage, analyse and visualise environmental data would help solve these challenges and enable us to move to a position where it will be possible to set and monitor progress against an effective outcome-based target. This is anticipated to come from the Natural Capital and Ecosystem Assessment programme in the form of outcome indicator D1, habitat quantity, quality and connectivity. However, a large-scale assessment of this kind will take time to develop and will not be ready to provide useful information in time for the first round of target setting. Therefore, an action-based indicator was proposed for reporting against the target.

Data for this action-based target will come through current committed and expected habitat creation and restoration through a variety of interventions.

[4] 2a_Extent_and_condition_of_priority_habitats.pdf (publishing.service.gov.uk)

Assessing action to create or restore wider habitats in England

As outlined above, an action-based indicator is proposed, as an outcome-based' target for wider habitats covering habitat condition and extent is not feasible due to data limitations. Action-based assessments have been used previously as a proxy for habitat condition.

Under the Biodiversity 2020 Strategy (Outcome 1A) of 'Better wildlife habitats with 90% of priority habitats in favourable or recovering condition', an action-based assessment was, in part, used as a proxy for habitat condition. The lack of a standard condition assessment process for measuring the precise condition of habitat outside SSSIs means that it was necessary to rely on the SSSI reporting process, combined with an assessment of the extent of additional priority habitat under 'favourable management', i.e. within an Agri-Environment Scheme (AES) agreement or similar arrangement. For this, a selection of 'beneficial management' options are selected matching the 'right option against the right feature' to ensure that reporting results are as ecologically sound as possible. This approach helps to ensure that degraded or poor habitat is not counted in any reporting, so that a proxy action or extent indicator is as reliable as possible.

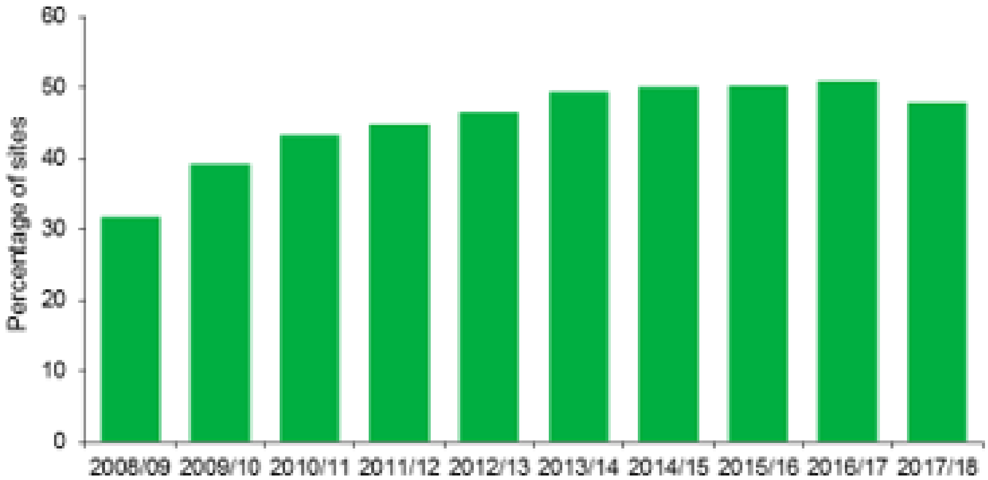
As of 1 April 2021, almost 1.23 million hectares of priority habitats were in target condition (a 7.4% increase since 2011). This equates to 65.6% of all priority habitats in a favourable or unfavourable recovering condition. Only saltmarsh, of all the 24 habitat types, achieved 90% of their area in favourable or unfavourable recovering condition, with a further 9 exceeding 80% of the target value for each individual habitat.

The action-based Biodiversity 2020 approach outlined above has been used for all terrestrial non-woodland habitats but was not appropriate for use on habitats not considered suitable for AES. For example, for some open freshwater habitats the condition was based on Water Framework Directive (WFD) status; or for woodlands, FC's 'woodlands under management' database was used as a relevant proxy.

The England Biodiversity Indicator ***Integrating biodiversity considerations into local decision making*** shows the proportion of the total number of Local Sites in England where positive conservation management is being implemented or has been implemented in the last 5 years. This is again a management-based assessment rather than an assessment of the condition of the habitat in these sites. Local Sites are non-statutory areas identified and selected for their substantive local nature conservation value (Local Wildlife Sites) and/or their local geological value (Local Geological Sites).

In 2017/18, 48% of Local Sites across England were identified by local authorities as being in positive conservation management (Figure 1)**.** Though another action, not outcome, based measure it shows an increase of 16 percentage points since the beginning of the time series in 2008/09 and of 1.5 percentage points since 2012/13. The total number of responding local authorities and number of sites varies between years. In 2017/18, 101 (67%) local authorities were included in the analysis.

Figure 1: Proportion of Local Sites under positive conservation management, 2008/09 to 2017/18 Source: Defra, Local Authority Single data list 160-00 on local nature conservation/biodiversity.



Biodiversity 2020 also included an outcome (1B) for establishing 200,000 ha of new priority habitat. Delivery towards this outcome was intended to be focussed on land outside SSSIs and to include contributions from a range of delivery mechanisms including selected AES options for creation and restoration, woodland creation, Forestry Commission's Open Habitats policy, Environment Agency's 10-year habitat creation project, and actions by external partners including mineral companies and other activity associated with development e.g. Green Infrastructure. As with the habitat condition assessment under Biodiversity 2020, this is based on management action to create or restore habitat.

All increases in the extent of priority habitat since 2011 counted towards the target. In January 2015, delivery was reported at 60,377 ha. By the end of 2021 it was reported that 260,469 ha had been created or restored, so the Outcome 1B target was met. However, it has not been possible to establish mechanisms to report habitat losses and therefore assess 'no net loss' (9).

For some habitats (e.g. broadleaved woodland) achieving good condition will take many years or decades. AES management, based on 'right option-right feature', can be considered as a good indicator that habitat improvement is taking place. Based on the results of research carried out under the AES Monitoring and Evaluation Programme (e.g. ' Agri-Environment Monitoring and Evaluation Programme Annual Report 2016/17[5]*),* a range of habitats (e.g. grassland, lowland heathland, upland heathland and fens) under an

[5] Agri-Environment Monitoring and Evaluation Programme Annual Report 2016/17 - NERR074 (naturalengland.org.uk)

AES scheme were found, in general, to be in better condition when under AES agreements.

An action-based target assumes that management will create or restore wildlife-rich habitat, but does not detect loss of habitat, or its condition, this would require an outcome based measure. The use of AES data also means that the habitat, and any improvement in its condition, may be lost once a land holding's AES ceases. No comprehensive spatial dataset is available to measure loss of habitat or identify the location of action to increase the extent of new habitat through either restoration or creation.

Relevant indicators

Action based target

An action-based target was proposed and tested with stakeholders.

The potential target will comprise the gross number of hectares of habitat restored or created through implementation of relevant policy interventions including agri-environment schemes and other measures, such as Biodiversity Net Gain (we do not yet have the tools to be able record losses). This includes both Priority Habitats as well as non-Priority wildlife-rich habitats (i.e. such as dynamic mosaics and natural function driven ecosystems, rich in structural diversity and species niches). See Annex 1.

Potential additional supporting indicators

Two indicators currently in development could support future monitoring of habitat outcomes: D1 and B6. The indicators are expected to be available in 2024.

The D1 indicator, which is outlined in the 25 Year Environment Plan outcome indicator framework, seeks to measure both positive and negative change in habitat quantity, quality and connectivity for all terrestrial habitats in England. D1 sits in the framework within the Wildlife theme, the Thriving Plants and Wildlife goal and contributes to headline 7 'Changes in nature on land and water that support our lives and livelihoods'. It is an indicator for all terrestrial habitats classed as Priority habitats and/or other wildlife-rich habitats (contributing to the matrix of a habitat network) forming an environmental system providing wider benefits. D1 provides the wetland habitat component (i.e., terrestrial habitats that are water dependant like bogs and fens) in parallel to and supported by B6.

The B6 indicator assesses natural function of water and wetland ecosystems and provides the open freshwater, estuarine and coastal water component (i.e. lakes, ponds and rivers) sitting withing the Water theme of the framework. It is anticipated that measuring the outcome through the 25 Year Environment Plan B6 indicator will be the main means for reporting progress against this target for freshwater habitats.

They each use the same complementary framework to assess five processes of ecosystem function of hydrology, soil/sediment, chemical, biological and vegetation control. Information allowing the measurement of D1 is anticipated to come from the Natural Capital & Ecosystem Assessment (NCEA) and Living England layers which are currently in development.

Notional targets

Notional targets were agreed to support development of the evidence base. In developing the notional targets, a range of levels was used in order to not pre-judge the ambition level,

The three ambitions levels were set as:

- **400,000 hectares of habitat created or restored by 2037.**
- **500,000 hectares of habitat created or restored by 2037.**
- **750,000 hectares of habitat created or restored by 2037.**

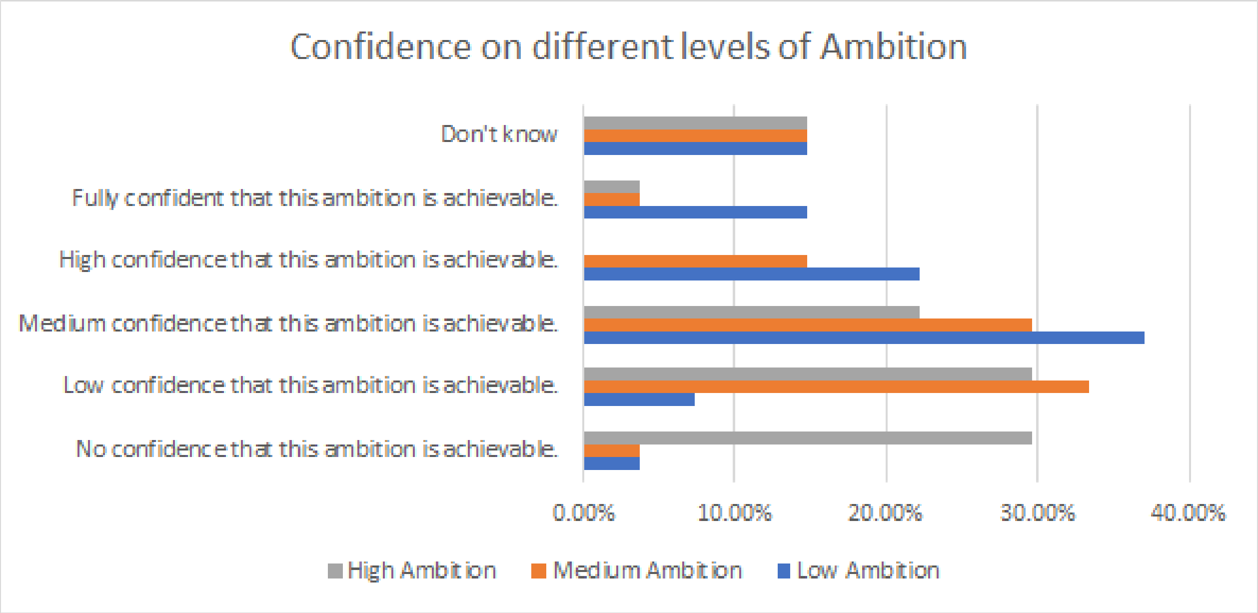
In defining the notional targets, wider habitats were broadly defined as habitats outside the protected sites network. This broad definition was used during the workshop to assess feasibility. Subsequent to this the definition of what should count under this target was explored further; this is discussed in the section 'Defining 'wildlife-rich habitats' for the proposed target'.

Feasibility assessment

Feasibility

This section summarises the views of experts on target feasibility and should be read in that context. From the questionnaire and workshop conducted, there was general agreement, in terms of participants confidence, in the achievability of the three levels of ambition within the 15-year timeframe. Generally, respondents had higher confidence in achieving the lower levels of ambition in the timeframe. Results from the questionnaire are illustrated in Figure 2 with the key takeaways set out below.

Figure 2: Respondent confidence when asked the achievability of various levels of ambition for the Wider Habitat target



- **400,000 hectares of habitat created or restored by 2037 -** 74% were medium, high or fully confident that this level of ambition was achievable.
- **500,000 hectares of habitat created or restored by 2037.** This would support the delivery of the 25 Year Environment Plan goal - 48% were medium, high or fully confident that this level of ambition was achievable[6].
- **750,000 hectares of habitat created or restored by 2037 –** 26% were medium, high or fully confident that this level of ambition was achievable.
- Many respondents didn't know how long it would take for any level of ambition to be achieved (64% for low; 47% for med and 42% for high).

During the workshop participants were asked to mark a spot on a sliding scale of ambition suggesting what level the target should be set. 69% of respondents (n=26) thought the level of ambition should be set at 750,000ha. Participants were also asked to capture their associated assumptions under PESTLE[7] framework, some of the responses are set out below. Participants held a range of assumptions, as such there are some inconsistencies.

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[6] During the questionnaire and first habitat workshop, attendees were only asked about confidence to meet 400k, 500k or 750k ha in 15 years and with little evidence provided on current delivery rates. After discussions and further data analysis a second workshop with Natural England's habitat specialists resulted in higher confidence that the high ambition could be met and that it was required to stem the decline of wildlife.

[7] PESTLE stands for Political, Environmental, Social, Technological, Legal and Economic.

- There will be sufficient political will, buy-in and funding for any of the three levels of ambition. Respondents assumed that biodiversity would continue to be a priority for government amidst competing pressures. Delivery mechanisms required for this target will also be properly resourced and run, e.g., Environmental Land Management schemes. Monitoring and evaluation schemes will also be properly funded.
- A common assumption made was that the target will drive improved quality of habitats created / restored, not just quantity. Additionally, the target will not drive perverse outcomes by creating ‘quick wins’ and avoiding targeting more challenging habitat types. The type of habitat being recorded was a common assumption with respondents listing that we value successional / mosaic / dynamic habitats and natural processes within the target.
- Participants assumed mechanisms to secure protection of habitats were in place and that enforcement powers were used.
- A main assumption was that a change in societal attributes occurred and that the public would see biodiversity loss as critical; that they support and want to create habitats. Assumptions included that there will be sufficient support and advice for landowners to deliver these habitats and local partnerships are in place.

Expert views on actions required to deliver the creation or restoration of 400,000 ha of habitat.

The following summarises the discussions during the stakeholder workshops to produce a list of necessary actions. These incorporate the initial questionnaire results on the sufficiency of policies affecting the target, where respondents were asked to place the actions on two axes between ‘moderate – critical importance’ and between ‘sufficient – major policy changes required’.

In most instances there was consensus around a range of actions identified by experts as critical in order to create or restore 400,000 ha of habitat by 2037. Common themes are listed below:

- Sufficient policies to ensure the protection of habitats from unsustainable development i.e., no net loss alongside utilising enforcement measures when damaging activities occur were seen as being of critical importance. Complementing protection of habitats was the large-scale creation / restoration of habitats outside of protected sites and restoring protected sites to favourable condition. There was medium-high confidence in these actions but were deemed critical to achieving the target.
- Respondents considered ecosystem functioning and natural processes as of critical importance to delivering the low ambition for the target. Processes such as improving water quality for freshwater, estuarine and coastal sites (mixed confidence), protecting sites with peat soil from planting and restoring those which are degraded, targeting of woodland planting and natural regeneration to address pressures e.g., chemical exposure, water quality, air quality, fragmentation (high

confidence with minor changes required) were listed as being of critical importance to the target. Increased investment in Catchment Sensitive Farming activities and restoring the management of woodland outside of protected sites were also considered to be of high importance. Furthermore, a reduction in the use of pesticides and critical loads of atmospheric nitrogen was deemed critically important but requiring significant changes to make this deliverable.

- Innovative delivery mechanisms were considered critical. Respondents highlighted the need to both incentivise actions to create, improve and maintain the wider habitats as well as sustainable farming practices which supported biodiversity as being critical.
- Monitoring and surveying and reporting actions through CBD and BERN were seen as important. There were, however, mixed views on the changes required and the confidence in these actions in delivering the goal.
- Collaborative and partnership working featured highly (e.g., working with partnerships to connect and buffer Protected Sites through the Nature Recovery Network).
- Tackling invasive species as well as increasing connectivity sat towards the more moderate action required. These were still deemed important (less so than above) but required less policy changes to be successful.
- Discussion within the workshop highlighted that critical to a target ambition being reached was the need for a change in government resourcing of the necessary actions to take place

Expert views on actions required to deliver the creation or restoration of 500,000 ha of habitat.

When considering what would be required to meet 500,000 ha, it was noted by many participants that more of what was required to deliver 400,000 ha was needed, i.e. at a greater scale:

- Rewilding at different scales, as a viable option for landowners (with support from ALBs), was suggested several times as being critically important.
- More and stronger emphasis was placed upon biodiversity in planning policies. The relationship between biodiversity and net zero should be addressed further to support this ambition level. The link to net zero was raised several times in relation to air quality and nature recovery.
- Stronger/new policies on the use of chemicals and standards to protect biodiversity, to tackle chemical use on land which pose a risk to the environment (e.g. link with the government wide Chemical strategy and Defra’s Pesticides National Action Plan).
- In the views expressed in the workshop, it was noted that the higher the target, the more difficult it would be to find land; state-led acquisition was suggested as being of critical importance to address this

- Significant increases in funding and resources, whilst incentivising further changes in land use and measures to promote an efficient farm economy of profits/yields.
- Significant societal shift especially if land acquisition were to be an option.

Expert views on actions required to deliver the creation or restoration of 750,000 ha of habitat.

As above, the participants indicated that more of the actions required for the medium level of ambition were required to reach 750,000 ha. The main theme was that more coherent thinking was needed on preserving habitats across urban and rural environments, recreating priority habitats to benefit both, scarce and common species.

- A shift in environmental regulation and regulatory culture was seen as critical.
- Stronger rules/ban of use of chemicals that pose an environmental risk, be it on agricultural land, in private ownership or Local Authority owned.
- Policies that tackle emerging chemicals of concern to maintain nature recovery and restoration (avoiding new impacts).
- Stronger restriction on invasive species plant movement or complete ban on movement of any species causing degradation of habitats in UK.
- Additional new policies are needed to protect landscapes and priority habitats based on ecosystem restoration principles.
- More support to landowners including advice from ALBs resourced for the task, targeting restoration, and addressing food supply chain pressures, were critically important.

Defining ’wildlife-rich habitats’ for the proposed target

All habitats can have value for wildlife to varying degrees. Criteria to identify the more important habitats have been produced over the years, particularly since the introduction of Biodiversity Action Plans under the 1992 Convention on Biological Diversity[8] (CBD). The definition of priority habitats is now enshrined in legislation under Section 41 of the Natural Environment and Rural Communities Act, 2006. They are defined as habitats of principal importance for the conservation of biodiversity in England.

With the launch of the 25 Year Environment Plan the word ‘wildlife-rich’ was introduced in connection with the goal to create or restore an additional 500,000 ha of new habitat. The term ‘wildlife-rich’ was not defined except that it was proposed to focus on protected or priority habitats and that its delivery would be linked to the Nature Recovery Network.

A definition for ‘wildlife-rich’ habitats is not intended to re-classify all existing habitat types but to provide a clear description of the habitat types that could be counted under the

[8] https://en.wikipedia.org/wiki/Convention_on_Biological_Diversity

proposed target. For a more detailed overview the proposed definition of 'wildlife-rich' habitats and what we propose counts under a Wider Habitats target see Annex 1.

The following definition of wildlife-rich habitat is proposed:

'Wildlife-rich' habitat is "natural or semi-natural habitat that is identified as:

- A habitat of principal importance for biodiversity[9] under Section 41 of the Natural Environment and Rural Communities Act 2006, or
- A habitat equivalent to that identified as being of high or very high distinctiveness under the biodiversity metric 3[10] (10), or
- A habitat equivalent to a habitat of medium distinctiveness as defined by the biodiversity metric 3 that is in good or moderate condition and of high to medium strategic significance".

The proposed habitat types to be included in the target are listed at Annex 1 and outlined in the main consultation document.

The biodiversity metric User Guide provides a method of assessing the quality of habitat[11]: clear thresholds for habitat value for a wide range of habitats, including priority habitats, and instructions relating to assessing the likely outcome of the proposed habitat creation and restoration activity. This information can be used to help report delivery against the Environment Act target.

Measuring progress, and reporting against, the proposed target

Once the habitat that will count towards the target is agreed, following consultation, we can more clearly determine the mechanisms that will deliver actions to meet the target. For Bio2020 this included Agri-Environment Scheme (AES) agreements, Forestry Commission's woodland creation and management activity, Environment Agency's

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[9] Also known as a 'priority habitat'

[10] The Biodiversity Metric 3.0 (JP039)

[11] 'To assess the **quality** of a habitat biodiversity metric 3.0 scores: a. Habitats of different types, such as woodland or grassland, according to their relative biodiversity value or **distinctiveness**. Habitats that are scarce or declining typically score highly relative to habitats that are more common and widespread. b. The **condition** of a habitat. Scoring the biodiversity value of the habitat relative to others of the same type. c. Being 'better' and 'more joined-up' are important facets of habitats that can contribute to halting and reversing biodiversity declines, so the metric also accounts for whether or not the habitat is sited in an area identified, typically in a relevant local strategy or plan, as being of **strategic significance** for nature.'

delivery under their habitat creation target, mineral restoration etc. For AES delivery there is an existing process of selecting all the suitable options and matching these against a range of features to determine the extent and type of delivery e.g., restoration or creation. For the other mechanisms Natural England previously have relied on the relevant organisation to provide the data in the understanding that the target's goal is increasing the extent of priority habitat.

To expand recording to encompass the proposed definition of 'wildlife-rich' into the Environment Act target, Natural England will continue to apply the same principles.

In many cases the process for collecting data from the relevant organisation or delivery process is already well established particularly with respect to priority habitats. Because the target proposes using similar criteria to those developed for the biodiversity metric, any new process will be able to either draw on the biodiversity net gain data or replicate the process used for biodiversity net gain.

Recording the delivery spatially is considered to be the ideal option for reporting against the target. Work is currently ongoing to develop a baseline as part of the Natural Capital and Ecosystem Assessment (NCEA) project. Further work is required to ensure a more comprehensive picture can be collated/reported building on the current delivery mechanisms that already undertake some form of spatial reporting e.g., agri-environment scheme, FC, EA, National Trust and delivery from local planning authorities.

Estuarine and coastal waters will be covered by some of the above measures: the intertidal sections are included in the biodiversity metric and can be included in AES schemes. Additional data will come from on-going Environment Agency monitoring and developments from NCEA.

Scenario Analysis

Introduction

Data and evidence around habitat creation / restoration activity was collated and then mapped against the five scenarios and displayed as estimated trajectories below (except scenario 5). Key actions identified by stakeholders as being crucial to achieving a wider habitats target have been categorised into scenarios. These four scenarios form the basis for the trajectories. These scenarios are illustrative and no decisions on policy pathways have yet been made.

The trajectories assume that there is no prioritisation of actions for differing habitats; that habitat will be delivered at a constant rate and that the target will run from 2022 – 2042. Delivery rates are based on this 20-year time span.

Scenario 1

Scenario 1 has been calculated as a continuation of average delivery rates for Outcome 1B of Biodiversity 2020 (Figure 3). The rate of delivery (based on data for 2011-2019) was c. 16,595 ha of habitat per annum.

Figure 3: Average delivery rates of habitat per year (taken as an average between years 2011 and 2019). Average annual delivery rate is 16,595 ha.

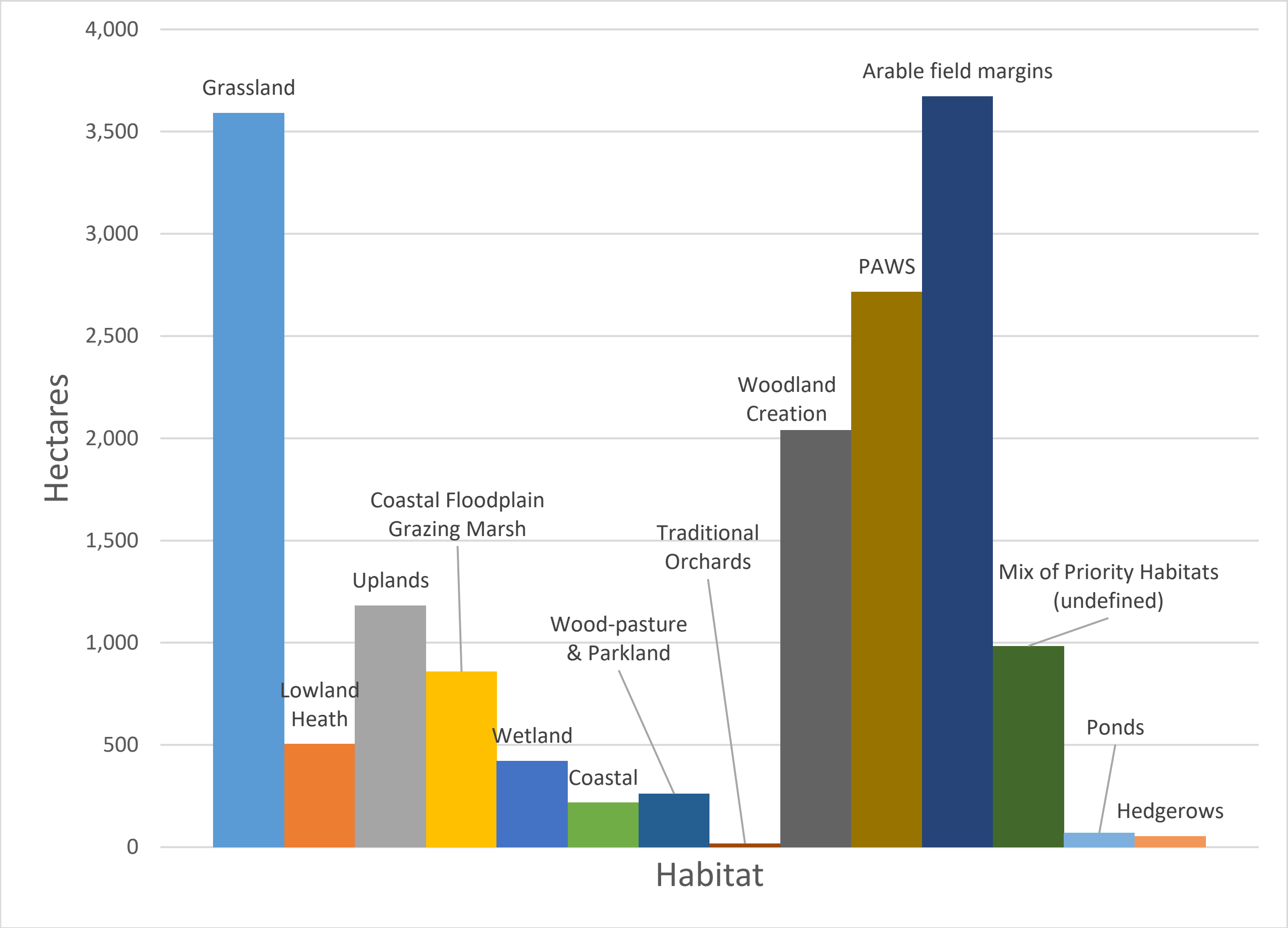
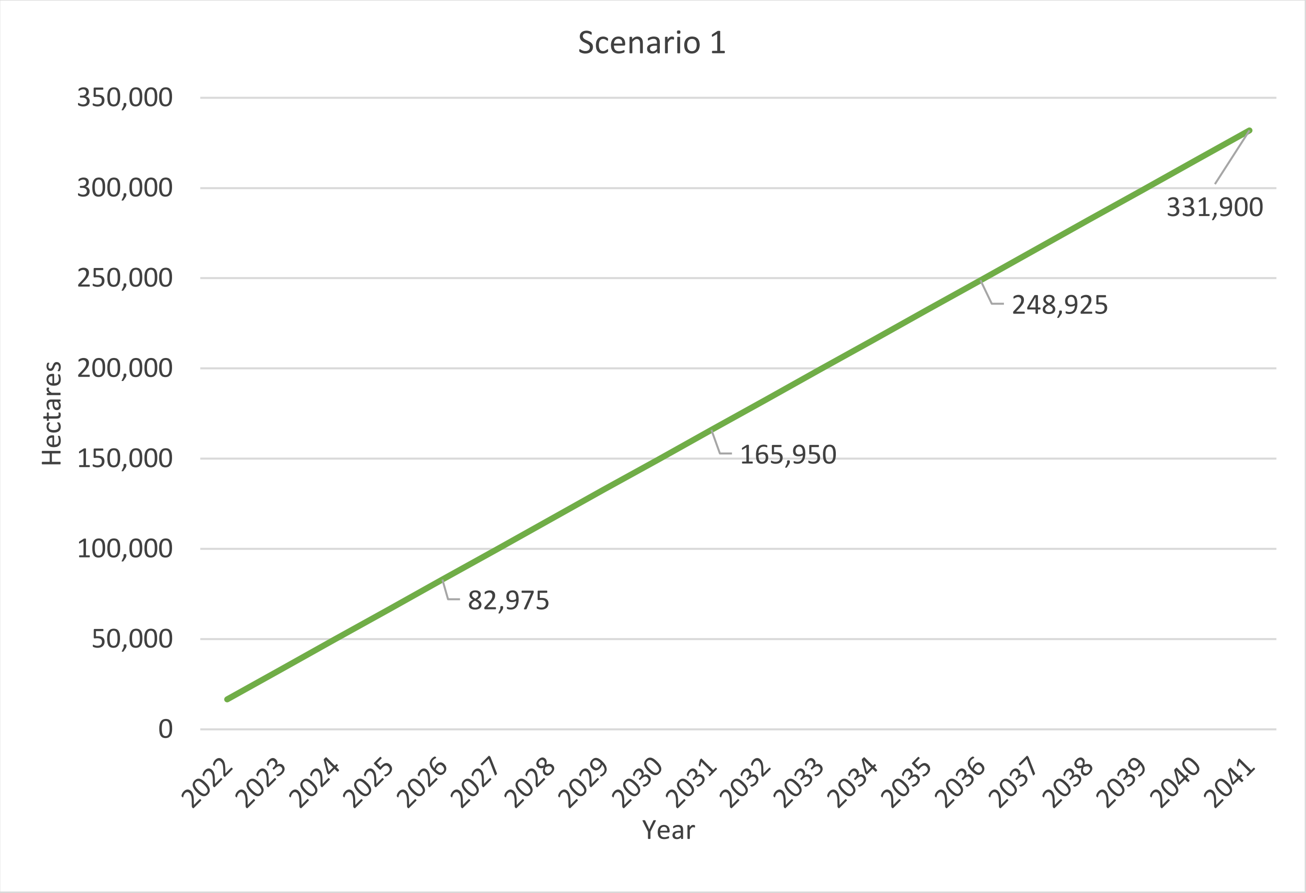


Figure 4: Wider Habitats Scenario 1 (based on 2011-2019 delivery rates)



Assumptions used to produce Scenario 1 trajectory:

- This is a model based upon an annual delivery rate of 16,595 ha. This figure is the average delivery of priority habitats delivered between 2011 – 2019 by all partners (see Annex 2).
- There are no losses to any habitat type (as this cannot be determined from past data), and no limits to volume / extent of habitats that can be restored or created.
- There is no consideration of where habitats are placed.
- All habitats will be of ‘good’ condition as defined in the biodiversity metric 3.
- The data used does not consider habitat delivered in 2020 and 2021 as this data was not available at the point in time in which the trajectories were produced.

Scenario 1 (Figure 4) shows that **331,900 ha of habitat** could be delivered over 20 years (2022 – 2042). Given the current delivery rates have not stemmed the continuing declines in species abundance it is evident that Scenario 1 is not sufficient. A more ambitious target should be set to be confident of ensuring biodiversity recovery under this statutory target.

Scenario 2

Actions listed under this scenario are:

- Creation of new habitat – including creation of new wildlife-rich habitat.
- Restoration of existing habitat – including peatland restoration.
- Maintenance of existing habitat inside and outside of protected sites – important principle of conservation before considering restoration and creation.
- Natural regeneration of woodland.

Creation of new habitat – including creation of new wildlife-rich habitat

The Biodiversity Net Gain Impact Assessment[12] estimates that 15,900 ha of non-developed land is to be developed annually. Biodiversity Net Gain aims to deliver a minimum of 10% of habitat gain. The impact assessment further estimates an annual creation or enhancement of between 1,551 and 17,060 ha. The lower figure of 1,551 ha per annum, has been used in the scenario in line with advice of the Biodiversity Targets Advisory group to used conservative assumptions and recognising that not all habitat creation will likely meet the proposed definition of wildlife-rich habitat.

A proposed tree canopy and woodland cover target expects to create around 145,000 ha of native woodland by 2042. Initially, delivery will be supported by the England Woodland Creation Offer (EWCO) and other Nature for Climate Fund delivery mechanisms, which aim to at least treble rates this Parliament as England's contribution to the commitment of achieving UK planting rates of 30,000 ha/yr.

Restoration of existing habitat – including peatland restoration

At the time of the analysis the current delivery mechanism, the Peat Action Plan, proposed to deliver 35,000 ha of peat restoration between 2020 and 2025. We have assumed that much of this delivery will be within the SSSI network and has therefore been excluded from the scenario. After 2025, peatland restoration is anticipated to be c. 234,000 ha. This is considered a long-term aim beyond both the 25 Year Environment Plan and the Statutory Environment Act targets. The government's new Sustainable Farming Incentive, Local Nature Recovery and Landscape Recovery Schemes will provide the main delivery mechanism for peatland restoration after 2024-25 and Nature for Climate grants will act as an important precursor. For this analysis we have assumed that, of the upland peat that is not in near natural condition or already restored, 198,000 ha will be restored. This is 92% of the upland peat in that category (215,217 ha total). A further 44,000 ha of cropland (24.7% of the total) and 35,000 ha of lowland grassland (53% of intensive grassland) on peat will be restored. An initial analysis indicates that much of this habitat is within the SSSI network but c. 20,000 ha of non-priority habitat outside SSSIs on deep peat that needed restoration. In addition, there is c. 79,000 ha of deep peat habitat creation on arable/improved grassland (outside of the SSSI network) with the potential to deliver new wetland habitats. Therefore, it is assumed that 99,000 ha of peat restoration could be delivered with the Peat Action Plan.

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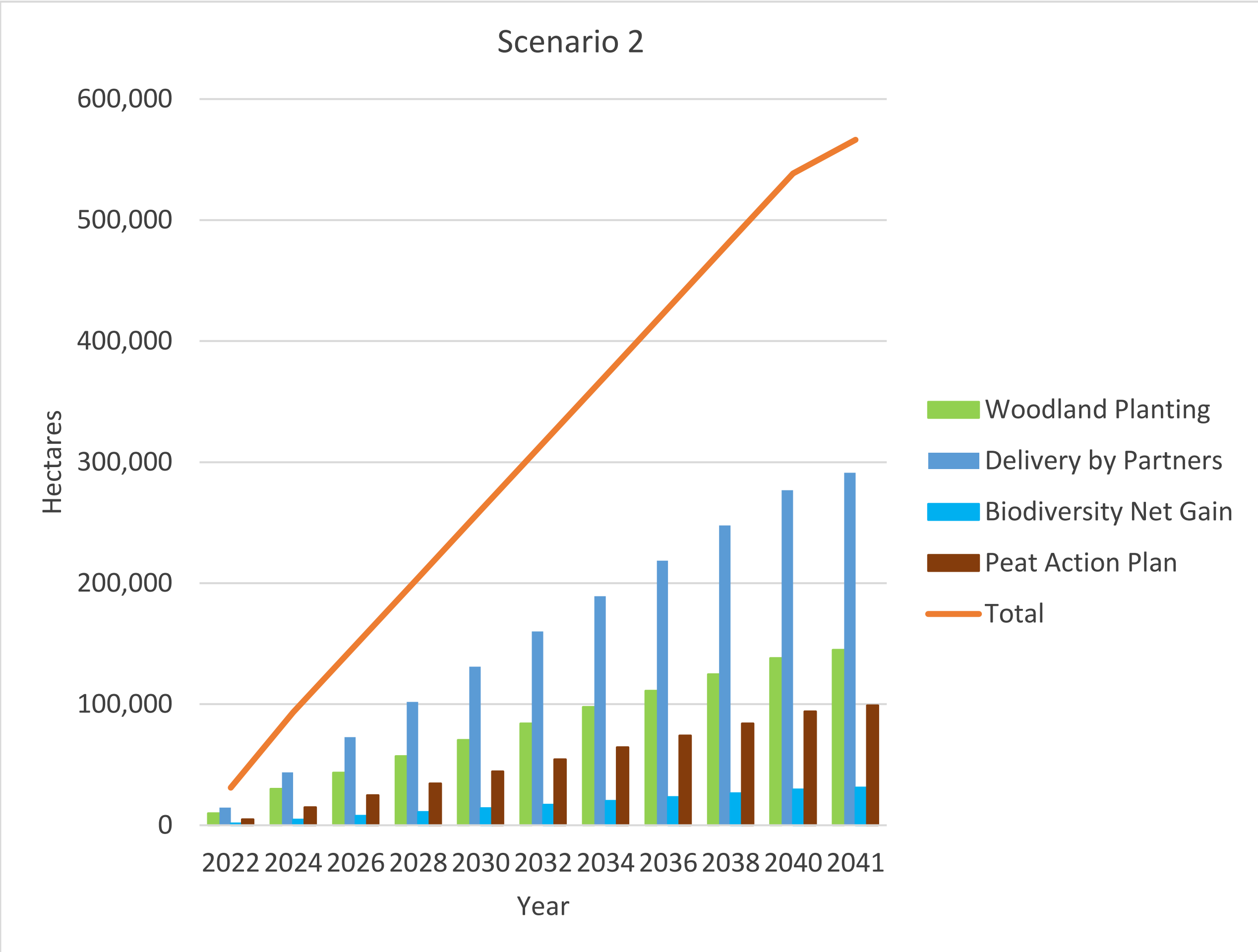
[12] Biodiversity Net Gain and Local Nature Recovery Strategies

Scenario 1 includes the baseline rate of delivery of woodland habitats (2,039 ha per annum). To avoid double counting of this baseline woodland creation, between the scenarios, the BAU delivery of woodland was removed when applying the baseline habitat delivery to scenarios 2, 3 and 4. This takes the average annual delivery of habitats that Scenario 1 contributes to further scenarios down to 14,556 ha. Contributions from Scenario 1 to other scenarios going forward is referred to as ‘delivery by partners’ (see Figure 5).

Figure 5: Scenario 2 with 14,556 ha delivered under ‘Scenario 1’. This 14,566 ha excludes the annual delivery of 2,039 ha of woodland in Scenario 1 (called here “Delivery by Partners”)



Assumptions:

As above, plus:

- BNG delivery at constant rate at the minimum level (1,551 ha/y)
- Peat Action Plan delivery at constant rate at the maximum level (4,950 ha/y). A total of 99,000 ha would be delivered under this mechanism.
- Woodland creation under business as usual (2,039ha per annum) has been excluded from scenario 3 and 4 to avoid double counting between the scenarios.

An estimated total of 566,340 ha would be delivered.

Scenario 3

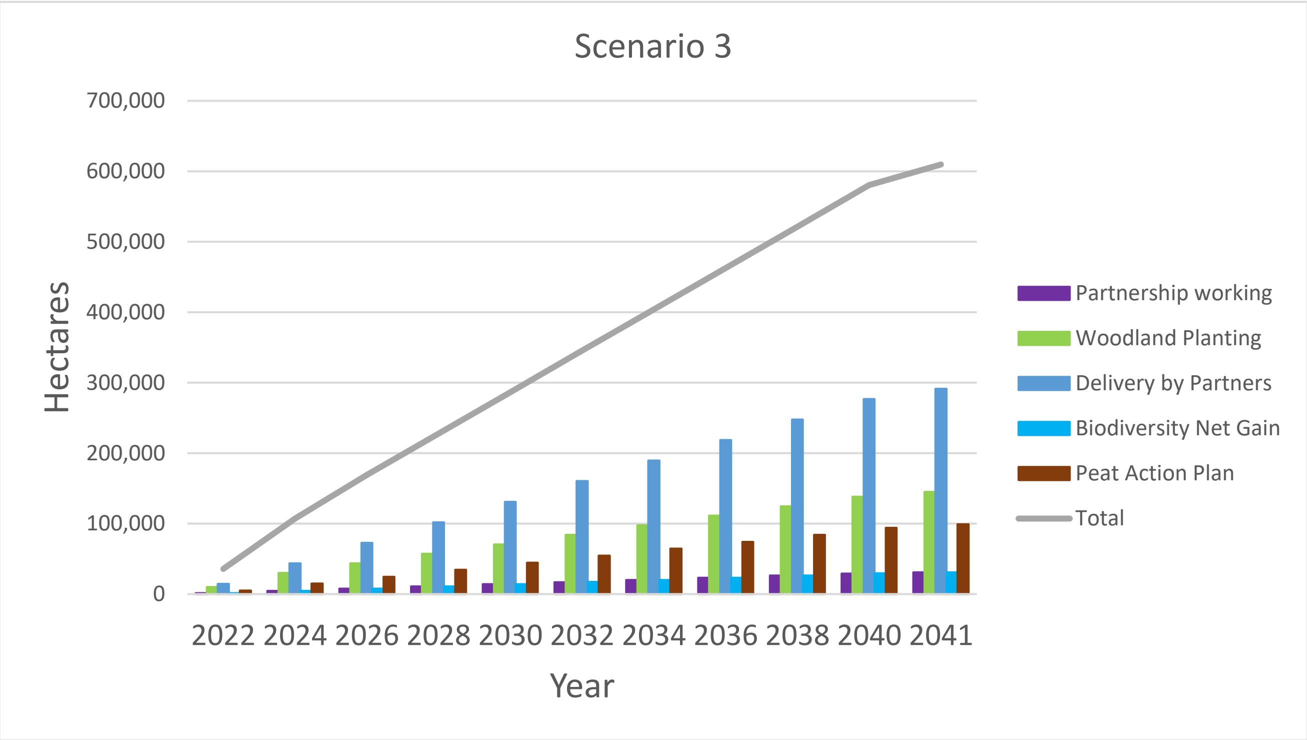
The two additional policy actions falling under this scenario are partnerships and site designations and protections. It is expected that site designations will not support the delivery of hectares of wider habitat but rather secure these against loss over time. This has therefore not contributed to the scenario.

With respect to partnership working, the Nature Improvement Areas (NIA) (11) reports show a delivery (outside of AES) of 1,541.66 ha of priority habitat per annum. If this was provided continually then it would support the delivery of the wider habitats target by providing an extra c. 30,820 ha of habitat.

A second example of partnership working, via the National Trust, aimed to deliver 25,000 ha per annum between 2018- 2025 (12). This equates to 3,125 ha per annum to 2025.

Scenario 3 is set out in Figure 6.

Figure 6: Wider Habitat Scenario 3



Assumptions:

As above, plus

- Partnership working delivery at constant rate at the maximum level (1,541.66 ha per annum).

- The figure of 1,541.66 ha per annum is reflective of all partnership working programmes. In all likelihood, partnership working would deliver different levels of outcomes however this is the only data we currently have that could inform the analysis.

Note, the figure for partnerships was taken from one study only as other data sources were not available. However, should this level of partnership working delivery be applied to the future partnerships c. 7,000 ha per annum could be delivered. This figure is expected to fluctuate depending upon the funding success of partnership working and the incentives available. **A total of 609,660 ha may be delivered under this scenario**.

Scenario 4

For 'wildlife-rich' habitats, Annex 1 defines habitat creation as establishing wildlife-rich habitat on land, freshwater, coastal, and estuarine, where it is currently not present (e.g., ponds). Whereas habitat restoration refers to improving the condition of relict or degraded habitat, leading to an expansion of the extent of the habitat (e.g., restore river meanders, reduce pollution). Restoration of habitats often requires a change in activity 'offsite' which are often widespread and/or local interventions to reduce pressures. Actions in this scenario are essential and are typical requirements for restoration.

The additional potential actions falling under this scenario are:

- Offsite remedial actions to restore habitats: Tackling diffuse pollution, including the delivery of nutrients, sediments and other agriculturally-derived contaminants from land to water.
- Sustainable farming practices to reduce pressures: management of grazing, mowing, and nutrient management planning at farm scale, to include fertilisers, manures and slurries
- Environmental land management to create habitat: Creation of ephemeral habitats: nectar-rich margins, creation of nesting and feeding sites as well as other beneficial habitats. Planting of hedgerow trees.
- Reductions in atmospheric nitrogen deposition.
- Enhanced monitoring and evaluation.
- Advice to landowners.

Initial analysis from Natural England suggests that on average a 50% reduction in nutrient pollution (total nitrogen and total phosphorus)[13] would be required across the protected site network (Natura and SSSI sites) to help reach favourable condition. Evidence for

[13] Natural England evidence collated from Catchment Specific Site Evidence summaries for Nutrient Neutrality advice (March 2022)

freshwater habitat needs outside of protected sites is unknown so this figure has been extrapolated out to wider habitats for this scenario.

To achieve an average reduction in nutrient pollution of 50%, evidence indicates that a range of measures would be needed, including regulatory compliance, increased uptake of agri-environment measures, and targeted habitat creation. Internal EA modelling of options to reduce phosphorus loads to riverine protected sites[14] indicates additional measures are likely to be required for many sites. These additional measures would need to include action to reduce point sources of nutrients. The most relevant evidence we have relates to open freshwater wider habitats, whilst not completely aligned to our proposed definition of wildlife-rich habitats, it is not unreasonable to broadly assume similar measures are necessary to restore wildlife-rich habitats (outside of protected sites). It is necessary to note that recovery from legacy pollution *in situ* in the system will also take time to reduce/remediate. The B6 indicator will assess whether the open water habitat has reached the threshold to be considered wildlife-rich; or how much deviation from this threshold there may be. The D1 indicator will do the same for the terrestrial wetland ecosystems (see section 180 above).

Presently there are no available figures for restoration of freshwater habitats. This scenario uses identified necessary action towards achieving the target and assumes effective delivery plans and implementation are in place to facilitate the scale of change and design of local measures to achieve habitat creation/restoration.

The scenario assumes that 6,000 ha of freshwater habitats are restored. This is baselined against the Water Framework Directive (WFD) definition of good status. Actions that would contribute towards this include, for example, addressing modified morphology (relevant for 41% of waterbodies) which would benefit c. 4,100- of the 10,000ha of freshwater habitats; and reducing over abstraction (relevant for 20% of surface water bodes) which could restore c.2,000 ha of freshwater habitats.

The Environment Agency aims to deliver 1,200 ha of habitat creation and restoration for the benefit of people and wildlife (13) by 2025. It has also committed to delivering a further 20,000 ha of priority habitats by 2030, primarily through flood defence schemes.

We have proposed including estuarine and coastal waters in the wildlife-rich habitat definition (Annex 1). They are likely to benefit from any actions undertaken upstream to reduce sources diffuse pollution. Coastal water habitats and freshwaters will also benefit from the proposed statutory Water target for wastewater. A long-term view to the policy solutions is being considered for resilience and adaptation in response to changes in

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[14] Environment Agency internal report produced (April 2021), Options & Costs for Delivering the Common Standards Monitoring Guidance River Phosphorus Targets

rainfall, urban creep, and population growth. However, these do not provide a figure in hectares that can be applied to the scenario analysis.

Reductions in nitrogen deposition

With respect to reductions in nitrogen deposition there is no evidence showing how this might contribute towards a hectarage based target. However, a report published by JNCC in 2020[15] shows that it is possible for the UK to, using scenario modelling, achieve a substantial decrease in risk of impacts on sensitive vegetation by 2030. Through the implementation of the UK National Air Pollution Control Programme (NAPCP) it is anticipated that we could achieve the UK Government's Clean Air Strategy target for England, defined as a 17% decrease in total reactive N deposition onto protected priority sensitive habitats, with a predicted 18.9% decrease from a 2016 base year (14). This has not been shown in the scenario as there are no figures directly relating to hectarage delivered but reductions in nitrogen are expected to deliver and maintain habitats created / restored in the long-term.

Enhanced monitoring and evaluation and advice to landowners

There is significant evidence from Catchment Sensitive Farming (CSF) on the benefits of monitoring and evaluation as well as advice to landowners (15). However, there is no data available that links these benefits to how much habitat might be delivered in hectares. This scenario assumes effectiveness of delivery of advice is in place alongside other incentives and regulatory policy/mechanisms.

Sustainable farming to reduce pressures and create habitat

At the time of the analysis the Environmental Land Management (ELM) agri-environment scheme proposed to deliver up to 325,000 ha of habitat outside of protected sites by 2042[16]. For this scenario we have assumed a constant delivery of 16,250 ha per annum. Delivery may vary per year depending on roll out of ELM and engagement with land managers and farmers. Please note that to avoid double counting we have excluded 'delivery by partners' total figure from scenario 1, because this a large part of this was based on historic habitat creation from agri-env schemes. However, there may be some underestimation of total habitat actually created as not all of 'delivery by partners' from scenario 1 was from agri-env schemes. Hence it is likely that the following scenario may underestimate delivery of habitat.

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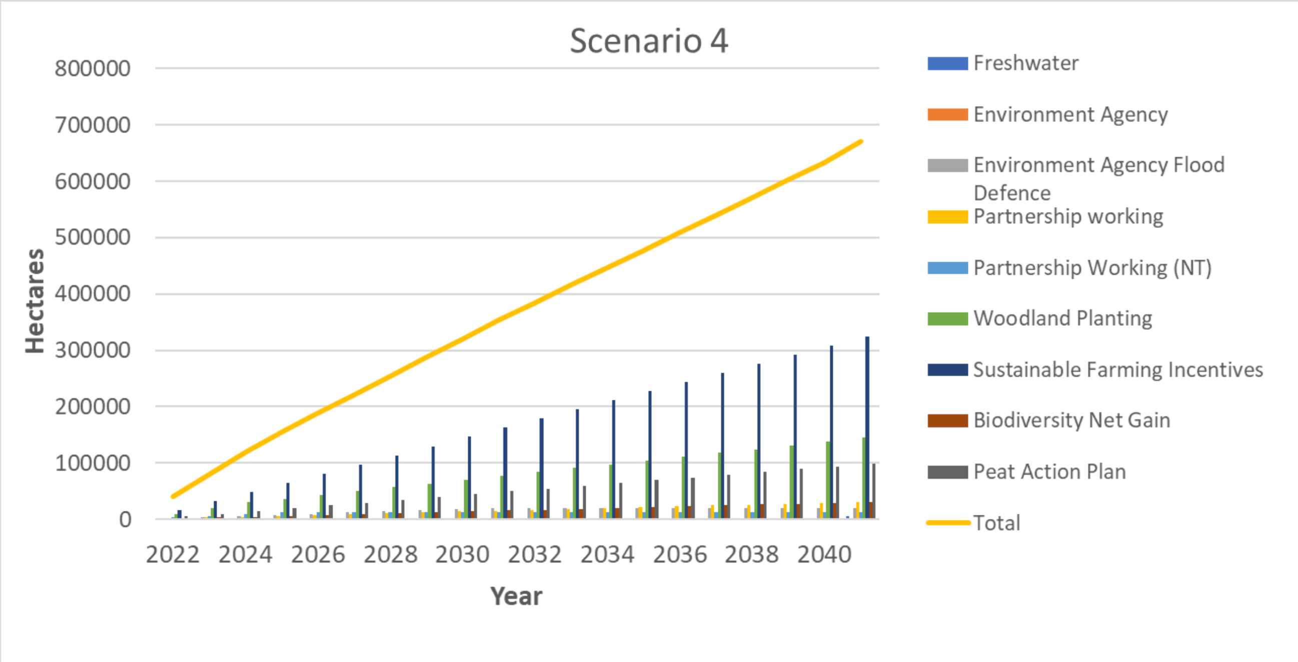
[15] Nitrogen Futures, 2020 Dragosits et. al

[16] Environmental Land Management schemes: outcomes - GOV.UK (www.gov.uk)

Figure 7: Wider Habitats Scenario 4



Assumptions:

- As above, plus
- Environmental land management schemes delivery at constant rate (16,250 ha/y)

This builds upon what would be delivered under Scenario 1, the 325,000ha delivered under environmental land management schemes and the predicted delivery of 6,000 ha restored from diffuse pollution works depending on the water target. The water target was not set at the time we produced these trajectories, so this is an estimate based on expert opinion. **A total of 670,300 ha could be delivered under this scenario (Figure 7).**

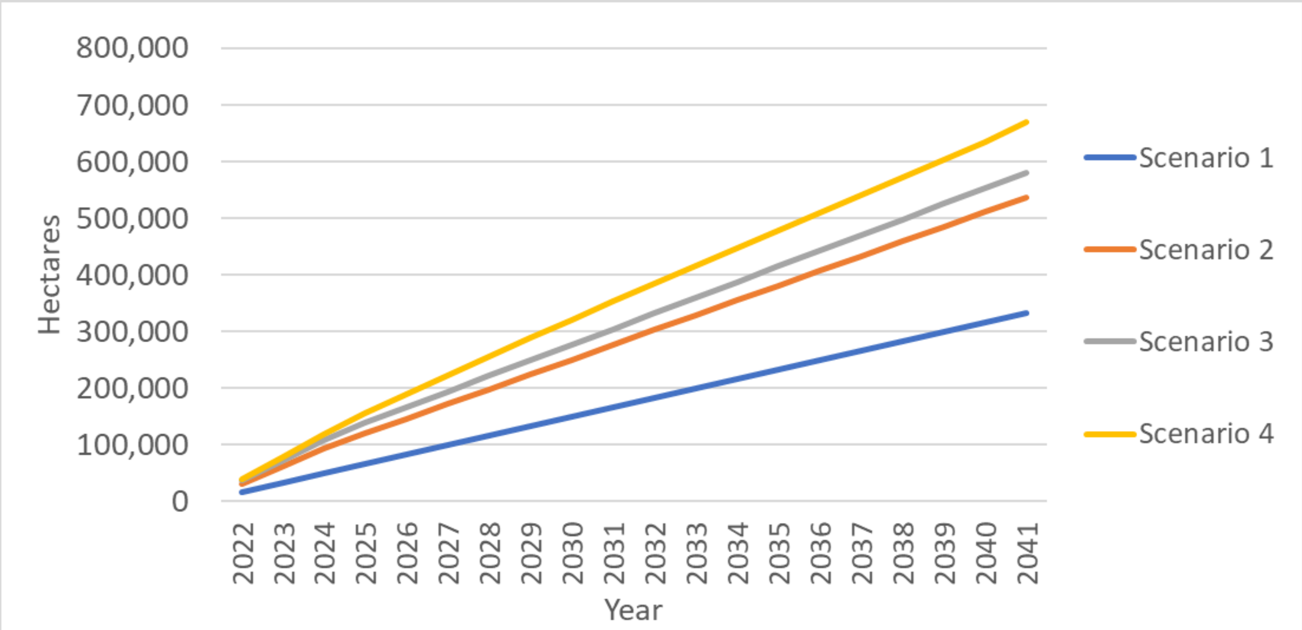
Comparison of scenarios

The above details the processes, actions and resultant impact of each of the scenarios on creation and/or restoration of wider habitats. Each scenario results in a different number of hectares delivered by 2042 as part of their associated actions (Figure 8), where:

- Scenario 1 delivers 331,900 ha
- Scenario 2 delivers 566,340 ha
- Scenario 3 delivers 609,660 ha
- Scenario 4 delivers 670,300 ha

This difference is illustrated in Figure 8 which highlights that there is little difference in final output between the Scenario 2 (orange line) and Scenario 3 (grey line). However, there is a large difference between Scenario 1 (blue line) and Scenario 2 (orange line). There is a much smaller difference between Scenario 3 (grey line) and Scenario 4 (yellow line). It should be caveated though that figures for some of the activities listed in Scenario 3 and Scenario 4 cannot be quantified and will automatically reduce the scenarios effectiveness at capturing the full extent of likely habitat delivery. We have taken advice from our advisory group to be conservative with our trajectories, this should be considered when analysing the results.

Figure 8: Wider Habitats scenario comparison of the first four scenarios over 20 years, starting from 2022



Scenario 5

The fifth scenario has not been analysed as the previous scenarios have, specifically we have not attempted to quantify the impact of identified actions. This scenario includes the more speculative actions that were identified through the workshops for which limited evidence or understanding exists.

Caveats and assumptions

Scenario 1

Data for Scenario 1 comprises mainly priority habitat delivery with some other habitats that could be classed as ‘wildlife-rich’ i.e., arable field margins. This is the best evidence available and has been used to produce an average yearly delivery rate. It is assumed this will continue, there will be no habitat losses and no action to increase delivery per year will occur. This average rate was based on delivery between 2011-2019, no data for 2020 and 2021 were available.

Scenario 2

Data provided for habitat creation under Biodiversity Net Gain (BNG) is based on projections from the BNG impact assessment and expert advice from Natural England. The lower estimate of 1,551 ha has been applied per annum, but this is expected to fluctuate. It does not account for losses. It is also unknown at this stage what habitats will be delivered and can be expected that not all would count under this target as being wildlife-rich.

Both the woodland and peatland creation / restoration goals are in development. The woodland target is a percentage of the area of England. It is expected that other delivery mechanisms contributing towards higher levels of creation / restoration will be available in the future and these increased figures will count under the Wider Habitats target.

Scenario 3

Only one example of how partnership working and advice to landowners contributes towards delivering hectares of habitat has been used within the scenario. The Nature Improvement Areas (NIA) project delivered specific outcomes; therefore, it is expected that other examples of these policy actions may delivery more or less habitat than shown here. This figure should be treated with caution. However, if this were extrapolated to all counties (as per the LNRS scheme) then the figure for delivery could be much higher at c. 7,000 ha per annum.

Scenario 4

Around 34% of the total area of farmed land in England benefited from the Catchment Sensitive Farming (CSF) scheme which provided targeted advice to landowners followed up by increased monitoring and evaluation of the outcomes (15). This equates to c. 3.3 million hectares of land included in the scheme. This figure has not been included within the scenario as it would significantly skew what is considered to be deliverable under the policy action ‘advice to landowners’. Furthermore, it is not clear how much of it represents habitat creation.

The data on how much priority and wildlife-rich habitats will be delivered through Environmental Land Management is limited at this stage. For the purposes of this analysis, in Scenario 4, the figure of 325,000 ha from the Environmental Land Management outcomes paper and assumed constant annual delivery of 16,250 ha per annum. This may not reflect actual delivery and will be updated for future impact assessments based on the latest data from the future farming programme. .

Similar to the approach set out previously for woodland planting, habitats delivered under Scenario 1 by Environmental Land Management schemes will henceforth count under ‘delivery by partners’. As such, Scenario 1 contributions are removed to reduce the risk of double counting.

Conclusions

Target Ambition

The 25 Year Environment Plan proposed a total figure of 500,000 ha over a 25-year period. In terms of ambition this represents a continuation of the Biodiversity 2020 ambition of 200,000 ha over 10 years. However, it is important that this target contributes adequately towards the species abundance target and represents a full range of habitats, particularly where habitat expansion is seen as necessary for habitats to reach favourable conservation status[17].

The scenarios suggest that 670,300 ha of wildlife-rich habitat could be created, depending on the policy pathway adopted as the scenarios have sought to model. Published (16) and unpublished habitat specific definitions (statements) provide estimates for the extent of habitat that requires restorative action to achieve favourable conservation status.

However, as outlined above there are many variables that impact the reliability of the scenarios developed. Table 2 below sets out a current RAG rating for Wider Habitats and resulting potential legislative target.

Table 2: Wider Habitat RAG rating of the areas that influence the reliability of the model which feeds into the potential target level to be set in legislation.

	Red	Amber	Green	Notes
Data Availability i. Frequency of collection ii. Coverage (England) iii. Representative (Species/Habitats) iv. Existing baseline and trend		X X	X X	i. Data are collected from a variety of partners under current Biodiversity 2020 reporting for Outcomes 1A and 1B. Data are also collected on Agri-Environment Schemes currently. Further data collection methods will be required for Biodiversity Net Gain etc. ii. Current reporting covers England.

[17] Defining Favourable Conservation Status in England (EIN062), 9th June 2021

				iii. Current reporting covers priority habitats, however this target will expand to wildlife-rich. iv. Existing baseline comprises data from Bio 2020 and is suitable for use.
Indicator suitable for measurement		X		The indicator is suitable for an action-based target although a condition metric would be preferable and is in development.
Scale of assumptions		X		A range of assumptions and caveats are included in the analysis
Actions v. Is delivery method/mechanism clear vi. Is this clear in development of scenarios		X X		V. Whilst some mechanisms are either in place or in development, there are many unknowns on the amount of habitat they will deliver. VI. This is considered in the scenarios as far as possible
Consensus between expert opinion and scenario analysis			X	Currently the trajectories for wider habitats align with what expert opinion believes is achievable (See footnote 9).

Species

Introduction

The Government has committed in the Environment Act 2021 to set a historic target to halt the decline in the abundance of species by 2030. This will be complemented by the proposed species extinction target which seeks to also protect the most vulnerable species. These proposed legal targets will provide statutory underpinning to achieving the 25 Year Environment Plan goals and create a mechanism by which we can monitor progress against species recovery commitments and actions in England.

Targets on species abundance and status will not only support actions for species recovery but also provide an indicator of wider ecosystem health. Ultimately, targets in this area will drive action to improve the extinction risk of species and underpin actions to recover wider nature. It will help attract investment and action from NGOs, landowners and the wider public.

Data availability

Data collection and availability

This section summarises the data and indicators that are available to monitor species trends.

Much of the data on species is collected through well-established volunteer-based recording schemes, many of which are run through partnerships between government bodies, NGOs and research organisations (Table 3)[18].

[18] https://jncc.gov.uk/our-work/surveillance-schemes/

Table 3: JNCC supported UK species recording schemes and value for money programmes

Structured schemes
Breeding Bird Survey (BBS)
Wetland Bird Survey (WeBs)
Goose and Swan Monitoring Programme (GSMP)
Avian Demographics Scheme (ADS)
Seabird Monitoring Programme (SMP)
National Bat Monitoring Programme (NBMP)
UK Butterfly Monitoring Scheme (UKBMS)
National Plant Monitoring Scheme (NPMS)
Ad hoc recording schemes
Rare Breeding Birds Panel (RBBP) collation of breeding bird records
Support of recording schemes and societies through the Biological Records Centre (BRC)

In addition to the schemes supported by JNCC, national recording schemes exist for pollinators[19] moths[20] and Amphibians and reptiles[21].

Structured schemes where data are collected annually, following a strict pre-determined protocol, allow reliable conclusions to be derived from the data on the national status of species and how their populations are changing in the long term. The methods used vary by scheme to allow data collection to be appropriate for the target taxonomic group, but include repeat sampling in randomised stratified surveys, complete censuses and targeted

[19] https://www.ceh.ac.uk/our-science/projects/pollinator-monitoring

[20] http://www.mothscount.org/text/27/national_moth_recording_scheme.html

[21] http://www.narrs.org.uk/

surveys. Schemes may weight sampling to areas of interest e.g. the NPMS sample locations are weighted towards sampling semi-natural habitats, but planned biases of this nature can be accounted for in analysis to understand national species trends.

Alongside these national structured schemes, there are also many UK schemes aimed at engaging the public with recording wildlife (e.g. the Big Garden Bird Watch, the Great British Wildflower Hunt). These and similar “entry-level” schemes involve recording at more self-selected monitoring sites and may focus on recording a subset of more common species, as such they are less useful for determining national trends over time.

As well as contributing to recording schemes, each year amateur recorders submit many thousands of *ad hoc* species records to publicly available databases (e.g. to the NBN Atlas via the iRecord online recording system). These data are more numerous than records submitted from structured schemes and cover a greater breadth of taxonomic diversity. They can provide information on species distribution (rather than abundance) but may introduce greater bias in the data as sampling is more common for easily recognised species and in accessible locations. Both *ad hoc* recording and more “entry-level” recording schemes are important for developing and maintaining taxonomic skills and encouraging engagement with biological recording.

Additional unstructured species data will exist at the local level (including the Local Environmental Record Centres (LERC)) and academic institutions. Data from unstructured schemes is used for Red List assessment, however low confidence records are removed (especially important for rare taxa).

LERC data are not routinely used for Red Lists because of costs involved) but many recorders send their data to multiple databases.

Data analysis and assessment

The information gathered from these schemes is used to assess trends in distribution and/or abundance at UK, GB or country scales, and to produce evidence both on current status and long- and short-term changes. Many of the results feed into the UK and England biodiversity indicators[22], as well as being used for wider reporting purposes, including for international commitments. Data collected through these schemes also contribute to national official statistics on UK biodiversity while *ad hoc* data contribute to Red List assessments and distribution-based indicators. For the two proposed species targets those schemes that provide robust long-term data on abundance and all data that contributes to Red List assessments have informed the species abundance and extinction risk target development, respectively. More detail on how these data were used in target development is presented in the remainder of this section.

[22] https://jncc.gov.uk/our-work/uk-biodiversity-indicators/

Official statistic UK level indicators[23] are available for:

- UK priority species (abundance and distribution)
- Birds of the wider countryside (abundance) (National Statistic)
- Breeding farmland birds (abundance) (National Statistic)
- Breeding woodland birds (abundance) (National Statistic)
- Breeding water and wetland birds (abundance) (National Statistic)
- Breeding seabirds (abundance) (National Statistic)
- Wintering waterbirds (abundance) (National Statistic)
- Butterflies (abundance)
- Bats (abundance)
- Pollinating insect (distribution)
- Abundance and distribution of cetaceans other than coastal bottlenose dolphins
- Abundance and distribution of coastal bottlenose dolphins
- Abundance and distribution of seals
- Abundance of marine birds
- Distribution of marine birds
- Abundance of fish (biodiversity)
- Plankton biomass and abundance
- Physical loss of seafloor habitats

The England Biodiversity indicators includes England-level indicators for:

- Breeding birds on farmland (abundance) (National Statistic)
- Widespread butterflies on farmland (abundance)
- Widespread bats on farmland (abundance)
- Breeding birds in woodland (abundance) (National Statistic)
- Widespread butterflies in woodland (abundance)
- Breeding wetland birds (abundance) (National Statistic)
- Wintering waterbirds (abundance) (National Statistic)
- Breeding seabirds (abundance) (National Statistic)

The data that underpin these indicators are used to contribute to various other publications, such as the State of Nature Report (17) and those that meet criteria set out below contribute to the species abundance target being proposed.

Data quality and consistency

Volunteer-based biodiversity recording allows deployment of many individuals to record across the country during a set time period. This allows more data to be collected annually

[23] https://www.gov.uk/government/statistics/biodiversity-indicators-for-the-uk

than would be feasible using professional surveyors. Bigger biodiversity datasets mean that trends produced through their analysis are likely to be more representative of national change. Large sample sizes reduce the impact of annual changes in participation and sample location on the national species trend evaluation. Structured schemes invest significantly in volunteer training, support and resources to enhance the accuracy of species records made by volunteers, many of whom have significant taxonomic skill. All records undergo automated and/or manual verification procedures to “clean” anomalies from datasets before analysis. Many schemes have collected long time series of data with consistent methods. Where changes to methods have occurred, the effect of these changes on the data series have been investigated to allow continuous trends to be evaluated. The official statistics adhere to the Code of Practice for Statistics[24] overing the three pillars of trustworthiness, quality and value.

It is known that structured scheme sampling involves bias. Some biases are built into stratified sampling protocols; others are known because the nature of the schemes involves sampling self-selected, high-quality habitats using a set protocol over a long time period. Some bias is less controlled due to the necessity of giving volunteers some choice over where they record, to retain their interest. For example, there is a general trend in schemes for under sampling in more remote and inaccessible areas, some urban areas, and some areas perceived as “less interesting” e.g., large homogeneous arable regions. The effect of these biases is less evident in England than other countries of the UK, given a more evenly distributed volunteer population.

There is ongoing research and development work into improving the evidence generated from volunteer schemes, including reducing bias in volunteer datasets, enhancing verification methods, and integrating different types of volunteer datasets to better understand species trends at finer spatial scales.

Indicator selection

The data for species can be presented in many ways to represent different taxonomic groups (e.g. butterflies); species within specific habitats or contexts (e.g. woodland) and different aspects of species population (e.g. distribution). In considering indicators for species targets we took the indicators from the 25 Year Environment Plan Outcome Indicator Framework as a starting point, whilst considering whether the legally-binding nature of targets made other indicators more suitable. The 25 Year Environment Plan Outcome Indicator Framework identified 4 indicators specific to species, within which are multiple measures of species status. The requirement for targets to be quantitative and allow a clear assessment of when the target has been met means that each target should

[24] Code of Practice for Statistics

have a single measure. Below, we discuss how the assessment against the defined criteria shaped our proposed targets and indicators, and outlines the perceived benefits, disadvantages and challenges. This section has been informed by discussions between Defra, Natural England, JNCC and members of Defra's Science Advisory Council and the Biodiversity Targets Advisory Group, as well as research.

Species coverage and indicator sensitivity

The number of species varies between indicators, from 214 species for *Status of priority species: relative abundance*, to nearly 8,000 in the D5: *Conservation status of our native species* indicator (in development). Targets where the analysis includes data for a wide range of species, should remain relevant over a longer timescale and avoid focussing on a narrow set of taxonomic groups that could drive perverse outcomes on the assumption that those data are representative and accurate. The proposed indicator for extinction risk is based on GB red list assessments (D5) has the widest species coverage of all the indicators and is directly relevant to domestic and international commitments to prevent further human-induced extinctions and improve the status of threatened species. The Red List process is well-established internationally and easily communicable. Repeated Red List assessments can then be used to derive a Red List Index using well established methods to capture changes in extinction risk through time. The wide species coverage does mean that it can be difficult to draw any meaningful trends, without subdividing the data into smaller taxonomic groups. This is true for the Global Red List Index which has changed little since its development.

Species coverage is closely linked to sensitivity and the potential for change in some species to be masked by change in others. Indicators of abundance are the most sensitive to change but are only available for a small number of species where regular structured monitoring programmes are in place. This sensitivity will be useful in demonstrating whether policy action is leading to improvements, especially over the timescale of interim targets. The sensitivity resulted in abundance being recommended for targets over distribution indicators despite the wider number of species included in distribution indicators. In addition, in some situations, species distribution can increase while abundance declines.

A combined abundance and distribution indicator was considered. Ecologically, these metrics are not comparing the same attributes, so to combine them would conflate a change in the abundance of a particular magnitude with a change in distribution of the same magnitude. A combined indicator also diverged from the proposed indicators in the 25 Year Environment Plan Outcome Indicator Framework.

We know that structured monitoring, and thus abundance and distribution indicators are biased towards characteristic species (e.g., birds and butterflies), which makes capturing changes in populations of very rare species, those with limited distributions and challenging to record, where changes will be masked by larger changes in populations of more widespread and abundant species. One of the challenges is the limited data available for rarer species due the lack of structured surveys which makes the changes in population difficult to model. A standard monitoring programme is unlikely to record rare species in sufficient numbers to be able to monitor their populations adequately.

The D5 Red List Indicator is still in development. There is a baseline of assessments for nearly 8000 species but repeat assessments have yet to be made for most taxa and there are some significant gaps in coverage, notably marine and freshwater species, many fungal groups, algae and some invertebrate groups including micro-moths. Therefore, unlike for the abundance and distribution indicators, we have no historic trend information and have less knowledge on how this species status will change over time. In addition, there is no systematic data collection for many of the species and there is a risk that identifying change between reassessments could be hampered by insufficient data. Evidence shows that even with a high frequency of repeat assessments, a Red List Index will only be sensitive to biodiversity change over decades, rather than years, with an expectation of small changes in the Red List Index trend. However, the Red List Index remains the recommended, most consistent assessment available for measuring progress against extinction risk.

Geographical representation

England-only abundance and distribution indicators have been produced and are awaiting quality assurance. The vast majority of the available Red List Status Assessments are GB in scope. Ideally, as the targets are for England the indicators should be responsive to action taken in England.

We are proposing two species targets based on the two species indicators:

D4: Species abundance index for England

D5: Extinction risk of our native species- Red List Index

No one metric will fully represent all aspects of species status. The following sections discuss how the indicators have been developed balancing different requirements.

Detail on the evidence development for species abundance is covered in below and is then followed by evidence for the species Extinction risk target.

Targets: Species Abundance

Summary

Proposed 2030 target – to meet Environment Act 2021 commitment

- To halt the decline in species abundance by 2030

Proposed long-term target

- To increase species abundance by at least 10% by 2042, compared to 2030 levels

The following section summarises the evidence and analysis that has informed the development of proposed targets for species abundance. Key points covered in this section of the evidence report are:

- The proposed indicator covers 1,071 species for which we have sufficiently robust data. The indicator initially included birds, bats, butterflies, moths and has been expanded to include 164 plant species and 237 freshwater invertebrates, to make it as representative as possible, subject to the data that is available.
- Modelling for the species abundance targets was developed by UKCEH, RSPB and QMUL, with guidance from Defra and Natural England. Due to evidence limitations and high levels of uncertainty, it was not possible to precisely model how the species abundance indicator might change in response to specific actions over a twenty-year period.
- Increasing species abundance by at least 10% between 2030 and 2042 could be considered to be ambitious, but statistically plausible based on UKCEH's initial high level quantitative analysis. UKCEH's analysis also suggests that the level of improvement necessary to halt the decline by 2030 would result in a 2042 index value similar to 2022 and be roughly equivalent to a 10% increase on the 2030 value. This modelling does not consider the wider factors that would define the feasibility of achieving this ambitious target.
- Increased habitat creation and restoration, improved water quality, alongside improved agri-environment schemes with significantly increased spatial coverage will all be needed to increase species abundance, to support the delivery of the target to halt decline by 2030 and the proposed target to increase abundance by 10% by 2042 relative to a 2030 baseline. Given the level of ambition/challenge, it will also be necessary to reduce wider pressures on biodiversity such as, but not limited to, pesticide use, and improving the condition of protected sites.
- Due to the limited time-period and time-lags involved both in terms of creation and ecological response, habitat creation and new agri-environment schemes will have a greater impact on trends in abundance beyond 2030. Achieving the target to halt declines in species abundance by 2030 is therefore extremely challenging and ambitious. During this period, it will be particularly important to reduce pressures such as pesticides, improve the condition of existing priority habitat in protected areas, rapidly increase the extent of habitats that are quick to establish, and improve water quality.

Desirable qualities for an abundance indicator

The Living Planet Index[25] (LPI) is an international standard for measuring annual changes in the abundance of (vertebrate) populations around the world. We seek something that is broadly comparable: one index to summarise trends in abundance for the broadest possible set of organisms.

The 25 Year Environment Plan Outcome Indicator Framework outlined the intention to develop indicator D4: Relative abundance and/or distribution of widespread species. Aggregating and building on existing UK-level and England indicators (listed in the data availability section above) to produce an England abundance and distribution indicator.

The index and target are framed in terms of the abundance of species. In order to assess whether the target has been met, it is essential that the data measure changes on a regular basis (i.e. annually). In order to indicate change, it is essential that the data are collected in a consistent manner over time. The first criterion, therefore, is that datasets should have a standardised protocol which delivers annual measures of abundance that are comparable over time.

A desirable property is that the index should be representative of English biodiversity. This has two components. One component is that it should contain data from a broad set of organisms, although the taxonomic coverage of current data is limited by the monitoring schemes that already exist. A second is that the data come from a spatially replicated survey design with coverage across England. Time-series of individual populations are not likely to be representative, except for species for which it is the sole population in England. Thus, our second criterion is that the data should come from a spatially replicated monitoring scheme, except for cases where the vast majority of individual species are counted. In this criterion we differ from the LPI, which is a collation of individual time-series.

Ideally the sample sites would also be a random sample of the English landscape. Datasets that we have identified below include schemes for which the sites are selected at random (e.g., Breeding Bird Survey) and those that are volunteer-selected (e.g., Butterfly Monitoring Scheme). Note that even randomly selecting sites may not be sufficient to guarantee that the sites with data are wholly representative, because some sites in remote parts of the country may fail to attract a volunteer to collect the data.

The target relates to the abundance of species. The index should therefore represent changes in the abundance, averaged across species. The LPI and UK Biodiversity Indicators do this using the geometric mean abundance. Thus, it is desirable that the data going into the index should measure the abundance of species, rather than some higher

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[25] Living Planet Index

taxonomic group (e.g., family). However, in some cases it may be desirable to include data at some intermediate level (e.g., species aggregate or genus level) in order to boost the taxonomic coverage.

In summary, our three criteria for including data in the index are:

1. Standardised protocol delivering annual abundance indices
2. Spatially replicated survey design with coverage across England
3. Taxonomic resolution ideally to species level.

Indicator development

The initial iteration of the indicator took abundance data from seven datasets, consisting of 670 species in total (Table 4). All these datasets have been previously used for indicators of abundance at UK level (the Priority Species indicator, C4a) and contribute to a Terrestrial Abundance Indicator for Scotland. Many of these datasets have time-series going back to the 1970s, although some species have shorter data runs and missing years in the middle of the time-series; virtually all species have a complete run of data since 1998. At the point at which data were collated for the first phase of developing this indicator, time-series were available up to 2016 for three datasets, 2017 for two datasets and 2018 for four datasets.

Table 4: Datasets contributing to the initial version of the abundance index

Abbreviation	Name	Taxon	Timespan	Nsp
SCARRABS	Statutory Conservation Agency and RSPB Annual Breeding Bird Scheme	Birds	1971-2016	7
NPMP	National Bat Monitoring Program	Mammals (bats)	1998-2018	10
prior_m	Priority Moths	Moths	1991-2016	10
SMP	Seabird Monitoring Program	Birds (seabirds)	1986-2018	11
WeBS	Wetland Bird Survey and England Wintering waterbird indicator	Birds	1975-2017	21

RBBP	Rare Breeding Bird Panel	Birds	1970-2017	21
UKBMS	UK Butterfly Monitoring Scheme	Butterflies	1976-2018	55
BBS	Breeding Bird Survey and England Breeding bird indicators	Birds & terrestrial mammals	1970-2018	114
RIS	Rothamsted Insect Survey	Moths	1968-2016	421

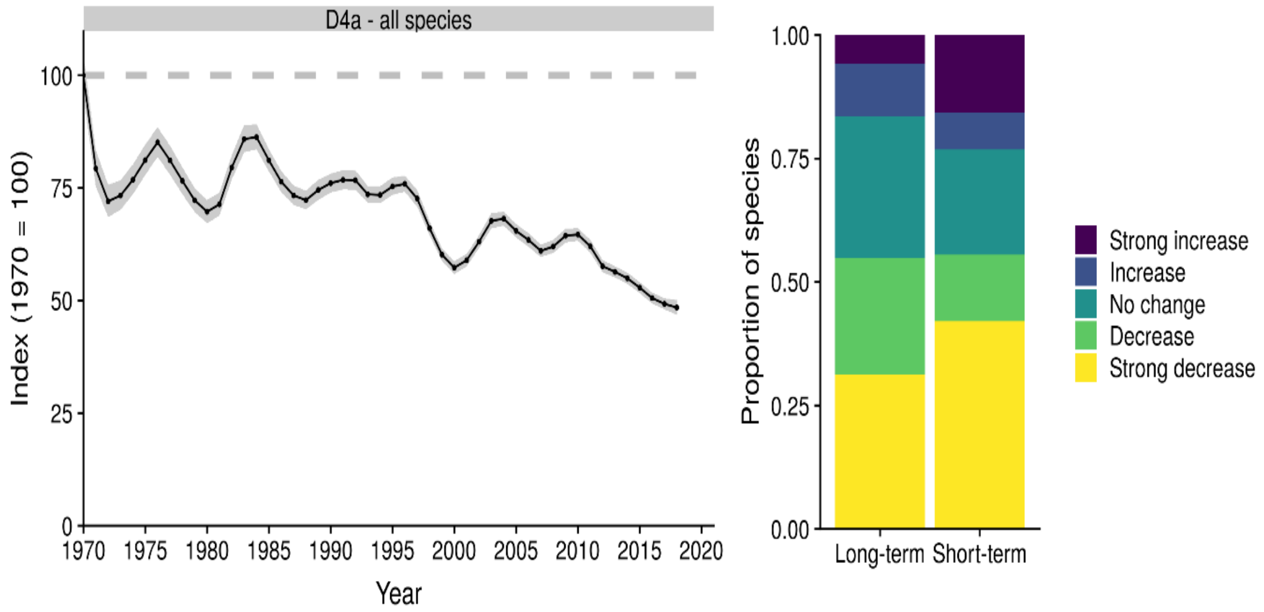
All meet criterion 1 (standardised protocol), although by different means. For example, the RBBP delivers absolute counts of individual birds, whereas the UKBMS, RIS and NBMP produce an index of abundance derived from a statistical model.

All meet criterion 2: the NBMP, BBS, UKBMS and RIS all have national coverage and large numbers of sites (>1000 for NBMP & BBS). The BBS and NBMP have a spatially stratified sampling design that ensures that landcover and habitats across England are properly represented. The SCARRABS, Priority Moths, SMP, RBBP and WeBS datasets all cover specialised species with restricted distributions, and the schemes each capture the majority of the populations in England for those species. Sites for the RIS and UKBMS data are more opportunistically located, so particular habitat types are likely over-represented.

All meet criterion 3. A very small number of species are reported as aggregates, e.g. some butterflies that are difficult to distinguish on the wing.

The UK Centre for Ecology and Hydrology and RSPB presented a composite multispecies index of all 670 species to Defra in March 2021. The indicator used a new method that estimates the geometric mean abundance with smoothing *in situ* and accounting for intermittent data. The index has a value of 48 in the final year (2018), indicating that average abundance has declined by 52% since 1970.

Figure 9: Version 1 of the abundance index: Change in the relative abundance of 670 terrestrial animal species in England, 1970-2018. Source: UK Centre for Ecology and Hydrology



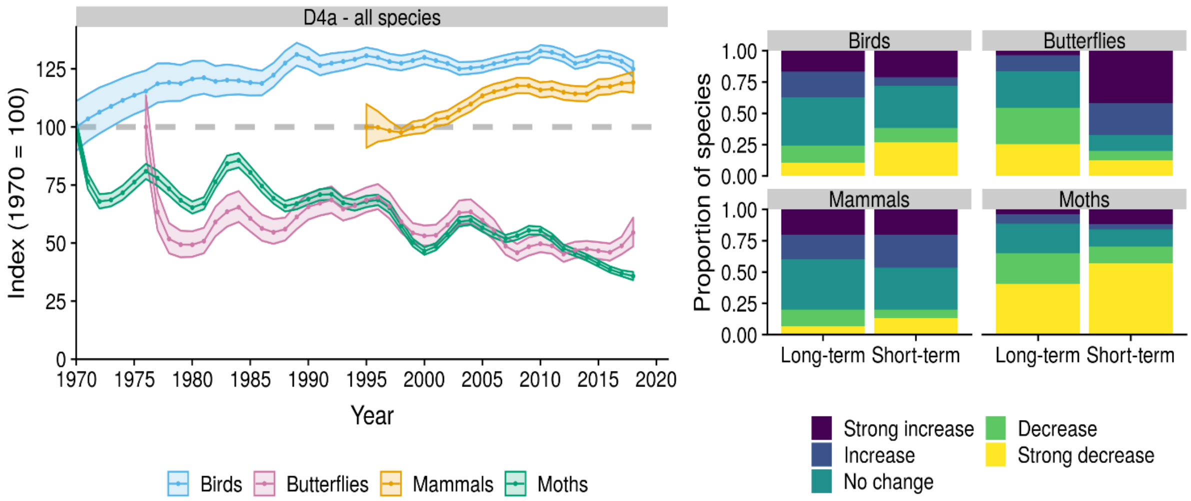
The trend in the index has been remarkably consistent in recent years (Figure 9). In each of the past six years, the index has fallen by 0.8-2.3 percentage points, representing a decline in abundance of 2.8% per year, on average. This rate of loss is our best guide to future change under "Scenario 1", so any target to increase abundance by 2042 must factor in the need to turn around this steady erosion of biodiversity in recent years. The Environment Act 2021 commits to setting a target on species abundance for achievement by 2030.

The initial species abundance index represented just four groups (mammals, birds, butterflies and moths) from three major taxa (butterflies and moths being from the same insect order, Lepidoptera), with no representation of plants, or of freshwater ecosystems. Whilst there was general support for progressing an abundance index similar to the Living Planet Index discussions with stakeholders and experts (including BTAG) recommended further exploration of representativeness of indicator and potential to broaden species coverage.

A related concern was that trends in the four groups have been very different (Figure 10); Moths (and butterflies) have declined markedly whereas birds and mammals have increased, on average. This is exacerbated by the fact that the constituent taxonomic groups are made up of markedly different numbers of species: nearly ⅔ of the total (431 out of 670) were moths, and ⅔ of the remainder (169 out of 239) are birds. While this means that moths are likely to have a disproportionately strong pull on the indicator, their distribution covers a diverse range of habitats, such as grassland, heathland, woodland and scrub habitat mosaics. These habitats are also important for a diverse range of other species that are not included in the indicator (due to insufficient data). A review in 2021 by Dar and Jamal provides an overview of how moths have been used as ecological indicators for different environmental pressures.

Thus, the choice about how to weight the dataset has a potentially large impact on the degree to which the putative targets can be achieved. We sought to address these issues and they are addressed in the following sections. Weighting the index and expanding species coverage were explored.

Figure 10: Trends in the abundance of species in each of four major groups, 1970-2018. ***Source: UK Centre for Ecology and Hydrology***



Exploring options for a weighted index

One suggestion to address concerns around representativeness was to weight the contribution of species according to some value-based set of rules to achieve better representation of biodiversity. Different options for weighting were considered and sensitivity analysis undertaken to explore the impact of five weighting options in terms of the change in the index value arising from the addition or deletion of one dataset.

The initial iteration of the indicator weighted each species equally. This is standard practice in all UK Biodiversity Indicators, the Living Plant Index (PLI) and most others around the world.

The LPI also includes a weighting system to ensure that each group of vertebrates is represented in proportion to the number of extant species globally, rather than the number with data, as well as a weighting to correct for the over sampling and under sampling of different regions (Europe and North America being oversampled).

Any decision to weight species comes with a set of assumptions about how the abundance of those species with data are capable of indicating the status of a larger set of species for which no data are available. Equal weighting assumes that all species are equally indicative of the true average abundance of all species. Weighting by diversity (as in the LPI) assumes that species within each major taxonomic group are indicative of trends within that group, but not of species in other taxa. It is important to recognise that there is no objective 'right answer' for how to weight species. Rather, the decision to weight species is essentially a subjective statement about the values that the index is intended to embody.

Table 5 shows the different weighting options that were considered. The first alternative to equal weighting for species is to weight taxonomic groups equally, to create a metric that is the average of the trends in Figure 10 (i.e., one trend each for butterflies, moths, birds and mammals). This would address the current bias towards moths but would create other issues that may not be desirable. The first issue is that each of the 15 mammal species would the exert almost 29 times as much influence on the trend line as each moth species. A second problem is that it's not obvious which taxonomic level to choose. Butterflies and Moths are in one Order of the Class Insecta, so we'd get a different answer if grouping by Linnean Classes than by groups that are familiar to ordinary people. We'd get a different answer again if we gave equal weight to vertebrates and invertebrates. So, this option suffers from substantial subjectivity in how it is implemented.

Alternatively, we could choose to weight the taxa by the degree to which they represent the actual known diversity of that group, as in the LPI. In the case of this dataset, it would further amplify the "moth effect", given that moths and butterflies represent a far smaller fraction of English insect species compared with birds and mammals. This method also assumes that trends in the unsampled species would match those sampled when there are strong reasons to suspect they might not, although this is true for all methods to a degree. Other proposals include weighting by biomass, representation of particular habitats, or number of populations. The rationale, implications and challenges for these different weighting options (and others) are outlined in Table 5. Note that not all of these options are implementable with current data.

Table 5: Implications and challenges with each option.

Weighting option	Rationale	Implications and challenges
Equal weight to each species (current approach)	All species with data are equally representative of the status of species for which no data are available	• Easy to communicate and understand. • Standard practice in UKBI. • Do not have a random subset of all species.

	Lack of an objective 'right' way to weight the data	• Does not address biases in the data availability that have a large influence on the indicator.
Equal weight to each taxonomic group Butterflies, Moths, Birds, Mammals Class (Insects, Birds, Mammals) Vertebrates, Invertebrates	Each taxonomic group has equal value (as opposed to each species). Not all taxonomic groups are represented by the same number of species.	• Can make the meaning and communication of the indicator less transparent. • Subjective statement about the values of higher taxa. • Impact on the indicator will vary depending on which taxonomic level weighting is conducted. • Only have data for limited number of taxa. • Cannot correct for biases in instances where no data is available at all.
Weight by degree of representation of taxonomic group (similar to method used for LPI)	Not every species of each taxonomic group is represented. Not all taxonomic groups are represented by the same number of species. Some taxonomic groups are more diverse than others.	• Can make the meaning and communication of the indicator less transparent. • More complicated than for LPI because of the addition of invertebrates. • Insects will have a much greater influence on the indicator than other groups. • Impact on the indicator will vary depending on which taxonomic level weighting is conducted. • Would be more effective if more taxonomic groups are added to the indicator. • Cannot correct for biases in instances where no data are available at all.

Weight by biomass of taxonomic group	Indicator would be a measure of total mass of living organisms	• Difficult to communicate • Lack of good data to estimate biomass
Equal weighting to different habitats/geographic areas	Species composition within the indicator may be biased towards those using widespread and accessible habitats	• Requires a decision on how to define habitat types. • Cannot correct for habitats that are not currently represented at all.
Weight by the degree of representation of habitat type	Trends for individual species may be biased towards certain habitats	• Requires a decision on how to define habitat types. • Cannot correct for habitats that are not currently represented at all.
Equal weight to each dataset	Data for each group of species come from different datasets No clear rationale behind weighting in this way	• Species recorded in smaller datasets would exert greater influence than species recorded in larger datasets.
Weight by degree of precision of the datasets	More confident in the precision of some datasets than others	• Don't have the information for all of the datasets
Weight by number of populations	Species that are more widespread are over-represented	• Rarer species will have higher influence on the indicator. But weighting in this way would put more value on those species.

Sensitivity analysis was undertaken to understand the impact of the different weighting options. We find that most datasets exert a "pull" on the index that is proportional to the number of species that it contains. None of the alternatives offers a big advantage to the default of equally weighting for each species, either in terms of the statistical properties or the degree to which the index can be communicated to stakeholders.

Expanding the indicator to include additional species

Here we describe the expansion of the index to plants and freshwater invertebrates, thus addressing many of the concerns about taxonomic representation. We describe the two datasets, their readiness for inclusion. We then present a "first cut" of an index version 2 that includes both datasets, taking the total number of species to over 1,000.

National Plant Monitoring Scheme

The National Plant Monitoring Scheme[26] (NPMS) was launched in 2015 to produce annual measures of abundance for plants. The scheme has national coverage across the UK, with repeat samples taken on a weighted-random selection of 1 km grid cells using a standardised protocol. The scheme therefore meets all the essential requirements for datasets identified above.

A bespoke statistical model has been developed to estimate annual indices of abundance of plants in specific habitats. In August 2020, NPMS data was used to create an experimental statistic "C7: Plants of the Wider Countryside"[27] for the UK Biodiversity Indicators, using the first five years of data.

The NPMS data therefore provides an ideal opportunity to expand the taxonomic scope of the English abundance index to include plants. The short time-series means that adding NPMS data now would not lead to dramatic changes in the status of the index, nor provide much information about the degree to which specific policy interventions might influence the future trajectory of the index. However, including NPMS data would greatly increase the representativeness of the index going forward.

The C7 experimental statistic was presented as four separate measures: Arable field margins (24 species), Lowland Grassland (85 species), Broadleaved woodland & hedges (64 species), Bog & wet heath (41 species). Models for species in other habitat types have been fitted but were not included in the C7 experimental statistic. Thus, a substantial amount of data on trends in plant abundance is available for inclusion in the index now. Here we discuss the caveats and issues that should be addressed before the index is published:

a) Existing models use only those survey locations that fall within one of the four habitat types named above. So, the results represent only those four habitats but not others. There are eleven focal broad habitats for NPMS: models already exist for all eleven habitat types, although models for a majority of species have not been through a formal quality-assurance process.

[26] National Plant Monitoring Scheme (npms.org.uk)

[27] https://hub.jncc.gov.uk/assets/ffedfa90-0764-479f-a0bd-65adf326c0c0

b) A number of species contribute to more than one of the four habitat-specific measures, so the total number of species represented is 198, not 214. It would not be appropriate for any species to contribute multiple times to the index, so some kind of averaging would be appropriate. It would be relatively straightforward to calculate the mean effect for each species across habitats, although this may not be the most appropriate treatment. Rather, it may be appropriate to weight the effect of each habitat according to the degree to which it represents the range of that species. In addition, some consideration should be given to the degree to the relative uncertainty of parameter estimates from the different models.
c) The NPMS is a UK scheme and the existing models include all sites in the scheme. Ideally, the models would be refitted using only sites in England: there are currently no plans within the NPMS workplan to fit country-specific models. The majority of sites are within England for three of the four habitat types, so we would not expect a dramatic change in the index values for most species. The exception to this rule is the Bog and wet heath habitat, it would not be appropriate to include UK models for this habitat. Including the current UK model outputs would be reasonable for the other three habitats, if caveated by the assumption that UK trends represent England.
d) It is recognised that further improvements to the modelling framework are required to address time-varying spatial biases in the underlying data. Work to address these biases is a priority for the NPMS workplan. Thus, a revised set of statistics that account for spatial bias are likely to be produced during the next year. Thus, the existing data should be treated as preliminary[28].

Based on the above analysis and considering the caveats and assumptions the 164 species with existing models in three habitats (Arable field margins, Lowland Grassland, Broadleaved woodland & hedges) have been added into the model. For five of these species, we take the average index value in two habitat types. This should be followed by a program of work to be conducted in collaboration with the NPMS team to address the issues raised above. Including the five other habitat types with a majority of sites in England would add a further 117 species; including habitats for which a majority of sites are outside England would add ≤57 additional species.

EA bioSYS Freshwater invertebrates

As part of their remit to protect and improve water, land and biodiversity, the Environment Agency (EA) routinely monitor the diversity and abundance of benthic invertebrates at river and stream sites throughout England. Benthic macroinvertebrate community data are

[28] On the subject of spatial biases, it’s worth noting that Breeding Bird Survey is the only one among the seven existing datasets for which spatial sampling biases have been wholly addressed. So the current lack of control for spatial bias in NPMS trends does not, *a priori*, make them inferior to other dataset already contributing to the index.

available from the EA largely from the mid-1990s to the present. These data have been collected and processed by EA staff or contracted environmental consultants using the standard UK biological monitoring protocols in the field (3-min kick sample of all stream bed habitats) and in the laboratory (all material carefully sorted through to remove, identify and count animals). The dataset consists of abundance records for over 1000 different taxa from over 30,000 samples collected from over 7000 river sites across England. The monitoring scheme therefore meets all of the essential requirements for datasets identified above.

These data are a valuable resource, providing important insights into the status of freshwater invertebrates. Including the data in the index would greatly increase the representation, both taxonomically and by realm.

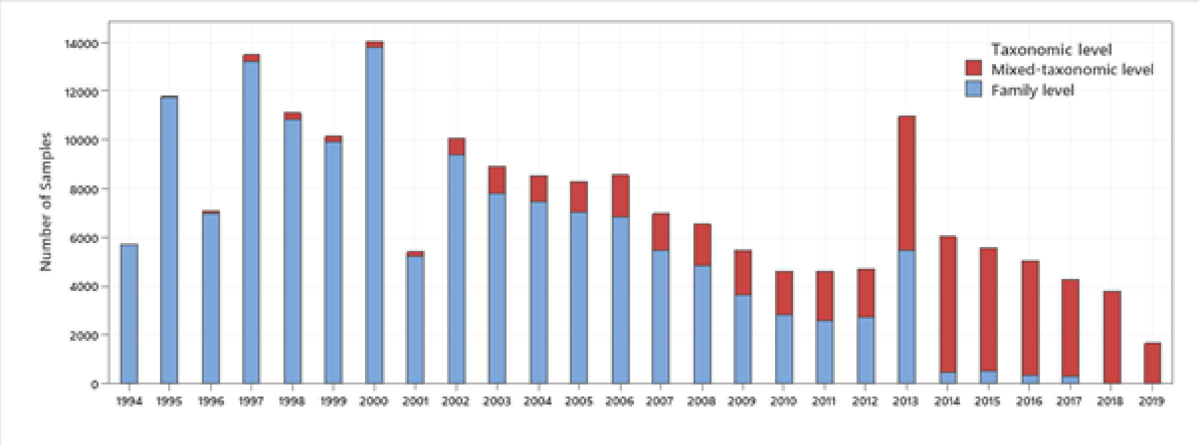
Readiness for inclusion

The raw data is available from the Environment Agency website. However, it is not suitable for modelling in its raw format. The team at Queen Mary University of London has built a relational database to store and manage a cleaned version of the data. This database is updated annually. The data cleaning steps include harmonizing the taxonomic nomenclature and correcting other inconsistencies in how the raw data is presented.

The Queen Mary team has invested considerable time and resources into the database, adding substantial value to the records collected by the Environment Agency. However, there are four issues to resolve before the data could be included in a national index of abundance, as follows:

a) A critical aspect of the EA macroinvertebrate data is that up until about 2002 most samples were identified to a relatively coarse taxonomic resolution (family level). From about 2002 onwards the proportion of samples taken in each year that were identified to a more resolved mixed-taxonomic level (MTL) has steadily increased (Figure 11). Thus, a choice has to be made about the taxonomic level for the index. Using only the MTL would create just a short time-series; by contrast the family-level data span a long period of time but aggregating many species together reduces the ability to detect change. In addition, the switch from family to MTL did not happen evenly across England: some regions (notably the East Anglian region) made the transition much earlier than others. This could potentially introduce a bias into the estimated abundance trend.

Figure 11: Variation in the number of river macroinvertebrate samples taken by the Environment Agency from 1994 to 2019. The number of samples identified and enumerated at family and mixed taxonomic level is also indicated for each year



b) In addition, abundances for family-level data were downgraded to the appropriate $\log_{10}$ category; actual abundance recorded when 1, 3 recorded when <10, 33 recorded when abundance 10-99, 333 recorded when abundance 100-999, etc. This practice was phased out as MTL processing became more common. By 2013, most samples were processed to MTL. The 2013-2019 MTL data was therefore selected to form the basis for inclusion of the river benthic macroinvertebrate data in the indicator. The dataset consists of abundance records for over 1000 different taxa from over 30,000 samples collected from over 7000 river sites across England (Figure 12). These data also contain confirmed absences; sites or samples where no records of a particular taxa have been returned.

c) Another feature of the EA MTL data is that it is not always possible to identify specimens to discrete, mutually exclusive taxa. For many groups, while larger, late-instar specimens can be identified to species, smaller, early instar individuals can only be resolved at genus or family level. Therefore, multiple levels of resolution within a group can occur within the same sample. As a first step in any analysis of these data, there needs to be a harmonisation of the taxonomy across the dataset.

d) The data are counts with repeats across the season. At present, there is no established method for converting these repeated counts into an annual index of abundance for each species.

Analytical approach

A number of harmonisation options were considered. We could downgrade all records to family level to retain as many records as possible but in doing so we would lose information on species-level changes in abundance. This would not meet the key requirement that the indicator measures relative change in abundances of species. Alternatively, we could only retain species-level records and discard those resolved to higher taxonomic levels. This approach would mean that many records would be omitted and estimates of abundance would be biased for those taxa that tend to have mixed levels of resolution. A further option would be to allocate coarse-resolution records to species in proportion to the occurrence of species in same sample. This is an approach that is used for other groups, e.g., butterflies. However, it would not be appropriate for benthic macroinvertebrates as it is likely that coarsely resolved early instar individuals are not the same species as more easily identifiable, closely related, late instar individuals in the same sample.

The option we considered to be the most appropriate was a combination of selectively excluding and downgrading records depending on the relative distribution of records/counts across taxa within a group (family) with the aim of retaining as many records as possible. For example, across all samples, if the bulk of records within the mayfly family Baetidae were resolved to genus level then all species-level records were downgraded to genus. However, across all samples, if the bulk of records within the mayfly family Caenidae were to species level, with a minority resolved to genus or family level, then these latter records were omitted from the analysis. Only species, species group and genus level records were retained. We further excluded taxa that were very rare (< 100 records) in the 2013-2019 dataset. This process retained 239 discrete taxa for consideration in the indicator (63 genera, 12 species groups and 164 species).

The raw data were converted into counts per sample for each of the 239 taxa. This conversion created a large number of zero counts where in fact the taxon was present but counted as part of some higher taxonomic unit (e.g., for sample locations where the mayfly *Baetis w*ere identified only to genus level, the count for *Baetis rodani* would appear in the database as zero). We therefore performed an additional data cleaning step to identify apparent zeros, which we identified as cases where there was a nonzero count for taxa with a coarser taxonomic resolution. For each taxon, samples with apparent zeros were excluded from the analysis (i.e., converted to NA).

We converted the sample counts into annual indices of abundance using a linear mixed-effects modelling framework. For each of the 239 taxa, we fitted a model with $\log_{10}(x+1)$ counts as the response variable, year (2013-2019) and season (spring, summer, autumn, winter) as a categorical fixed effects, and site as a random effect. The year effects from each model are estimates of the annual abundance for the taxon in question. These indices of abundance are conceptually similar to the indices that derive from other national scale monitoring schemes (BBS, UKBMS) that contribute towards the indicator.

We then explored the precision of our abundance indices following the methods detailed by Field & Gregory. To do this we modified the model above, replacing the categorical year term with a continuous effect. The precision of this linear term provides a convenient measure of the ability of the data to detect change over time. For each taxon we compared the precision of this linear trend estimate with (a) abundance in the year 2013, and (b) number of sites occupied over the whole time period. Whilst both these factors influence the ability of the index to detect change confidently, the mean abundance of taxa appeared to have a larger influence on precision. As population changes of 25% and 50% are frequently used to indicate conservation priorities, an ability to detect a change of 25% was used to exclude those taxa where estimates were insufficiently precise. Hence, two taxa were excluded from the list of taxa recommended for inclusion in the index, namely *Nephrotoma* sp. and *Dixella* sp., both Diptera. The final recommended list of 237 taxa to be included in the indicator comprised 61 genera, 12 species groups and 164 species Table 6.

Figure 12: Environment Agency sites sampled for benthic macroinvertebrates and processed to mixed taxonomic level in each year between 2013 and 2019.

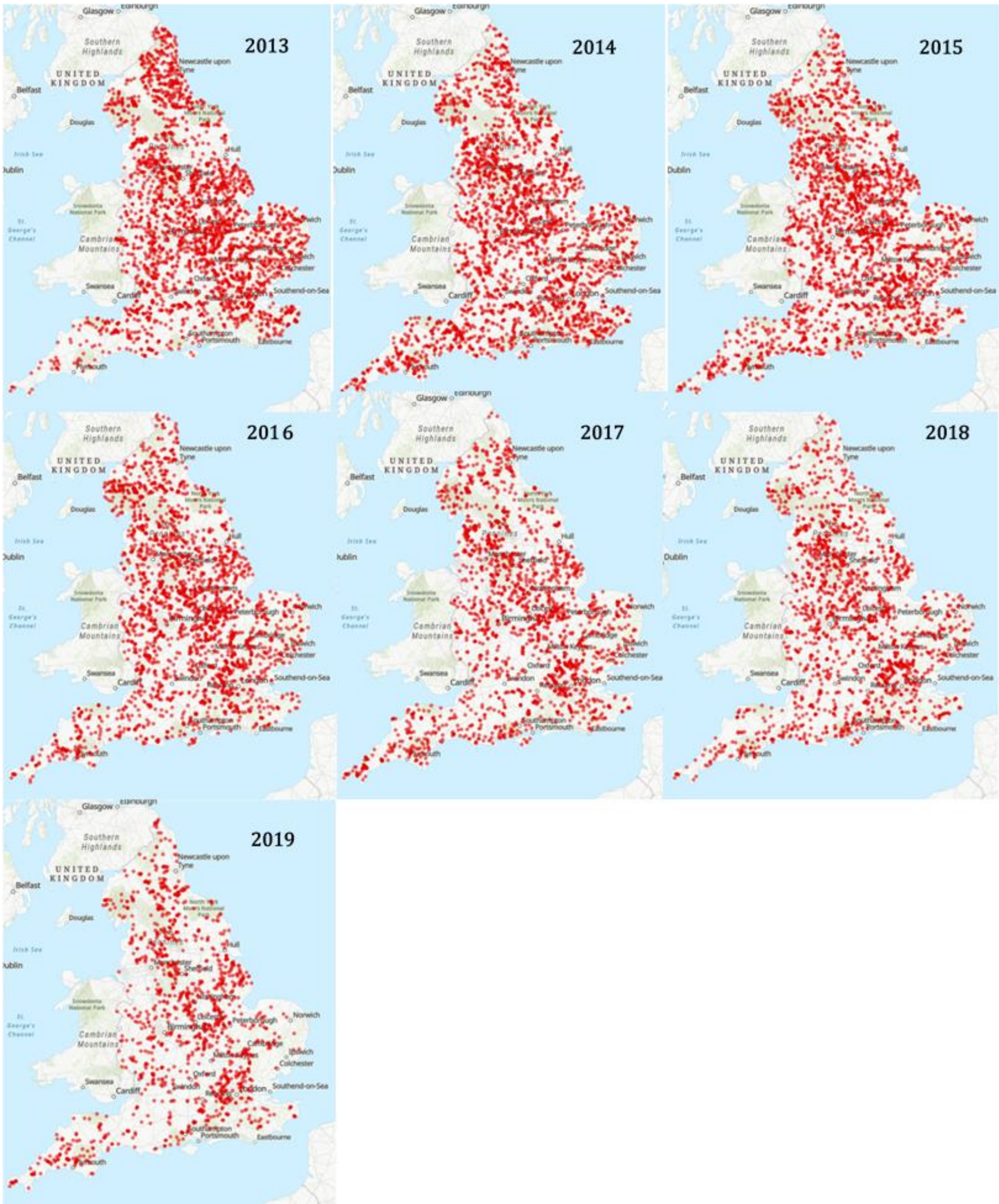


Table 6: Distribution, among major groups, of freshwater macroinvertebrate taxa considered for inclusion in the indicator.

Higher group	Order	Number of taxa
Turbellaria	Tricladida	5
Mollusca	Gastropoda	23
	Bivalvia	3
Annelida	Hirudinea	9
Crustacea	Decapoda	1
	Isopoda	2
	Amphipoda	3
Insecta	Ephemeroptera	26
	Plecoptera	14
	Zygoptera	7
	Anisoptera	2
	Hemiptera	15
	Coleoptera	34
	Megaloptera	2
	Neuroptera	1
	Trichoptera	65
	Diptera	25

Prospects and recommendations

The database and models produced by the Queen Mary team, building on the EA records, is an extremely valuable addition to the abundance index. Adding 237 freshwater invertebrates is a big step toward increasing the representativeness of the index. We therefore recommend that the indices of abundance for the 237 taxa be taken forward and adopted in the index.

However, we note that the methods described above have not yet been subject to external scrutiny. We also recommend that some kind of quality assurance process should be set up to ensure the data going into the indicator are of the highest standard.

Finally, we note that the EA is reviewing its commitment to regular monitoring of freshwater invertebrates. The analyses presented here demonstrate that the existing BIOSYS freshwater invertebrate dataset is of national significance. If the data are taken forward into an indicator for a legally-binding target, then it is essential that surveillance monitoring of the existing network of sites should continue.

Other datasets that could contribute

In this section, we briefly review the datasets that could be added to future iterations of the indicator, but for which further development work is required.

Marine and fisheries

Our proposed index does not contain any datasets from purely marine organisms. There are a small number of seabird species, which nest on land but forage at sea. Thus, the index (described below) is essentially an index of terrestrial and freshwater biodiversity. We note in Scotland, the seabirds are presented as an index of marine species' abundance, separate from the index for terrestrial species[29]. Some datasets on marine fisheries were identified in the development phase of the Scottish indicator[30], but these were deemed unrepresentative and not taken forward to the official statistics. Thus, it is likely that suitable data for marine species in England's waters does exist, but that substantial further development would be required to make these data suitable for inclusion in the index. Targets for marine species are included in the UK Marine Strategy.

Bumblebee Conservation Trust "BeeWalks"

BeeWalks is a spatially replicated sampling design with coverage across England and a standardised protocol. It collects data primarily on bumblebees (22 species covered) but

[29] https://www.nature.scot/doc/marine-and-terrestrial-species-indicators-experimental-statistic

[30] https://www.gov.scot/publications/development-combined-marine-terrestrial-biodiversity-indicator-scotland/

also accepts data on other bee species (48 other species currently covered). Including BeeWalks within the index would expand the taxonomic coverage of terrestrial insects, which are currently represented by only butterflies and moths.

The survey design and sampling protocol are similar to UKBMS. There are 623 fixed transect routes in England (this number changes annually, so far always upwards - might be worth quantifying the year for this), each of which is walked regularly. Counts of bees are reported on sections within the transect.

Data is available from 2008, but the number of routes increases through time as the survey became more popular (from 37 records in 2008 to 25629 in 2019). The location of the transects are chosen by the volunteers, which creates spatial biases, e.g., spatial coverage is better near highly populated areas and in areas rich in bumblebees. Turnover of volunteers means that spatial coverage is uneven over time. However, these issues are in common with other schemes (e.g. UKBMS) and can be resolved statistically.

The transects are walked at least monthly from March to October, however, in the year a new transect is established, surveys may start in any month during the season (if the transect was established in July, the months of March, April and June will be missing for that year). Some observations are not reported at the species level if the species could not be identified (for example they are reported as Bombus sp.); this makes up 7% of the dataset. So more work is required to make them ready for inclusion.

To date, there has been relatively little investment in the analysis of BeeWalks data. In principle, the data would be amenable to analysis using the analytical pipeline developed for UKBMS, and variants of previous UKBMS models have been used successfully to analyse the BeeWalks data. However, there are issues to resolve with data structure, taxonomic resolution, as well as spatial biases described above.

Environment Change Network

The Environment Change Network (ECN) has operated a network of sites across the UK since 1992. A key feature of ECN is the co-location of biodiversity surveillance with monitoring of air and water quality. There are 11 terrestrial, 17 lake and 29 flowing water sites. The relatively small size of the network, combined with their locations (most are strict nature reserves) means that the data are unlikely to be representative of the wider countryside. Moreover, the taxonomic scope of ECN data adds relatively little to datasets already included in the index.

Pollinator Monitoring Scheme

Launched in 2017, the Pollinator Monitoring Scheme consists of several surveys that operate in parallel (including the BeeWalks). These include a “systematic survey”, which is a network of 75 sites across the UK. At each site there is a set of pan traps at which insects are collected regularly during the summer. In theory, these data could be used to create species-level measures of abundance for many terrestrial insect species. However, substantive doubts have been raised about the degree to which counts from pan traps reliably indicate abundance. For this reason, the data are regarded as reliable measures of site occupancy, but not local abundance.

Countryside Survey

The Countryside Survey is a national (UK) survey of vegetation and other landscape features within approximately 500 randomly-located 1km grid cells. The data are rich and include species-level data on plant abundance within quadrats. The main problem is that these data exist only for the years 1978, 1990, 2000 and 2007. Although the protocol is now being applied to a rolling subset of squares from the Countryside Survey, the data lack the spatial and temporal coverage of the National Plant Monitoring Scheme. There would be substantial technical challenges to integrating Countryside Survey data with the NPMS.

National Amphibian and Reptile Recording Scheme (NARRS)

NARRS was created in 2007 to monitor the abundance of native Amphibian and Reptiles. It was designed on the principles of the Breeding Bird Survey, so in theory the data are suitable for inclusion in a national index of abundance. Unfortunately, recruitment of volunteer surveyors fell short of expectations, resulting in fewer sites being monitored than planned. A 2017 review concluded that the data were not sufficient to detect meaningful trends for the majority of species. A new research project is investigating how NARRS data could be integrated with other surveys in order to generate abundance indices that would be suitable for inclusion in the index.

Other Environment Agency datasets

The EA also uses a suite of methods to collect abundance data on 30 freshwater fish species. The main issue for including this dataset is that very few sites have repeat surveys within a year. It's unclear how much variation in abundance within the season might be expected: if substantial then counts may not be truly reflective of local abundance in the year sampled. In principle this could be addressed by the development of a formal statistical framework, such as that which exists for the UKBMS.

EA benthic diatom data is not suitable for the indicator as the data collected does not record absolute abundances of species in each sample. Furthermore, recently the EA have moved to DNA metabarcoding as a means of describing the diatom community in each sample: interpreting abundances from these new data will be complicated and uncertain.

As well as benthic invertebrates, the EA routinely monitors the diversity and abundance of aquatic plants, fish communities, and benthic diatoms at river and stream sites throughout England. These three datasets have a number of issues that limit their suitability for use in a national abundance index.

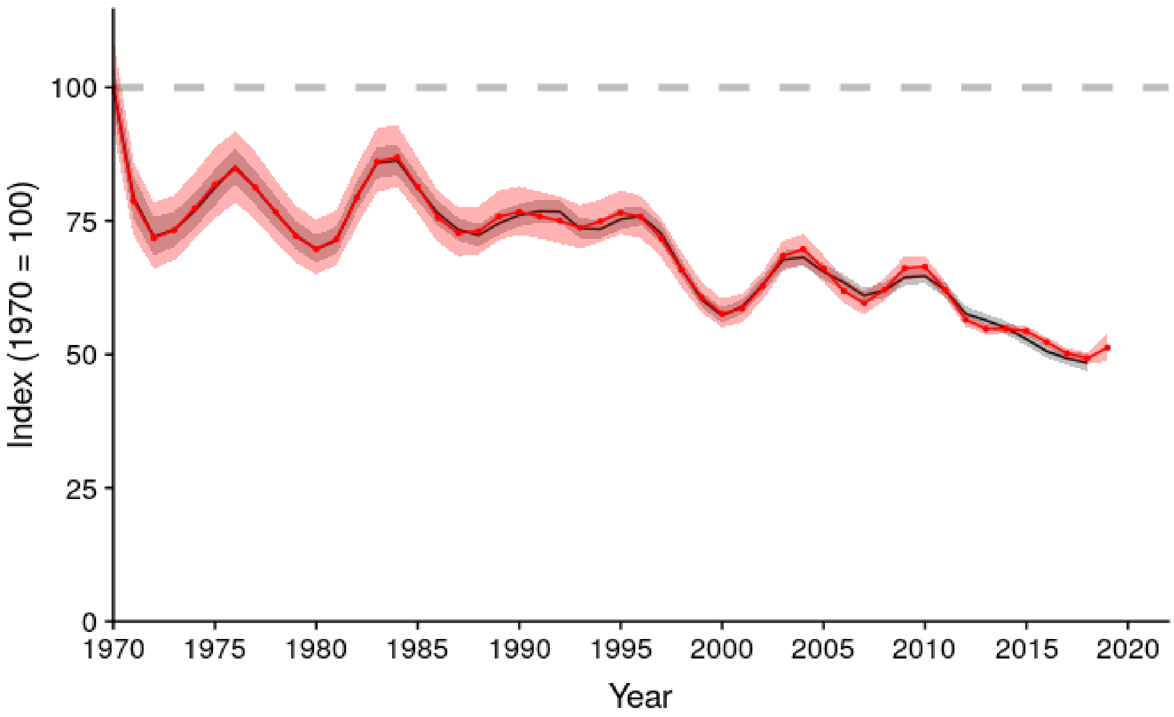
- *EA BioSYS Macrophytes* - The aquatic plant community is surveyed over a 100m river reach using a well-established protocol. However, the non-linear ordinal method of recording the abundance of species complicates its inclusion in the Indicator. Further examination of approaches to convert the areal cover categories to ‘abundance’ data would be necessary. This was not possible within the timescales of the current project but if a satisfactory protocol could be devised, these data could be considered for inclusion. There are approximately 150 aquatic plant taxa that are recorded in over 1% of surveys.
- *EA Fish* - A range of different survey methods are employed by the EA to survey river fish communities including fyke nets and seine nets, but by far the most common is electric fishing using a catch depletion model to estimate densities of captured species within a set sampled area of river. Data are recorded as density at the species level. These abundance data would be appropriate for the Indicator. These data are available from the EA from the mid-1980s to the present, with consistently over 1000 surveys per year from 1993 onwards. However, there would be concern at the fact that there is usually only one sample per year at a site. Many freshwater fish species are quite mobile within a river and by chance may not be present within the sampled reach at the time of sampling. This can inflate uncertainty around estimates of abundance. It has not been possible within the timeframe of the current project to investigate this issue in more detail. There are 30 species of native freshwater fish found in English rivers. It is likely that, following more detailed analyses, it would be possible to confidently quantify the relative change in abundance for the most frequently occurring sub-set of these species.

EA Diatoms - the benthic diatom data is not suitable for inclusion as the data collected does not record absolute abundances of species in each sample. Furthermore, recently the EA have moved to DNA metabarcoding as a means of describing the diatom community in each sample: interpreting abundances from these new data will be complicated and uncertain.

Finalised Indicator

Here we present an updated version of the index, incorporating additional data from 164 plant species from the NPMS (2015-19) and 237 freshwater invertebrates (2013-2019).

Figure 13: Version 2 of the abundance index: Change in the relative abundance of 1071 terrestrial and freshwater species in England, 1970-2019 (red line; ribbon delimits 95% credible intervals). Version 1 (based on 670 species) is plotted underneath, in grey/black. ***Source: UK Centre for Ecology and Hydrology***



On the face of it, the impact of adding these datasets is not substantial: both end up with an index value close to 50. We should not find this surprising, because these new datasets start only recently (2015 for NPMS; 2013 for EA freshwater).

To understand the impact of adding these new data, we must restrict our view to the years 2013-2018. During this period, the red line in Figure 13 (v2) is noticeably flatter than the black line (v1). The average decline in the red line is 1.1 percentage points, compared with 1.6 in version 1. Thus, to a first approximation, the addition of freshwater and plant data reduces the rate of recent decline (and hence Scenario 1 trajectory) by a third. Thus, to achieve a halt in decline by 2030 (or any other date) is much more plausible than when we considered only the terrestrial animal subset in version 1.

There are several other minor differences between the red and black lines in Figure 13. One is that version 2 is more uncertain in the period before 2013: this is because trends from freshwater and NPMS are missing for this period and hence interpolated. The second is that version 2 is smoother in the early 1990s than version 1: this reflects the constraints imposed by smoothing: the additional data has caused the trendline since 2013 to become less smooth, so the model compensates for this by imposing smoothness elsewhere in the timeseries.

The final difference is that we've added an extra year of data (2019). However, this final year of data reflects only trends in the NPMS and Freshwater datasets: we have not updated the others, so the index value for the year 2019 is not representative. The model will need to be updated prior to include the most recent data at the point the target period commences.

It should be noted that the work to improve the indicator, described above, was carried out alongside work on feasibility, therefore, some of the analysis relates to an initial iteration of the indicator, that was later updated.

Representativeness of the abundance indicator

Introduction

It is estimated that the UK is home to around 55,000 native species of fauna, flora, and fungi (Table 7). The indicator, which focuses specifically on English wildlife, tracks the abundance of 1,071 species[31] (2% of UK species). A comprehensive list of species was only available for the whole of the UK, not for only England, so comparing the list of the indicator species to the list of UK species does not give perfect insights about how well the indicator represents specifically English wildlife. However, if one assumes that the proportions of species in different groups is largely similar in England as it is across the UK, then useful insights about the representativeness of the indicator can be made. While it is of course unrealistic that any indicator could track all of these species, it is useful to consider which species are included in the indicator and how representative they are of English biodiversity as a whole.

While vertebrate animals are always of great conservation interest, they make up only 0.7% of the UK's ~55,000 species (Table 7). It would be impossible to monitor a truly representative sample of invertebrate animals, given that there are so many, therefore it is unavoidable that vertebrates will be overrepresented in species indicators. In the UK, there are 362 recorded vertebrate species (amphibians, birds, fishes, mammals, and reptiles; (19) Burns et al. 2018). Of vertebrates, 218 are bird species, making this the largest vertebrate group in the UK (fishes are the next largest vertebrate group (Table 7). The indicator tracks the abundance of 169 species of birds, i.e. 78% of the UK's bird fauna. There are 49 species of mammals recorded in the UK, and the indicator tracks the abundance of 15 species (31%); 10 of these are bat species, so taxonomic diversity of mammals in the species abundance indicator is limited. No abundances of amphibians, fishes, or reptiles are monitored using the indicator.

Table 7: Number of species in the UK as reported in Supplementary Table A2 of Burns et al. (2018) (19) compared to the number of species included in the indicator.

[31] For invertebrates, in some cases species within a genus are hard to distinguish and so the abundance of the genus is monitored in D4a; this is the case with 63 freshwater invertebrate species

Because the indicator focuses on English species only, numbers of species per group are presented as proportions, assuming that the proportion of species per group across the UK generally reflects the proportions that would be observed in England. Proportion of total UK species is relative to the figure of 54,614 total species across the groups in the table reported in Burns et al. (2018) (19).

	Subgroup	Species in the UK	Proportion of total UK species	Species in the abundance indicator	Proportion of total indicator species
Vertebrates	Amphibians	7	0.01%	0	0.00%
	Birds	218	0.40%	169	15.78%
	Fishes	82	0.15%	0	0.00%
	Mammals	49	0.09%	15	1.40%
	Reptiles	6	0.01%	0	0.00%
	Total Vertebrates	*362*	*0.66%*	*184*	*17.18%*
Invertebrates	Hymenoptera (bees, ants, wasps)	7154	13.10%	0	0.00%
	Diptera (flies)	7099	13.00%	25	2.33%
	Coleoptera (beetles)	4093	7.49%	34	3.17%
	Lepidoptera (moths and butterflies)	2404	4.40%	486	45.38%
	Other insects	3197	5.85%	132	12.32%

	Non-insect invertebrates	5369	9.83%	46	4.30%
	Total Invertebrates	*29316*	*53.68%*	*723*	*67.51%*
Plants	Vascular plants	1497	2.74%	164	15.31%
	Non-vascular plants	1056	1.93%	0	0.00%
	Total Plants	*5017*	*9.19%*	*0*	*15.31%*
Fungi	Lichens	2354	4.31%	0	0.00%
	Non-lichen fungi	15100	27.65%	0	0.00%
	Total Fungi	*17454*	*31.96%*	*0*	*0.00%*

Over half of the UK's species (54%) are invertebrates; this is primarily insects (23,947 recorded species, (19)) accompanied by other invertebrates such as arachnids, crustaceans and molluscs (an additional 5,369 species). The best represented invertebrate groups in the indicator are butterflies and moths; the indicator tracks 55/59 butterfly species recorded in the UK (93%) and 431 out of the 2,345 moth species (18%). There is some question as to whether the choice of moth species is random or is biased toward declining species (UK & England Biodiversity Indicators Quality Assurance Science Panel 2016[32]). Regardless, 67% of the invertebrates monitored by the indicator are butterflies and moths, whereas these species make up only 8% of total UK insect species (Table 7). The majority of invertebrate species in the UK come from 3 groups: Hymenoptera (bees, ants, and wasps; 24% of invertebrate species), Diptera (true flies, 24%), and Coleoptera (beetles; 14%). These groups are underrepresented in this indicator (0%, 3%, and 5% of invertebrate species in the indicator, respectively). Plants make up 9% of UK species, while fungi make up the remaining 32%. There are no fungi monitored

[32] This report refers to the UK version of the priority species indicator (C4a), which only included 79 moth species and is not England-specific. Only the English species have been retained in D4a, and many more moth species added, so perhaps this criticism is not valid of D4a.

on the indicator, and the plant species are vascular plants only (vascular plants make up 30% of the plant species in the UK; non-vascular plants like mosses are not monitored in the species abundance indicator).

Priority Species

Species are recognised as priority species because they are threatened (20), which is primarily indicated by declining or small populations (20, 21). Therefore, these are important species to include in an abundance indicator, as many are actively declining.

An earlier version of an abundance indicator for priority species across the whole of the UK (C4a) used many of the same species and data sources as the original indicator (birds, butterflies, moths, and mammals). This earlier version was found to be unrepresentative of priority species by an independent scientific panel (UK & England Biodiversity Indicators Quality Assurance Science Panel 2016), as it did not include any other types of invertebrates, any plants, or any marine mammals- groups with a large number of priority species. Therefore, species have been added in an attempt to fill some of those gaps. The 1,071 taxa currently included in the indicator include 160 priority species (Table 8), for more detail on the breakdown of species, priority habitats, species contributions to ecosystem services as well as species value by the public.

Table 8: Representation of priority species (S41) in the indicator of abundance

Higher group	Group	Species on S41	Species on the indicator
Vertebrates	Amphibians	4	0
	Birds	49	44
	Fish	48	0
	Mammals	34	6
	Reptiles	8	0
Invertebrates	Beetles	75	2†
	Butterflies	23	21
	Dragonflies/Damselflies	2	2†

	Hymenoptera	31	0
	Moths	142	79
	True bugs	10	0
	True flies	28	0
	Riverflies (Caddisflies, Mayflies, Stoneflies)	7	3 (2†)
	Other insects	4	0
	Other Invertebrates	76	3 (2†)
Plants	Vascular plants	149	0
	Bryophytes	77	0
Chromists	Algae	15	0
Fungi	Fungi	64	0
	Lichens	94	0
Total		**940**	**160**

† Indicates that in S41, a full binomial (genus, species) name is given, while in the indicator, only the genus is indicated (e.g., in S41 *Agabus brunneus* is listed as a priority species, while the data in the indicator are for *Agabus sp.*)

Ability of the indicator to predict changes in species not included

Butterflies as a wider indicator

Butterflies have long been considered a representative indicator of wider biodiversity changes (reviewed in (22)) and the UK Government recognises butterflies as "good indicators of the broad state of wildlife and the countryside" (23).

Butterflies are considered a good indicator of terrestrial insect abundance (22,24), which implies that the indicator's gaps in coverage of England's largest insect groups (Hymenoptera, Diptera, Coleoptera) may be partially compensated for by the inclusion of over 90% of England's butterfly species. Britain's butterfly species occupy all successional stages of terrestrial habitat types in similar patterns to most of Britain's insect taxa, with the exception of ancient rotting (saproxylic) trees, which no butterfly species utilise as habitat (24). Large numbers of threatened arthropods and molluscs utilise saproxylic habitats, so butterflies in the indicator will not reflect their status.

However, butterflies provide no indication about the status of freshwater invertebrates, which are considered to be more threatened than terrestrial invertebrates (24).

Whilst the inclusion of 237 freshwater invertebrate taxa to the indicator is a step in the right direction, it is hard to tell if these species are representative. Of these taxa, only 3 have been assessed on the England Red List, so it is hard to tell how representative of threatened freshwater species the indicator will be. However, the Environment Agency sampling scheme for benthic invertebrates covers all of England and is done in a systematic way, so we may assume that it reflects the abundance of benthic invertebrates. However, this may not reflect invertebrate species occupying other freshwater zones.

While many priority vertebrates are not included in the indicator, monitoring of their priority habitats (via inclusion of NPMS data in the indicator) may allow us to make inferences about their status. For example, Wolton (26) found that 130 English priority species are associated with hedgerows, which is one of the fine-scale habitat types within the NPMS broad habitat type Broadleaved Woodland; indicator plants for this habitat type are included in the species abundance indicator. Wolton (26) found that hedgerows are key habitat for several species that are not included directly in the indicator, including lichens (n=10 species) and reptiles and amphibians (n=5). Mammal species that are dependent on hedgerow habitat that are of particular interest to the public, but are not included in the indicator, include hedgehogs, stoats, and dormice.

Broadleaved woodland habitats (one of the 3 NPMS broad habitat types for which indicator data are included in the indicator) are home to many mammal species, including hedgehog, harvest mouse, common shrew, red fox, pygmy shrew, weasel, water shrew, stoat, wild boar, mole, polecat, red squirrel, pine marten, dormouse, badger, bank vole, field vole, red deer, wood mouse, and yellow-necked mouse (27). Woodland habitats are also home to a number of fungal and lichen specialist species (27).

Bumblebees are important pollinators in lowland grassland (28), another NPMS habitat included in the indicator, so changes in these plant species may reflect changes in bee abundance (i.e., more plants due to increased numbers of bees, or reduced numbers of bees and plants due to habitat loss/degradation). However, because bees are also susceptible to taxon-specific threats (parasites, fungal diseases) and because butterflies and moths are also considered primary pollinators (29), this link is not necessarily tight.

Finally, there is mixed evidence that arable field margins create preferred habitat for some small mammal species compared to cultivated margins and grassland[33].

Gaps in the Abundance Indicator

While the indicator will be able to monitor many species groups successfully, there are nonetheless some gaps:

One of the most obvious exclusions from the indicator are marine species. Whilst 11 seabirds are included in the indicator (data from the Seabird Monitoring Programme), there are no other marine taxa represented. The tiny fraction of marine taxa in the indicator will likely not register in the combined indicator, meaning that it is unlikely to be informative about trends in marine species. However, we work through OPSAR to coordinate our approach to the management of species with those countries we share our seas with. In this forum we submit data for the UK as a whole using the targets in the UK Marine Strategy (UKMS).

The addition of data for 237 taxa of freshwater benthic invertebrates brings the proportion of freshwater species to 24% (including 21 bird species from the Wetland Bird Survey and England Wintering waterbird indicator). While the inclusion of these species is a step in the right direction, the lack of other freshwater species (e.g., plants, non-benthic macroinvertebrates, fishes) will likely mean that trends in benthic macroinvertebrates will drive the freshwater contribution to the combined indicator trend-- meaning that species in other freshwater zones may not be represented.

In terms of terrestrial ecosystem services, species that play a primary role in decomposition are almost absent from the indicator. While many invertebrates are important decomposers, this also highlights the complete lack of fungi in the indicator.

While pollinators are well-represented in the indicator by moths and butterflies, bees are entirely absent, and the trends of these primary pollinators could change independently of species in the indicator (e.g., due to taxon-specific diseases).

Compared to Central and South England, the plant species in the indicator represent a much lower proportion of the priority habitats that make up North England.

The indicator can only use the data which are available, and of those only data that have been collected in a repeated and systematic way. It seems that the inclusion of species collected under sampling schemes with various aims and taxonomic foci will help alleviate some of the perceived weaknesses of the indicator- e.g., NPMS plant sampling was designed to monitor quality of priority habitats across England (30), which should be correlated with the abundance of many terrestrial animal species.

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[33] Conservation Evidence, www.conservationevidence.com/actions/2365

Overall, the large number of terrestrial taxa, sampled across England, should allow the indicator to be a decent indicator of terrestrial animal and plant abundance (but see specific exceptions in *Gaps*).

While inclusion of freshwater invertebrates helps balance the invertebrate contribution to the indicator away from simply being driven by lepidopterans, the lack of other terrestrial invertebrate species means that species crucial to the ecosystem services of pollination and decomposition are not being tracked. Whilst terrestrial species in the indicator benefit from the combined coverage of very different taxa (mammals, birds, lepidopterans, and plants), freshwater species are overwhelmingly represented by benthic invertebrates, indicating that we can be less certain that the indicator will pick up trends across freshwater species as a whole.

The potential to add additional species will need to be considered as appropriate in future.

Notional targets

The purpose of notional targets is described on page 11. Whilst past policies have aimed to improve outcomes for species, this has not included quantitative targets. We used the current status of species, past rates of decline as well as international commitments to inform the notional targets.

It is worth noting that the three notional targets listed below were developed in 2020/21 and used to inform workshops held in March 2021, at which time the duty to set a 2030 target to halt the decline of species abundance had not yet been included in the Environment Act 2021. At the time of the workshop the timeframe was set at 15 years as this is the minimum length of time a target can cover as set out in the Environment Act 2021. For the longer-term target, this was later extended to 20 years to align with the end date of the 25 Year Environment Plan. As such the evidence developed and set out below has been used to generally inform the analysis and potential target identification but does not directly map onto the proposed abundance targets.

Rates of decline in abundance for species for which reliable trends are available informed the development of the notional targets. The initial iteration of the indicator, (which was used to support this analysis) has declined to approximately half its value since the 1970s. Increasing species abundance at the same rate as past declines (30%) was agreed as a suitable higher ambition scenario. Halting biodiversity loss was agreed as the lowest ambition level for testing, with an additional ambition level (15%) falling between the two:

- Halting further decline in species abundance by 2037 i.e. flattening the current trend.
- 15% increase in species abundance by 2037. Equal to improving species abundance at half the rate of decline over the past 50 years (i.e. the rate that would return abundance to 1970s level in 100 years)

- 30% increase in species abundance by 2037. Equal to improving species abundance at the same rate as the decline over the last 50 years (i.e. the rate that would return abundance to 1970s level in 50 years)

It is important to define these terms clearly in discussing the target ambition. The Feasibility section above provides detail on the proposed indicator and projections of future decline under Scenario 1. Improvements on the current trend could be achieved by slowing the rate of loss, stabilising the trend or increasing the trend.

Here we define a target of halting decline to mean that the value of the indicator is equal to or less than the original value, but that the rate of change is not significantly different from 1. Halting Decline anticipates that there will be further loss, but that the indicator will stabilise. See Figure 14 and Figure 15. Note that halting decline by 2040 rather than 2030 results in stabilisation of abundance at a lower value.

Figure 14: Illustration of halting decline by 2030. ***Source: RSPB***

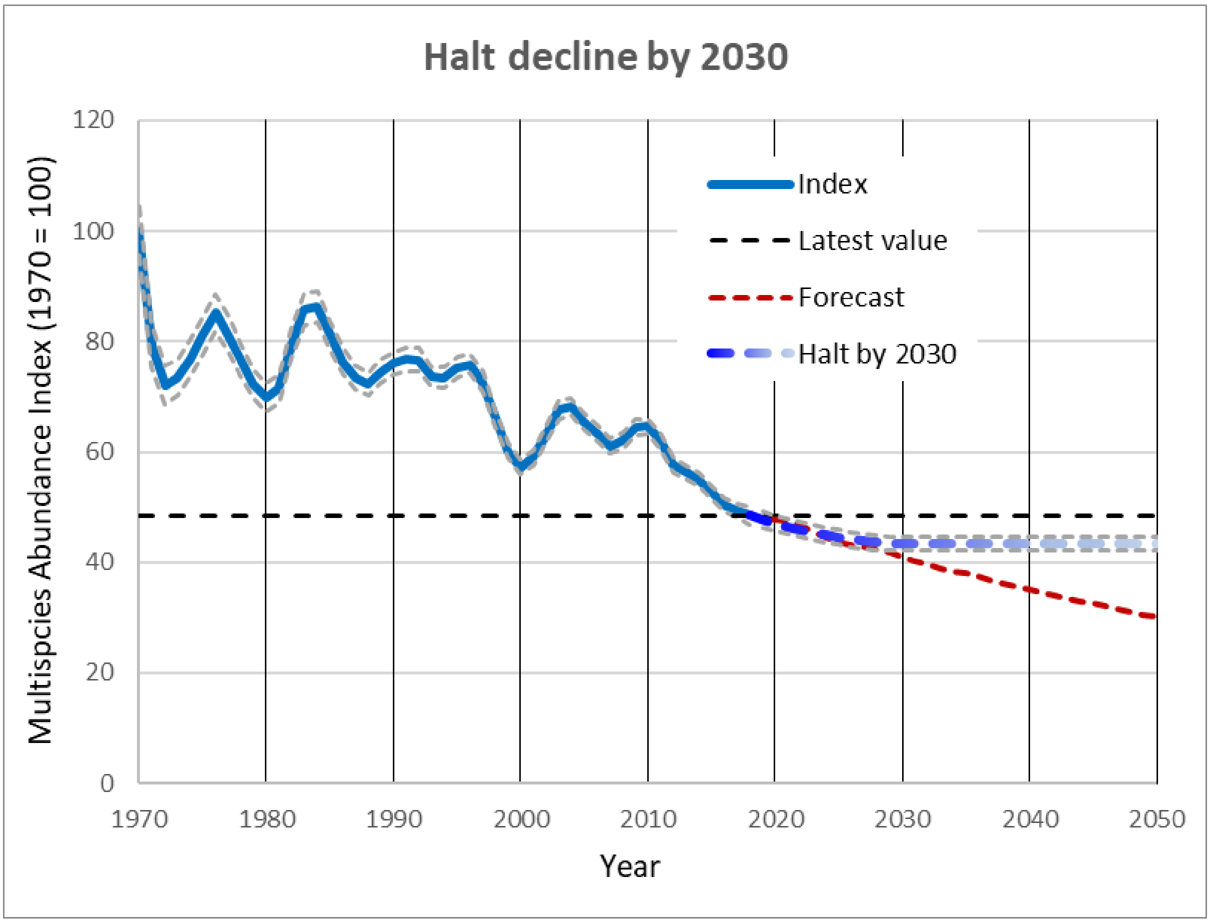
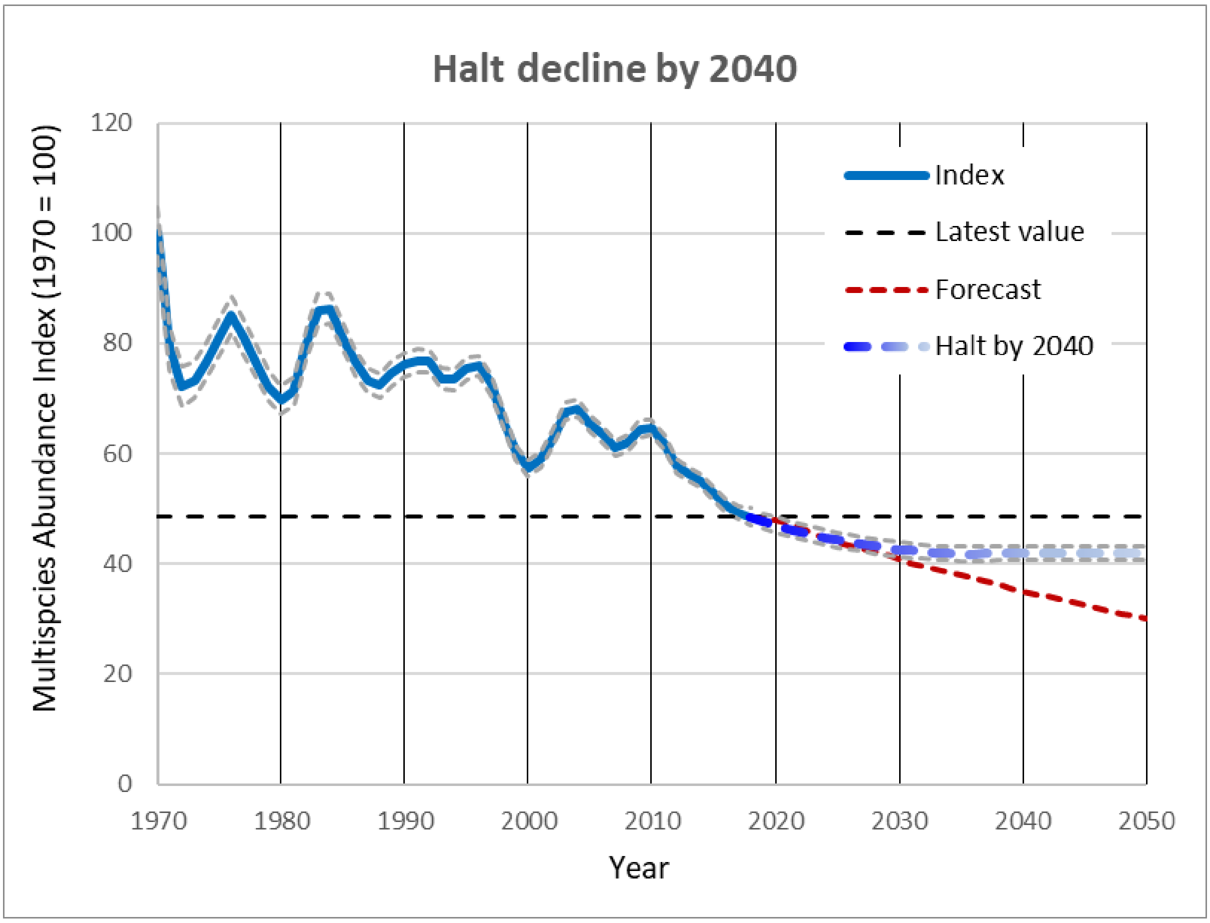
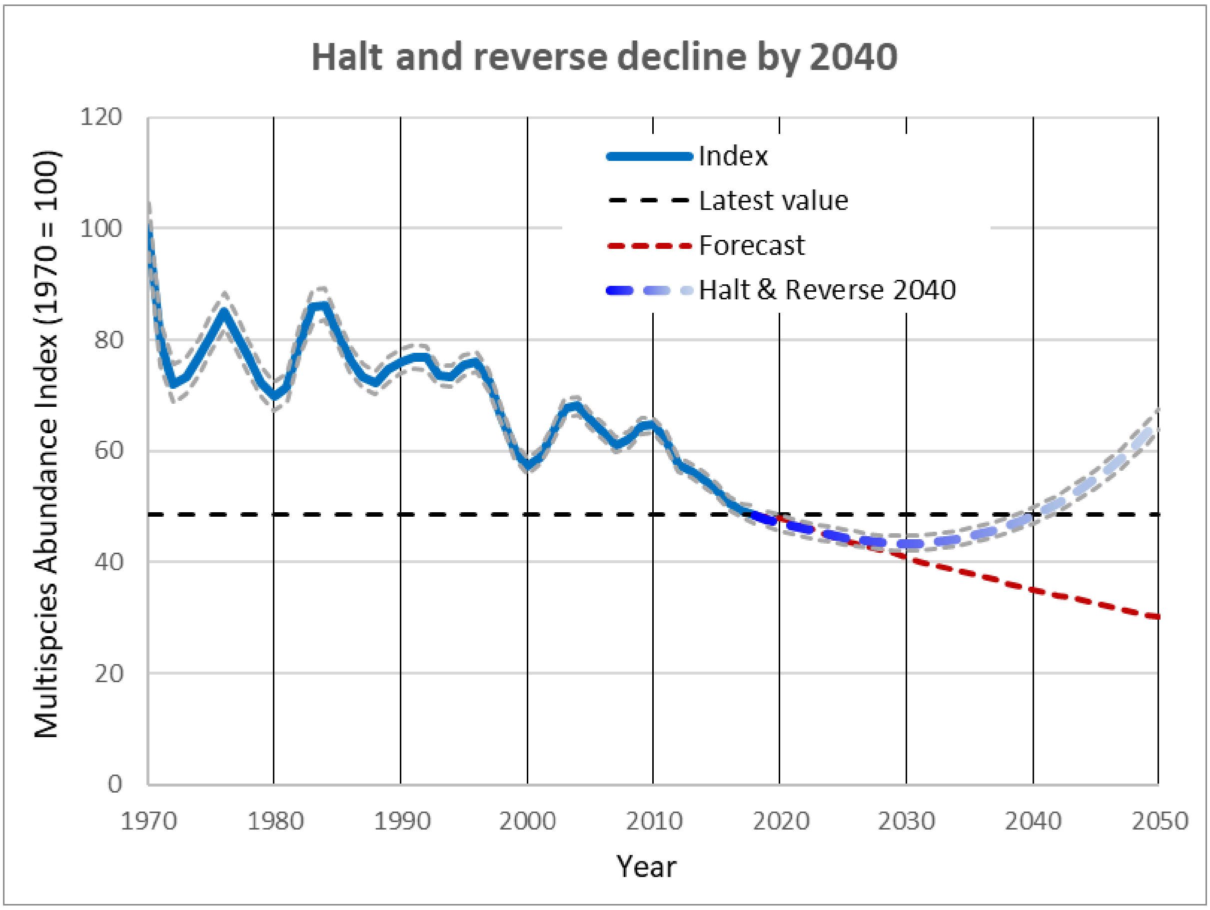


Figure 15: Illustration of halting decline by 2040. ***Source: RSPB***



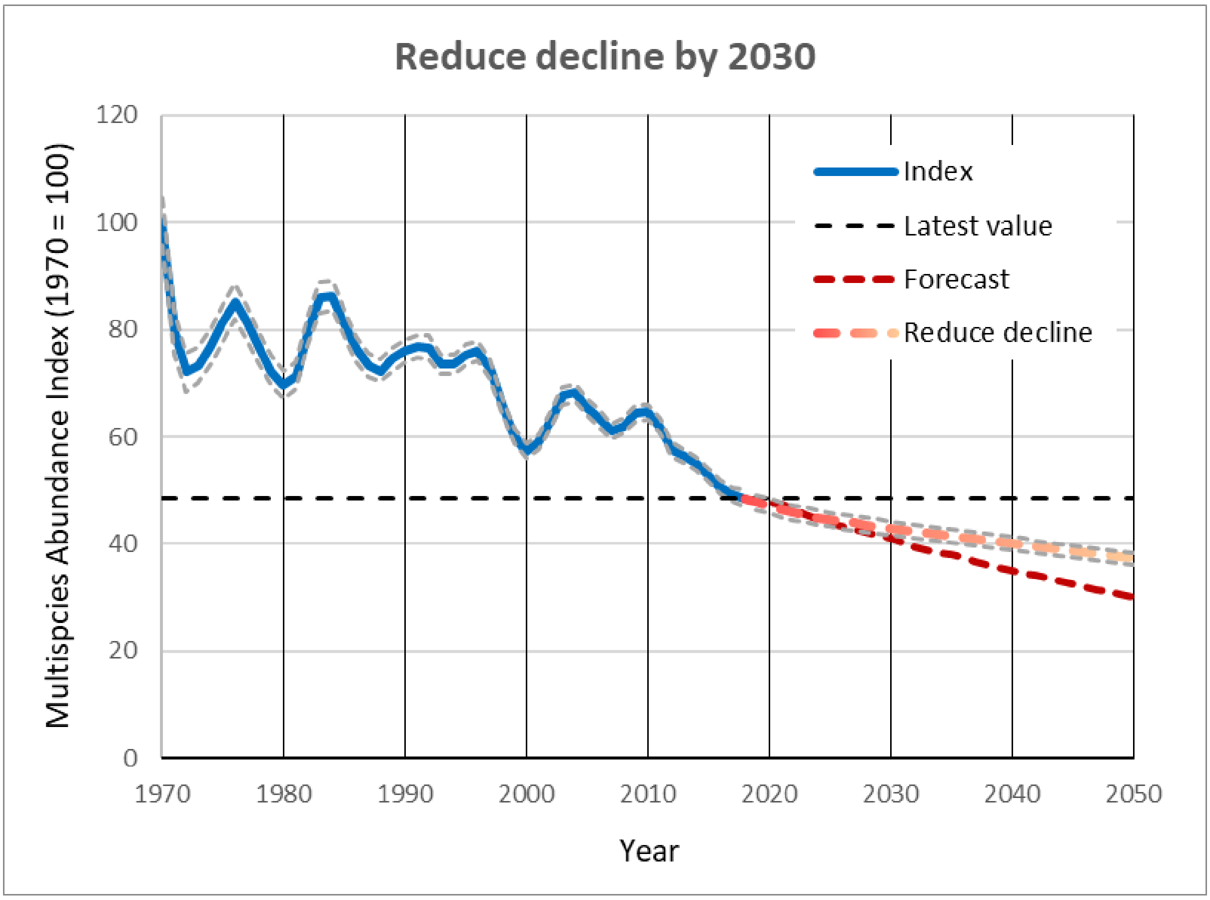
Due to ongoing declines, to have the indicator be at the same value at the end of the target period as at the beginning would require a period of slowing and halting decline followed by a period of increases. See Figure 16. Having the value of the indicator be at a higher value at the end of the target period than at the beginning would require more rapid progress to halt the declines and start seeing increases.

Figure 16: Illustration of reversing decline by 2040. ***Source: RSPB***



Reducing the rate of decline would mean setting the trend on a trajectory where the value of the indicator at the end of the target period is less than the original value and still declining, but higher than the predicted rate of decline. See Figure 17. Achieving a slowed rate of decline would still require several species trends to stabilise or increase.

Figure 17: Illustration of slowing the decline. ***Source: RSPB***



The above analysis sets out the different scenarios proposed by the notional targets and the impacts this has on indicator levels at the end of a target period. Halting Decline will stabilise the indicator, however choosing a target period sooner rather than later results in less of a decline from baseline to target period, e.g., 2030 or 2042. If the target indicator level is to be higher than the baseline level then it is expected that more rapid progress would be required in order to halt declines and then see increases.

Feasibility assessment

Species exist within a complex system, with multiple factors influencing their populations. This section outlines analysis that has been done to understand how the indictor may change. It has not been possible to review each species in detail to develop an accurate picture of future change. Instead, we have looked at properties of the indicator, the species it contains and past trends to understand the scale of the challenge in meeting the notional targets. **This section does not make a detailed assessment of whether the targets are realistic based on implementation of specific policies**, although elements of policy delivery are assessed. This is due both to the long-term nature of the targets and data availability. No decisions have yet been made about policy pathways and these scenarios are illustrative only.

Statistical assessment

Current trend and mathematical trajectory to target ambitions

While there are a range of potential actions necessary to achieve the ambitions of the 2030 and the proposed 2042 Species Abundance targets there is also a need to understand the scale and speed at which change needs to occur in order for such targets to be met. The UK Centre for Ecology and Hydrology (UKCEH) carried out a high-level assessment of what this rate of change year on year would need to be to halt declines by 2030 and increase species abundance by 2042. This change is outlined in Table 9 and illustrated in Figure 18 below. The year-on-year rate is consistent in all years before 2030 (0.265) and consistent between 2030 and 2042 (0.13), though to note, the rate of change is slighter higher from 2022 to 2030 than it is 2030 to 2042.

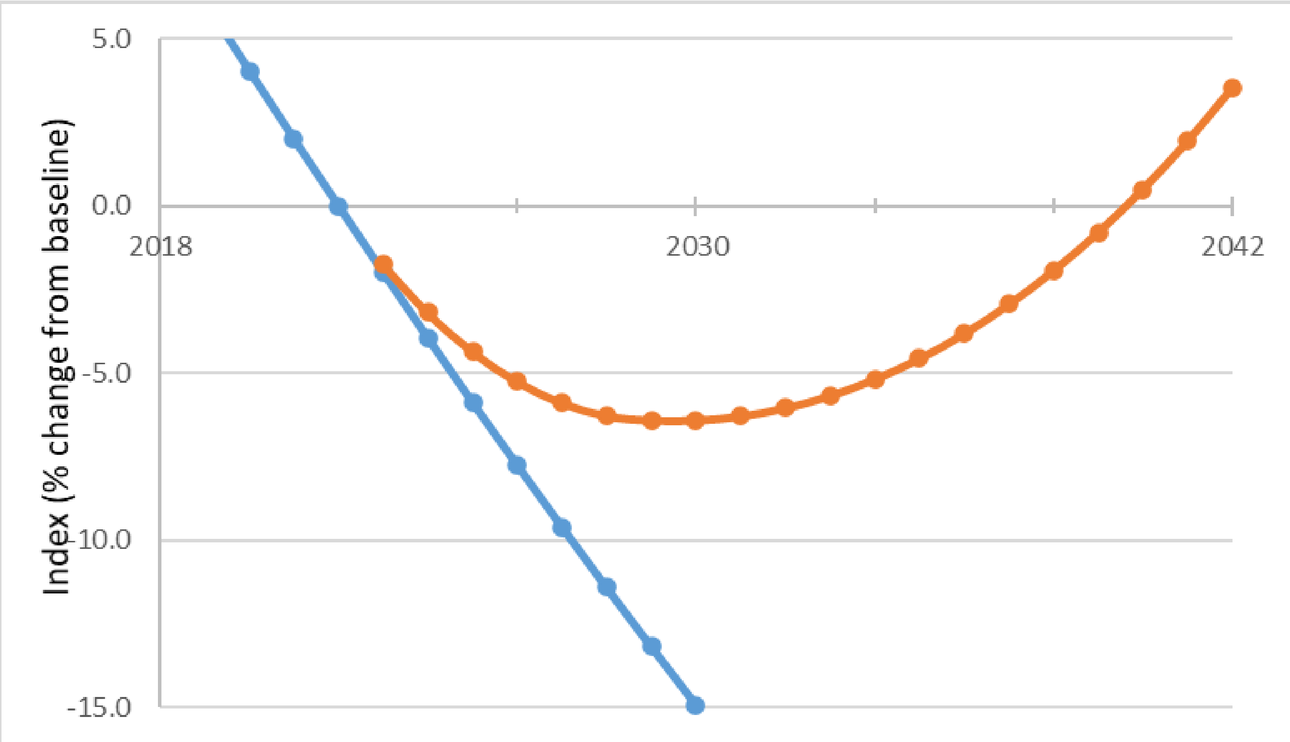
Table 9. Mathematical representation of rate of change necessary to reach existing 2030 target to halt decline of species abundance/ proposed target to increase species abundance by 2042, illustrated in Figure 18

Year	Scenario 1 Index trajectory	'Bend' factor necessary to reach 2030 target and increase by 2042	Percentage change in Scenario 1 with respect to 2022 baseline	Percentage change with respect to 2030
2017	110.408		10.40808032	
2018	108.243		8.243216	
2019	106.121		6.1208	
2020	104.04		4.04	
2021	102		2	
2022	100		0	
2023	98	0.265	-2	5.0%
2024	96.04	0.265	-3.96	3.4%
2025	94.1192	0.265	-5.8808	2.2%
2026	92.2368	0.265	-7.763184	1.2%
2027	90.3921	0.265	-9.60792032	0.6%
2028	88.5842	0.265	-11.4157619	0.1%
2029	86.8126	0.265	-13.1874467	0.0%
2030	85.0763	NA	-14.9236977	0.0%
2031	83.3748	0.13	-16.6252238	0.1%
2032	81.7073	0.13	-18.2927193	0.4%
2033	80.0731	0.13	-19.9268649	0.8%
2034	78.4717	0.13	-21.5283276	1.3%
2035	76.9022	0.13	-23.0977611	1.9%
2036	75.3642	0.13	-24.6358059	2.7%
2037	73.8569	0.13	-26.1430897	3.6%
2038	72.3798	0.13	-27.6202279	4.6%
2039	70.9322	0.13	-29.0678234	5.7%
2040	69.5135	0.13	-30.4864669	7.0%

2041	68.1233	0.13	-31.8767376	8.3%
2042	66.7608	0.13	-33.2392028	9.7%

Figure 18 shows a theoretical trajectory necessary in order that both targets are achieved (orange line) against the continuation of current declines (blue line). This modelling does not consider the wider factors or actions that would define the feasibility of achieving this target. These are explored in other sections of the document. This figure suggests the need for a significant and sustained improvement to bend the curve and demonstrates the rate of change necessary to halt decline by 2030 and recover species abundance to 2022 levels by 2042. The mathematical analysis suggests this would need an increase of approximately 9.7% to 2042 compared to a 2030 baseline, as displayed in Table 9.

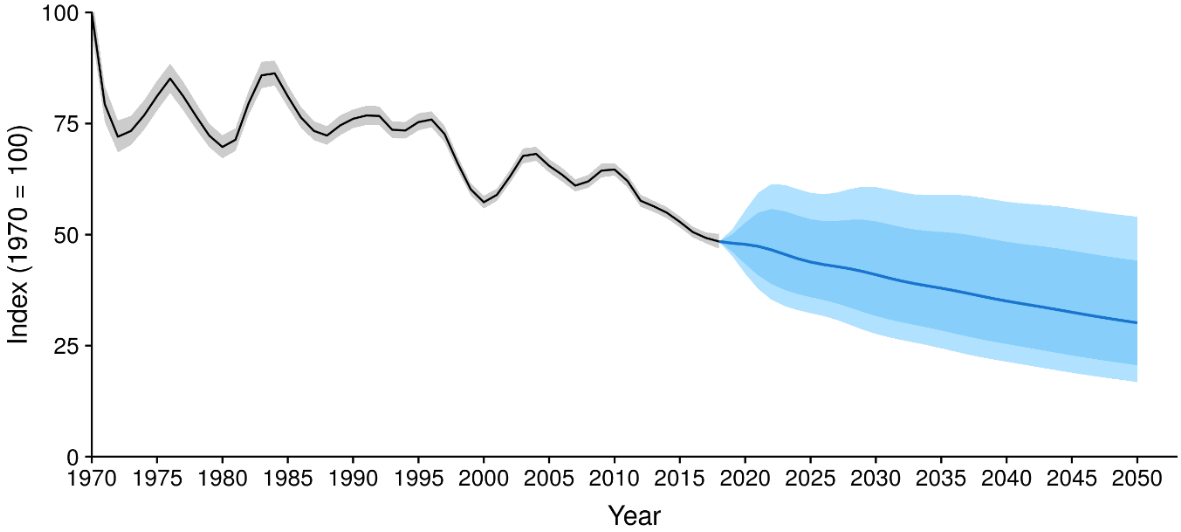
Figure 18: Illustration of the necessary rate of change required in order that the 2030 species abundance target is met and there is an increase in species abundance in line with notional targets by 2042. ***Source: UK Centre for Ecology and Hydrology***



Current trend and Scenario 1 projection

Modelling approaches were used to estimate what might happen to the indicator under Scenario 1, in other words, a forecast of the current trend. Based on the most recent data (2018 – containing 670 species), the indicator value is currently 48% of its 1970 value. We used Auto-ARIMA models to evaluate an array of different time series modelling approaches (including an autoregressive component, a differencing component, and/or a moving average component with differing numbers of terms) and identify the best model, based on AICc. The analysis shows that the indicator is expected to, on average, continue to decline into the future (Figure 19). By 2030 the indicator is predicted to be 41% (80% prediction interval: 32-53) of its 1970 value. By 2050 the indicator is predicted to be 30% (21-44) of its 1970 value.

Figure 19: Forecast of the biodiversity index to 2050. Blue line shows the mean forecast from an Auto-ARIMA model (Bane, Cooke, et al. in prep), with the 80% (blue envelope) and 95% (light blue envelope) prediction intervals. Source: UK Centre for Ecology and Hydrology



Feasibility of improving the trend

Progress in line with the notional targets will require moving a declining trend to a stable or increasing one. The indicator proposed presents a geometric mean of species' abundance, which means that a 10% increase in one species would be exactly cancelled out by a 10% decline in another species, regardless of whether they are rare or very widespread species.

Statistical analysis was undertaken to understand what delivery of the notional targets would mean for the number of species that would need to increase in abundance and by how much. This analysis was undertaken not to develop a plan for delivery, but to understand how ambitious the notional targets are.

Species deficits and growth rates [34]

The value of the indicator reflects changes in the abundance of many thousands of animal populations. A key question for the feasibility of the notional targets is how easy it is to move this system from one position to another. We estimated how easy the system could be to move by looking at the *inertia* or *potential* for change in the indicator components. To do this we calculated species deficits (the difference between the current abundance level and the most recent maximum abundance) assuming species with greater deficits have greater potential to increase over the timescale of the targets. The analysis showed that, unsurprisingly, many species have deficits. We then reviewed how these species deficits scale up to the multi-species indicator. If all species were to attain their recent maximum abundance, then 175% of historic (since 1970) losses could be recovered. Thus, we might assume there is sufficient potential in the indicator to meet the notional targets. This would, however, rely on all species either increasing to, or remaining at, their recent maxima, which is unrealistic. This analysis therefore provides insight into the *potential* within the indicator for change but does not directly inform us of how *realistic* the notional targets are.

Interaction between proportion of declining species and annual growth rates[35]

As a more realistic alternative, we can focus on the recovery of declining species. Based on annual growth rates (the rate at which a species' abundance increases or decreases per year). In the 15 years between 2003 – 2018, 67% of species declined (annual growth rates < 0; median = -3.6) and 33% either increased or showed stable trends (annual growth rates ≥ 0; median = 2.3). For example, Blotched Emerald (*Comibaena bajularia*) and Golden Oriole (*Oriolus oriolus*) have both declined by >20% per year over the last 15 years. By contrast, Glanville Fritillary (*Melitaea cinxia*) and Bittern (*Botaurus stellaris*) have both increased by >10% per year; Brown Argus (*Aricia agestis*) and Treble Lines (*Charanyca trigrammica*) have increased by >5% per year; and Red Underwing (*Catocala nupta*) and Silver-washed Fritillary (*Argynnis paphia*) have increased by >3% per year.

We then investigated what proportion of declining species' trends needed to change, and by how much, to meet the notional targets. To do this we can project the multi-species indicator into the future based on interactions between the proportion of declining species and annual growth rates, building on scenarios outlined by Gregory et al. (31) for the farmland bird indicator. In the following analyses, we assume non-focal declining species

[34] This analysis was undertaken using the first iteration of the indicator- containing 670 species of birds, bats, butterflies and moths

[35] This analysis was undertaken using the first iteration of the indicator- containing 670 species of birds, bats, butterflies and moths

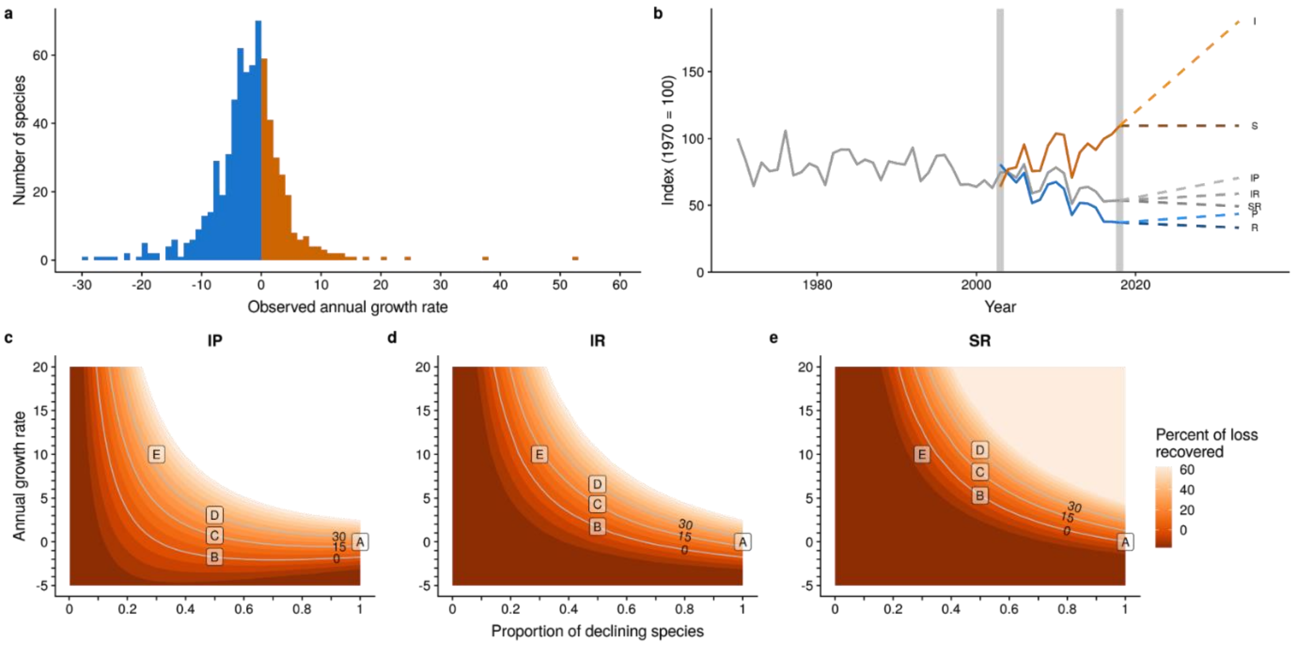
(i.e., those not selected) continue to decline at their recent (over the last 15 years) annual growth rate. However, we vary the assumption for increasing species and how declining species are selected (Figure 20).

First, we assumed that increasing species continue to increase at current rates and the most declining species are recovered first (Figure 20b - label IP). Under these assumptions, if we stabilized all declining species, we would recover 22% of historic losses (Figure 20c - label A). While, to bend the curve of biodiversity decline (i.e., flattening of the curve in the indicator over the next 15 years) we would need to reduce the rate of decline for 50% of declining species to -1.7% per year (Figure 20 label B). To increase abundance by 15% we would need 50% of declining species to increase at 0.7% per year (Figure 20c - label C); and to increase abundance by 30% we would need 50% of declining species to increase at 3.0% per year to reach the high ambition target (**Figure 20**c - label D).

However, the most declining species are often the most difficult and expensive to recover. So, to compare, we then assumed that the recovering species are a random subset of declining species (Figure 20b - label IR). As above, if we stabilized all declining species, we would recover 22% of historic losses (**Figure 20**d - label A). However, to halt decline we would need 50% of declining species to increase at 1.7% per year (**Figure 20**- label B). For abundance to increase by 15%, we would need 50% of declining species to increase at 4.3% per year (**Figure 20**d - label C), or at 6.6% per year to increase abundance by 30% (Figure 20**d**- label D). This random selection of declining species is likely more realistic but shows that the targets are more difficult to achieve.

Finally, we assumed that increasing species are stabilized at their current levels (annual growth rate = 0) and decreasing species are selected at random (Figure 20b - label SR). Reflecting the difficulty in maintaining increases for currently increasing species. In this scenario, if we stabilized all declining species, the indicator would not change over the next 15 years (**Figure 20e**- label A). No change could also be achieved by 50% of declining species increasing at 5.3% per year (**Figure 20**e - label B). To increase abundance by 7.5% would require 50% of declining species to increase at 8.0% per year (Figure 20**e**- label C), or at 10.5% per year to reach the 30% target (Figure 20e - label D). For context, to reach the 30% recovery target we would need 50% of declining species to increase at rates greater than the success seen for Bittern over the last 15 years. Thus, without continued improvement in species that are currently increasing, the notional targets will be very difficult to achieve.

Figure 20: Projecting interactions between the proportion of declining species and annual growth rates for multiple scenarios. (a) Observed annual growth rates for indicator species over the last 15 years (2003 - 2018); declining species in blue, increasing/stable species in orange. (b) Abundance indicator through time. The overall indicator is shown in grey, as well as an indicator for declining species (blue) - species with negative annual growth rates between 2003 and 2018 (grey vertical lines) and increasing/stable species (orange) - non-negative annual growth rates. Dashed lines show the trajectories for differing assumptions: I - increasing species continue to increase; S - increasing species are stabilized; P - most declining species are recovered first; R - recovered species are a random selection of declining species; IP, IR, SR - combinations of the assumptions for increasing and declining species. To allow comparisons, the scenarios are fixed to 30% of declining species increasing at an annual growth rate of 10%. (c) Increasing species continue to increase and the most declining species are recovered first (IP). (d) Increasing species continue to increase and declining species are randomly selected (mean across 100 random samples) (IR). (e) Increasing species are stabilized and declining species are randomly selected (mean across 100 random samples) (SR). Contours show the percent of loss recovered, 100 * (future indicator - current indicator) / (100 - current indicator), for the indicator over the next 15 years, with contours at 0, 15 and 30% recovered - reflecting the low, medium, and high targets. Labelled are example combinations described in the main text. *Source: UK Centre for Ecology and Hydrology*



Species recoverability

The analysis in the previous section provided some idea of the level of annual increases that would be necessary to meet the notional targets. Whilst we were not able within the time to assess individual species within the indicator to understand their potential recovery, we sought to provide context by looking at species that had either increased or been subject to targeted conservation action, assuming that they provide some, if limited, insight into the level of improvement that is possible.

Studies where conservation action had been taken focused mostly on species that had suffered significant declines or had become extinct nationally and were subject to reintroduction programmes, therefore are not necessarily representative of the range of species within the indicator.

There are several success stories where species have been reintroduced, translocated or responded positively to targeted conservation measures. The scenarios explored in the previous section highlighted what annual growth rates may be required to reach the notional targets. This section uses case studies to demonstrate what growth rates have been seen in in practice for comparison. It would seem sensible to assume that in order to reach any of the notional target, some species will need to increase by large amounts to offset species that can either not be recovered or which may take a long time before recovery is seen.

Bittern, cirl-bunting and stone curlew are notable conservation success stories for which average annual growth rates have been calculated. The average annual growth rate over the last 15 years has been 10.2% for Bittern and 3.4% for cirl bunting. Targeted action for crane, including reintroductions, has seen the population increase by an average of 15.1% annually over the last fifteen years.

Red kite is the biggest recent conservation success in the UK and shown the largest population increases, increasing 217% between 2008 and 2018. Buzzard is England’s most increasing bird in the long-term, increasing over 1000% since 1970. Between 2008 and 2018 Buzzards have increased 34%.

Some large increases have also been seen for some butterfly species. Small heath butterfly has increased 332% in woodlands between 2015 and 2020, however even this large increase has failed to make up long-term declines with the long-term trend (1990-2020) still showing a decline of 48%.

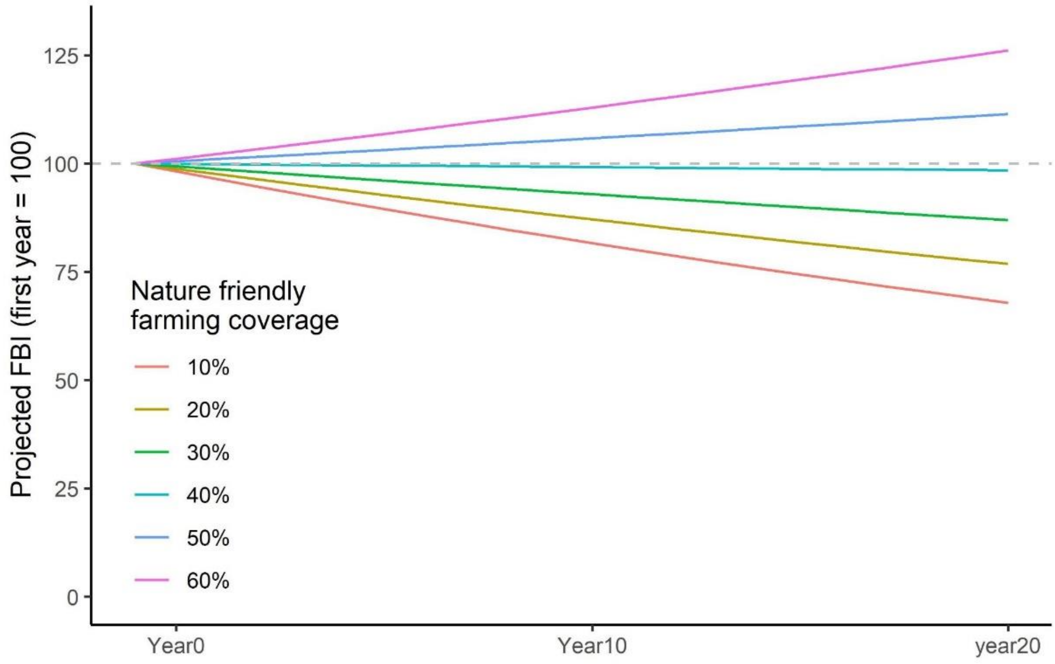
In summary, large population increases and high annual growth rates have been seen in the UK/England in recent years for some species. It is worth noting however that these are associated with notable conservation successes where action informed by focussed research has been taken over long timescales often in association with translocations or reintroductions; and have not been enough to prevent declines in other species. Our analysis shows that targeted action for many more species would be required to reach growth rate akin to what is needed. Whether similar growth rates could be replicated for a much larger range of species in the timescale to support target delivery is uncertain. However, what is clear is that “Scenario 2” would not be sufficient to reach the notional targets: some kind of transformation in the delivery of nature conservation would be required.

Impact of Agri-environment on species recovery

Agri-environment schemes have been a key mechanism for supporting nature recovery, including improving outcomes for species. The evidence providing clear link between action taken under agri-environment schemes and changes in species abundance at national level is limited. Some evidence does exist relating to the response of birds within the Farmland Bird Index (FBI) and agri-environment schemes at the local level. We have sought to understand how these relationships might scale up at a national level, assuming that the relationships would be maintained at the wider geographical scale. The outputs are summarised here.. The research modelled how many farms would need to implement nature friendly farming activities to see improvements in the FBI in line with halting or recovering declines. The research assumed that each farm implemented nature-friendly farming actions on 10% of the farm, and that actions were roughly equivalent to Higher Level Stewardship (HLS) that targeted actions to delivering a broad range of environmental benefits. Currently approximately 10% of farms in England have HLS-type options implemented on farms. The simulation suggests that nature friendly farming options would need to be in place in around 41% of farms or farmland to lead to a stabilisation in the FBI in England (Figure 21).

For the ‘**Halt decline’** scenarios, assuming that from 2022 there was a steady rate of increase in coverage of nature friendly farming from 10% to **41%** by 2030 or 2040 and subsequently no further increase in coverage, the value of the FBI in 2040 was predicted to be 36 under the ‘**halt by 2030**’ scenario and 33 in the ‘**halt by 2040**’ one, compared to the ‘Business and Usual’ value of 30.8 (Figure 21).

Figure 21: Projection of the English FBI into the future under different future scenarios of nature friendly farming provision, showing the predicted change in the indicator over twenty years for a range of coverage levels. Coverage level remains constant throughout the scenario. ***Source: UK Centre for Ecology and Hydrology***



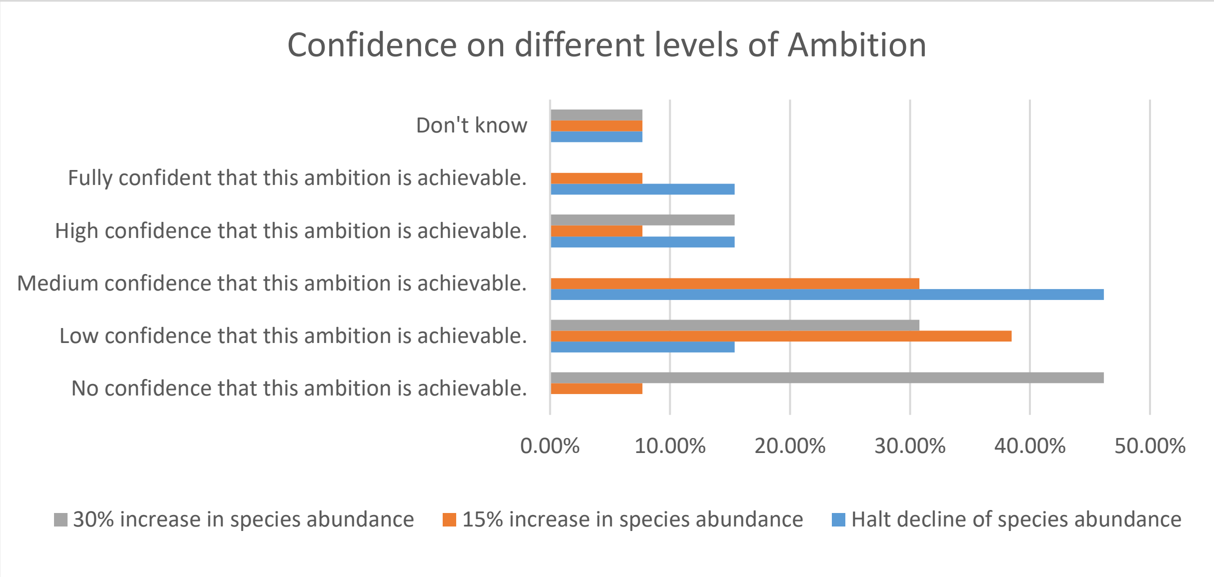
To return the FBI to its 2022 value (38.8) by 2030 would require a steady increase in the rate of uptake of nature friendly farming options from ~10% in 2022 to **65%** in 2030. In order to return the FBI to its 2022 value by 2040 would require a steady increase to **68%** in 2040. The 2040 value of the FBI was predicted to be 45 in the scenario that declines are halted by 2030.

While simplistic, our modelling of the FBI, which is based upon empirical data on the response of farmland birds to higher level agri-environment schemes in England and robust population estimates, suggests that around 40% of farms would need to adopt nature friendly farming to halt the decline of farmland birds by 2030. To return the FBI to its 2022 value by 2040, the number of farms in these types of agri-environment schemes would need to increase to 68%. By "adopting nature friendly farming", we mean that these farms would adopt options similar to the old Higher Level Stewardship scheme in which approximately 10% of the land area was set aside for nature (e.g. as sown field margins).. Given uncertainties in the data and the extrapolations made, these figures should be treated with caution, though they provide a sense of the step-change in action that is required to bring about change for this well studied group of animals.

Expert Assessment of Feasibility

In discussing the species abundance target at the statutory expert workshop, the species limitation of the indicator was discussed. It was agreed in defining the actions participants should consider those actions that would support improvement for species as a whole, whilst recognising that the target level and ambition will need to be based on the species within the indicator. The key results from the questionnaire can be seen in Figure 22 with the key takeaways listed below; these are based on the notional targets described earlier.

Figure 22: Stakeholder confidence when asked the achievability of various notional levels of ambition for Species Abundance by 2037 n=13



Halting decline by 2037: 76% had medium, high or full confidence this was achievable, there was medium confidence in answers on the low ambition.

15% increase in species abundance: 46% of respondents had medium, high or full confidence in achieving this ambition. Of those who were not confident the ambition was deliverable in a 15-year timescale suggested an additional 10-20 years would be required. Respondents had low-medium confidence in their answers.

30% increase in species abundance: 15% of respondents had high confidence that the high ambition was achievable in a 15-year timescale, no one felt medium or fully confident. There was no consensus on the additional time that would be required to deliver the target, with 40% responding ‘don’t know’ and an even spread across the other options of; unachievable in any timescale, an additional 10 years, additional 20 years and more than 20 years. Respondents had low to medium confidence in their responses.

At the end of the workshop participants were asked to mark a spot on a sliding scale from below the low ambition to above the high ambition suggesting what level the target should be set, whilst at the same time capturing the associated assumptions under a PESTLE framework heading[36]. There was a mixture of views with the majority falling somewhere between medium and high. There were more people at the workshop than responded to the questionnaire, however the spread of responses suggested that the experts favoured setting a target at a level above which they were fully confident was achievable. This is likely to be explained by the tension of defining feasibility by what is ecologically feasible versus realistically feasible considering likely political, social, environmental and economic constraints and experience. This was reflected in the discussion and the assumptions captured. The assumptions covered a few themes, but with differing views:

- Some participants made the assumption that political will and the importance of biodiversity in government decision making and investment would not be a barrier in future, whilst most reflected that past performance limited the ability to have confidence in future progress. The lack of a mechanism to embed biodiversity in decision making was also raised as an assumed barrier.
- Most participants assumed continued competition for land use.
- Environmental and ecological assumptions included the existence of an unquantified extinction debt; the widespread nature of species requiring action on biodiversity outside of the usual rural areas where we lack a mechanism; time lags in recovery and unquantified impact of environmental pressures including climate change.
- Economic assumptions focussed on continued volatility, unpredictability with the Covid 19 pandemic used as an example.
- Assumptions on social issues were less detailed but included references to increasing population growth and the likelihood of increased political will and public concern for biodiversity leading to the necessary shifts in public behaviour.
- Few technological or legal assumptions were made, likely reflecting the ecological and social science expertise present.

Expert views on actions required to deliver the notional target- halting further decline in species abundance by 2037

- Increased large-scale creation and restoration of habitat was seen as critical alongside improvement in the condition of protected sites (Confidence: High). Similarly, improving connectivity of habitats alongside improvements to quality was seen as important as was addressing physical barriers such as roads.
- Improved monitoring and evaluation, local level assessments, trialling of novel management solutions and research to support improvements on protected sites were highlighted as important actions. An additional suggestion was greater role for independent experts in assessing progress and indicators. Wider research and

[36] PESTLE stands for Political, Environmental, Social, Technological, legal and Economic.

development including more socio-economic research was seen as moderately important with the need for moderate changes required (confidence high)

- Improvements to the water environment and reduction in the impact of pesticides were seen as critical actions requiring increased action to be regarded as sufficient. Confidence medium.
- Targeted action for species was seen as critical with moderate changes required to be sufficient (confidence medium).
- Protection of species from unsustainable development, spatial planning, sustainable farming approaches and partnership working were all deemed important with the need for moderate changes to implementation to be sufficient (confidence medium-high). A strategic approach to tree planting was also suggested as important.
- Legislative approaches were seen as moderate to low importance, as were managing wildlife crime; protecting species at risk of taking, killing and sales; obligations to achieve favourable conservation status; and legislative approaches to support long-term planning (Confidence medium). Implementation of the Natural Environment and Rural Communities Act was seen as more important requiring moderate change to be sufficient.
- Managing invasive species was seen as moderately important, requiring moderate changes to be sufficient. (Confidence M-H)

Expert views on actions required to deliver the notional target- 15% increase in species abundance by 2037.

On top of the actions defined for the low ambition ('halt decline by 2037') experts highlighted the following actions they believe would support delivery of the medium ambition. Although it was recognised that many of the same actions would be required over a greater scale and pace.

- Broader changes to the management of land and the countryside. Specific suggestions included:
    - Shift toward more high nature value food production, supported by advisors to support land managers.
    - Managing conflicts with other land uses, with human development and reshaping public opinion on how land should look.
    - Greater emphasis on prioritising the right habitats in the right place
- It was suggested that the low ambition was more feasible whilst cherry-picking specific species but moving towards the medium ambition required a change in approach to prioritising species for action, suggestions included greater focus on habitat specialists rather than widespread species and taking a taxonomic focus in setting priorities.
- The greater requirement for land was deemed to make it more important to manage the broad pressures on species such as nutrient pollution, which will require more cultural and societal change. Rebalancing incentives and regulations were seen as a potential approach with the need for greater

regulation. Improving uptake of agri-environment schemes was also seen as important.
- Greater cooperation with near neighbours and other countries along migratory routes was suggested as necessary to meet the medium ambition.

Expert views on actions required to deliver the notional target- 30% increase in species abundance by 2037.

In addition to action identified for the previous notional targets experts identified the following actions. There was less confidence in identifying needs at this level and several participants expressed that they did not know what was needed to deliver the ambition level.

- The need for greater scale of action and the need for integration of policies on air, water, soils, and biodiversity
- Moving away from actions that government would typically pay for was raised as a potential option to rapidly increase compliance alongside greater regulation and enforcement.
- Greater international leadership was also seen as important, as was tackling global pressures such as climate change.
- A greater role for those outside government was seen as important, support experts and local level action.

Scenarios Analysis

There are a variety of actions that could contribute to achieving increased species abundance (and help to achieve the other targets). Following the workshop, where experts considered the key actions, the actions were scored for tractability of inclusion in modelling based on the ease of constructing a logic model and the availability of data. Actions that scored highly for importance of inclusion and tractability were taken forward.

From the list of actions, we could classify three broad types of intervention: a) those that target individual species, b) management and creation of semi-natural habitats (including restoration of freshwater habitats), and c) Agri-Environment schemes (AES). In order to determine what impact these types of interventions might have on the indicator; it is useful to think about them in terms of the impacts they will have on the landscape and the types of species they will benefit.

For simplicity, we can think of each intervention type as being beneficial to a subset of species in the indicator. We can relatively easily split species into two groups: habitat specialists, and wider countryside species. Habitat specialists will generally have distributions that are restricted to particular habitat types (i.e., semi-natural habitats) and will benefit from interventions that target their specific habitat, whereas wider countryside species will typically be found in larger scale habitats such as farmland, parks and gardens and are more likely to benefit from broad-brush interventions, such as AES. Interventions that are targeted towards particular species will generally focus on creating or restoring habitat types and can therefore be treated as a subset of the interventions under the management and creation of semi-natural habitats.

In the sections that follow, we model the impact of three broad types of intervention for the proposed 2042 target. The first is a model for the creation of semi-natural habitat, building on work within the wider habitats model. The second is a model of how AES might benefit species of the wider countryside. The final model explores the impact of improvements in water quality to the abundance of freshwater invertebrates. Following each section, a brief qualitative assessment is given with regard to the 2030 species abundance target for context.

In all cases, there are substantial evidence gaps and conceptual barriers to projecting how species abundance might change. Overcoming these gaps is only possible by making a series of simplifying assumptions: these are laid out in the text for each section, and the assumptions lead to caveats about how the results should be interpreted.

Early in the development of these models, it became apparent that the goal of modelling a trajectory in species abundance (i.e. a future trend over time, in response to actions/policy interventions undertaken) was not practical. Principally, this is due to substantial lags in the system: there are uncertainties about when the policies would be initiated and how quickly they would be rolled out (implementation lags), and about how long it might take for increases in species abundance to be realised (ecological lags), whilst accounting for density dependence. Uncertainty about these lags is so great as to make unreliable predictions about the rate of change in species abundance in response to specific actions.

For the three models, we make the simplifying assumption that all benefits from these policy interventions can be realised by the maturation of the long-term targets, which is expected to be the year 2042. The projections for these models are an estimate of the potential increase in abundance that could be realised by 2042. For each scenario, we include background to the intervention, what is required within the modelling, data availability, the approach taken for each of the three models, the results from this modelling including limitations and assumptions and finally, a section speculating on the proportion of these benefits that could be realised by 2030. It was not possible to model the impact of the interventions by 2030 in the same way as for 2042 due to the much I a shorter time frames, therefore more qualitative assessments are provided under each analysis.

Creation and restoration of semi-natural habitat

Aim: to model the improvements that could be realised by 2042, through creation of semi-natural habitats.

Background

Management and creation of semi-natural habitat is a key component of nature recovery and is included in existing commitments. Large amounts of habitat have been created in the past, particularly under Biodiversity 2020 (England's biodiversity strategy to 2020), much of which has been created through agri-environment schemes (e.g. creating field margins, grassland and hedgerows). Natural England has developed trajectories for the creation of habitat going forward, based on assumptions about the uptake of new agri-environment schemes, and Biodiversity Net Gain, Peat Action Plan and woodland planting. These data are likely to form the basis for a target on habitat creation and provide a natural starting point for assessing benefits to species abundance.

In this scenario, we explore the increase in the abundance that could derive from the creation of semi-natural priority habitats. These projections are limited to terrestrial animal species, i.e. the 670 species in version 1 of the index. Freshwater species are dealt with in a separate scenario; for plants there was insufficient time and data to produce a trajectory.

What would be required to model habitat creation

The first stage of the analysis was to assess the information that would ideally be used to inform modelling of the impacts of habitat creation on species abundance. Firstly, we identified the need for data on the total area, condition and location of wildlife rich semi-natural habitat that already exists in England, to provide a baseline from which to model the benefits arising from habitat creation.

We would also ideally need to know plausible scenarios of improvement in the condition and extent of these habitats under the different policy scenarios. Ideally these scenarios would be spatially explicit, i.e. they should include information about which habitat types will be created, and where. This is important because extension to an existing habitat patch will have a different effect (on abundance) than the creation of a new patch that is isolated from others. We would also need some estimates of the condition or quality of the habitats before and after intervention, and the timescales over which improvements in habitat quality and species abundance would occur, given our knowledge of ecological lags. We would also require some estimates for the success of previous habitat creation schemes in delivering high quality habitats capable of supporting abundance populations of animals.

We would also need to know which species will benefit from the newly created habitat, and by how much. If the projections were spatially explicit and identified which habitats would be created, we would have information about the local pool of species that could easily colonise the new patches. In order to assess which species would benefit most, we would need good data on the habitat requirements of each species, ideally expressed in terms of preference (i.e., relative abundance) for each type of priority habitat. Due to data limitations, it was not possible to model the responsiveness of species abundance to habitat creation in this fully detailed and spatially explicit way. The following sections set out what data was available to inform the modelling, and the approach and assumptions that were used.

Data availability

We accessed data on the geographic extent of Section 41 habitats (henceforth priority habitats) of principal importance from the Priority Habitat Inventory (PHI). In the most recent version (v2.3) of the PHI, the total area of priority habitats (excluding arable field margins) in England is approximately 22,300 km^2 (about 17% of the land area).

From 2011-2019, the area of new priority habitat created was 166 km^2 per year. These figures provide a basis for Scenario 1 of the Wider Habitats target. Additional scenarios exist for Biodiversity Net Gain, the Peat Action Plan and Partnership delivery.

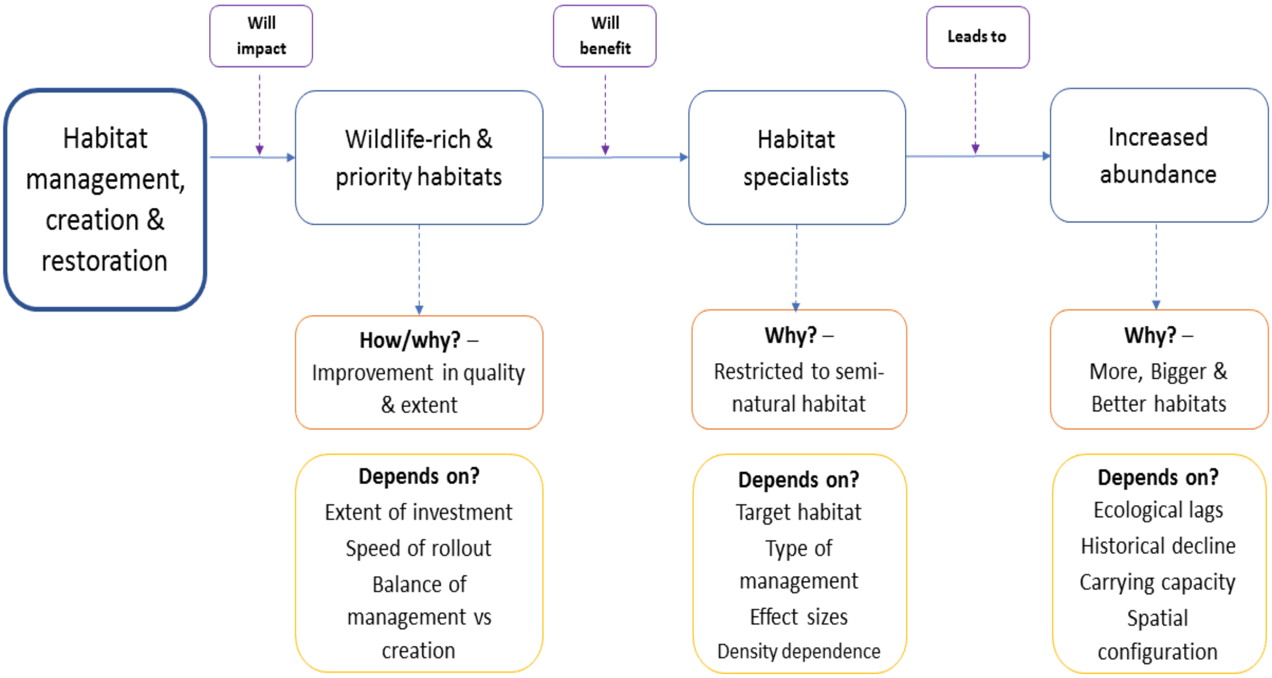
Although information on the location of existing priority habitats is also available from the Priority Habitat Inventory, there are currently no considerations of the placement of the habitats that will be created under different potential future policy scenarios.

We have some information on the habitats used by each species in the indicator. In theory it would be possible to extract information on species' relative abundance in different habitat types from the monitoring scheme data, but this would not be straightforward given how those data are stored and the way that habitats are classified by the various schemes.

Approach to modelling for the impact of habitat creation on species' abundance

Management, creation and restoration of wildlife-rich semi-natural habitats will benefit the species that specialise in those habitats. Whilst these actions may also bring some benefits to generalist (or wider countryside) species, any increase in overall abundance is likely to be marginal, given that (by definition) the majority of the species' populations (and hence total abundance) are in non-priority habitats. By contrast, habitat specialists are restricted to one or a very small number of habitats, meaning that expanding the area of priority habitats will translate into an increase in abundance of the species that rely on them. We therefore assume that only those species classified as habitat specialists will increase in abundance as a result of the newly-created habitat. The logic model to describe this scenario is shown in Figure 23.

Figure 23: Logic model for assessing the potential of habitat creation to increase species' abundance. ***Source: UK Centre for Ecology and Hydrology***



We use the projections for habitat creation provided in the wider habitats scenarios work to inform modelling the impact of habitat creation scenarios for species abundance, with a focus on habitat specialists. We do not consider arable field margins, since these are temporary habitats that mostly benefit wider-countryside species. Moreover, they derive from agri-environment schemes (AES), the benefits of which are modelled in the next section and for farmland birds above, Figure 23. Also, we do not model the effects of woodland creation, because the slow speed at which woodlands mature creates enormous uncertainty about the rate at which the benefits to species abundance might be realised.

Scenario 1

Of the 166 km^2/year of priority habitat that was created during the past decade, 36.7 km^2 was arable field margins and 20.4 km^2 was woodland creation. As stated above, these will fall outside of the scope of our modelling. Thus, our Scenario 1 projection is for 108.9 km^2 of priority habitat per year, or 2,176 km^2 over the 20 years of the targets (1.68% of England's land area).

The PHI data do not include arable field margins, because these are not mapped in detail. However, the data do include the area of deciduous woodland, which is the most extensive habitat within the PHI: removing this habitat type reduces the current area to 14,937 km^2. Thus, the amount of newly created habitat in the first year is projected to be 0.73% of the baseline; the total amount created over the 20 years of the target period is 14.6% of the current area.

Scenario 3

The Wider habitats trajectories include a sequence of three high level scenarios: “Scenario 2”, Scenario 3 and “Scenario 4”. Scenario 2 considers woodland creation, partnership working, Biodiversity Net Gain and delivery of the Peat Action Plan. Scenario 3 additionally considers partnership working. Scenario 4 additionally considers uptake of AES and improvements in freshwater quality, which are considered elsewhere in this document. The habitat created by partnership working is relatively small compared with “Scenario 2”, so for simplicity we model only one scenario based on the area created by Scenario 3 but excluding the area of woodland created. The total area of priority habitat created under this scenario over 20 years is 1,733 km^2 (1.3% of England’s land area). When added to Scenario 1 projection, this represents an increase of 31.1% of the current area. The total extent of priority habitat would increase from 17% to 22.3% of England’s land area.

Mitigation for ongoing declines

In the past 20 years, the average change in the England priority species index has been a decline of approximately 2% per year (NB that represents 2% of the previous year’s abundance, not 2% of the baseline value). This has occurred during a period in which new habitat has been created, so we need to reflect these other pressures when predicting the impact of habitat creation. This is more pessimistic than the ensemble mean projection of 1.2% per year, which covered the full set of 670 species.

The most parsimonious assumption would be that the trend in abundance under Scenario 1 would be the same as the trend of the past two decades, i.e., a 2% decline per year (in other words, we would assume that future pressures would be the same as recent pressures). However, we lack a basis for estimating what the recent decline would have been in the absence of habitat creation. Thus, for simplicity our baseline assumption is that from habitat creation will lead to gains in abundance but overlain upon a declining trend of 2% per year.

A more optimistic alternative scenario is that targeted management (including improved condition of SSSIs) is sufficient to offset these declines, such that even small amounts of habitat creation would lead to a net increase in species abundance. We therefore include a “+Mitigation” variant of Scenario 1 and Scenario 3 in which the background trend of species abundance is flat, rather than declining, i.e. assuming that pressures driving the recent declining trend will have been mitigated.

Species responses to habitat creation

Whilst the logic model (Figure 23) specifies that habitat creation will benefit species that are habitat specialists on one particular type of priority habitat, the creation of priority habitat will also have wider benefits to other species. Given this uncertainty, we do not attempt to estimate the effects on specific species, nor in the wider index. Rather, our projections are for an idealised set of habitat specialists.

For simplicity, we assume that our idealised set of habitat specialists are specialists of just one habitat type and that any increases in the area of semi-natural habitat will be evenly spread across existing habitats in proportion to their current area (i.e., the proportional increase in habitat area is equal for all habitat types and will translate to a proportional increase in abundance of the habitat specialists in the indicator).

Many habitat specialists are listed on Section 41 of the Natural Environment and Rural Communities Act. Thus, we can think of the impact of this scenario as being most relevant to the trend of the England priority species indicator(“D6a”), which was published in 2021 with data from 149 of the 670 species in our version 1 of the abundance index described above.

In reality, any increase in abundance (from habitat creation) will depend on restrictions to species’ population growth. These restrictions include ecological lags, the carrying capacity and spatial configuration of the habitat (it could take many years for isolated patches to become colonized). In addition, newly created habitat may take some time to become suitable (e.g. due to reliance on hostplants in a particular growth form). These lags create substantial uncertainty about how rapidly habitat creation is capable of bending the curve of species abundance.

Results of the habitat creation scenario

Results of our habitat creation scenarios are shown in Table 10. The Scenario 1 + Decline trend results in a net loss in abundance of 18.6% by 2042. As noted above, even this might be considered conservative: if we had assumed Scenario 1 delivers zero benefit to abundance then the trend over 20 years would have been -33%. Scenario 3 is almost, but not quite, sufficient to mitigate the background losses, so the net result is a modest decline of 2.1% over 20 years.

Table 10: Results of the habitat creation scenario. The % change column is the predicted change in abundance for an idealised specialist species over the 20-year period of the target, measured relative to the 2022 baseline.

Scenario	% change
Scenario 1 + Decline	-18.6%
Scenario 3 + Decline	-2.1%
Scenario 1 + Mitigation	14.6%
Scenario 3 + Mitigation	31.1%

Not surprisingly, both variants in which background losses are mitigated show strong increases by 2042. The benefit of Scenario 3 is to approximately double the amount (and therefore the rate) at which abundance will increase.

The enormous difference between the +Decline and +Mitigation scenarios is salutary. It shows that creating large areas of new habitat is likely not sufficient to bend the declining biodiversity curve on its own. The results emphasise the critical importance of reducing other pressures that have reduced species abundance to historically low levels. In the context of terrestrial biodiversity in England, the most important of these pressures are a) the intensity of agricultural land-use (including the use of pesticides), and b) poor condition of existing priority habitat.

Assumptions & Limitations

Any increases in semi-natural habitat will be evenly spread across existing priority habitat types in proportion to their current area. This means that the proportional increase in area is equal for all habitat types. Our scenarios are based upon an idealised species that is restricted to a single habitat type. The results might be generalised to a set of species that are mostly comprised of habitat specialists, such as the priority species indicator. The English priority species indicator contains 149 species, all of which are among the 670 species in version 1 of our abundance index, described above (i.e. 22% of the total). For some groups, the proportion of species classified as habitat specialists is greater (approximately half for butterflies).

For wider countryside species (i.e. the majority), any increase in abundance arising from new habitat is likely to be minimal under this scenario, because the newly created habitat represents only a small portion of the English landscape (1.3% under Scenario 3).

We have ignored any benefits that might accrue from the substantial areas of woodland that are likely to be created in coming years (although we do include Planted Ancient Woodland Sites (PAWS). Our justification for exclusion is that substantial uncertainty exists around the rates at which any new woodland would reach a sufficiently mature state to support large populations of birds, butterflies and moths that specialise on woodland. However, even immature woodland would have substantial benefits to the abundance of many animal species preferring successional habitat, although some of these benefits might be lost as the canopy closes.

Beneficiaries increase in abundance in direct proportion to the area of new habitat created. This is a very generous assumption. So, a 10% increase in area would be reflected in a 10% increase in abundance. This assumes that either a) new habitat is adjacent to existing habitat, thus increasing the local carrying capacity, or b) new monitoring sites are located in habitat patches that have been created, in order to detect the growth of these new populations. It further assumes that no additional restrictions exist on the population growth of these specialists (i.e., they are limited by available habitat, not any other driver nor dispersal). These are generous assumptions (i.e., they make the target easier to achieve): relaxing them assumption could be explored using values of $r < 1$, i.e. r defines the relationship between gain in area would translate to a gain in abundance. This full gain in abundance might not be realised for a few reasons: [1] lags in the realisation of gains [2] the restoration/creation might fail or be less effective than we think it will be, [3] colonization deficits (some will be too far from existing populations to be colonized, or outside the climatic range for some species); [4] scale-area effects; [5] the habitat is created but monitoring stations are not introduced to measure the effects; [6] the habitat that existed prior to conversion of priority habitat already harboured some populations of habitat specialists.

Conversely, it is possible that newly-created habitat could support higher densities of certain species than existing semi-natural habitat. One reason for this is that given half of protected sites are in favourable condition, species abundance on these sites is lower than it might be. We have not modelled the gain in abundance that would be realised if existing semi-natural habitat on protected sites were to achieve favourable condition. Our scenario effectively assumes that new habitat will be on average similar in “quality” (i.e. condition) to existing habitat patches. If all the newly-created habitat were equivalent to the best quality protected sites, then the total increase in abundance would be greater than estimated here.

We have modelled “Mitigation” separately from Scenario 3. In reality, many of the specific interventions in Scenario 3are designed to mitigate ongoing declines. So “Scenario 3 + Decline” (-2.1%) is arguably pessimistic but “Scenario 3 + Mitigation” (+31%) is certainly optimistic.

Our mitigation scenarios assume that the average trend in the absence of habitat creation is zero. Applied to large numbers of species, this means shifting the average trend from the recent decline of 2-3% per year. It does not assume that all pressures (including climate change) be completely removed. This is because the recent decline is an average, with some species experiencing much steeper declines and others actually increasing. Recent evidence suggests that the average trend might be stabilised by the recovery of relatively few species that have experienced substantial losses, so long as other, previously stable, species do not experience substantial declines over the same period.

2022-2030

The above analysis has addressed the development of a habitat creation scenario and the contribution to the 2042 target. Here the question of whether the benefits of habitat creation could play a substantial role in delivering the 2030 target of halting declines in species abundance is briefly considered. In terms of the contribution of habitat creation between 2022 - 2030:

- **Beneficiaries are limited.** As noted above, our scenarios for habitat creation are relevant to an idealised species whose distribution is restricted to one or a few habitat types. The majority of species occur in multiple habitat types, so the benefits of increasing the area of priority habitat by a few percentage points is likely to be marginal for most species.

- **Short time horizon.** The predicted effect sizes above are based on the habitat created over 20 years (2022-2041). Under most scenarios of habitat creation, the amount of new habitat created is expected to be approximately constant. So by 2030, only about 40% of the total habitat will have come into existence.
- **Lags.** There are likely substantial lags between the creation of certain habitat and an increase in species abundance, due to colonization deficits and (especially for specialists with narrow ranges) time taken for the habitat to become suitable. Moreover, there are likely to be implementation lags of at least a year between any decision about habitat creation (location, budget) and that habitat becoming a reality. In addition, indices of species abundance are always at least one year out of date, further limiting the impact they can have in an eight-year window.
- **Rapid increase in the extent of early succession habitats**. It should be noted that there are numerous examples from across England of species recovering at the local scale within less than 10 years of starting action to restore habitats at scale, including at Wallasea Island in Essex, the Great Fen in Cambridgeshire, Geltsdale in Cumbria and Wild Ken Hill in Norfolk. For example, the Knepp Castle Estate in West Sussex supported the second largest population of the rare purple emperor butterfly, within 10 years of action to 'rewild' the estate, despite this species not having previously been recorded at the estate. Many species in England depend upon early successional habitats and their populations respond quickly to habitat creation, indicating that meeting a rapid increase in the extent of early succession habitats that are quick to establish, will likely be important in terms of supporting increases in species abundance.

Agri-environment schemes

Aim: To model the improvements in abundance that could be delivered by rollout of the new agri-environment schemes.

Background

Agri-environment schemes (AES) are key levers by which governments can incentivise landowners and managers to manage their land in an environmentally beneficial way, including (but not exclusively) for biodiversity. AES are typically split into entry-level and higher-level (or targeted) options. In England, the area of land under entry-level options has declined over recent years, with the expiry of most Entry-Level Stewardship (ELS) agreements, whilst the land area covered by targeted and higher-level schemes has remained relatively constant. These targeted schemes have been responsible for the majority of new priority habitat (grassland and arable field margins) that have been created in recent years. The government is designing three new Environmental Land Management schemes.

Data required to model potential impact of Environmental Land Management schemes

At the time of the modelling the new Environmental Land Management schemes were still in development, detailed information on the options, and their likely uptake over time, was not available. Given that some impacts of AES are felt at scales larger than the individual farm, this analysis would benefit from plausible scenarios of the degree to which uptake might be clustered in space.

Data on the beneficial effect of those schemes on the abundance of species in the farmed landscape would also be helpful. This would ideally include effect sizes for each species in the index and the rates at which those effects might be realised (i.e. the biotic lags). For those species that benefit, we would need to know the proportion of their English populations that are exposed to Environmental Land Management schemes (i.e. on farmland). And usefully know the degree to which benefits of Environmental Land Management schemes might be limited by density dependence.

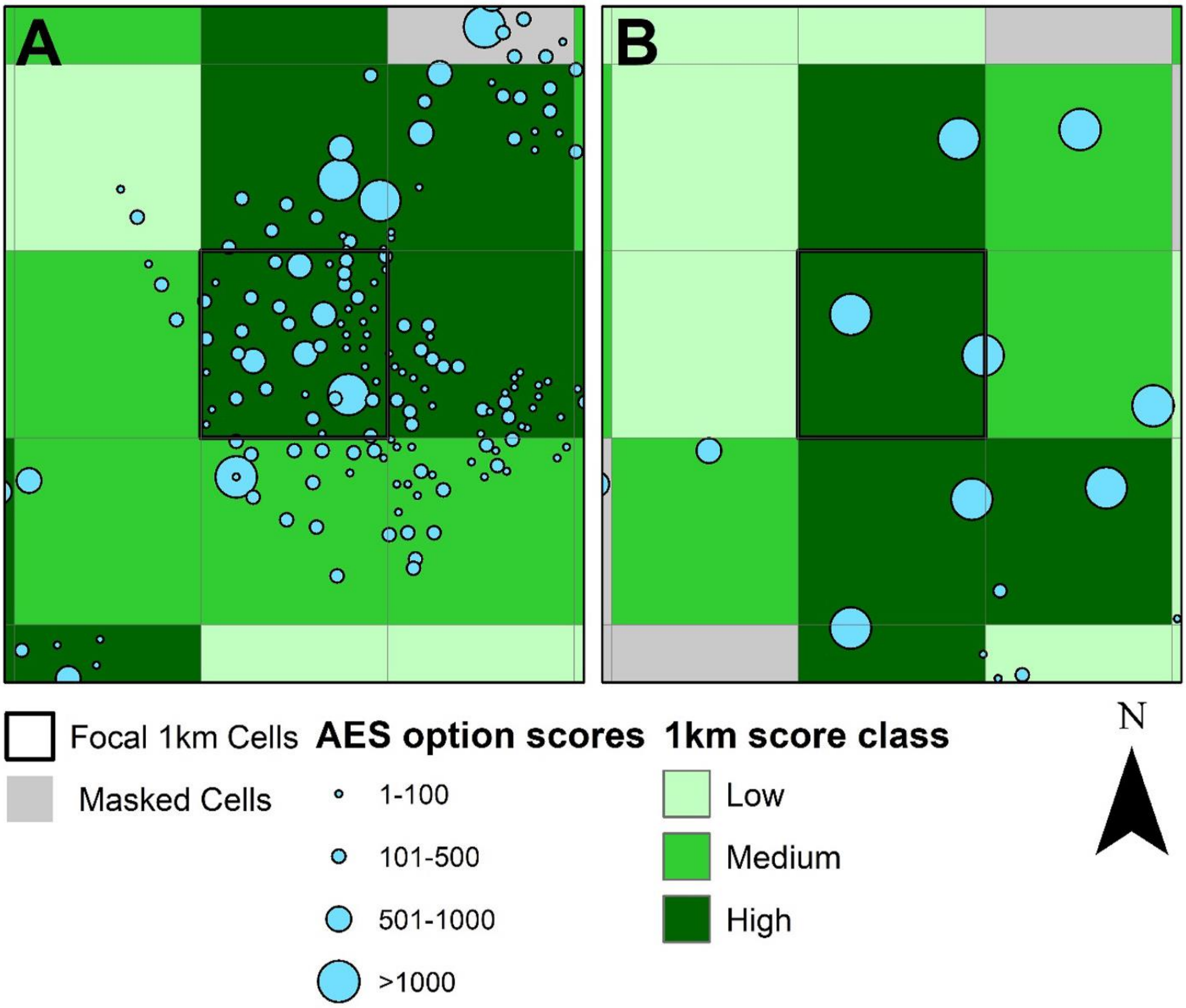
Data Availability

At the time of producing the model the schemes were still in development, limiting the amount of information we had access to, but it seemed reasonable to assume that many options contained in previous schemes will be taken forward to Environmental Land Management schemes, such that the benefits to biodiversity will be broadly similar at a minimum. The modelling also didn’t have data about the speed of rollout of new schemes, and on the uptake of different options by farmers.

There is now a large amount of literature on the impacts of AES options on biodiversity. Much of the relevant information was synthesised by the Landscape-scale species monitoring of agri-environment schemes (LandSpAES) project, led by UKCEH and funded by Natural England. LandSpAES field survey is built on a recognition that many impacts of AES are felt at scales larger than the individual farm, i.e., at landscape scale.

As part of the pilot phase, LandSpAES developed a scoring system for the biodiversity benefits for a broad range of AES options. These option scores have been summed for each 1km grid cell in England, as well as for the eight surrounding cells. A focal 1km square of land can achieve a high AES score with different configurations of options (Figure 24), for example many low scoring options or a few options that score very highly.

Figure 24: LandSpAES concept. From Staley et al. (2021)



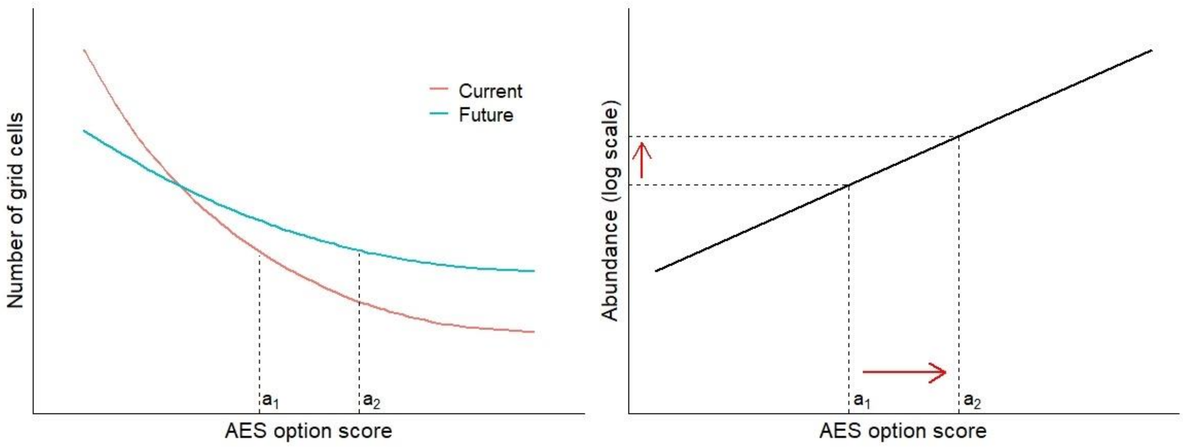
Three years of intensive field data has been collected at 54 grid cells in six Natural Character Areas for a range of organisms, including macro-moths, butterflies and birds. The data have not yet been analysed at species-level, but there exist provisional statistical models for how the abundance of each group of organisms (summed across species) is affected by AES options scores at the farm scale (1km) and landscape scale (3x3km).

These data, collected using standardised protocols and a stratified sampling design, provide a basis for exploring the potential effects of future Environmental Land Management scheme options on species in the abundance index. It is important to note that LandSpAES fieldwork is ongoing, so the relationships used in this modelling are provisional and may change following final analyses.

Approach to modelling for Environmental Land Management scheme impacts on abundance

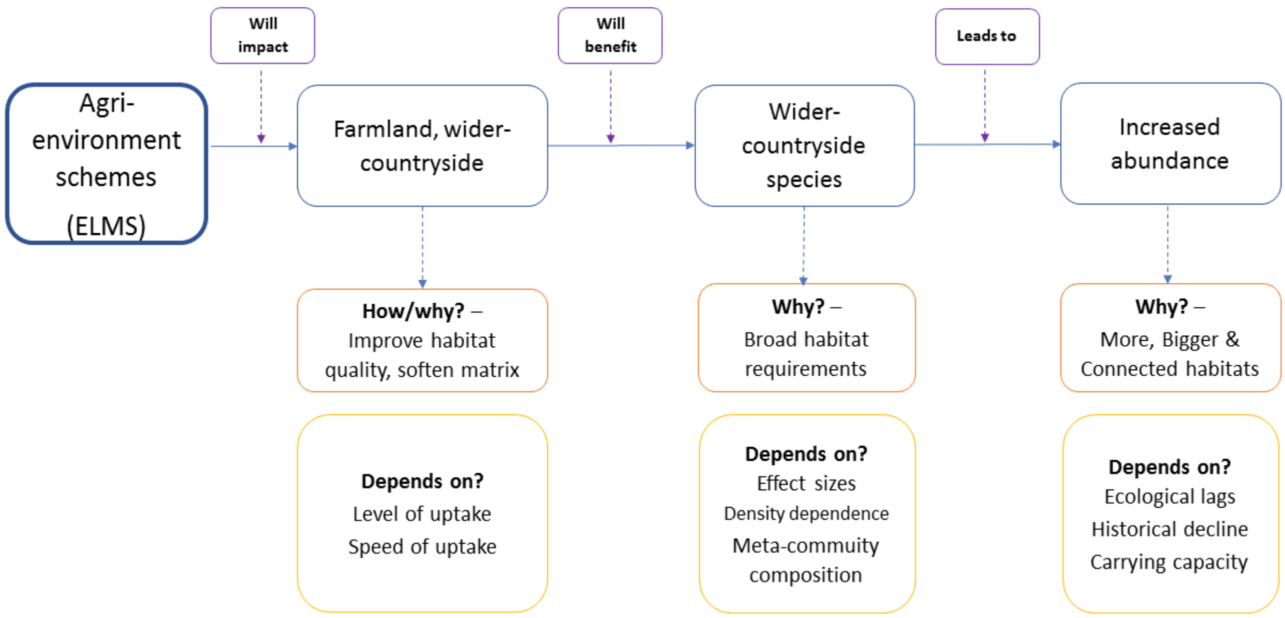
We have based our trajectories on the assumption that the beneficial impact of Environmental Land Management schemes on wildlife (in terms of increased abundance) will be similar to old schemes on a per-farm basis. We use the effect sizes from LandSpAES models in a “space-for-time” substitution, i.e. assuming that the relationship between AES option scores and abundance is the same in space and in time. This assumption allows us to use a spatial pattern of AES scores collected under LandSpAES to make projections for the change in abundance of species in those grid cells (Figure 25).

Figure 25: Schematic representation of the space-for-time substitution. The left-hand panel shows an idealised representation of the frequency distribution of AES scores on grid cells in England. The vertical lines show the median score in the present (red curve, a2). The right-hand panel shows the relationship between AES option scores and abundance, as revealed by the LandSpAES models. *Source: UK Centre for Ecology and Hydrology*



Although AES are responsible for the majority of priority habitat that has been created in recent years, the types of grassland and arable field margins created are unlikely to have massive benefits for the majority of species that depend on these (or other) semi-natural habitats. The ecological impact of AES, as they have previously been implemented, is best thought of in terms of softening the matrix , i.e. to make the farmed landscape less inhospitable. The species that benefit from AES are typically those widespread common species that are typically found in the farmed environment (henceforth “wider countryside” species). The logic model to define this scenario is shown in Figure 26.

Figure 26: Logic model for assessing the potential of Environmental Land Management schemes to increase species' abundance. ***Source: UK Centre for Ecology and Hydrology***



Within the 670 terrestrial animal species in the abundance index[37], we suspect that a majority can be classed as wider countryside species (given that only 150 are priority species). Thus, Environmental Land Management schemes have potential to increase the abundance of large numbers of species.

Since the new Environmental Land Management schemes are voluntary and so we don't know which farms will take them up yet, we took a simplistic approach based on the distribution of AES option scores across all grid cells on farmland in England. The distribution of scores is highly skewed, with more than half of values currently zero. We explored two measures of central tendency that might be useful: the 60th percentile, and the geometric mean of the scores +1. We explore the following scenarios, based on moving farms between the three classes of AES option scores in Stanley *et al* (32): low scores $\leq$500, medium (501-5000) and high (>5000):

- **Scenario 1.** Future uptake of schemes is maintained at recent levels, so there are no net gains to species abundance arising from Environmental Land Management schemes.

[37] First iteration, see above

- **Wider Uptake Low**. Half of cells that currently have no AES options (score = zero) were placed at the top of the Low class (score = 500). All other cells remain unchanged.
- **Wider Uptake Medium**. Half of cells that currently have no AES options (score = zero) were placed in the middle of the Medium class (score = 2500). All other cells remain unchanged.
- **Better Options 1**. Half of cells that currently have no AES options (score = zero) were placed at the top of the Low class (score = 500). All cells with scores between 1 and 5000 had their scores increased by a factor of 10, which moved all “low” scoring cells into “medium”, and all “medium” scoring cells into “high”.
- **Better Options 2**. All cells that currently score zero are redistributed according to the existing distribution of non-zeros.

Statistics for these scenarios are shown in Table 11. This shows that the measures of central tendency differ for nearly all options. We note that the two Wider Uptake scenarios both correspond broadly to Defra’s ambition that new Environmental Land Management schemes will be taken up by around two thirds of all farms (i.e., pZero = 0.33) and about 15% would be in higher level agreements (pHigh = 0.15). The two Better Options scenarios have much greater levels of uptake (of both basic and higher-level options) than is likely.

The data in Table 11 reveal that it is not simple to convert uptake scenarios into a single number to describe the degree to which species abundance will be improved through Environmental Land Management schemes. Thus, for simplicity we conduct our extrapolations using three levels of the 60th percentile: 680 (representing Scenario 1), 2500 (midrange) and 5500 (optimistic).

Table 11: Statistics on AES scores under five scenarios of uptake. gMean refers to the geometric mean of (AES scores+1); q60 is the 60th percentile; pZero is the proportion of cells with zero score (i.e., outside any scheme); High is the proportion of grid cells in the “High” category (i.e. >5000).

Scenario	gMean	Median	q60	pZero	pHigh
Scenario 1	42.7	0	680	0.51	0.14
WiderUptakeLow	211.7	500	680	0.26	0.14
WiderUptakeMedium	320.2	2500	2500	0.26	0.14
BetterOptions1	467.6	500	5505	0.26	0.42
BetterOptions2	2331	2657	3607	0	0.29

We then calculate the change in abundance of each taxonomic group that would result from moving from the current to revised point along the gradient. To do this, we first estimate the change in the AES scores of the surrounding landscape that might be expected from many changes to individual cells. We used a generalized least squares model with heteroscedastic error structure to estimate that the AES score at 3km increased by 0.45 units for every unit increase at the 1km scale. We then plug the projected change in AES score into the LandSpAES model for each taxon to estimate the resulting change in abundance. Finally, we modified these projections for Scenario 1 by adding the projected decline in abundance over 20 years. As in the habitat creation scenario our +Mitigation variant assumes that the background trend is stable.

We do not know over what time period, or how quickly the effects might be realised. We therefore adopt a simplistic modelling approach that does not attempt to model the rate at which benefits might be realised. Instead, for each scenario we will produce a point estimate of the potential increase in abundance that could be realised via Environmental Land Management schemes. We therefore avoid difficulties imposed by potentially lagged responses. As such, our model is not a strict trajectory of change in abundance over time. However, given the time available, we consider it a reasonable assumption that the benefits would be fully realised by the time of the 2042 target date.

<u>Assumptions</u>

- The options in future environmental land management schemes, and their effects on species abundance, will be of similar magnitude to those in Countryside Stewardship. At the time this work was conducted, the Sustainable Farming Incentive, Local Nature Recovery and Landscape Recovery schemes were in the early stages of development.
- The effects of other drivers continue into the future, i.e., “Environmental land management schemes effect” is an uplift against a background of continuing decline.
- “Specialists” do not benefit from Environmental Land Management schemes but benefits to wider countryside species are fully realised.
- Freshwater and plant species do not benefit from Environmental Land Management schemes.
- Change in total abundance is equal to the change in geometric mean abundance. The total abundance is proportional to the arithmetic mean, which is usually larger than the geometric mean (which is used in indicators). Thus, this assumption is optimistic (overstates the effect of Environmental Land Management schemes). However, this assumption is less unrealistic than if we had also included the habitat specialists in our estimates, since these species are generally less abundant.
- The proportion of species’ distributions that benefit from Environmental Land Management schemes is, on average, equal to the proportion of England that is used for agriculture. According to official statistics, about 63% of England is

farmland. We could use a higher figure of 84%, since this is the proportion of grid cells in the LandSpAES dataset that conformed to their definition of agriculture.

- Monitoring schemes will be expanded to record any increases in abundance due to Environmental Land Management schemes.
- In making a single space-for-time extrapolation, we avoid assumptions about the rate at which the benefits of Environmental Land Management schemes might be realised (given uncertainties about the rollout of Environmental Land Management schemes and biotic lags). We assume only that the schemes will have been rolled out and the benefits realised in time for the assessment of the target in 2042.
- We assume benefits from past AES had already been realised.

Results of the Trajectories

Preliminary results are presented for birds, butterflies and moths in Table 12 under three uptake scenarios.

Table 12: Effects of Environmental Land Management schemes uptake on biodiversity in England, based on different uptake scenarios of increasing the average AES score of farms in England. Numbers are the percentage change in abundance of "wider countryside" species in that group, accounting for local and landscape level effects. For consistency with the habitat creation scenario, we include "+Mitigation" and "+Decline" in the names of the uptake scenarios

Uptake Scenario	Q60 AES score	Moths	Butterflies	Birds
Scenario 1+Decline	680	-62.1%	NA	-7.9%
Midrange+Decline	2500	-56.7%	NA	-7.0%
Optimistic+Decline	5000	-48.0%	NA	-3.2%
Scenario 1 +Mitigation	680	0	0	0
Midrange+Mitigation	2500	+5.4%	+6.0%	+0.88%
Optimistic+Mitigation	5000	+14.1%	+15.1%	+4.68%

Overall, the increase in abundance by 2042 is rather moderate. Even under the optimistic scenario, the increase in abundance of butterflies and moths is just 14-15%, which is less than the baseline trend expected in the absence of mitigation (see above), which is a 2% decline per year (33% decline over two decades). In other words, Environmental Land Management schemes (if similar to previous agri-environment schemes) alone cannot turn around a declining trend but could produce increases among wider countryside species if other pressures were reduced. Note that the effect sizes above represent the 83% of

English grid cells with some farmland (according to LandSpAES definition), so the national figure would be lower still.

This optimistic scenario of uptake is unlikely to be achieved unless large numbers of farmers can be persuaded to take on at least some high-level options (i.e., enough to take the farm's score well into the "medium" category). Analysis earlier in this document outlines the positive impact AES can have on farmland birds (see Impact of Agri-environment schemes on species recovery), however, this is not seen when looking at birds more widely, where the effects from the modelling are negligible[38] .

In the absence of mitigating the wider pressures abundance is predicted to continue decline significantly for moths, even under the most optimistic scenario, whereas birds see modest declines under Scenario 1 and midrange scenarios and a 7.2% increase under the most optimistic scenario.

Although the effect sizes are smaller, in absolute terms, than those for habitat creation (previous section) the overall benefits are expected to be greater because there are approximately four 'wider countryside' species for every habitat specialist.

2022 - 2030

The analysis outlined above relates to the responsiveness of species abundance to agri-environment schemes by 2042; here we consider how the agri-environment scheme uptake may contribute as well to the 2030 target. The Agricultural Transition Plan sets out the trajectory for the new environmental land management schemes to be rolled out across England between now and 2028, in line with reductions in the previous scheme's Basic Payments. The pace of roll out of particular schemes and standards within them, such as the Farmland Biodiversity standard, will be relevant to the pace of change in species abundance. Once implemented, it will take time for the actions to take effect and for increases in abundance to be realised (especially if there are colonization deficits). Pace of implementation will therefore be an important factor in delivering the 2030 target.

Conclusions

Effect sizes remain small or negative where wider pressures are not mitigated, suggesting that Environmental Land Management schemes alone (if similar to previous agri-environment schemes) will not be sufficient to realise the target. As with the habitat creation scenario, the projected increase in abundance under the optimistic scenario is

[38] The two analyses approached the work slightly differently and so cannot be directly compared. Firstly AES were measured and therefore scored differently (semi-quantitative for trajectory work and binary for FBI work) and secondly the measure used for the bird response (total abundance for trajectory work and population growth rates for FBI work. All birds were considered for the trajectory work whereas 18 species on the FBI)

less than the projected decline that would be expected from extrapolating trends of the past two decades. However, the number of species that might benefit from Environmental Land Management schemes is potentially very large. Finally, we emphasise that the benefits (to species abundance) from Environmental Land Management schemes will be maximised if farmers can be encouraged to adopt higher-level nature-friendly options.

Future scenario of impact of improving river water quality on abundance of freshwater macroinvertebrate ETI taxa

The 25 Year Environment Plan set the ambition for England to have clean and plentiful water by improving at least three quarters of our waterways such that they are close to their natural state as soon as is practicable. This will be achieved through a variety of measures designed to mitigate the impacts of pollution from agricultural run-off including nutrients and sediment, pollution from wastewater; pollution from urban areas and transport; changes to the natural flow level of water; and invasive non-native species.

Currently 14% of English rivers are at Good Ecological Status based on reference benchmarks representative of degrees of impact. The biggest single pressure is physical modification (affecting 41% of water bodies) - this means loss of diversity of habitat which is then reflected in lower invertebrate scores. The next most significant pressure is pollution from rural areas, largely originating from agriculture and rural land management affecting 40% of water bodies. Pollution from wastewater affects 36% of water bodies, largely related to the water industry, but occasionally also affected by the general public and urban areas. We are proposing targets to reduce pollution from both agriculture and from treated wastewater effluent as part of this suite of targets under the Environment Act (see Detailed Evidence Report for Water Targets for more details).

In the current assessment system, Good Ecological Status is defined as a situation where there is evidence of, at most, low levels of distortion resulting from human activity and only slight deviation from undisturbed conditions. Good Ecological Status can therefore be equated to the target of being 'close to their natural state' as set out in the 25 Year Environment Plan. The overall Ecological Status of a river is conservatively assigned by the element which scores the lowest. In general, biological and physio-chemical elements other than macroinvertebrates are being impacted more by environmental pressures. When judged just on the integrity of their macroinvertebrate communities, 76% of rivers are in Good or High Ecological Status. When judged just on the integrity of their plant or fish communities, only about 40% of rivers are in Good or High Ecological Status.

General Approach

The ultimate aim of this analysis is to estimate how much the abundance index might be increased by 2042 if a larger proportion of English rivers were to move up in their

Ecological Status classification. To do this, we first explore how the average abundance of freshwater macroinvertebrates is correlated with standard metrics for assessing water quality. This provides a basis for assessing how abundance might change under two scenarios for improvements in water quality.

Linking abundance with water quality metrics

We first need to understand the relationship between the freshwater macroinvertebrate sub-set of the index (ETI_{fw}) and variation in Ecological Status of rivers. To enable this, we compiled available data on Ecological Status for English rivers from the Environment Agency for the period 2013-2018. The ETI_{fw} is an unscaled multispecies index of abundance for the 237 taxa contributing to the overall index.

We then calculated two metrics of Ecological Status for macroinvertebrates in each site and year using standard methods. The NTAXA metric is a measure of taxon richness; the ASPT metric is a measure of the average organic pollution tolerance of the taxa found at the river site. Both these indices will vary naturally from river site to river site, even in the absence of pollution, depending on the type of river and its location within the country. Therefore, to be able to make national-scale assessments both NTAXA and ASPT must be standardised relative to the river site-specific predicted value you would expect to find if that site were close to its natural state. The River Invertebrate Classification Tool provides this prediction and, to provide an assessment of ecological quality, this value is combined with the observed value in the form of a ratio (observed: predicted), termed the Ecological Quality Ratio (EQR). EQR values close to unity indicate a community that is close to that expected in the absence of impacts from human activity. For reporting purposes, EQR values are classified into five quality classes: Bad, Poor, Moderate, Good and High (Table 13). The final Ecological Status classification for a site based on the macroinvertebrate community is the lower of the two classifications (NTAXA EQR and ASPT EQR).

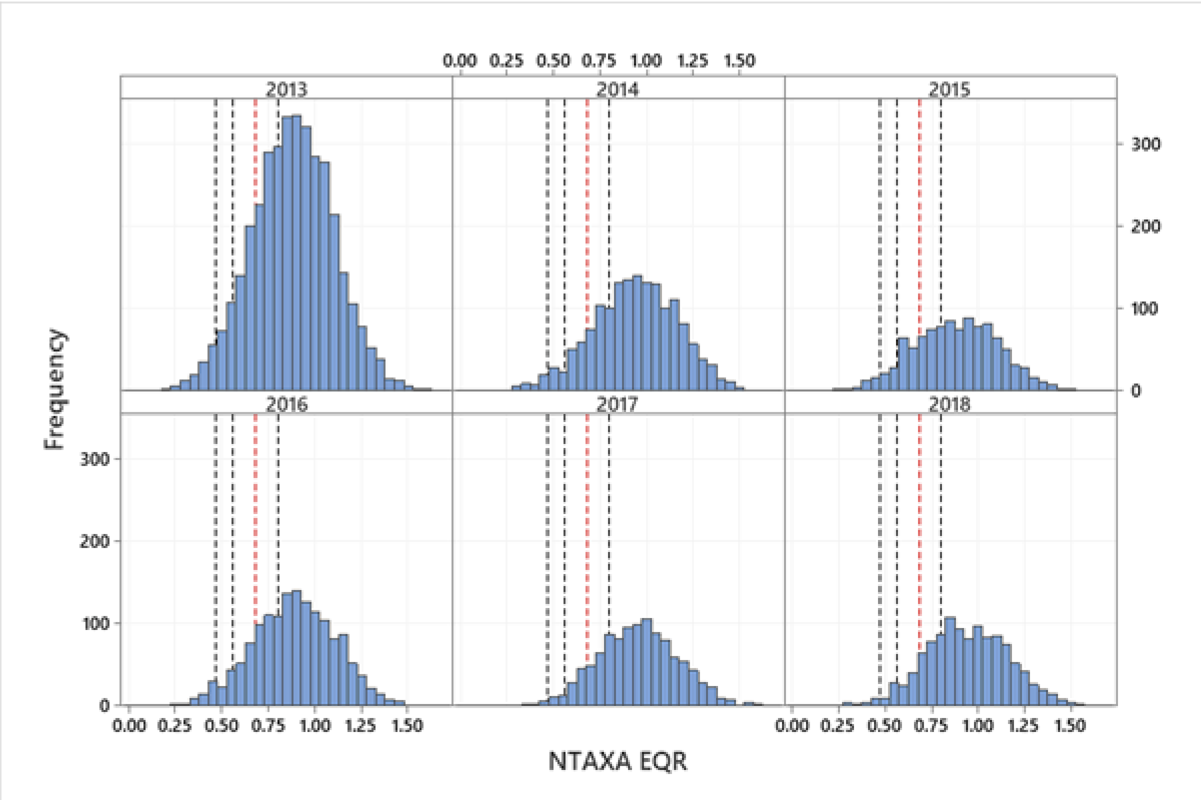
Table 13: Class boundaries for ecological quality ratios (EQR) based on NTAXA and ASPT indices

	NTAXA EQR	ASPT EQR
High	> 0.80	> 0.97
Good	0.68	0.86
Moderate	0.56	0.72
Poor	0.47	0.59

Bad	< 0.47	< 0.59

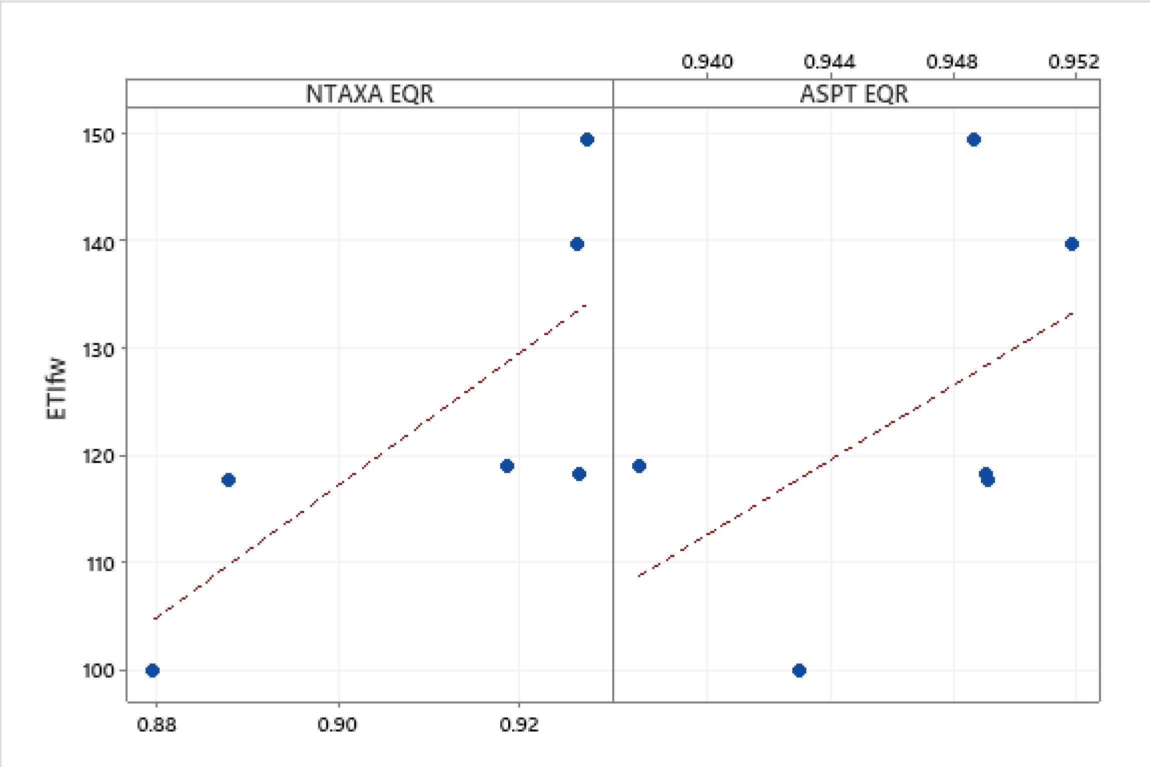
The distribution of EQRs for both indices varied only slightly between years over the period 2013-2018 (Figure 27). In the most recent year (2018) over 88% of river sites were judged to be in Good or High status for macroinvertebrates by NTAXA EQR and over 80% by ASPT EQR.

Figure 27: Frequency distributions for NTAXA EQR (top) and ASPT EQR (bottom) for English rivers monitored in each year between 2013 and 2018. Vertical dashed lines indicate the EQR class boundaries with the red line indicating the Good-Moderate boundary



We then calculated a single measure of central tendency in NTAXA EQR and ASPT EQR for each year in the dataset, and compared this to our annual measure of invertebrate abundance ETI_{fw}. We found that there was a positive relationship between ETI_{fw} and both NTAXA EQR and ASPT EQR across the six years for which we had data. As expected, we found a positive relationship between ETI and both measures of EQR (Figure 28 indicating that both quality ratio metrics have high values in years when the average abundance is high.

Figure 28: Relationship between ETIfw and NTAXA EQR and ASPT EQR. Dashed line represents the linear relationship between the variables



The relationship was strongest for the NTAXA EQR (r=0.75) than for ASPT (r=0.512), so the former is a better predictor for how the abundance index will change with water quality. Note that neither relationship is statistically significant (p=0.086 and p=0.3 respectively) on account of the small number of years used.

Effect of improvements in water quality on abundance

Having derived a statistical relationship for how abundance (ETI_{fw}) changes with ecological status (EQR), we can explore the consequences for ETI_{fw} of directed management intervention leading to all English rivers being classified as in Good ecological status.

In our simple scenario, we assume that all sites that are already in Good and High status experience no change in EQR, but that all sites in the Moderate, Poor and Bad categories were improved to an NTAXA EQR of 0.68 (i.e. just above the Good-Moderate boundary). In this way, all rivers would be classed as in Good ecological status. As a result, the mean NTAXA EQR would increase slightly from 0.927 to 0.954. The left-hand panel Figure 28 shows that ETI_{fw} increases by 6.143 units for an increase of 0.01 in the NTAXA EQR, so ETI would be expected to increase by 16.58 units, or 12.4%.

Using the more uncertain relationship between ASPT EQR and ETI_{fw} would suggest an even more substantial increase, of 35.3%.

An alternative, but more ambitious scenario, could be a shift in the mean reported NTAXA EQR or ASPT EQR to 1, indicating that on average rivers are in the condition expected in the absence of impacts from human activity. Such a shift in NTAXA EQR and ASPT EQR would result in an increase of ETI_{fw} to 34% and 69%, respectively.

2022 - 2030

The analysis above relates to change by 2042, here we consider how the improvements in water quality may contribute as well to the 2030 target. The recent trend for freshwater invertebrates has been quite stable, so unlike the other taxa we don't need to factor in a "Scenario 1" scenario involving large declines. Increases in abundance of freshwater invertebrates make a substantial contribution towards realising the overall target: these species make up nearly a quarter of species in the index. If the increase of 12.4% were fully realised by 2030, it would constitute about ⅓ of the change in the index required to meet the target. The proposed water targets[39] will help to drive the necessary improvements in the water environment by reducing nitrogen and phosphorus, sediment and water usage.

Caveats and Conclusions

The main limitation is that we have evaluated the relationship between at the national scale using just six years of data. Evaluation at the national scale is problematic because the average condition (EQR score) for macroinvertebrates is actually very high: much higher indeed than the threshold NTAXA EQR score of 0.68 for Good Ecological status. If there had been more time, we would have repeated all these analyses at the site level, which could produce different results. Having only six years of data means that the relationships we estimated are rather imprecise.

Although the EQRs and ETI are based on the same data, it does not necessarily follow that we should observe strong correlations between them. This is because they are measuring different aspects of the data. EQRs were developed to measure specific aspects of quality, whereas our ETI is a generic measure of annual abundance and could, in principle, take high values in cases where the EQRs were low (e.g. if a particular event led to a massive increase in a small number of pollution-tolerant taxa).

Conclusions

Developing evidence-based targets for species abundance was a challenging task. Ideally, we would be able to precisely answer the question of "how much will species in the

[39] Details of proposed water targets can be found at https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/supporting_documents/Environment Targets Public Consultation.pdf

indicator improve over the timescale of the target period" in a way that allows us to understand the rate of change over time. This is not possible with the current available data, so instead we have undertaken analysis to answer a subset of nested questions. Meeting the 2030 target will be extremely challenging and will require a rapid step change in action to create and restore habitats, whilst addressing pressures. Our analysis has shown that plans for habitat creation and Agri-environment schemes (based on past schemes) alone will not be enough to meet targets, although they will have benefits for many species. Action will be required to mitigate the many other pressures acting on species.

There is strong consensus between our analysis and expert assessment in outlining the type of actions that are required to meet the ambitious goals of first halting decline and then increasing abundance. The gaps in the data and the number of assumptions that have been made, means it is not possible to set out a precise pathway for delivering these goals by 2030 and 2042 respectively. Furthermore decisions on policy pathways have not yet been made and will inform the development of the Environmental Improvement Plan. Further detailed analysis of potential policy pathways will be needed to inform target delivery planning. As outlined above there are many variables that impact the reliability of the trajectories developed. Table 14 below sets out a current RAG rating for Species Abundance and resulting potential legislative target.

Table 14: Species Abundance RAG Rating

	Red	Amber	Green	Notes
Data Availability i. Frequency of collection ii. Coverage (England) iii. Representative (Species/Habitats) iv. Existing baseline and trend		X X X	X	i and ii. Data is collected for the main taxonomic groups regularly however there is an issue with coverage of species. iv. The existing baseline is suitable for the main taxonomic groups however there is an issue with coverage and representativeness of species.
Indicator suitable for measurement			X	The indicator is based on global standards.

Scale of assumptions		X		See full section for related assumptions.
Actions v. Is delivery method/mechanism clear vi. Is this clear in development of trajectory scenarios		X X		There is good understanding of the types of actions that are requires, this is difficult to relate to a specific level of improvement. This has been taken into account and demonstrated in the trajectory assessment as far as possible, however only some actions could be taken into account.
Consensus between expert opinion and scenario analysis		X		The above evidence shows that meeting a target will be challenging

Target: Extinction risk of our native species – Red List Index

Summary

Proposed target-

- To improve the England-level GB Red List Index for species extinction risk by 2042, compared to 2022 levels.

The following section summarises the evidence and analysis explored to inform the development of proposed targets for species extinction risk. Key points covered in this section of the evidence report are:

- We propose using Great Britain (GB) level data to create a new England-level Red List Index to use as our target indicator. This draft England-level Red List Index, with data for nearly 8,000 species, includes birds, mammals, reptiles, amphibians, some invertebrates, vascular plants, bryophytes, lichens and some fungi. The assessment and analysis is not yet complete, therefore figures may change.
- Natural England assessed recovery potential of a subsample of species under different scenarios. Under the most ambitious scenario over 60% of threatened species were considered likely to improve in extinction risk status by 2040. This is akin to very small increase in the overall index.

Indicator development

Development of an England-level GB Red List Index

The 25 Year Environment Plan Outcome Indicator Framework proposed development of a Red List Index, utilising GB data, which was a starting point for developing the target. A preliminary indicator has been produced (Figure 29). The indicator tracks changes in the extinction risk of terrestrial, freshwater and marine species using established international (IUCN) categories and criteria. A Red List Index is compiled using data from all assessed species, not just those that are threatened or at risk of extinction. In this way the indicator can be used to give an impression of the overall extinction risk of species at a specific geographical scale. Species are classified in the following categories (from lowest to highest extinction risk): Least Concern; Near Threatened; Vulnerable; Endangered; Critically Endangered; and, Regionally Extinct. The Red List Index summarises the distribution of species in each category. The Red List Index varies between zero (all species Regionally Extinct) and 1 (all species Least Concern).

GB baseline assessment data is available for 9,568 species, of which nearly 8,000 have sufficient data to be included in an England indicator. This includes birds, mammals, reptiles, amphibians, some invertebrates, vascular plants, bryophytes, lichens and some fungi. Assessments are currently undertaken for Great Britain. Further assessments are required for a wider range of species across a broad range of environments e.g., aquatic, and geographical regions, to be fully representative. As more red lists are published, it is technically feasible to expand the indicator and avoid spurious changes in the trend through hindcasting. Red List assessments for individual species will need to be repeated every 10 years in order to monitor change via the Red List Index (full rationale included later).

In Figure 29 numbers at the top of the bars show the value of the Red List Index; numbers at the base of the bars show the number of species assessed within each taxonomic group. Fungi are the most threatened taxonomic group, with a Red List Index value of 0.767 (Table 15). Note, however, that only a low proportion of fungal species have been Red List assessed. Other similarly threatened groups are birds and herptiles. The least threatened groups are lichens and bryophytes. Lepidoptera and other invertebrates have relatively high Red List Index values of 0.933 and 0.923 respectively, but collectively contain a large number of species across a diverse range of habitat types and environments, including terrestrial, freshwater and coastal brackish. Whilst some invertebrate groups appear stable or increasing, others are in steep decline (18,33). The combined Red List Index value for the nine major taxonomic groups is 0.918. This preliminary index is based on GB Red List statuses for species considered extant in England. As assessments are repeated, the change in the Red List Index can be presented as a trend through time, as is done for the global Red List Index[40].

[40] IUCN Red List of Threatened Species

Figure 29; Preliminary England-level GB Red List Index for each of the major taxonomic groups, with combined Red List Index on far right.

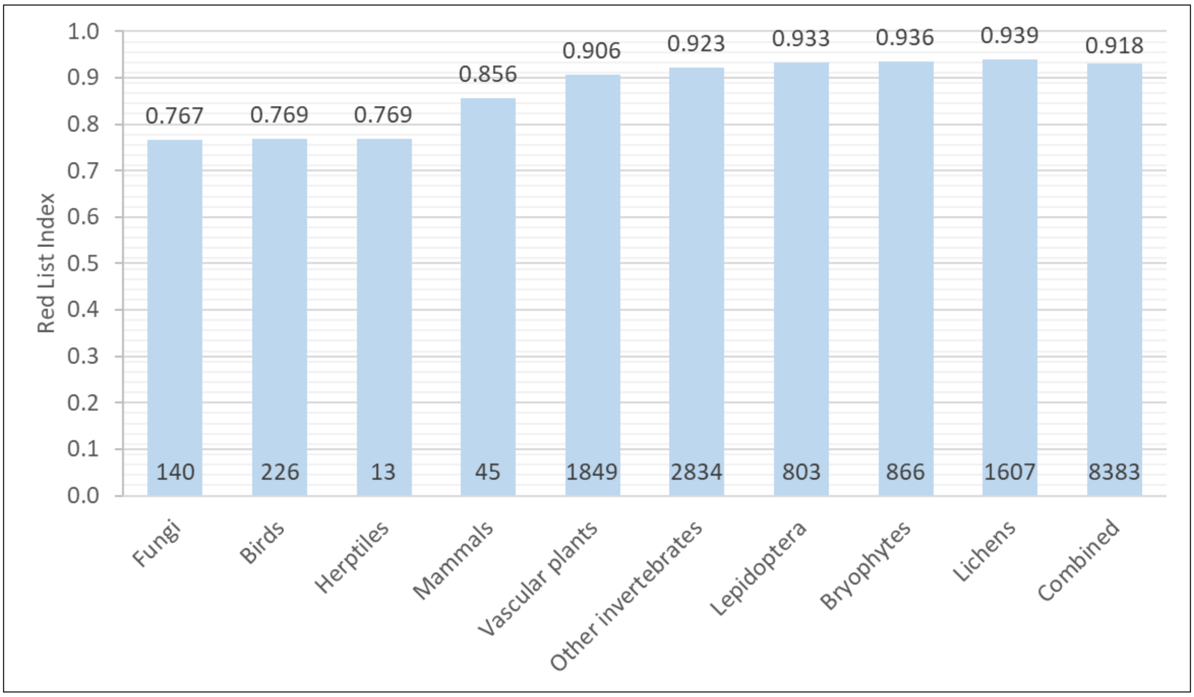


Table 15: Approximate number of species in England in Threatened (Critically Endangered, Endangered and Vulnerable) and Non-Threatened (Near Threatened and Least Concern) categories by taxon group.

Taxonomic Group	Number of species assessed* in taxonomic group	Number of species assessed 'Threatened'	Number of species assessed 'Not Threatened'
Birds	217	84	133
Bryophytes	844	88	756
Fungi	109	46	63
Herptiles	13	4	9
Lepidoptera	775	71	704
Other invertebrates	2678	327	2351

Lichens	1463	114	1349
Mammals	39	9	30
Vascular plants	1784	288	1496

* GB Red List assessments. Excludes Data Deficient, Not Evaluated/Applicable, and all Extinct categories.

Geographical coverage

In the absence of published England-level Red Lists for a broad range of taxonomic groups, it has been necessary to use GB Red Lists for the indicator. For this to be functional, all taxa known not to occur in England (but in other parts of Britain) were removed. This approach assumes that threat levels at England and GB scales are the same or similar. To test this assumption we compared England-level and GB-level Red Lists for plants and mammals. For the former, 79% of threat categories were the same and for the latter, 91%. However, some species have highly contrasting threat categories – e.g., pine marten is Least Concern at GB level but Critically Endangered at England level (34).

The differences appear stronger in some taxonomic groups than others. For example, the diversity and population sizes of lichens contrasts strongly between Scotland and England. Consequently, the GB Red List category for a species can be unrepresentative of its status in England.

For the same reason the indicator could be insensitive to changes in England. At worst, the complete loss of a species in England that retained populations in Scotland or Wales, would not be accurately reflected in the indicator – e.g., the loss of Golden Eagle from England. Reporting such losses is important, hence in future producing Red List assessments at both GB and England scales would provide more accurate and comprehensive information. A parallel issue could arise with the successful recovery of a species in England that is tempered by ongoing declines elsewhere, potentially resulting in an unchanging threat category.

Reporting such changes is important, hence in future producing Red List assessments at both GB and England scales would provide more accurate and comprehensive information. Although the Red List Index may not respond adequately in every case, additional ways of reporting against D5 are being explored.

When a Red List Index is created for the first time (to form a baseline), it is standard practice to remove already extinct taxa (35). For D5, this means that the baseline RLI only comprises England taxa that are extant, or possibly extant.

The current D5 indicator is preliminary and will be subject to quality assurance before publication. This is planned ahead of September 2022.

Alternative indicators of extinction risk

In the above we identified some of the criteria used to determine indicators for the species targets. Criticisms of the Red List Index are that it is slow to change, change appears small, and it can be difficult to relate to real life change. We have considered options to address these issues. This is discussed in the following sections. In this discussion, we recognised the need to have a clear single measure against which the legally-binding target is judged as well as being able to show something meaningful that is easily understood.

Alternative options for presenting the data were considered, including options that present change in a more relatable way that is understandable to a wide range of audiences. This included considering the development of alternative indicators based on red list assessment data. The focus of this work was to decide whether the indicator for the target should:

- include all the data from the red list assessments, or focus only on species in the threatened categories;
- focus on an index or on the number of species or percentage of species in each category.

One alternative considered, included focusing the indicator only on species within the threatened categories or on the threatened categories plus Near Threatened, recognising that most species are in the Least Concern category and therefore cannot be further improved in terms of their red list status. Using the threatened categories is more representative of where recovery effort will be focussed. Improvement in an individual species will be proportionately greater (e.g., percentage of threatened species becoming less threatened), allowing for a target that better reflects ambition, and is likely to resonate more with the wider public. However, focussing on threatened species only, creates an issue on how species move into and out of the indicator over time. Least Concern species that are reclassified as threatened could be added into the indicator, but the resultant increase in total threatened species would affect proportionality. The same issue arises as species move from a threatened category to least concern. A combination of such changes at any one point in time could result in masking recovery successes since little net change would be reported.

Alternatively, the indicator could just represent change in species categorised as threatened in 2022, with no species being added or removed from the indicator. This would allow species that move into non-threatened categories to be represented in the indicator but would create a potentially misleading representation of extinction risk over time, as species that become threatened in future would be excluded from the indicator. Newly published red lists covering additional taxonomic groups would also be excluded.

In comparison, using the entirety of the red list data set provides a better assessment of change over time. Focussing only on threatened species would also drastically reduce the number of species in the indicator, weakening the main strength of the Red List Index, in that it can represent a wide range of species.

With support from the Biodiversity Targets Advisory Group, it was decided that the challenges associated with focussing on threatened species only were inconsistent with the purpose of the indicator and therefore that the indicator needed to represent all Red List categories (excluding Data Deficient and Not Evaluated/Applicable).

Index versus number/proportion of species

In addition to the fact that the change in the index is likely to be small and may appear unambitious, we also considered whether reporting the change in the index is meaningful, and whether the number or percentage of species in each category would be better. Two approaches were tested. The first approach was a simple expression of the number/percentage in each category as they change over time. This was considered useful for communicating where net change was occurring (i.e., if most change was occurring for the most threatened species for instance), something that is not apparent in the Red List Index. This approach was discounted as an increase or decrease in a category could result from a positive (if species were moving from a more threatened category) or negative (if species moved from a less threatened category) movement. For example, change in a single category could not be used alone to indicate whether overall change was negative or positive, except at the extremes (regionally extinct and least concern). Using a simple measure of the number or proportion of species, only seems viable as an indicator if the number/proportion of species that are threatened versus non-threatened are assessed. This option is less sensitive than the index as any positive movement within the threatened categories would only register when a species moves from a threatened to a non-threatened category, and vice versa.

A relative assessment of change between categories was also tested. This captured the number/percentage of species in each category that had improved, deteriorated, or stayed the same over time. For example, if 200 species were in the vulnerable category in 2022 and by 2042, 50 had improved by one or more categories and 25 had declined by one or more category, the net improvement would be 25 species or 12.5%. This option was considered unfeasible due to the fact that it did not account for the scale of change. Using the example above, if all the species that had declined had done so by three categories but all those that increased had only improved by one category, the number/percentage improvement would remain the same. Whilst this option was the most sensitive to change, it risked presenting change in a way that could be misleading.

Between these options, proportion is preferred over number as it is more meaningful and would allow addition of further species as new assessments become available.

Following these discussions, the recommendation is that the legally binding target should be based on the Red List Index. The alternatives considered above have significant limitations and could potentially demonstrate misleading assessment of change. They remain valuable as communication tools and their use will be considered when communicating change in the Red List Index.

Sensitivity of the Red List Index

The England-level GB Red List Index is a newly created indicator with no established trend. We undertook sensitivity analysis to determine the frequency and number of assessments that would be required to identify a trend in extinction risk.

It would not be cost-effective to conduct a reassessment of each group annually, because the status of the vast majority of species would not have changed. However, if the time between assessments is too long then the data would be too outdated to be used as a meaningful indicator for the desirable outcomes of the 25 Year Environment Plan. A structured approach, where groups of species are reassessed in a cyclical fashion is most pragmatic.

The periodicity of that cycle should be informed by the rate at which species are expected to transition between statuses. In Finland, 4.7% of species changed their Red List category between 2000 and 2010 (36). Thus, assessing species more frequently (than every 10 years) would be unlikely to produce much useful information (the vast majority of species would not have changed status).

Our analysis showed that at least 800 species will need to be reassessed annually to detect a trend in the index with 95% confidence.

Red List updates could be cycled so that a proportion of groups are systematically reassessed every 5 years.

Notional targets

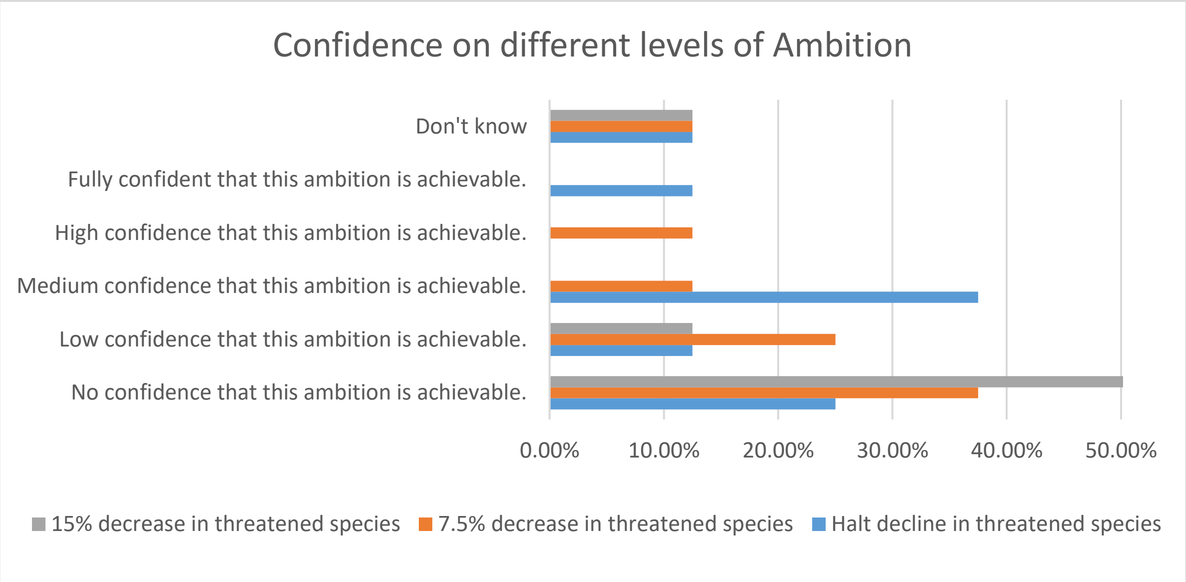
The purpose of notional targets is described on page 12. The notional targets for the species extinction risk target focussed on the proportion of species in the threatened categories based on an estimate that 15% of species in England are threatened (the State of Nature Partnership's 2019 report noted that 13% of species in England were threatened with extinction in Great Britain red lists).

Species extinction risk notional targets:

- Halting of decline -no increase in % point of threatened species and no species entering the extinct category
- 7.5% point reduction in the number of threatened species (e.g. 50% of threatened species moving out of the threatened categories) and no species entering the extinct category.
- 15% point reduction in threatened species (i.e. all threatened species moving out of the threatened categories) and no species entering the extinct category.

Feasibility Assessment

Figure 30: Stakeholder confidence when asked the achievability of various levels of ambition for the Species Extinction Risk target



As outlined under ‘The approach to Scenario Analysis’, experts from a range of organisations answered a questionnaire and attended a workshop on feasibility. The focus was on feasibility by 2037, although the timeframe for the targets was later changed to 2042 (Figure 30).

<u>Halting decline by 2037</u>: Respondents to the questionnaire did not have a consistent view on the feasibility of the low ambition, 37.5% of questionnaire respondents said they had either no or low confidence that the target was achievable. 37.5% of respondents had medium confidence that it was achievable. One respondent (12.5%) had full confidence that the ambition was achievable. Respondents that were not confident suggested that the ambition was not achievable in any timescale or answered that they did not know what a suitable timescale for delivery would be, although one respondent suggested the target could be achieved with an additional 10 years. Overall, respondents had medium to low confidence in their answers.

7.5 percentage point decrease in threatened species: Most respondents had no or low confidence that the medium level of ambition was achievable, whilst again indicating that the target was either unachievable in any timescale that they did not know what a suitable timescale for delivery would be, although one participant suggested this ambition could be achievable with an additional 20 years. Again, respondents had a medium confidence in their responses. In the workshop there was discussion that although this level of ambition is technically feasible, the level and speed of change that would be required did not seem feasible.

15 percentage point decrease in threatened species: 75% of respondents had no confidence that the high level of ambition was achievable in the fifteen-year timescale, with the remaining respondents equally split between low confidence and 'don't know'. Respondents had low to medium confidence in their answers.

During the workshop the need for feasible targets was raised as part of the discussions, with participants highlighting examples where infeasible target have been set unfeasibly high. There was general support for targets that are feasible.

At the end of the workshop participants were asked to mark a spot on a sliding scale from below the low ambition to above the high ambition suggesting what level the target should be set, whilst at the same time capturing the associated assumptions under a PESTLE framework[41]. There was a mixture of views with the majority falling somewhere between medium and high. There were more people at the workshop than responded to the questionnaire, however the spread of responses suggested that the experts favoured setting a target at a level above which they were fully confident was achievable. This is likely to be explained by the tension of defining feasibility by what is ecologically feasible versus realistically feasible considering likely political, social, environmental and economic constraints. This was reflected in the discussion and the assumptions captured. The assumptions were captured for both species targets and are presented in relevant chapter.

Expert views on actions required to deliver the notional target - Halting of decline

There were many overlaps with the actions suggested for the abundance target.

- Large-scale creation and restoration of habitat was seen as critical alongside improvement in the condition of protected sites (Confidence: high). Participants suggested that the current level of delivery is not sufficient, and that action requires significant modification in implementation or scale of delivery. Restoration of peatland was mentioned specifically as critical to delivery of this notional target. In a similar vein, the creation of corridors and steppingstones was also seen as

[41] A PESTLE framework looks into the Political, Economic, Sociological, Technological, Legal and Environmental factors influencing an organisation from the outside.

important, as was the implementation of nature-based solutions. Tree planting was seen as low importance. `

- Investment from both the public and private sector were seen as critical and requiring improvements to be sufficient to deliver the target. This was a prominent theme of discussions, with general agreement that actions require an increase in investment to be successful. This is often a barrier to implementing supporting actions such as enforcement and monitoring.
- Sustainable low-input farming and partnerships were seen as critical (Confidence medium-high), requiring moderate improvements to be sufficient, as was integration of species actions into Environmental Land Management schemes. However, working with voluntary and recreational groups was seen as of lower importance (Confidence low-medium)
- Protection and improvement of the water environment and reduction in the impact of pesticides were seen as critical, with the former seen as requiring greater change to be sufficient (Confidence: medium)
- Supporting actions such as monitoring and evaluation, spatial planning and implementation of existing tools such as the green book were seen as important. Participants suggested that there is a good level of research and tools available to support action, as such further research and development was considered of medium importance requiring moderate improvements to be sufficient. The benefit of monitoring and evaluation is to demonstrate what works.
- Legal protection was generally seen as of less importance and at a sufficient level, with the exception of protection from unsustainable development (confidence medium). This reflected discussion that protections have not delivered in the past without additional investment and enforcement. Implementation of the Natural Environment and Rural Communities Act was seen to be of medium importance requiring some modification to implementation (confidence: medium). Managing wildlife crime was seen as highly important, but with current action mostly sufficient.
- Control of invasive species and biosecurity was seen of medium importance with moderate changes required to be sufficient. (confidence: medium)

Expert views on actions required to deliver the notional target - 7.5% point reduction in the number of threatened species

To deliver the medium ambition, participants were asked to suggest additional actions required over and above the actions required to deliver the lowest ambition. Participants commented that the lowest ambition was aligned to ramping up effort on actions we are already doing. A change in the current approach would be needed to deliver the medium or high notional targets. Specific requirements mentioned were:

- There was a view from some participants that the actions required are the same, but they would need to be delivered more quickly and at a greater scale.

- Greater focus on integrating environment and biodiversity into decision-making by all parts of government was seen as critical to delivering the medium notional target.
- Change to the approach to land management. Specific suggestion was rethinking the current approach to protected areas and priority habitats, including dedicating large areas of land to nature and focussing on creating naturally functioning ecosystems. There was a lack of confidence that we know how to deliver the scale of change that would be required.
- The types of changes required would impact society as a whole and require action to influence public perceptions and behaviour. This is an area where the experts had less knowledge and confidence. A lack of social and economic research would likely be a barrier.

Expert views on actions required to deliver the notional target - 15% percentage point reduction in threatened species

Discussions on the actions required to deliver the high ambition referenced very broad and mostly open-ended actions such as changing humans' interaction with nature. Experts were generally not confident in suggesting actions that could deliver this notional target, reflecting the general view that this is unlikely to be feasible. Specific suggestions from experts included eradication of established non-native species and rewilding large areas of land.

Expert opinion on the target ambition

Experts were asked to place a marker on a sliding scale to indicate where they felt the ambition for the target should be set. As with other targets the desired ambition exceeded the feasibility assessment, with most experts suggesting target ambition should fall between the middle and highest-level notional target.

Scenario Analysis

To make a target recommendation it was necessary to construct scenarios, as described in introductory passages above.

Methodology

The total number of taxa in England that are classed as either Threatened (VU, EN, CR, CR/PE) or Near Threatened (NT) in GB Red Lists is over 1,500 (approximately 18% of those taxa assessed). These are species requiring recovery, i.e., their conservation statuses need improvement.

Since it is not possible to derive a trend for the Red List Index until repeat assessments have been undertaken, statistical modelling using past data was not possible. Instead, trajectories were based on the expert opinion of Natural England's species specialists, from which Red List Index values were generated.

As there was insufficient time to investigate the recovery dependencies of all the above species, a sampling strategy was employed. A stratified random sample of species was taken across taxonomic groups of sufficient size to be representative (Table 16). Sampling was restricted to species extant and native to England, with 20% or more of their GB range (hectads) in England, on the assumption that recovery would be feasible with sufficient country-level action. Lower ranking taxa (below species), hybrids and microspecies (main critical groups of plants) were excluded to avoid over-representation in the sample. The total sample comprised 253 GB IUCN Threatened and NT species (24% of taxonomic groups included). The inclusion of NT taxa captured a higher proportion of widespread decliners as well as conservation dependent species; it also allowed the results to be presented as a Red List Index.

Computation of the Red List Index (RLI) followed Bubb et al (36). In summary, the number of species in each Red List category is multiplied by the category weight (which ranges from 0 for Least Concern, 1 for Near Threatened, 2 for Vulnerable, 3 for Endangered, 4 for Critically Endangered and 5 for Regionally Extinct, Extinct in the Wild, and CR Possibly Extinct). These products are summed, divided by the maximum possible product (the number of assessed species multiplied by the maximum weight), and subtracted from one. This produces an index that ranges from 0 to 1.

The number of Least Concern (LC) species in England was estimated at the same proportion as the Threatened/NT sample; this was necessary to calculate RLI values. However, although the method allowed for NT species to move to LC, hence increasing the number of LC taxa, the reverse was not possible. The rate of movement of LC taxa to NT or Threatened categories could be estimated from past Red Lists potentially but not for all the groups included (some have yet to be reassessed); this work has yet to be undertaken (see assumptions & limitations).

Table 16:Sample sizes for combined Threatened (T) and Near Threatened (NT) species. Each group was calculated separately at a confidence level of 95% and margin of error of +/-10%.

Groups	T/NT sample	% of England T/NT
Invertebrates	86	19.7%
Bryophytes	20	15.4%
Herptiles	6	100.0%

Mammals	12	85.7%
Birds	54	51.4%
Vascular Plants	75	20.0%
Total	**253**	**23.7%**

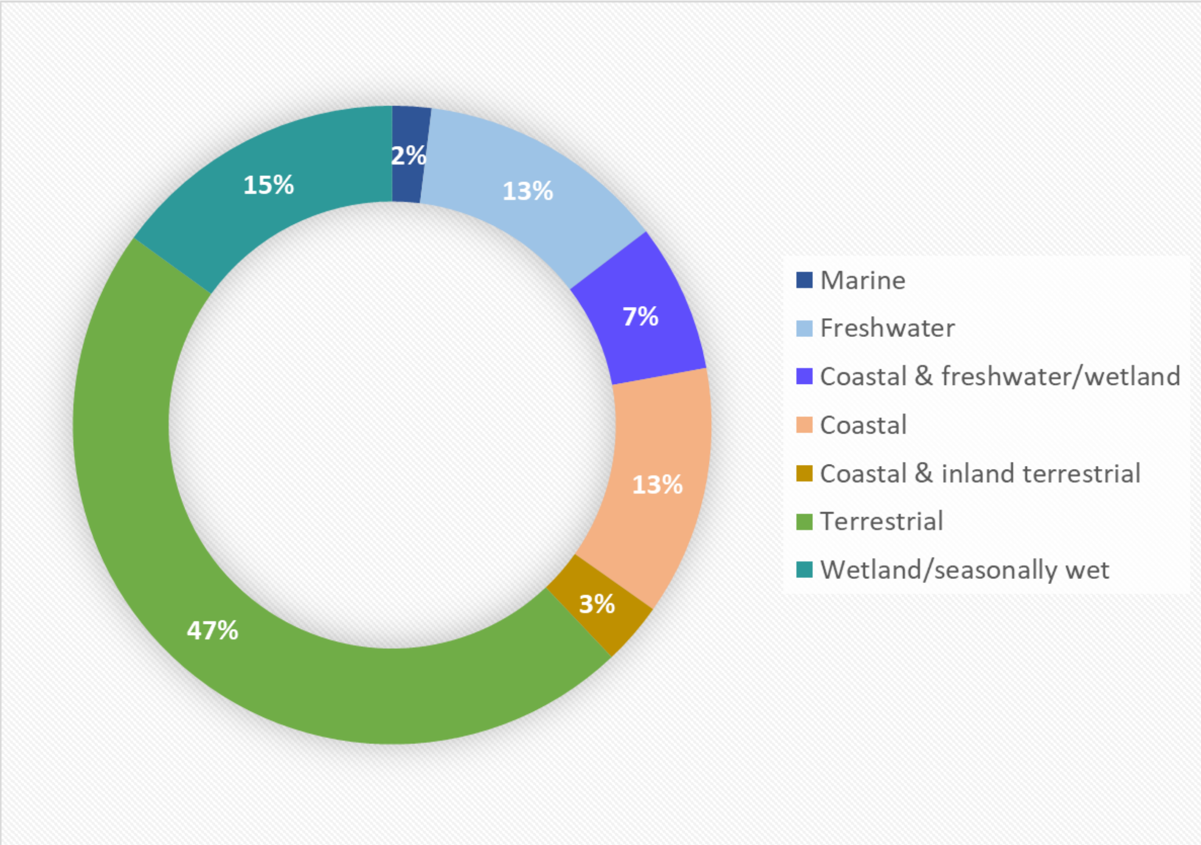
Table 17: Spread of threat categories in sample (counts of species) by taxonomic group.

Groups	CR	CR(PE)	EN	NT	VU
Bird	7	1	13	13	20
Bryophyte	1	0	4	8	7
Herptile	1	0	3	2	0
Invertebrate	16	2	20	25	23
Mammal	1	0	4	3	4
Plant	5	0	23	19	28
Total	**31**	**3**	**67**	**70**	**82**

Sample representativeness was tested by threat category (Table 17 and basic habitat type (Figure 31). Generally, there was good range of threat categories represented. Although only three CR(PE) species were included, equating to 1.2% of the sample, this was not very different to the actual proportion of 2.2% of all T/NT taxa in D5. About half of the species in the sample (47%) primarily occurred in terrestrial habitats. This compared to nearly 30% which were associated with freshwater/wetland habitats (including seasonally inundated/riparian land and temporary pools). Coastal habitats including overlaps (where a species occurred in inland habitats well as), amounted to nearly 25%. However, only 2%

(n=5) marine species were included, highlighting the overall lack of published GB Red Lists for marine groups.

Figure 31: Sampled species by high-level habitat in England (n=253).



Each species was assessed against a predefined list of actions comprising three different scenarios (Table 18). Up to five actions were selectable as those most likely to result in an improvement in threat status (best possible outcome). Five in number was considered optimal based on the current Section 41 actions (n=3,840, mean=3.4, SD=2.2; indicating the majority of species have no more than 5.5 actions). Assessors were blind to the scenarios which were subsequently assigned by a colleague. Species were assigned to scenarios according to the most ambitious action selected - e.g. if 3 actions were in scenario A, 1 in B and 1 in C, the species would be assigned to scenario C.

Specialists were asked to assess the recovery potential of each species over four timeframes: 2030, 2040, 2050 and post-2050 i.e. was a change (positive or negative) in threat category:

- Probable/possible?
- Improbable/impossible?
- Unknown?

Once the key actions had been chosen for a species, specialists were asked to identify the decade in which status was most likely to change by one threat category. Assessment took into account the period for action implementation and response times of species (which can, for example, depend on habitat maturity). Options to record ‘no change’ or a deterioration in threat status were also available. Once a change in status had been recorded, it was assumed to continue in future (over remaining timeframes) unless otherwise indicated.

Table 18: Rationalised list of actions used by assessors in scenarios 2, 3, 4 and 5.

	Scenario			
	2	3	4	5
Habitat creation	X	X	X	X
Habitat management & restoration	X	X	X	X
Protected sites management (onsite/offsite)	X	X	X	X
Bespoke species measures		X	X	X
Survey, monitoring and evaluation (incl status reviews/ red listing)		X	X	X
Research		X	X	X
Education and awareness		X	X	X
Sustainable farming practices: agri pressures reduced			X	X
Sustainable farming practices: non-PH created			X	X
Air pollution reduction/mitigation (incl N)			X	X
Policy, regulation and planning			X	X
SUPPLEMENTARY Land sparing/rewilding				X
SUPPLEMENTARY Protected Site designation				X

SUPPLEMENTARY Climate change adaptation				X

Species expected to continue to decline were indicated by selecting a higher threat status in the appropriate decade. Those that showed net deterioration over the whole timeframe were considered to face insurmountable pressures/threats such as climate change, or extinction debts. For example, a Critically Endangered species with populations showing continual decline and pressures that were not readily mitigated; or a species threatened by climate change with reference to climate envelope modelling.

The third and final option concerned species that were too poorly understood to determine relevant actions or estimate recovery timescales. These species will have been minimised by the exclusion of Data Deficient taxa. In the trajectories, they have been treated in the same way as species with unchanging status.

For RLI values to be comparable, each scenario included all species in the subsample. When a species was unaffected by a scenario, its threat status remained unchanged. Status improvements were cumulative across the scenarios: species that showed a change in Red List status in Scenario 2 were included in 3, and those in 3 are included in 4, and so on. This was consistent with the way other trajectories have been presented. Similarly, species considered declining under more ambitious scenarios were included as declining under less ambitious ones.

Assumptions & limitations

i. The method used a fixed list of species (a sample of the D5 indicator), meaning it was assumed no further species would become Threatened or Near Threatened (e.g., move from Least Concern) over the period of the trajectories; similarly it was assumed extinct species would not be reintroduced.
ii. Although the sample was considered statistically valid, it did not include Least Concern species (76% of native taxa), some of which are in decline but not sufficiently to be classed Near Threatened or Threatened. The sample also excluded Data Deficient (DD), Not Evaluated (NE), Not Applicable (NA) and already Extinct taxa (EW, EX, RE) which meets the requirements when setting a Red List Index baseline.
iii. In order to make clear distinctions for assessors between the actions, it was necessary to rationalise these to 11 headline actions (Table 18).
iv. No attempt was made to generate a scenario analysis for Scenario 5. However, unique actions namely: land sparing/rewilding, protected site designation, and climate change adaptation, were presented to assessors as supplementary actions.
v. For recoverable species it was assumed status improvement was attainable through no more than five actions, and that implementing all five actions would

achieve the best recovery outcome i.e., an improving conservation status. This was supported by an analysis of Section 41 species actions (see above).

vi. Resources necessary to implement the actions were considered to be full and there were no constraints hampering delivery e.g., selected actions could be delivered at all locations of a species.

vii. Timeframes for action implementation and species (population) response times were best estimates based on current understanding but excluded the IUCN 5y rule which guards against downgrading threat level until a 5y period of positive status has elapsed.

viii. Once a change in threat status was recorded, it was assumed the status change would continue over remaining decades unless otherwise indicated.

ix. GB Red List species statuses, as used in the D5 indicator, are assumed to have a strong parity with England species statuses (there are too few published England Red Lists assessment to be used in an index). For species that occur in Scotland and/or Wales as well as England, achieving an improvement in threat status may be less deliverable through conservation efforts solely in England. This effect was reduced in the trajectories by resampling when species with <20% of their GB range in England were encountered.

x. The D5 indicator is currently unpublished and provisional. There may be some changes to the total England counts of species in threat categories although these are expected to be small. Such changes would alter the Red List Index values but not the trends in the trajectories.

xi. Beyond the trajectories work, there are a number of ‘real world’ lags that impact recovery timeframes, these are: 1. Assessment lags: once a species has recovered, it needs to be reassessed. 2. Data aggregation lags: The data used for a red list assessment is a snapshot of its status over several years, e.g., a decadal trend, or the Extent of Occurrence measured over a multi-year window. If a species was assessed immediately after the recovery had been completed, most of the data going into the assessment would cover the recovery phase, i.e. Its status might appear worse than it actually is. 3. Data compilation lags: The data used for assessments is often gathered over a period of time before the actual assessment is completed. This can add an extra few years between recovery and a change in the Red List Index.

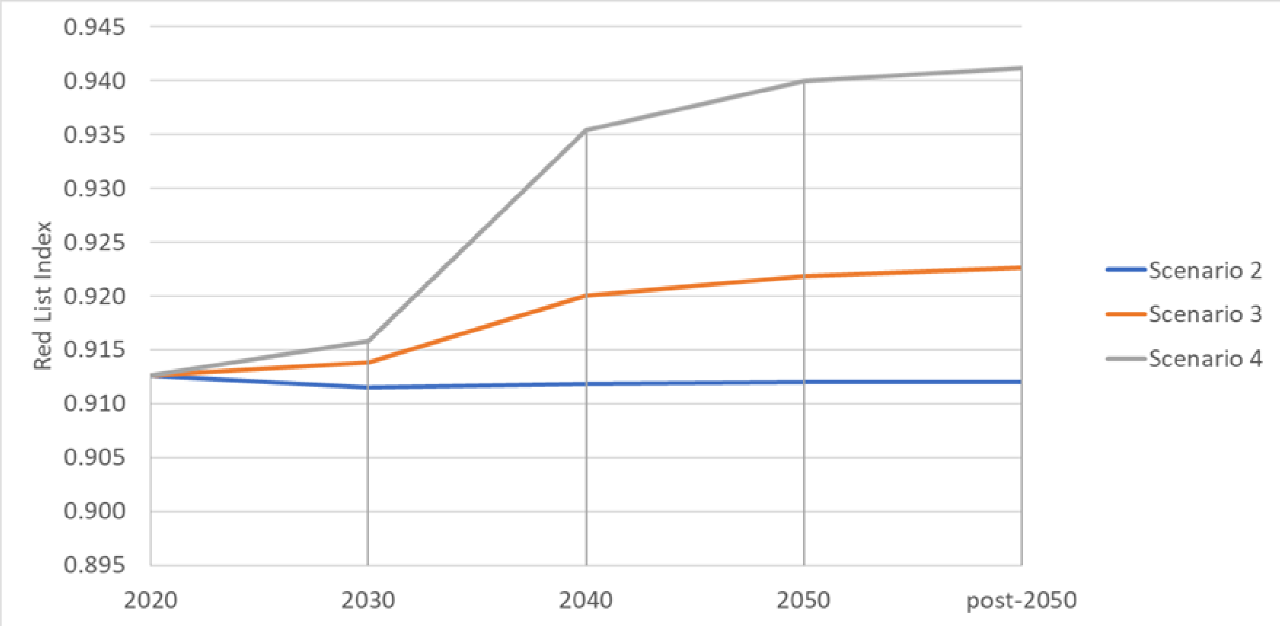
Scenario analysis results

Table 19: Number of species uniquely assigned to each scenario and to other categories to post-2050 (n=253).

	Improving threat status				
Scenario >	**2**	**3**	**4**	**Net decline**	**No change/ Unknown**
Invertebrates	0	43	37	0	6
Bryophytes	4	3	1	2	10
Herptiles	0	1	0	2	3
Mammals	0	0	6	1	5
Birds	2	7	25	0	20
Vascular plants	2	9	48	1	15
Total	**8**	**63**	**117**	**6**	**59**
% of sample	**3%**	**25%**	**46%**	**2%**	**23%**

Nearly half (46%) of species were assigned to Scenario 4, the most ambitious policy pathway, and a quarter (25%) assigned to Scenario 3 (Table 19). Species unaffected by all scenarios, or where recovery potential was not known, and those showing a net decline, amounted to the final 25%. Presenting the data in a cumulative way, 74% (188/253) of sampled species were expected to show some long-term recovery under Scenario 4. However, this translates into small percentage change in the Red List Index (discussed below).

Figure 32: Red List Index trajectories for the three scenarios. pp = percentage points. The green column shows actual percentage change to 2040.



Scenario	2020	2030	2040	2050	post-2050	2020-30 pp	2020-40 pp	2020-40 %	2020-50 pp	2020-post-50 pp
2	0.9126	0.9115	0.9118	0.9120	0.9120	-0.11	-0.076	-0.083	-0.06	-0.06
3	0.9126	0.9138	0.9201	0.9219	0.9226	0.12	0.746	0.818	0.93	1.01
4	0.9126	0.9158	0.9354	0.9400	0.9412	0.32	2.284	2.503	2.74	2.86

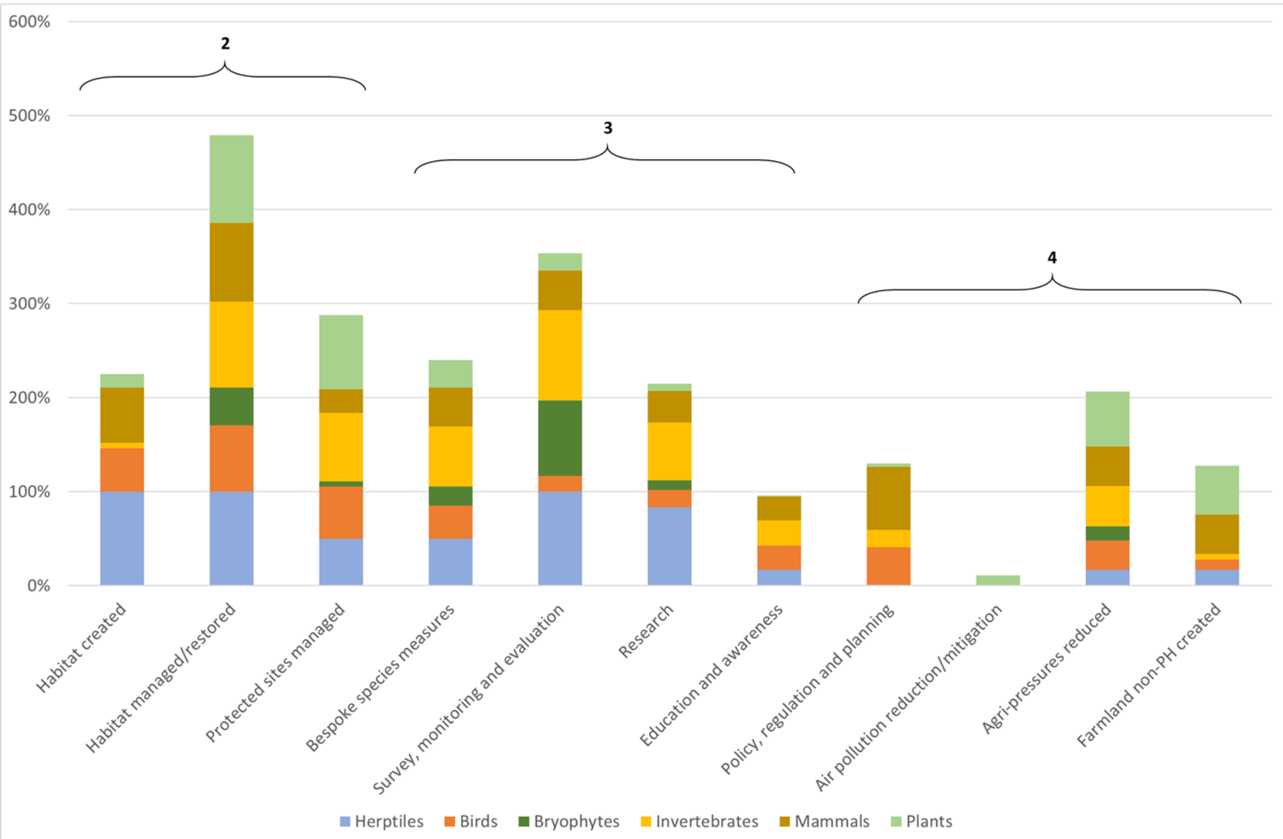
The Red List Index (RLI) value of 0.9126 at 2020 represents the baseline. This value is the combined RLI for all the groups in the sample (a marginally higher figure of 0.9175 if all Red List assessed species were included).

An upward trend in the graph line of Figure 32 (increasing RLI values) means there is a decrease in extinction risk expected (i.e. a reduction in the rate of biodiversity loss). A downward trend (decreasing RLI values) means the opposite (i.e. that the rate of biodiversity loss is increasing). A horizontal graph line (unchanging RLI values) means no change is expected to the rate of species extinctions.

Comparing change from 2020 to 2040, a slight increase in collective extinction risk is evident under Scenario 2. In contrast, Scenario 3 shows a modest improvement, with 0.8% increase in the RLI. However, under Scenario 4 the improvement is much more pronounced with a 2.5% increase. Although such changes appear small, they can equate to substantial shifts in the numbers of species across Threatened and Near Threatened categories. For example, the underlying data for Scenario 3 show 59 species improving, 10 deteriorating and 184 not expected to change in status. This represents a net improvement of 19% of the sample. As a result, we will explore methods additional to the Red List Index to communicate progress against the D5 indicator.

The value of the first iteration of the index is 0.9175 out of 1. If all species in the Threatened or Near Threatened categories were to move to the Least Concern category, this would represent an improvement of 8.99%. Hence a small percentage improvement in the Red List Index value can represent a highly ambitious target. The analysis indicates that we should expect the improvement in the RLI to be a fraction of this, despite requiring rapid improvement in a large number of species and representing a step change in conservation action.

Figure 33: Percentage of sampled species for which actions were selected, by taxonomic group and scenario. Data are presented as percentage of sample size for each group to aid comparison. Actions are those in Table 17 with names shortened



Scenario 2

Of all the actions, high-level habitat management and restoration stood out as collectively the most important action for most species (>80% of sample) (Figure 33). Five of the six taxonomic groups identified this as benefiting 70% or more of species; the exception was bryophytes at 40%. However, considering this as the proportion of total actions selected per group, 'habitat management and restoration' was chosen between 18-25% of the time.

In contrast, high-level habitat creation, was considered of much lesser importance for plants (15% of species), invertebrates (6%) and bryophytes (nil). Birds and mammals showed a less marked contrast, this action being relevant to between 40-60% of species, but for herptiles it was selected for all species (as was restoration & management).

'Protected sites management' (maintenance of existing habitat inside and outside of/bordering protected sites) was collectively the second most important action, with over 60% of sampled species benefitting. It was considered key for the recovery of 70-80% of vascular plants and invertebrates, 50-60% of birds and herptiles but only 25% of mammals and 5% of bryophytes. Looked at by the proportion of actions selected per group, birds showed an increased emphasis on this action (16%), as opposed to 15% for invertebrates and 9% for herptiles.

Note that although all the above actions fall under Scenario 2, they were frequently chosen in combination with Scenario 3 and/or Scenario 4 actions. Hence only 3% of species were actually assigned to Scenario 2 (Table 19).

Scenario 3

Overall, bespoke species measures (targeted actions, including site re/introductions and reinforcement) were considered key to recovery of over 40% of species. Although this might appear a high proportion, many of sampled species are IUCN Threatened or Near Threatened and therefore likely to be specialists. This action was important for over 60% of invertebrates, 50% of herptiles, and 42% of mammals. About one third of birds and plants also benefited. As a proportion of actions selected per group, the amounts were more even, ranging from 8-13%.

By proportion, 'survey, monitoring and evaluation' was the third most important action for all species, this action being selected for just over half of the species. It was considered necessary for all herptiles, almost all invertebrates and 80% of bryophytes. For mammals it was chosen for 40% of species, and approximately 20% for birds and plants. Nearly half of the actions for bryophytes fell in this group, over double that of any other group.

Research was identified as key for about one third of all sampled species, and particularly so for herptiles (>80% of taxa) and invertebrates (>60%). One third of mammal species and about 20% of birds also benefited, but 10% or less of bryophytes and plants.

Education and awareness raising (including land manager advice) was selected for 17% of sampled species, and about a quarter of birds, mammals and invertebrates; 17% of herptiles would also benefit from this action.

Scenario 4

'Policy, regulation and planning' was defined here as a wide range of actions including species licensing, flood defence planning (incl coastal), fisheries management, and water pollution reduction (WFD), but excluded agricultural and air pollution measures. Collectively it was selected for 19% of species (5% of actions), and most relevant to nearly 70% of mammal species, approximately 40% of birds and 20% of invertebrates.

Reduction of air pollution levels (including nitrogen oxides/compounds) and mitigation of impacts was only considered important for 11% of vascular plants, representing just 1% of all actions for the whole sample.

Lastly, two actions related to sustainable farming practice: 1) reducing pressures on wildlife (management of grazing, mowing, fertiliser, slurry, buffers etc), 2) habitat creation (ephemeral habitats, nectar-rich margins, provision of nesting and feeding sites, hedgerow tree planting, etc). This last was interpreted as principally non-Priority Habitat. Collectively, reducing pressures was chosen as key to just over 40% of species in the sample, and many plants (nearly 60% of plants). About 30-45% of invertebrates, mammals and birds also benefited, but only c15% of herptiles and bryophytes. The creation of farmland habitats was considered only relevant to about 20% of species, but again of most relevance to vascular plants (c50%) and also mammals (c40%); it was less relevant to birds and herptiles (both below 20% of species), and just 6% of invertebrates.

Supplementary actions

Whilst outside of the trajectories, supplementary actions could be selected by assessors if considered important to the recovery of a species. These concern Scenario 5. Experts were presented with three optional actions of particular relevance to species: 1) Land sparing and rewilding approaches, 2) New site designations and protections, and 3) Climate change adaptation. Land sparing and rewilding was selected by experts for nearly 40% of all sampled species. Invertebrates were most strongly represented (71% of species in this taxonomic group), followed by mammals (42%) and birds (28%). New site designations and climate change adaption were selected for only 6% of sampled species. The former was most important for mammals, birds and herptiles (17-25% of species in each group); and the latter for the same groups but less so (15-17%).

As outlined above there are many variables that impact the reliability of the trajectories developed. Table 20 below sets out a current RAG rating for Species Extinction and the recommended legislative target.

Conclusions

This target aims to prevent the loss of the rarest or fast declining species while preventing species at a lesser threat risk from further decline.

Change in the Red List Index may be subtle as higher extinction risk species improve in status. This is because the index includes many Least Concern species, and a sufficient number of species need to change in status to register a trend in the index. For example, the ‘medium ambition’ notional target (*7.5% point reduction in the number of threatened species and no species entering the extinct category*) equates to approximately 600 fewer threatened species in the preliminary Red List Index. Assuming these reductions are spread uniformly across threatened categories and that 50% move to Near Threatened and 50% move to Least Concern, this would result in an improvement in the index of 3.3 percentage points. Therefore small shifts in the index can indicate substantial changes in the fortunes of threatened species.

For the same reason, quantifying a level of ambition for the target, e.g. setting a percentage improvement, is problematic. The ‘high ambition’ notional target (*15% point reduction in threatened species and no species entering the extinct category*) which attracted little support for its achievability in the expert workshop and questionnaire (over 85% of respondents had no or low confidence it was achievable) would result in a shift in the index of 5.7 percentage points.

From the above it can be inferred that even a very small increase in the index value can represent substantial successes in species recovery, with many species facing a reduced extinction risk. The recommended target wording reflects this and is most closely aligned to the notional target: *no increase in % of threatened species and no species entering the extinct category*, which was more strongly supported by experts as achievable (low to medium confidence) than the other notional targets.

The index can also appear unresponsive because of: i) IUCN Red List categories are quite coarse, not necessarily capturing subtle trends in populations, ii) Red Lists are typically only reassessed every 10 years (see ‘Sensitivity of the Red List Index’), iii) the index tracks net change in extinction risk of many taxa, hence species improving in status can be counterbalanced by species deteriorating in status. Moreover, a lag can occur between the implementation of policies, resultant improvements in biodiversity, and available data evidencing these.

Despite these limitations, the Red List Index remains the recommended, most consistent assessment available for measuring long-term progress against extinction risk. Setting a target to increase the Red List Index value will drive action to reduce biodiversity loss and overall extinction risk.

Table 20: Species Extinction Risk RAG Rating

	Red	Amber	Green	Notes
Data Availability i. Frequency of collection ii. Coverage (England) iii. Representative (Species/Habitats) iv. Existing baseline and trend		X X X X		
Indicator suitable for measurement			X	The RLI is based on a global indicator and is deemed as suitable metric for measuring extinction risk.
Scale of assumptions		X		The scenarios rely on quite a broad set of assumption.
Actions v. Is delivery method/mechanism clear vi. Is this clear in development of scenarios		X	X	Actions required to reduce species extinction risk have been considered. Actions for some species and for delivering improvements at a high level are known but require further work.

Consensus between expert opinion and scenarios		X		The expert assessment suggested halting the decline of the Index to be the most feasible of the notional targets, though opinions differed as to how feasible. While the scenario analysis indicates that halting decline would be the upper limits of feasibility, this is in part due to the stability of the Index over several years.

Value for money

A summary of the cost benefit analysis is provided below. For more information about the cost benefit analysis please refer to the accompanying biodiversity targets Environment Act Impact Assessment (IA). The IA sets out in detail the underpinning assumptions of the CBA. The assumptions used in the IA differ in part to the evidence used in other items of supporting evidence outlined in this evidence pack due to differences in methodology and gaps in the evidence base.

The proposed suite of legally-binding biodiversity targets assessed in the cost benefit analysis of the accompanying biodiversity Environment Act target IA includes:

- *Species abundance:* To increase species abundance by at least 10% by 2042, compared to 2030 levels.
- The **2030 target for species abundance** to halt the decline in species abundance by 2030
- *Species extinction:* To have an improvement in the England-level GB Red List Index for species extinction risk by 2042, compared to 2022 levels.
- *Wider habitats*: To create or restore in excess of 500,000 hectares of a range of wildlife-rich habitat outside protected sites by 2042, compared to 2022 levels.

The appraisal period covers the years 2022-2100. The sum of the present value of costs and benefits are discounted using a 3.5% annual discount rate for the first 30 years,3.0% for the years 31-75 and 2.5% thereafter (following Green Book guidance). Except for air quality regulation benefits which are discounted using a declining discount rate of 1.5%. All the costs and benefits are estimated in 2019 prices and discounted to 2020 present values.

As shown by Table 21 the estimated *additional* annual cost of meeting the wider habitats target is £53.8m. The estimated *additional* average annual cost of meeting the species targets is £206.6m, compared to baseline funding levels. The present value of costs of meeting the targets is £3,231m (Table 22).

Table 21: Estimated additional average annual cost of meeting the recommended wider habitats, species abundance and species extinction risk targets (2023-2042, £m)

Target	Average annual cost, £m
Wider habitats	53.8
Species abundance and species extinction risk	206.6
Total	**260.3**

Table 22: The estimated present value of costs meeting the recommended wider habitats, species abundance and species extinction risk targets, (2023-2100, £m)

Target	PV, £m
Wider habitats	1,133
Species abundance and species extinction risk	2,098

Total	**3,231**

Table 23 presents the EAV and PV estimates for the recommended targets. The value of cultural services is, on average, higher than the value for regulating services.

Table 23: Equivalent annual value (EAV) and present value (PV) benefits estimates for the recommended targets

Benefit	EAV (£m/yr)	PV (£m)
Carbon sequestration	211	5,303
Air quality regulation	19.7	740
Recreation	275	6,909
Physical health	186.4	2,171
Total	**591**	**15,123**

Note: Present values estimates are calculated over the 2022-2100 appraisal period.

The cost and benefit estimates provided in the above tables should be treated as indicative of scale due to a high level of uncertainty and gaps in the evidence base. The CBA presented above indicates that the benefits of implementing the proposed biodiversity Environment Act targets will far outweigh the costs. It is likely that the higher levels of ambition for the biodiversity targets will result in higher costs and benefits. However, for higher levels of ambition there will be increasing marginal costs, with additional actions costing more.

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Annexes

Annex 1. Definition of wildlife-rich habitat

All habitats can have value for wildlife but to varying degrees. Criteria to identify the more important habitats for wildlife have been produced over the years, particularly since the introduction of Biodiversity Action Plans under the 1992 Convention on Biological Diversity[42] (CBD). Section 41 of the Natural Environment and Rural Communities (NERC) Act, 2006 requires the Secretary of State to identify habitats of principal importance for the purpose of nature conservation, which we have referred to as priority habitats for the purpose of this evidence report.

With the launch of the 25 Year Environment Plan, the word 'wildlife-rich' was introduced in connection with the target for 500,000 ha of new habitat. The term 'wildlife-rich' was not defined except that it was proposed to focus on protected or priority habitats and that its restoration or creation would contribute to the delivery of the Nature Recovery Network (NRN).

The concept of 'wildlife-rich' habitats can also be used to produce a statutory target for restoration and creation of wider habitats, building on a 2022 baseline.[1] Habitat creation refers to establishing wildlife-rich habitat on land, freshwater, coastal, and estuarine, where it is currently not present. Whereas habitat restoration refers to improving the condition of relict or degraded habitat, leading to an expansion of the extent of the habitat.

A definition for 'wildlife-rich' habitats is not intended to re-classify all existing habitat types but to support making a decision on the habitat types that will be counted under the proposed target. As with all priority habitat definitions, this requires defining the type and quality of habitat.

For this Environment Act target we propose the following definition, based on the principles copied below:

'Wildlife-rich' habitat is natural or semi-natural habitat that is identified as:

- *A habitat of principal importance for biodiversity under Section 41 of the Natural Environment and Rural Communities Act, 2006 (1); or,*

[42] https://en.wikipedia.org/wiki/Convention_on_Biological_Diversity

- *A habitat identified as being of high or very high distinctiveness as defined in the biodiversity metric 3[2] (2); or,*

- *A habitat of medium distinctiveness as defined in the biodiversity metric 3[3] that is in good or moderate condition and of high to medium strategic significance (3): non-priority habitats with wildlife benefit.*

The classification of habitats by distinctiveness set out above seeks to capture the essential elements of the habitat considered to be 'wildlife-rich'. From this, a full list of habitats has been identified drawing on existing published biodiversity metric 3 and is proposed for inclusion under this target.

Priority Habitats: Rivers, Ponds, Aquifer Fed Naturally Fluctuating Water Bodies, Arable Field Margins, Hedgerows, Traditional Orchards, Wood-Pasture and Parkland , Upland Oakwood, Lowland Beech and Yew Woodland, Upland Mixed Ashwoods, Wet Woodland, Lowland, Mixed Deciduous Woodland, Lowland Dry Acid Grassland, Lowland Calcareous Grassland, Upland Calcareous Grassland, Lowland Meadows, Upland Hay Meadows, Coastal and Floodplain Grazing Marsh, Lowland Heathland, Upland Heathland, Upland Flushes, Fens and Swamps, Purple Moor Grass and Rush Pastures, Lowland Fens, Reedbeds, Lowland Raised Bog, Blanket Bog, Mountain Heaths and Willow Scrub, Inland Rock Outcrop and Scree Habitats, Calaminarian Grasslands, Open Mosaic Habitats on Previously Developed Land, Limestone Pavements, Maritime Cliff and Slopes, Coastal Vegetated Shingle, Coastal Saltmarsh, Saline lagoon, Coastal Sand Dunes, Maerl Beds, Oligotrophic and Dystrophic Lakes, Mesotrophic Lakes, Eutrophic Standing Waters, High energy littoral rock, High energy littoral rock - on peat, clay or chalk, Moderate energy littoral rock, Moderate energy littoral rock - on peat, clay or chalk, Low energy littoral rock, Low energy littoral rock - on peat, clay or chalk, Features of littoral rock, Littoral mud, Littoral mixed sediments, Littoral seagrass, Littoral seagrass on peat, clay or chalk, Littoral biogenic reefs – Mussels.

Very High/High Distinctiveness habitats: Littoral sand, Littoral muddy sand, Other inland rock and scree, Native Species-Rich Hedgerow with trees, Native Species-Rich Hedgerow - Associated with bank or ditch, Native Hedgerow with trees - Associated with bank or ditch, Other Rivers and Streams (for restoration).

Medium Distinctiveness habitats: Other lowland acid grassland, Other neutral grassland, Upland acid grassland, Blackthorn scrub, Bramble scrub, Gorse scrub, Hawthorn scrub, Hazel scrub, Mixed scrub, Ponds (Non-Priority Habitat), Other woodland: broadleaved, Littoral coarse sediment, Littoral sand, Native Species-Rich Hedgerow, Native Hedgerow - Associated with bank or ditch, Native Hedgerow with trees, Line of Trees (Ecologically Valuable), Line of Trees (Ecologically Valuable) - with Bank or Ditch.

Other Estuarine and coastal habitats: Infralittoral rock, Circalittoral rock, Subtidal stony reef, Native oyster (*Ostrea edulis*) beds, Coastal Saltmarsh and saline reedbeds, Littoral biogenic reefs – Sabellaria, Subtidal biogenic reefs: mussel beds, Subtidal biogenic reefs: Sabellaria spp., Subtidal coarse sediment, Subtidal mixed sediments, Subtidal mud, Subtidal sand, Subtidal seagrass beds.

The following principles are key to achieving nature recovery and will need to be considered when determining what actions taken within the agreed habitats are considered likely to lead to the creation and restoration of wildlife-rich habitat. It may not be possible to fully represent all of these principles in the reporting process of the target, due to data limitations. They will, however, be considered and taken forward as far as is practicable:

- **Habitat Quality** - To ensure the target drives nature recovery effectively it is important that the quality threshold set for 'wildlife-rich' does not include those that are excessively degraded or highly modified. Examples of degraded or highly modified habitats include any habitat on drained peat, open waters that are severely affected by pollution, woodlands that contain a high % of non-native species such as Plantations on Ancient Woodland Sites (PAWS) and areas of non-native or invasive scrub. These areas of poor-quality habitat may then be selected for restoration under this target. To meet the quality threshold for 'wildlife-rich' it is proposed that any habitat created or restored should be aiming to achieve at least a quality of moderate and for some habitats we may consider that a high value is required.

- **Species** - All new habitat creation and restoration works should seek to develop a range of habitat niches for a wide range of species. This is a well-established principle under AES and is described as the 'Mosaic Approach'[4].

- **Ecosystems and Natural Function** – To help further integrate management for long-term species survival, Natural England produced guidance[5] on delivering better integrated biodiversity decision-making in line with the 'ecosystem approach[6] outlined under the International Convention on Biological Diversity.

- **Permanence** –It is recognised that nature recovery needs to be long-lasting and that habitat creation can take many years to achieve its goal i.e., to be fully functional and support biodiversity recovery. Therefore, the target should encourage actions that produce and maintain habitats for the long-term benefit of wildlife. Where more ephemeral wildlife-rich habitat is included as part of the target e.g., arable field margins, then the total extent of that habitat at the start of the reporting cycle will be taken as a baseline and only increases above the baseline will be reported as contributing towards the target.

- **Net increase –** Habitat gains prior to reporting need to be maintained in-situ where possible. Habitat lost needs to be replaced and only the extent of additional habitat after replacement has been taken into account will be reported. This is currently achieved by only reporting delivery from live AES agreements, i.e., those areas of delivery within current agreements; those that have expired, therefore, need to be replaced before an increase in the target delivery figure can be reported. In addition, the following 'reporting rules' should apply:

    - Habitat replacement for losses e.g., 'compensatory habitat' for designated sites will not be counted as contributing towards the target; and,

    - Habitat losses from any other development will be recorded and replaced as part of the delivery under BNG, the loss of habitat relevant to this target relates only to 'wildlife-rich' habitats. Compensatory habitats for this loss will also not count under this statutory target.

- **Spatial Reporting** – The value of any habitat is greater if it is located in the right place (e.g., on right soils and adjacent to existing habitat). Spatial reporting will also allow better understanding on where created habitat is retained and where it is lost.

- **Inclusiveness –** No single habitat group should dominate in a way that is detrimental to the delivery of other habitats.

Annex 2: Business as usual datasets

Table 21: Habitat creation and restoration rates between 2011 – 2019 for all mechanisms.

Habitats	Total delivered	Annual
Grassland	32,316	3,591
Lowland Heath	4,542	505
Uplands	10,637	1,182
Coastal Floodplain Grazing Marsh	7,727	859
Wetland	3,799	422
Coastal	1,959	218
Wood-pasture & Parkland	2,352	261
Traditional Orchards	162	18
Woodland creation	18,353	2,039
PAWS	24,457	2,717
Arable field margins	33,068	3,674
Mix of Priority Habitats (undefined)	8,854	984
Ponds	629	70
Hedgerows	494	55
Total	154,755	16,595