Review of Evidence: Assessing and Monitoring Species Abundance and Extinction Risk for Biodiversity Conservation and Environmental Protection

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Client Ref: WD08821 / CA4555

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Executive summary

A statutory instrument underpinning biodiversity targets for species' abundance and species' extinction risk came into force in January 2023. The UK Centre for Ecology and Hydrology (UKCEH) were commissioned by the Office for Environmental Protection (OEP) to provide a critical appraisal of the concepts of "species abundance" and "species extinction risk", whether they can be used to achieve and assess improvement in the natural environment, and a review of the evidence used to develop the legally-binding targets. Specifically, this report aims to review the monitoring data and evidence that has been used to develop the indicators, identify their main strengths and weaknesses and outline opportunities that support successful use of indicators into the future. The second element of the report outlines the key assumptions made during the target development process and highlights where the key uncertainties lie in relation to target delivery and achievability. We document where the delivery pathways are well supported by existing evidence, what the key uncertainties are, and where there are weaknesses in the evidence for understanding pathways to meeting the biodiversity targets. For each of these elements, evidence was collated and critically appraised by UKCEH, and this process was supplemented by a series of meetings with an independent expert panel who peer-reviewed the evidence review and recommendations as the process developed.

In summary, our review of the monitoring and indicators highlighted that the England species abundance indicator has undergone significant improvements since work began to develop the legally-binding targets, expanding from 670 to 1195 species and encompassing a wider taxonomic range. However, significant taxonomic gaps remain (for example there is very limited representation of marine species), which introduces risks of skewed incentives and missed opportunities if too much focus is placed on improving the value of the indicator rather than improving biodiversity more generally.

Any dataset contributing to the species abundance indicator should aim to conform to a range of standards, especially given that the indicator will be used to track progress towards legally binding targets. Consensus emerged from stakeholder workshops on key criteria for contributing datasets, including comprehensive geographic coverage, consistent methodology, species-level taxonomic detail, and regular data collection for annual reporting. Defra's data inclusion criteria align with these expectations, and independent reviews have already assessed many contributing datasets. Our review found that although underlying methodologies vary, most monitoring programs either meet these criteria or have statistical corrections to address any shortcomings before data integration into the indicator. This ensures high-quality data underpinning the indicator's efficacy in monitoring biodiversity trends. However, there are concerns regarding the utility of the indicator in detecting true and meaningful changes between specific consecutive pairs of years (as required to measure the success of the 2030 species abundance target). This is due to the high levels of variability

associated with the data that contribute to the indicator (arising from both natural variation and observer-based variation in abundance estimates), combined with unknowns regarding the smoothing parameters to be used in the calculation of the final index. Alongside this, short-term funding agreements for independent monitoring schemes pose a threat to data continuity and potential biases may arise as the original intended purpose of data collection does not match that of the use for the indicator.

The development of the species abundance indicator, following the environmental targets consultation in 2022, lacks public documentation, which affected the ability to conduct a full review of the finalised indicator. In particular, it is unclear whether there will be any further methodological changes to the index calculation, and it is unclear how the indicator will ultimately be presented (e.g., alone as a single value or alongside disaggregated trends and other accessory indicators). A key takeaway from a series of stakeholder workshops, however, emphasised that the indicator alone cannot solely guide effective biodiversity conservation policies. It serves as a broad environmental health indicator, summarising progress towards the species abundance targets, but understanding the pressures driving species abundance declines is crucial for informed policy decisions. Therefore, additional information on biodiversity loss drivers and their links to abundance is necessary to achieve legally binding targets effectively.

The target-setting process laid out by Defra in the environmental targets consultation evidence report, relied heavily on scenario models and mathematical feasibility assessments. The policy scenarios developed by Defra outlined general intervention categories and resource requirements, but lacked precise details such as implementation pacing and scale. Although this reflected the information available at the time, it likely restricted the models' accuracy and applicability. Consequently, the models incorporated a multitude of necessary simplifying assumptions, driven by data gaps and conceptual challenges. Some policy-specific assumptions were made such as the relative rates of habitat creation across habitat types, as well as a like-for-like comparison between new and past agri-environmental options, and assumptions about the level of uptake of such options. In addition to this, much of the modelling was undertaken using the initial version 1 of the indicator (containing only 670 of the 1195 species in the final version of the indicator), and the feasibility assessment extrapolated recent rates of decline in species abundance to 2022, with no consideration of the potential error around this assumption. Furthermore, forward-looking projections about the impacts of pressures affecting species abundance, such as climate change and invasive non-native species were limited to the assumption that background decline would remain similar to that experienced currently. Limited consideration was given to the appropriateness of the target timescale in relation to ecological and political lags.

Despite the limitations of the scenario modelling and feasibility assessments, the targets set by Government relating to species abundance appear to be suitably ambitious. Based on responses to the OEP’s call for evidence on nature recovery, many stakeholders believe that a significant increase in the scale and pace of actions will be required to meet the target and that the target will be challenging to meet.

There was general agreement that the targets are achievable given an appropriate scale and pace of action. The Environmental Improvement Plan 2023 outlines broad actions, many of which are supported by evidence submitted by stakeholders to the OEP's call for evidence and evidence in the peer-reviewed and grey literature. In particular, tackling underlying pressures, engaging stakeholders, and enforcing regulations are crucial for achieving biodiversity goals. However, many stakeholders outlined that the plan lacks detailed timelines, prioritisation, and clarity on responsibilities for those working on the ground, which ultimately may hinder progress towards achieving targets if not addressed in the future.

In conclusion, despite the limited information and time available during the development of the species abundance indicator and legally binding targets, there is evidence to suggest that the indicator is based on robust monitoring of species abundance, and has the potential to be a key representation of the state of the environment under Government's *Thriving plants and wildlife* goal. Further, the process undertaken to set the ambition level of the targets, although based on limited evidence and therefore reliant on many simplifying assumptions, was based on the best available quantitative evidence at the time, resulting in targets that are ambitious yet likely achievable. Nevertheless, several opportunities exist to strengthen the efficacy of the species abundance indicator and its contribution to achieving the legally binding targets:

- Expanding monitoring and developing complementary indicators for underrepresented taxa and key drivers/pressures of biodiversity decline would offer useful context and help address some of the biases that exist, ultimately enhancing the indicator's utility for informing policy decisions.
- Increased transparency and trust can be generated by fully documenting the indicator's development process and acknowledging key limitations within supporting technical documents.
- Securing long-term funding agreements for monitoring schemes would futureproof the indicator and help to ensure sustained and effective data collection.
- Revisiting the scenario modelling used to develop the target ambition with the finalised species lists, conducting sensitivity analyses of key assumptions, and regularly updating the models with new data and policy implementation progress would allow for an assessment of accuracy.

By exploring these opportunities, we believe Defra can refine its biodiversity monitoring, assessment and policy framework. These opportunities are an important component of an adaptive management approach needed for effective delivery of the current and future EIPs.

Contents

1. Introduction

Government's ambition is to be the first generation to leave the environment of England in a better state than that in which it was found. This ambition was first articulated in 2011 in the Natural Environment white paper[1]. It was a manifesto commitment in 2017, followed in 2018 with the 25 Year Environment Plan (25 YEP)[2]. This Plan set out the Government's commitments and goals for realising its ambition. The Environment Act 2021 then provided a new governance framework for the environment, with four key provisions:

- a new oversight body (the Office for Environmental Protection);
- a long-term Environmental Improvement Plan (EIP) that must set out the steps Government intends to take to improve the natural environment;
- statutory targets; and
- an Environmental Principles Policy Statement applicable across government.

Parliament has established the Office for Environmental Protection as the new oversight body. It designated the 25 YEP as England's first EIP and has since published the first revision of the 25 YEP alongside an Environmental Principles Policy Statement in January 2023[3]. A statutory instrument underpinning biodiversity targets for species' abundance and species' extinction risk also came into force in January 2023.[4] The key targets relating to biodiversity are:

- **Species abundance 2030 target (to meet Environment Act 2021 commitment):** To halt the decline in species abundance by 2030
- **Species abundance long-term target:** To increase species abundance by at least 10% by 2042, compared to 2030 levels
- **Species extinction risk long-term target:** To reduce the risk of species' extinction by 2042, when compared to the risk of species' extinction in 2022.

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[1] Defra (2011) The natural choice: securing the value of nature. <https://www.gov.uk/government/publications/the-natural-choice-securing-the-value-of-nature> [accessed 27 September 2023].

[2] Defra (2018) A Green Future: Our 25 Year Plan to Improve the Environment. <https://www.gov.uk/government/publications/25-year-environment-plan> [accessed 27 September 2023].

[3] Defra (2023a) Environmental Improvement Plan.<www.gov.uk/government/publications/environmental-improvement-plan.>; Defra, 'Environmental Principles Policy Statement', 2023 <https://www.gov.uk/government/publications/environmental-principles-policy-statement> [accessed 27 September 2023].

[4] HM Government, *The Environmental Targets (Biodiversity) (England) Regulations 2022* (King's Printer of Acts of Parliament, HM Government (2022) The Environmental Targets (Biodiversity) (England) Regulations 2022. King's Printer of Acts of Parliament.

The OEP review and report on progress in delivering environmental improvement plans (EIPs), goals, and targets. As part of this, the OEP need to provide independent analysis and reporting of government's progress towards achieving the legally binding targets and the ten goals of the twenty-five-year environment plan (25 YEP) and subsequent Environmental Improvement Plans (EIPs).

1.1 Objectives

The UK Centre for Ecology and Hydrology (UKCEH) were commissioned by the OEP to provide a critical appraisal of the concept of "species abundance" and "species extinction risk", and whether they can be used to achieve and assess improvement in the natural environment. This was achieved through two elements:

A. ***Review of monitoring and indicators:*** A review and critical appraisal of approaches to monitoring species abundance and extinction risk in England, specifically in relation to achieving, and monitoring progress towards key targets arising from the Environment Act 2021.
B. ***Review of evidence used to develop targets:*** A review of the evidence and analysis used by government and its agencies to develop, and then make and assess progress towards, the species abundance and related targets for England.

The first element of this report (***"Review of monitoring and indicators"***) provides a clear understanding of the concepts of species abundance and species extinction risk, how they are assessed, and their utility as indicators of improvement in biodiversity. We review the evidence underpinning the indicators that will be used to monitor progress towards the legally binding biodiversity targets, identify their main strengths and weaknesses and outline opportunities that support successful use of indicators into the future. Specifically, the following, high level questions provided a focus for the review:

- What are the strengths and weaknesses of current species abundance monitoring schemes and the species abundance indicator in England?
- How effective are the monitoring approaches at providing an effective and accurate description of the state of species abundance (and extinction risk) in England?
- What is the value of the indicator in relation to its intended use to measure progress towards achieving legally binding targets?

The second element of the report (***"Review of evidence used to develop targets"***) outlines the key assumptions made during the target development process and highlights where the key uncertainties lie in relation to target delivery and achievability. We document where the delivery pathways are well supported by existing evidence, what the key uncertainties are, and where there are weaknesses in the evidence used to understand pathways to meet the targets. The following overarching question and sub-questions provided a focus for the review:

- Considering the available evidence, is the level of ambition in the UK Government's plan to deliver the targets for species abundance and extinction risk in England appropriate?
    - What are they key assumptions and uncertainties?
    - Are the targets achievable given the proposed delivery pathways?
    - Are the delivery pathways supported by existing evidence?
    - Are there risks of failing to meet the targets?

1.2 Structure of the report

The remainder of this report is presented in three sections:

- First, we set out the methodology used for evidence gathering and analysis to support this work. In this section we summarise the overall approach for evidence gathering and analysis, and then outline any details specific to each element (A & B) of the work.
- We then summarise the key findings of the work before presenting a detailed review of evidence for each of the two elements (A & B) outlined above. The detailed review for each element includes a summary of Defra's approach to the element in question, a review of their approach in light of the evidence surrounding best practice/effective implementation etc, and a critical appraisal of the evidence including details of any recommendations or opportunities stemming from the findings of the analysis.
- Finally, we conclude by providing a high-level summary of the findings and revisit the questions presented above for each of the elements (A & B).

1.3 Peer review process

The analysis and conclusions set out in this report are based on the work and views of the report authors. An independent panel of experts was set-up to peer review the review methodology, analysis, results and written report. The panel peer-reviewed the work as it progressed, providing input on the development of key messages and conclusions developed from the research. Members of the panel reviewed draft project reports and attended online presentations and workshops at each of the main project milestones.

2. Methodology

2.1 Summary of overall approach

This section sets out an overview of the review and methodology that was used to ensure that the evidence review process was rigorous and transparent. For each of the elements of the review the first step was to determine the high-level questions that needed to be answered. This was informed by the needs of the OEP as the end user of the evidence review. Once these questions had been determined, we followed principles provided in Collins et al. (2015)[5] and developed a protocol for the evidence review which set out for each aspect of the work: a strategy for where evidence will be searched for; an outline of the inclusion and exclusion criteria; and an overall schematic strategy for extracting information. This information is presented in detail for each element (A & B) of the review in the following sections. These protocols were presented to and approved by the independent expert panel, before being used to guide the search for evidence. Evidence was collated and critically appraised by UKCEH, and this process was supplemented by a series of meetings with the independent expert panel who peer-reviewed the evidence review and recommendations as the process developed.

Any information that was missing or that needed further clarification was sought directly from Defra via the OEP. Specifically, requests for any additional technical documentation and information on sources of data relating to updated versions of the species abundance indicator were made to Defra through the designated channels. Requests were also made querying any future plans pertaining to the species abundance indicator or extinction risk indicator.

2.2 Conceptual models for evidence review

We created a conceptual model (below) for the evidence review which outlines the various elements that the review will cover.

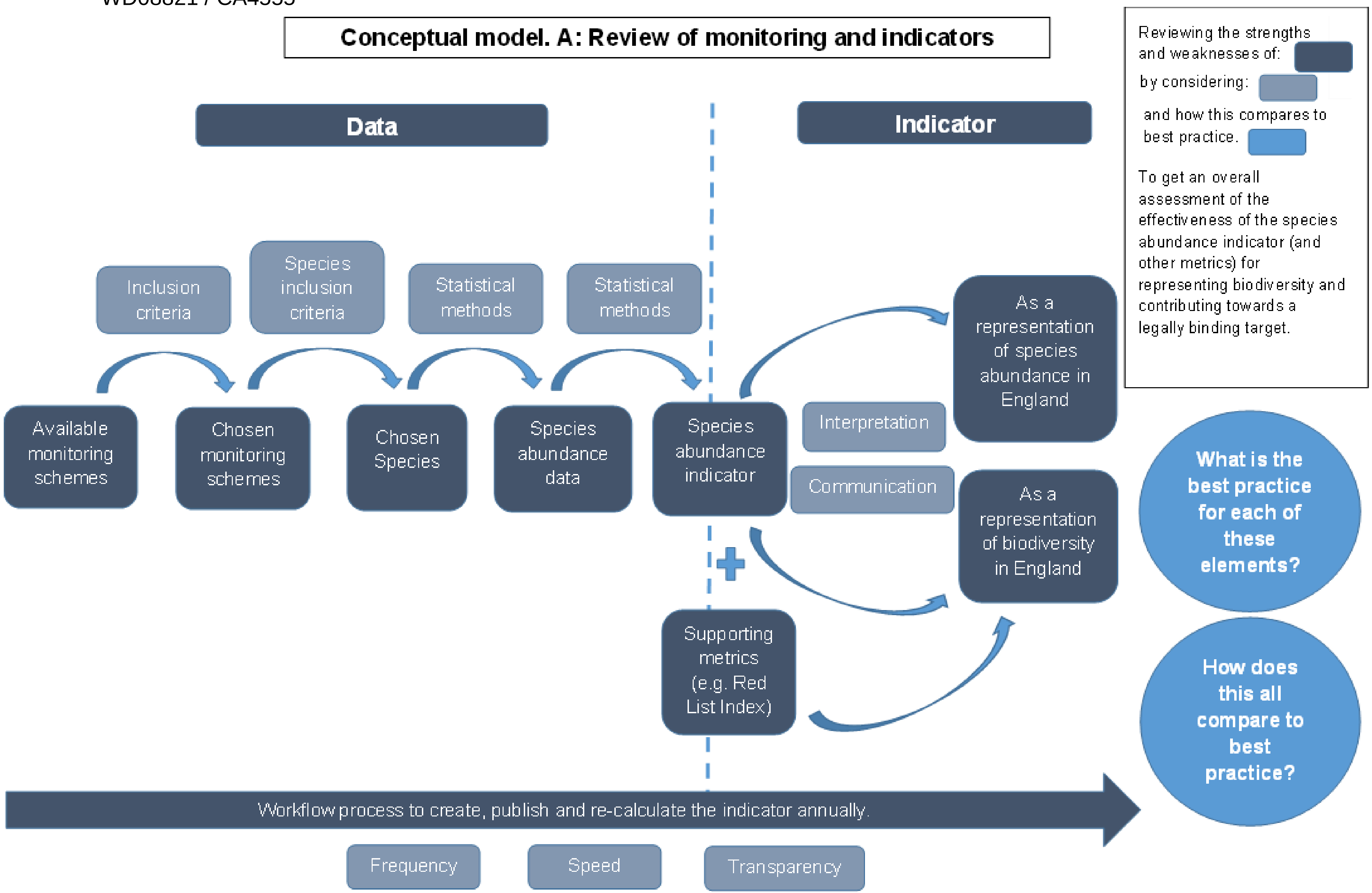
Our model for the first element of the work (***A: Review of monitoring and indicators***) is split into two key elements: the data feeding into the indicator, and the indicator itself. Both of these elements can be broken down into smaller items for consideration and the processes through which these items go through to generate an annual index value. Each of these elements can be compared to best practice to obtain an overall assessment of the effectiveness of the species abundance indicator (and other

[5] Collins, A.M., Coughlin, D., Miller, J., Kirk, S. 2015. The Production of Quick Scoping Reviews and Rapid Evidence Assessments: A Collins A, Coughlin D, Miller J, Kirk S (2015) The Production of Quick Scoping Reviews and Rapid Evidence Assessments A How to Guide.

supporting metrics) for representing biodiversity and contributing towards a legally binding target.

For the second element of the work (***B: Review of evidence used to develop targets***), the model is also into two key elements: the target development process, and Government’s plan for delivery of the targets, each of which can be broken down into smaller items for consideration. We assessed the evidence used in the policy scenario models that were used to develop the targets, considering the methods, key assumptions and uncertainties involved. We then assessed the ambition and achievability of the targets in light of the evidence surrounding the effectiveness of the chosen policy pathways for delivery.

Conceptual model. A: Review of monitoring and indicators



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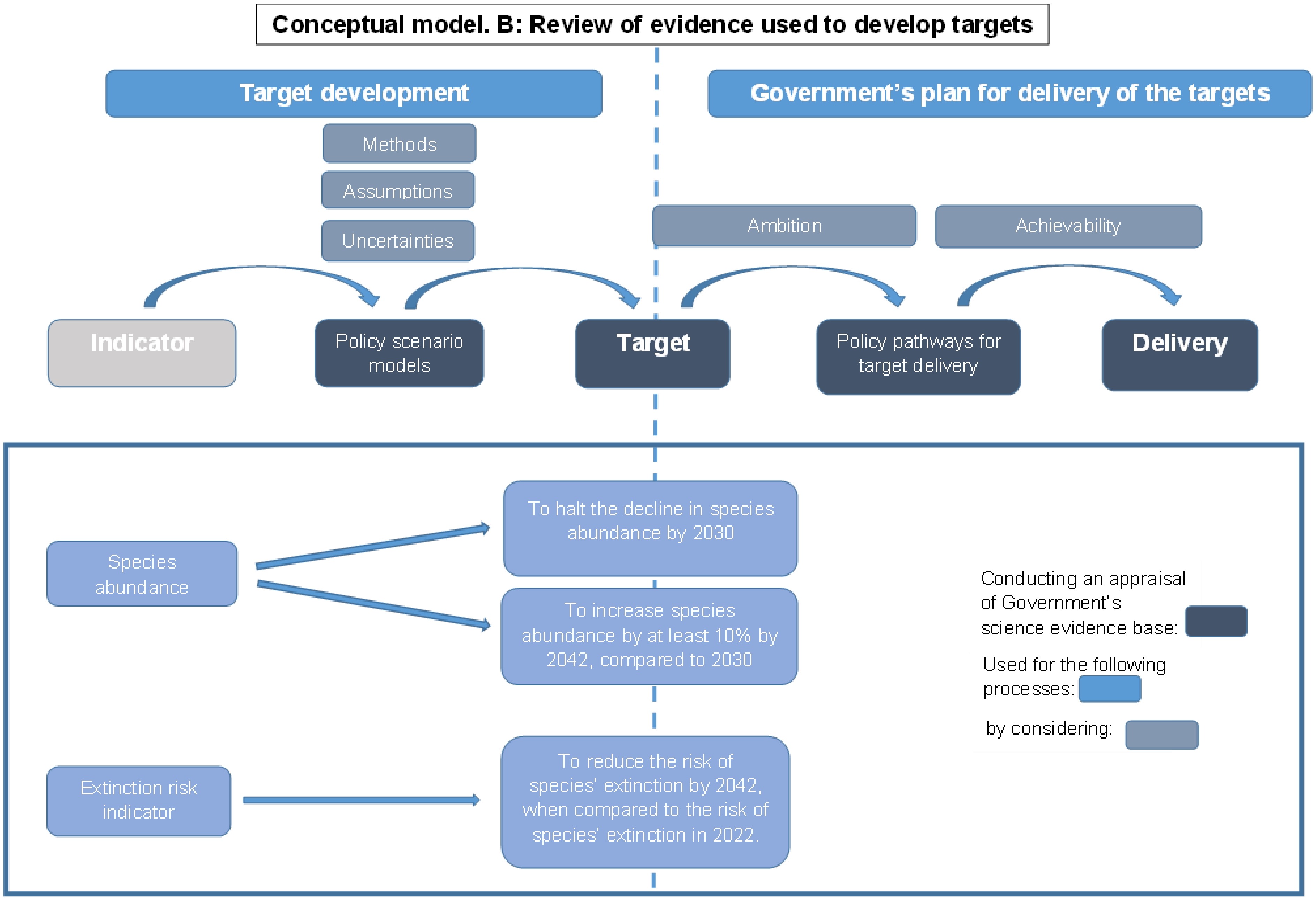
Conceptual model. B: Review of evidence used to develop targets
Target development
Government's plan for delivery of the targets
Methods
Assumptions
Uncertainties
Ambition
Achievability
Indicator
Policy scenario models
Target
Policy pathways for target delivery
Delivery
Species abundance
To halt the decline in species abundance by 2030
To increase species abundance by at least 10% by 2042, compared to 2030
Extinction risk indicator
To reduce the risk of species' extinction by 2042, when compared to the risk of species' extinction in 2022.
Conducting an appraisal of Government's science evidence base:
Used for the following processes:
by considering:

2.3 A: Review of monitoring and indicators

The following, high level questions provided a focus for this initial element of the review:

- What are the strengths and weaknesses of current species abundance monitoring schemes and the species abundance indicator in England?
- How effective are the monitoring approaches at providing an effective and accurate description of the state of species abundance (and extinction risk) in England?

To answer the high level questions of interest, all available evidence was required on the **data** feeding into the species abundance indicator, including the species monitoring schemes that were considered, which were chosen for inclusion (and why), which species from each of these monitoring schemes were chosen to be included in the indicator (and why), how the data for these species are converted into an abundance estimate, how the abundance data from multiple species is converted to the abundance indicator and how sensitive this is to variable start and end dates and missing information.

It was thought that this information would likely come from a number of sources, though it was recognised that much of the information about the data included in earlier versions of the species abundance indicator had been laid out in various documents published by Defra available on the gov.uk website. Missing information was sought from the following sources:

- Much of the data included in the indicator has already been used in other indicators at the UK and/or England level, so there was supporting information available to fill any gaps that could not be found from an initial search on the species abundance indicator itself. This information was gathered from technical documents surrounding the UKBI and England Biodiversity Indicators.
- There was less published information available for some of the data that has most recently been added to the indicator. These gaps were filled where possible from other sources, including directly from the data providers and experts during online workshop held by UKCEH to support evidence gathering for this work package (Annex A).

This allowed us to gather information on the **indicator** as a whole (alongside other metrics including the species extinction risk Red List Index), and to understand how it is interpreted and communicated to represent both species abundance and biodiversity in England. We also aimed to understand the planned workflow from sourcing data through to publication of the index (i.e., the speed at which this can be done, the planned frequency of publication, and any differences in the speed of publication year-to-year). This information was gathered from the following sources:

- Information on Defra's approach to the interpretation and communication of the abundance indicator was gathered from Defra's indicator-related publications, minutes from meetings and workshops in the lead up to the development of the indicator.
- Information on other biodiversity metrics (e.g., the Red List Index, and others), was sought from various grey and peer reviewed literature as well as from experts during the online workshops (Annex A).

We then reviewed all this information in the light of a set of ideals or **best practice** for biodiversity monitoring and indicator use.
First the ideals/best practice were defined:

- Information on the best practice surrounding both the collection and use of **abundance data** and **indicator methods/interpretation** was sought from a wide range of sources, including from peer reviewed literature, grey literature, and expert opinion (e.g., from the stakeholder workshop – Annex A).

Then, using the information gathered in the above steps, the data and indicator was compared to this best practice:

For the data

- Many of the datasets had already been independently critically evaluated, due to their use in other indicators. This information was reviewed and summarised, and any key evidence gaps identified. This evidence came from both peer reviewed literature, and grey literature. Some input was also sought from experts, to clarify anything that remained unclear.
- For the datasets that had not been previously independently reviewed, the information gathered about this data was mapped onto the defined best practice. The opinions of experts and data providers was sought (e.g., during workshops – Annex A, and independently) to ensure this was done accurately.

For the indicator

- For the indicator as a whole, the information gathered about the methods, interpretation, and workflow was compared to the defined best practice. The opinions of experts and data providers was sought (e.g., during workshops – Annex A, and independently) to ensure this was done accurately.

Inclusion/exclusion criteria for evidence

Although this evidence review is focussed on the species abundance indicator for **England**, evidence contributing to the review also came from sources that refer to UK-level, or other national level biodiversity indicators. This is because much of the data making up the species abundance indicator is collected at a wider spatial scale. Likewise, much of the evidence that discusses best practice for data contributing to abundance indicators may not refer to England directly. The evidence was only included if the key concepts from these sources of information can be related directly to the abundance data/indicator in England.
Only evidence referring to species abundance and species extinction risk data/ indicators was used (i.e., evidence relating to the best practice for other types of data/indicator such as species occupancy indicators or pressure indicators was not considered). The only section for which such information was relevant was the review of supporting metrics, but in this case the metrics discussed were only done so regarding how they complimented an indicator of species abundance.

2.4 B: Review of evidence used to develop targets

The following overarching question and sub-questions provided a focus for this element of the review:

- Considering the available evidence, is the level of ambition in the UK Government's plan to deliver the targets for species abundance and extinction risk in England appropriate?
    - What are they key assumptions and uncertainties?
    - Are the targets achievable given the proposed delivery pathways?
    - Are the delivery pathways supported by existing evidence?
    - Are there risks of failing to meet the targets?

To answer these questions, we needed to gather the available evidence on the **target development process** underpinning the legally binding targets for species abundance and species extinction risk. This includes the methods used in a series of scenario models which informed the ambition level of the targets, the key assumptions that were made during this process, and where the key uncertainties lie.

- The vast majority of this information came from the detailed evidence report on the terrestrial and freshwater biodiversity targets, which was published as a technical annex to the Consultation on Environmental Targets in 2022. Some key information also came from the peer reviewed paper Bane *et al*. (2022)[6].

We also gathered evidence on the **Government's plan for the delivery of the targets**, including the levels of ambition considered and chosen for both the targets themselves, and the proposed policy pathways for target delivery.

- This information came from the detailed evidence reports and impact assessments supporting the environmental targets consultation, as well as from the Environmental Improvement Plan.

We reviewed all of this information and evaluated the level of **ambition and achievability** of the targets. We documented where the delivery pathways were well supported by existing evidence, what the key uncertainties were, and where there were weaknesses or risks of failing to meet the targets. Information to support this evaluation came from various sources:

- We searched for evidence outlining international best practice on ambition of targets and action taken to achieve them in the grey and published literature.
- We analysed the written evidence received from experts to the OEP's call for evidence on nature recovery (details below).

OEP's call for evidence

In May 2023, the Office for Environmental Protection (OEP) launched a call for evidence to establish whether government's plans and delivery methods will achieve the species abundance targets, and whether they detail and address the major barriers, enablers, synergies, and trade-offs within and across policy areas.

The key questions asked were:

1. Considering the government's species abundance targets, to what degree do you consider these achievable in England's terrestrial, freshwater, and marine environments? What assumptions affect your consideration of feasibility?
2. Considering the 8 areas of action set out in EIP23 and other actions, what are the main interventions, or types of interventions, required to achieve the species abundance targets in England's terrestrial, freshwater and marine environments.

[6] Bane M.S., Cooke R., Boyd R.J., Brown A. Burns F., Henly L., Vanderpump J., Isaac N.J.B (2022) An evidence-base for developing ambitious yet realistic national biodiversity targets. Conservation Science and Practice 5:e12862.

Regarding these interventions, what scale and pace of deployment is required to achieve success?

3. What are the enablers and barriers to improving species abundance in the terrestrial, freshwater, and marine environment, and achieving the species abundance targets?
4. What are the synergies and trade-offs in improving species abundance in the terrestrial, freshwater, and marine environments, and achieving the species abundance targets?
5. What are the key uncertainties and knowledge gaps in assessing the achievability of the targets?

After receiving the call for evidence responses, a rapid read-through of these were considered alongside the questions, and key analytical themes were developed. First, responses were categorised by the stakeholder organisation and sector they represented. For example, it was noted whether they were from a non-governmental organisation (NGO), a government organisation/ arms-length body, research institute, park authority, professional institute, or representative body. If it was clear from the response to each question which areas of the natural environment (e.g., terrestrial, freshwater, marine, specific taxa) that the stakeholder had considered in their response, this was also noted. For each question, specific sub-questions were also developed to help draw out the key information. Where these sub-questions had been answered, responses were categorised based on these answers. In some cases, the respondents did not explicitly answer the questions set out, so the sub-questions and categorisations were key to helping pull out the key themes from the responses. The main sub-questions and categorisations considered for each of the questions are outlined below and are presented in detail in Annex C:

Question 1

- If it was made clear by the respondent which area of the environment they were referring to (e.g., terrestrial, freshwater or marine), responses were categorised as such.
- Are the targets considered achievable? – e.g., were they described as ‘achievable’, ‘not achievable’, ‘difficult to achieve’, ‘partially achievable’, ‘unsure’.
- What assumptions did the respondent make to come to that conclusion? – some examples of categorisations here included ‘adequate funding and resources’, ‘sufficient political will’, ‘ecological lags’, ‘current trajectory/ business as usual’ ‘appropriate enforcement’, and ‘climate change impacts’ among others.

Question 2

- If it was made clear by the respondent which area of the environment they were referring to (e.g., terrestrial, freshwater or marine), responses were categorised as such.
- Where it was done so by the respondent, the answers were categorised by the eight areas of action in the EIP23. Were respondents did not split the answers into the eight areas of action, the interventions were listed as separate categories (e.g., 'monitoring', 'enforcement', 'tackling invasive species', 'agri-environment schemes/ELM', 'tackle climate change', 'Local Nature Recovery Strategies', 'reduce intensive agriculture' among others.
- Were any intervention areas listed that were not included in the EIP23?
- What scale and pace did the respondents mention would be necessary for success?
    - Examples of categorisation for **scale** included: 'Joined-up/ cross-departmental', 'holistic', 'landscape-scale', 'local-scale', 'step-change'.
    - Examples of categorisations for **pace** included: 'urgent', 'multiple interim targets', 'long term measures'.
- Where is the bottleneck in scale and pace? Who is setting it?

Question 3

- If it was made clear by the respondent which area of the environment they were referring to (e.g., terrestrial, freshwater or marine), responses were categorised as such.
- The main enablers and barriers were listed and categorised. Examples included 'addressing underlying pressures', 'monitoring', 'planning', 'engagement', 'lags', 'regulation and enforcement', 'skilled people', 'research' among others.
- Where possible, enablers and barriers were categorised further into broad themes (e.g., 'governance', 'resources', 'engagement', 'research').
- After the responses had been reviewed, we considered the following questions:
    - How do the enablers and barriers compare to what is identified in the EIP23?
    - Are there any gaps?

Question 4

- Responses were categorised into synergies and trade-offs.
- Within the **synergies** category some examples of sub-categories included: 'cross-environmental benefits', 'healthy economy', 'healthy ecosystem', 'help to meet other targets', 'productivity of farmland' among others.

- Within the **trade-offs** category some examples of sub-categories included: ‘competing land users’, ‘converting habitat types’, ‘prioritising species’, ‘resource security’, ‘tree planting’ among others.

Question 5

- Examples of categories included ‘climate change impacts’, ‘monitoring data’, ‘relative importance of drivers’, ‘scale required’, ‘which species will benefit?’, ‘governance’, ‘enough funding’, among others.

A summary of the key analysis points is presented in section 3 of this report, and a detailed outline of categorisations and analysis is presented in Annex C.

Inclusion/exclusion criteria for evidence

Whilst this element of the review considered the modelling work used to underpin the development of the species abundance and extinction risk targets, it specifically focussed on the process, planning, consistency and transparency of the modelling rather than reviewing the specific modelling approaches per se. The assessment was therefore not concerned with modelling methods and the appropriateness of the technique, but rather focused on the critical elements required to understand the usefulness and inference that can be drawn from the models. We therefore focussed the review of the modelling work around evidence of:

- Representativeness
- Assumptions
- Sensitivities
- Caveats to interpretation
- Stationarity of extrapolation
- Consideration of ensemble modelling
- Definition of baseline

These aspects of modelling are critical to any approach that is linked directly to policy and they set out the key considerations when using models. Using these overarching themes for the review also allowed for consideration and exposition of any gaps that exist in the information available within the public domain.

3. Assessment

The following sections review (A) the monitoring and indicators used by Defra to track progress towards the legally binding biodiversity targets and (B) the evidence used to develop the targets. In each case, we first outline Defra's approach before using the broad questions and conceptual models outlined in the methodology sections above to guide the reviews. Below is a summary of the key findings from each of these sections (A & B).

3.1 Summary of key findings

A: Review of monitoring and indicators - summary

The species abundance indicator has gone through a number of iterations, through which Defra considered a number of different monitoring schemes for inclusion. The final version of the indicator includes 1195 species in total, which represents a significant increase in both number and taxonomic breadth of species from the 670 species originally included in Version 1. However, large taxonomic gaps remain and in the case of some habitats and realms, such as species from the marine environment, representation is almost non-existent.

Any dataset contributing to the species abundance indicator should aim to conform to a range of ideal standards, especially given that the indicator will be used to track progress towards legally binding targets. Some of the criteria such as: comprehensive geographical spread of sampling locations; consistency in sampling methodology over time; species level taxonomic resolution; and the collection of data at regular time intervals that support annual reporting - were considered essential by stakeholders that attended the workshops coordinated as part of this work. These criteria are mirrored in Defra's criteria for data inclusion in the species abundance indicator, and many of the datasets that make up the indicator have already been independently reviewed against these criteria. While the underlying methodology for data collection and analysis varies considerably between monitoring programmes, most of the monitoring programmes that have been assessed either meet these criteria or their shortfalls are corrected for statistically prior to their use in the indicator. Aside from the taxonomic gaps in the indicator, one key weakness identified throughout the review was the limited financial security of the independent monitoring schemes that contribute data towards the species abundance indicator. In most cases, Defra do not directly fund the monitoring schemes, and while many will have funding agreements in place, these are likely reviewed after relatively short time frames. Linked to this, as the monitoring schemes are designed from the ground up, there is potential to introduce bias into the datasets if the aim of the monitoring programme does not match up with the aims of the indicator.

The species abundance indicator is calculated from raw species indices using the Freeman method (developed by UKCEH), which generates an estimate of the geometric mean abundance and incorporates in-situ smoothing. It is not currently known whether there will be any changes to the methodology (e.g., the smoothing parameters) when the final indicator is calculated. A number of potential issues and challenges are associated with summarising biodiversity data as indicators, many of which apply to the England species abundance indicator. For example, heterogenous input data, representativeness and bias issues, inter-annual fluctuations, missing values, shifting baselines, and frequency and speed of the workflow to generate indices. Many of these issues have been considered by Defra during the indicator development process, and some are at least partially addressed by the indicator methodology. However, some issues persist and there is little information on how they will be addressed, which leads to potential weaknesses in the indicator. In particular, the index is likely to be associated with significant uncertainty, arising from both true (process-based) and artefactual (observation-based) variability in the underlying trends of individual species, as well as differences in their trajectories. It is therefore unclear as to whether such an index is a fine enough tool to detect meaningful changes between specific pairs of years (e.g. measuring the change in species abundance between 2029 and 2030, as would be required to understand whether the 2030 target has been met) and yet not be too sensitive to natural inter-annual variation.

Any further development of the species abundance indicator, following the environmental targets consultation in 2022, has not been documented in the public domain, and therefore could not be reviewed.

Nevertheless, a key message emerging from the stakeholder workshops was that the species abundance indicator cannot be used in isolation to guide effective policy actions to address biodiversity loss. Instead, it should be used as a broad indicator of the state of the environment, and further information would be needed on the pressures and drivers of biodiversity loss and how these link to species abundance to allow effective policy decisions to be made to meet the legally binding targets.

Overall, despite limited time and information during development, the species abundance indicator exhibits potential as a robust measure of environmental health under the "Thriving plants and wildlife" goal and is based on robust monitoring data. However, a number of opportunities have emerged after considering the strengths, weaknesses, and knowledge gaps surrounding the species abundance indicator. These include an opportunity for additional monitoring or focussed assessments on underrepresented taxa that may not be able to be used in the indicator itself but could provide important contextual information to aid decision making. Long-term agreements with data providers could also be considered that provide commitment, stability and an ability to plan effectively, as well as the recommendations to increase interpretation and transparency by presenting all key technical documentation alongside the indicator and acknowledging the limitations and representation bias that remain in the indicator. It is clear that the species abundance indicator should not be used in isolation (indicators of significant drivers and pressures affecting biodiversity will also be important to consider), and there is great value in disaggregating trends by domain or taxonomic groups where possible.

B: Review of evidence used to develop targets - summary

Defra outlined the criteria and principles that they applied in developing targets in the Environmental Targets consultation evidence report for the biodiversity and freshwater targets. They used a series of scenario models and feasibility assessments to guide the appropriate target level and understand the type and scale of interventions that might be required to meet the targets. The policy scenarios outlined the broad types of interventions that would be considered, and gave an indication of how they related to each other in terms of the scale of resources required for their implementation. However, they provided little detail to directly inform the accuracy and application of the scenario models (including details such as the scale and pace of implementation over the target time period). The scenario models therefore included a large set of simplifying assumptions, which were necessary due to substantial evidence gaps and conceptual barriers, but this limited the predictions that could be made about how species abundance might change under different policy options. For example, as well as some policy-specific assumptions such as the relative rates of habitat creation across habitat types, like-for-like comparison between new and past agri-environmental options, and assumptions regarding the level of uptake of such options; much of the modelling was undertaken using Version 1 of the indicator (containing only 670 of the 1195 species in the final version of the indicator), and the feasibility assessment extrapolated recent rates of decline in species abundance to 2022, with no consideration of the potential error around this assumption. Furthermore, forward-looking projections about the impacts of pressures affecting species abundance, such as climate change and invasive non-native species were limited to the assumption that background decline would remain similar to that experienced currently. Limited considerations was given to the appropriateness of the target timescale in relation to ecological and political lags.

Despite the limitations of the scenario modelling and feasibility assessments, the targets set by Government relating to species abundance appear to be suitably ambitious. Many stakeholders believe that a significant increase in the scale and pace of actions will be required to meet the target and that the target will be challenging to meet. It is generally agreed that the targets are achievable given an appropriate scale and pace of action. The Environmental Improvement Plan 2023 (EIP23) outlines a large number of actions that will feed in to delivering multiple goals, including a goal for Thriving Plants and Wildlife, which has been set as the apex goal.

However, due to the relative infancy of some of the actions being introduced, and the limited information on the planned timelines and prioritization of interventions, there is a lack of publicly available evidence to support an accurate assessment of whether the targets will in fact be achieved within the set timeframe. Defra's delivery plan lacks key details that lay out exactly how the actions listed in the EIP will help to achieve the target and how species will respond to them, and also is not clear in outlining who is responsible for delivering the various actions contained within the plan. Key enablers to achieving the species abundance targets will be long-term funding agreements to support long-term progress, tackling the underlying pressures of biodiversity decline, productive engagement with stakeholders and the public, and effective enforcement of regulations.

In assessing the evidence used to develop the legally binding targets for species abundance, and considering the knowledge gaps that exist, it is clear that the best available quantitative data at the time was used, resulting in challenging yet potentially achievable goals. Nevertheless, a number of opportunities have emerged. With a large set of, albeit necessary, assumptions made in the scenario modelling and explicitly recognised, it is important to reflect on the sensitivity of the modelling to these assumptions. That is, to consider how pertinent is it that any such assumptions are met for the modelling results to hold. Additionally, now that the species list for the target indicator has been finalised, it would be beneficial to revisit the scenario modelling work to understand the impact including the additional species will have on the outcome of the models. Related to this is a recommendation to revisit the scenario modelling on a regular basis as more data become available and policies have had some time to be implemented. Government is required to produce an Environmental Improvement Plan every 5 years, so revisiting the modelled projections before the future EIPs are produced will allow for an assessment of whether Government is on-track to achieve the targets, or whether an adapted approach to interventions is required.

3.2 A: Review of monitoring and indicators

Defra's approach

Available monitoring schemes

The UK has some of the longest-running and most extensive national biodiversity monitoring schemes in the world. Defra have considered a number of different monitoring schemes for inclusion in the species abundance indicator. Prior to the development of the legally binding targets for species abundance, the species abundance indicator included data only from national-scale monitoring schemes of birds, mammals, butterflies and moths. These data have all previously been used in other national- and UK-level biodiversity indicators. During the development of the targets a number of other datasets were identified and have since been considered for inclusion in the indicator. These include the National Plant Monitoring Scheme, Environment Agency BioSYS Macroinvertebrates, EA National Fish Populations Database, Bumblebee Conservation Trust 'Beewalks' data, National Water Vole Survey, National dormouse monitoring scheme (all of which have since been included in the indicator), as well as EA BioSYS Macrophytes, EA Diatoms, National Amphibian and Reptile Recording Scheme, Countryside Survey, Pollinator Monitoring Scheme, and Environment Change Network. Most of the monitoring schemes considered were from either terrestrial or freshwater environments. No specific marine datasets were mentioned as having been considered. The environmental targets consultation evidence pack highlighted that there is likely to be data available for marine species in England's waters, but based on previous experience in the development phase of the Scottish combined marine and terrestrial biodiversity indicator[7], these data would need substantial further development before inclusion in the England indicator. Overall, there is little information documented on how the search for potential monitoring schemes was conducted.

Defra's inclusion criteria for monitoring schemes

In the Environmental Targets consultation evidence report for the biodiversity and freshwater targets[8], Defra outlined desirable qualities for data feeding into the abundance indicator. The three criteria for including data in the index were:

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

The evidence report also acknowledged some further desirable properties or 'ideals' that would be advantageous, but highlighted that some key technical challenges can limit these standards being met.

Chosen monitoring schemes

The species' abundance indicator has been through a number of versions, each one adding new datasets that have been identified as appropriate for inclusion in the index. Version 1 of the index comprised 670 species obtained from 9 datasets. All of these datasets form the basis of national indicators of birds, insects and mammals, and the Priority Species indicator, C4a), which are published annually as part of the UK Biodiversity Indicators. They also contribute to multiple indicators within the suite of England Biodiversity Indicators.

Version 2 of the indicator was presented in 2022[9] within the evidence report published alongside Defra's Environmental Targets Consultation. It contained a total of 1071 species. 164 species of vascular plants and 237 species of freshwater macro-invertebrates were added to this version of the indicator. The plant data came from the

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[7] Scottish Government (2021) Development of a combined marine and terrestrial biodiversity indicator: research. http://www.gov.scot/publications/development-combined-marine-terrestrial-biodiversity-indicator-scotland/pages/8/ (accessed September 29, 2023)

[8] Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report. <https://consult.defra.gov.uk/natural-environment-policy/consultation-on-environmental-targets/supporting_documents/Biodiversity%20terrestrial%20and%20freshwater%20targets%20%20Detailed%20evidence%20report.pdf> [accessed 19 July 2023].

[9] Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report.

National Plant Monitoring Scheme, a dataset that has also been used for indicators within both the UK (Plants of the wider countryside, C7) and England biodiversity indicators. The freshwater macro-invertebrate data came from the Environment Agency (EA) BioSYS freshwater invertebrate monitoring program and has not previously been used in any of the UK or England biodiversity indicators. Other datasets that could be considered for future versions of the indicator were also listed in the evidence report. The final version of the species abundance indicator has not been officially published, but the statutory instrument underpinning biodiversity targets lists the species to be included in an indicator for the targets relating to the abundance of species. The list contains 1195 species. All datasets included in Versions 1 & 2 of the indicator remain (with some minor changes to the number of species included for each dataset (described in more detail below).

Some new datasets and species groups have also been added. Two mammals have been added to the list (water vole and dormouse), and these data are likely to come from the national water vole survey and national dormouse monitoring scheme. Each of these datasets have previously been used to contribute to the UK-level Priority Species indicator, C4a. Bumblebees (11 species) and Fish (38 species) are also new to this list of species. It is not stated which datasets these data have come from, but they are likely to come from the Bumblebee Conservation Trust's Beewalk dataset, and the EA National Fish Populations Database (Freshwater Fish and TraC: Transitional and coastal waters), each of which were mentioned in the Environmental Targets Consultation Evidence Report.

Taxonomic breakdown

Table 1 Taxonomic breakdown and datasets used in the first, second and final version of the England Species Abundance Indicator.

Indicator V3 (FINAL)	Group	Survey	V1	V2	FINAL	From
All species – D4a	Birds	England breeding bird indicators	107	107	107	1970
		England wintering waterbird indicator	21	21	20	1975
		Rare breeding bird panel	21	21	21	1970
		Seabird monitoring programme	11	11	11	1986
		SCARABBS	7	7	7	1971
		Breeding Bird Survey	2	2	2	1994
		TOTAL	**169**	**169**	**168**	**1970**
	Butterflies	UK Butterfly Monitoring Scheme	55	55	55	1976
		TOTAL	**55**	**55**	**55**	**1976**
	Mammals	National Bat Monitoring Programme	10	10	10	1998
		Breeding Bird Survey	5	5	5	1995
		National Water Vole Survey	-	-	1	1989

		National dormouse monitoring scheme (Peoples Trust for Endangered Species)	-	-	1	1993
		TOTAL	**15**	**15**	**17**	**1995**
	Moths	Rothamsted Insect Survey	421	421	421	1970
		Priority moths – Butterfly Conservation	10	10	10	1991
		TOTAL	**431**	**431**	**452**	**1970**
	Vascular plants	National Plant Monitoring Scheme	-	164	164	2015
		TOTAL	**-**	**164**	**219**	**2015**
	Freshwater Invertebrates	Environment Agency bioSYS	-	237	235	2013
		TOTAL	**-**	**237**	**235**	**2013**
	Bumblebees	Bumblebee Conservation Trust "BeeWalks"	-	-	11	?
		TOTAL	-	-	11	**?**
	Fish	The National Fish Populations Database (NFPD): Environment Agency Freshwater and TraC (Transitional and Coastal Waters) fish surveys	-	-	38	?
		TOTAL	-	-	38	**?**
	TOTAL		**670**	**1071**	**1195**	

Defra's criteria for species selection

Not all species recorded by each monitoring scheme are included in the indicator. The specific species selection criteria are likely to vary between monitoring programmes as a result of the varying methodologies used to collect the data, but each species is chosen on the basis that they have enough data to produce a reliable annual measure of abundance. Other specific species inclusion criteria were outlined in the consultation evidence pack for the additional two datasets added to Version 2 of the indicator. For example, for the Environment Agency Freshwater Macroinvertebrate data, the following species selection criteria were documented: (1) only species, species group and genus level records were retained, (2) very rare taxa (< 100 records) in the 2013-2019 dataset were excluded, (3) an inability to detect a change of 25% over the 2013–2019 period was used to exclude those taxa where estimates were insufficiently precise, as population changes of 25% and 50% are frequently used to indicate conservation priorities. In conversation with Queen Mary University, who were involved in the data preparation and analysis, it was noted that invasive species were also excluded. It is not currently documented in the public domain how the final species lists from the most recently added datasets were chosen.

Chosen species

Between Version 2 of the indicator and the published final list of species in the Statutory Instrument, there seem to have been some additions of species and also some removals. Overall, there is 1 fewer bird, 21 more moths, 55 more plants, 2 fewer freshwater invertebrates. It is possible to infer where and why some of these changes have occurred by comparing the species lists for Version 2 to those listed in the Statutory Instrument. It appears as though the two subspecies of *Branta bernicla* (the Brent goose) that were included in Version 2 of the indicator, have been merged into one species. Two species of moth appear to have been removed from the list (*Coleophora tricolor* and *Idaea dilutaria*), whilst 23 new species have been added. Two freshwater macroinvertebrate species have been removed (*Gammarus tigrinus* and *Musculium* sp.) – conversations with the data provider confirmed that the reason for their removal is that these species are either invasive (*Gammarus tigrinus*) or potentially include records of invasive individuals (*Musculium* sp.). Finally, in comparing the species lists, 28 of the 164 plant species that were included in Version 2 of the index appear to be excluded from those listed in the Statutory Instrument, and 83 new species have also been added (resulting in a difference of 55 species overall). The reasoning behind these changes in plant species is currently unclear. In the consultation evidence pack it was highlighted that only species from three out of the possible eleven broad habitat types surveyed by the NPMS were included in Version 2 of the Index, and all of the models to estimate annual indices of abundance of plants in specific habitats have been fitted at a UK-level, with the hope that in the future they would be refitted at an England-level. It is likely that the species list has been reviewed considering these caveats of the Version 2 data, however details of the changes are currently not documented in the public domain.

Calculating individual raw species indices

The species abundance indicator is based on data on the abundance of organisms that are referenced in space and time. These data are used to calculate raw species indices (indices for each species:year combination), which are then combined to produce an aggregated indicator that is used to make assessments of change in species abundance over time.

Data contributing to the species abundance indicator come from a variety of sources as the aim is to summarise trends in abundance for the broadest possible set of organisms. Due to the variety of species being monitored, each dataset contributing to a species abundance indicator has differences in the survey design, field methodology, and statistical methodology used to calculate raw species indices. A summary table outlining the statistical methods used to calculate the raw species indices for each of the monitoring programmes in Version 2 of the index is presented in Annex B. The methods used to calculate the raw species indices for the most recently added datasets are not publicly available.

Indicator methods

The method for creating the index was developed by UKCEH and is known as the "Freeman method"[10]. The resulting index is an estimate of the geometric mean abundance, set to a value of 100 in the start year (the baseline). Changes subsequent to this reflect the average change in species abundance; if on average species' trends doubled, the indicator would rise to 200, if they halved it would fall to a value of 50. A smoothing process is used to reduce the impact of between-year fluctuations - such as those caused by variation in weather - making underlying trends easier to detect. The smoothing parameter (number of knots) was set to the total number of years divided by three. The reasoning for this decision around the number of knots is not clear and it is not currently known whether these smoothing parameters will carry over to the final version of the indicator or if an alternative choice will be made. Credible intervals for the indicator are calculated based on the posterior distribution for each of the parameters within the fitted model.

Presentation of the indicator

The statutory instrument outlining the legally binding environmental targets states that the species abundance indicator is to be an annual measure. One would therefore assume that this would be accompanied by annual publication and reporting of the index value. At the very minimum Defra are legally required to report the value of the indicator at three data points (31st December 2022, 31st December 2030, 31st December 2042), however the reporting date for the latter two points have been set over one year after the time points (15th April 2032, and 15th April 2044). There is currently no published date for the expected publication of the 2022 indicator value or the first publication of the finalised indicator. There is also no information on how the indicator will be presented (e.g., whether only the headline indicator will be published or whether disaggregated trends will be reported alongside the headline trend).

Extinction risk indicator

The species abundance indicator will be presented alongside a species extinction risk indicator, which also has an associated legally binding target which seeks to protect the most vulnerable species. The indicator tracks changes in the extinction risk of terrestrial, freshwater and marine species using established international (IUCN) categories and criteria: (from lowest to highest extinction risk): Least Concern; Near Threatened; Vulnerable; Endangered; Critically Endangered; and, Regionally Extinct, and can vary between zero (all species Regionally Extinct) and 1 (all species Least Concern). 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.

[10] Freeman SN, Isaac NJB, Besbeas P, Dennis EB, Morgan BJT (2021) A Generic Method for Estimating and Smoothing Multispecies Biodiversity Indicators Using Intermittent Data. JABES 26:71–89.

Computation of the Red List Index (RLI) followed Bubb *et al.* (2009).[11] 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.

Available data and inclusion criteria

According to the consultation evidence report, GB baseline assessment data are 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. 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. In the absence of published England-level Red Lists for a broad range of taxonomic groups, all taxa known not to occur in England (but in other parts of Britain) were removed, which assumes that threat levels at England and GB scales are the same or similar. This assumption was tested by comparing England-level and GB-level Red Lists for plants and mammals. For plants 79% of threat categories were the same and for animals, 91% were the same. However, some species have highly contrasting threat categories – e.g., pine marten is Least Concern at GB-level but Critically Endangered at England level. Defra highlighted in their consultation evidence document that, in future, producing Red List assessments at both GB and England scales would provide more accurate and comprehensive information. As is standard practice when creating a Red List Index for the first time to form a baseline, any already extinct taxa were removed.

Data review - comparing against best practice

Ideal standard for data contributing to an abundance indicator

Despite broad underlying differences between data sources, there are a range of ideal standards that any dataset contributing to a species abundance indicator should conform to, given the intended use of the indicator as a mechanism to monitor progress towards a legally-binding target. Many of these ideals have been described in the peer reviewed and grey literature. Through the stakeholder workshop consultation, we also asked key stakeholders for their views on what constitutes an ideal standard for data contributing to an abundance indicator during workshops on biodiversity monitoring.

[11] Bubb P (2009) IUCN Red List index : guidance for national and regional use. Version 1.1. https://www.iucn.org/resources/publication/iucn-red-list-index-guidance-national-and-regional-use-version-11 (accessed December 8, 2023)

While it is easy to describe what an 'ideal' monitoring programme, dataset, or index should look like, in reality (as noted by Defra[12]) it is unlikely that all of these ideals will be met due to challenges faced by data providers. During the stakeholder workshops, we therefore also asked participants to outline which of the *ideals* they would consider to be *essential*, and to describe the key challenges that data providers face in meeting these requirements.

A summary of the information gathered from a literature review and from the stakeholder workshops on these topics are presented below. A full summary of the information gathered in the stakeholder workshops is presented in Annex A. We outline the *ideal* principles for datasets and monitoring schemes that contribute to an abundance indicator. For each, we describe the rationale behind this ideal and the common challenges (now and in the future) associated with meeting the requirement, summarize the evidence of whether these standards are met for each of the datasets from existing information and independent assessments, and outline where the main knowledge gaps lie.

Ideally, each individual dataset/monitoring scheme should:

- **Have comprehensive geographical spread.**

Rationale and common challenges

If sampling is focused only on those sites known to be occupied, decline is much more likely to be observed. In many cases, a complete survey of all locations is impossible for logistical reasons, so a subsample of sites will be surveyed. Biodiversity, and trends in biodiversity, can show great variation between locations (reflecting differing habitats, land uses, climates, etc.). Monitoring programmes should therefore be designed to take account of this spatial variation. Ideally, data should be a random sample that is representative of the landscape, different habitats and spatial gradients. There should be coverage across the area of interest and whole species distribution. This was considered essential by the stakeholders in attendance at the workshops.

Preferentially, a stratified, random sampling design should be used to do this because it minimizes bias in the data (Norris *et al.* 2016)[13]. However, some indicators rely on sites selected by volunteers, which can increase observation bias in the data as this may mean the surveys can be focussed on areas that are easily accessible or those where the population in question is likely to be relatively abundant. Choosing the best sites to monitor, can result in deterioration over time (an example of regression to the mean). Without resources to target additional survey effort, this geographical bias should be addressed in the trend analysis.

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[12] Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report.

[13] UK & England Biodiversity Indicators Quality Assurance Science Panelhttps://randd.defra.gov.uk/ProjectDetails?ProjectID=19504&FromSearch=Y&Publisher=1&SearchText=BE0102&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description> [accessed 31 July 2023].

A further challenge to achieving comprehensive geographical spread of survey locations that was identified in the stakeholder workshops is a limited capacity in the market for surveyors, volunteers and other individuals to complete surveys. One individual highlighted that it is becoming more difficult to recruit individuals (even professional surveyors) to survey biodiversity. Continuation of future funding to support surveyor recruitment and comprehensive geographical spread of locations will be necessary to ensure successful and informative monitoring into the future.

How do the data compare?
For many of the datasets that make up the species abundance indicator, the potential biases introduced by sample site selection have been well documented. The various monitoring schemes differ in the way sites are selected, so the spatial biases vary within and between taxonomic groups. For example, the BBS is a stratified random sample of 1km^2 grid cells and is thought to account for spatial biases well. Other schemes rely heavily on subjectively chosen sites (e.g., RIS) or volunteer-collected data (e.g., UKBMS), so spatial coverage can be biased and often reflects the distribution of volunteers who contribute data. Isaac *et al.* (2016)[14] assessed the degree of spatial bias across a number of the datasets used in the species abundance indicator (including BBS, RIS, UKBMS). They assessed whether the data were biased based on landcover type and whether they were evenly (randomly) distributed in space (or whether they showed signs of clustering). Overall, Isaac *et al.* (2016) found that there is generally high spatial bias in the datasets assessed, but this bias was not the same level for all surveys: datasets with non-random sampling (i.e., those that are self-selected by volunteers (RIS, UKBMS, NBMP) had the most bias, whereas those with randomly selected sites (BBS) had the lowest bias. For example, for the UKBMS, there are fewer sites in the uplands of England and lowland seminatural habitats are over-represented (Isaac *et al.* 2016). Norris *et al.* (2016) mirrored the general findings of varying degrees of spatial bias across monitoring schemes. Despite these biases, the analytical method to turn raw species counts into indices of abundance can help to account for some of the observed bias. The indices for each species are generally calculated from a statistical model which incorporates Site effects. Therefore, the Year effects will be estimated robustly even when there is a shift in the spatial distribution of sites sampled. However, if the sampling pattern becomes particularly unusual in one year then the ability of the models to account for spatial bias will decrease. This highlights the need for continued support to allow monitoring programmes to maintain good geographic coverage in each year.

It is difficult to quantify the spatial biases of some of the datasets as it is difficult to determine what the null distribution of sampling locations would look like. For example, for terrestrial species it is reasonable to assume that the null distribution of sampling

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14 http://sciencesearch.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=19528&FromSearch=Y&Publisher=1&SearchText=BE0112&SortString=ProjectCode&SortOrder=Asc&Paging=10> [accessed 1 August 2023].

sites would be a random distribution of points on land within England. On the other hand, for monitoring schemes that target species which themselves have a spatially biased distribution (e.g., species that are restricted to particular habitats such as freshwater or marine habitats) it is more difficult to generate a null distribution to which to compare the actual sample sites, because sufficiently accurate maps of these habitats are more difficult to come by. In these cases, it is necessary to rely on expert opinion and qualitative assessments of geographical representation.

For the monitoring schemes that were not assessed in the previous reviews (NPMS, BIOSYS, BeeWalks, TRaC Fish and Freshwater Fish), details of the survey design are available and can be used to infer the potential for spatial bias:

The BIOSYS dataset is collected by the Environment Agency (EA) and is derived from routine monitoring of benthic invertebrates at river and stream sites throughout England and has recently been described as spatially balanced and representative of rivers and streams in England (Jarvis *et al.* 2023)[15]. The fish data is also collected by the EA, and has coverage across England, but it is currently unclear which surveys are included in the indicator, so this limits the ability to make inferences about spatial representativeness for these data. In the stakeholder workshop it was highlighted that the remit of these surveys does not necessarily match that of the indicator requirements. This has the potential to introduce bias into the dataset. The aim of the Environment Agency's surveys (for both FW macroinvertebrates and fish) is to fulfil the requirements for classifying the environmental status of water bodies as set out in the Water Environment Regulations (previously the Water Framework Directive), rather than for solely monitoring the state of biodiversity. In practice, this could lead to uneven sampling effort across space if they were to target resources into sampling in areas where there are environmental problems. There may be less impetus to consistently sample locations that have no environmental problems, meaning there could be a conflict between their remit as a data provider for this indicator or their core business in improving environmental quality of rivers and lakes.

The NPMS consists of repeat samples taken on a weighted-random selection of 1 km grid cells, and so, like BBS, is likely to be less spatially biased than data from surveys where sample sites are self-selected by volunteers. However, only abundance estimates from a subset of the eleven broad habitat types surveyed are included in the abundance indicator, but it is currently unclear how this impacts spatial bias. The NPMS is also a UK scheme, and the data currently feeds into indicator C7 of the UK' Outcome Indicator Framework, so existing statistical models for each species have been fitted for the whole of the UK. There are plans to rerun the models for England-only data, but this work is yet to be completed.

[15] Jarvis SG, Mackay EB, Risser HA, Feuchtmayr H, Fry M, Isaac NJB, Thackeray SJ, Henrys PA (2023) Integrating freshwater biodiversity data sources: Key challenges and opportunities. Freshwater Biology

The Beewalks sampling design is spatially replicated and has coverage across England, but the survey design is similar to that of UKBMS - the location of the transects are chosen by the volunteers, which creates spatial biases. For example, spatial coverage is better near highly populated areas and in areas rich in bumblebees.

- **Be collected in a consistent manner over time (using a standardised protocol that measures actual species abundance).**

Rationale and common challenges

Ideally, surveys should be conducted from a reliable standardised protocol measuring actual species abundance (the number of individuals in a population: e.g., density per unit area, count per unit of effort) rather than a surrogate measure (e.g., occupancy, percentage cover, categorical scale). Methods such as counts per unit area can depend on many factors including movements, activity, resource availability, so it is important to bear in mind these dependencies and to recognise that the relationships between counts and abundance can be non-linear. The data collection method used should allow the data to be comparable over regular time increments. This requirement was noted as essential by the attendees of the stakeholder workshops. Consistent and standardised survey designs that measures actual species abundance are often more expensive and complex than for other measures of biodiversity so the species coverage is often more limited, but the inferences that can be made on the trends and status of populations are much richer. Inconsistencies in survey methodologies over time can introduce biases in the data. For example, differing survey methodologies (e.g., equipment used or variation in the time of year at which surveys are conducted) can lead to detection bias if detection rates of particular species vary across methodologies. In this case, trends in the indicator may reflect the ease with which species could be detected, rather than genuine changes in relative abundance.

Detection bias in current data could become a more evident problem in the future. For example, future technological advances may mean that a new method of collecting data is proved to be more accurate and reliable than the methods that have been used until now. In this scenario, a decision would have to be made on whether to continue monitoring using the less accurate method that has a long time-series associated with it, or to switch to the more accurate method, but shift the baseline year forwards. Another option could be to run the two methods in tandem with the aim of calibrating their relationship before switching to the more accurate method. This option, however, might require a significant increase in resources to support both methods running in parallel for a number of years before the switch is made.

Further complications can arise if climate change causes the timing of the emergence of species to shift significantly, while the survey period remains constant. For example, in the UKBMS, surveys are conducted annually over a set time frame, which corresponds with the known flight periods of butterflies. It is well documented that the flight period of butterflies is influenced by climate, so in the face of climate change, detection bias caused by changes in phenology may become more of an issue in the future.

As described above, changes in the spatial distribution of sites over time also have the potential to alter our interpretation of species trends within indicators. This is particularly an issue for volunteer-collected data, where turnover of volunteers can result in uneven spatial coverage over time. To address this, the statistical method used to analyse the data should ideally account for potential sources of bias or noise and should have a measure of uncertainty from which it is possible to infer the likelihood of the observed trend being true.

How do the data compare?
Most of the datasets that make up the species abundance indicator have a consistent survey design with a standardised protocol. The NPMS is the only survey out of those included in the species abundance indicator that does not record 'counts' of species. Instead, percentage cover is used as the measure of abundance. Individual counts of many plant species (e.g., grasses or mosses) are difficult to obtain, so percentage cover is used to allow for the inclusion of such species.

Isaac *et al.* (2016) noted that the main source of bias introduced over time is through differences in survey sites over time, which is partly addressed in the section above. There is high variety in the consistency of survey locations over time among the datasets. Specifically, Isaac *et al.* (2016) quantified spatial aggregation of sample sites are aggregated in space and how this has changed with each year of the survey data. There was very little consistency over time in spatial bias across all datasets, with some datasets (RIS and UKBMS) containing substantial shifts in the spatial footprint of sites they cover. The RIS data has increased in spatial bias over time due to a decline in survey sites in recent years, and other datasets contained large peaks in spatial bias during years where fewer sites were surveyed.

Norris *et al.* (2016) also described the turnover of survey sites over time for many of the datasets. For example, for the NBMP, turnover of locations is considerable – the annual number of sites covered can be as low as only 13% of the total sites covered throughout the time series, whereas, for moths, plots tend to stay the same with little turnover. Other temporal inconsistencies noted in Norris *et al*. (2016), include changes to field methods over time. For example, for bat surveys that utilise detectors, technical improvements in the early days might resulted in an upward bias in trends in bat pass counts.

For the monitoring schemes that were not assessed in these previous reviews, it is possible to infer information about consistency through time. Maps of the annual sample sites for the BIOSYS dataset were presented in the environmental targets consultation evidence report and show a decline in the number of sampling sites over time, so it is likely that there would be an increase in spatial bias over time (as seen with the RIS data). The Environment Agency has recently undergone a major transition in its monitoring portfolio with a new River Surveillance Network launched in 2020. The fundamental design of this network is, however, significantly different to that of the existing BIOSYS data. With the information available, it is difficult to assess how consistently the fish data are collected over time.

For the NPMS data, consistency over time is difficult to assess, particularly without knowledge of whether the raw species index values will be derived from UK- or England-level models. For the Beewalks data, turnover of volunteers means that spatial coverage is likely to be uneven over time, but spatial biases have not yet been quantitatively assessed.

- **Be collected at appropriate, regular time intervals to support annual reporting.**

Rationale and common challenges
In order to have sufficient statistical power to effectively indicate change and allow for an assessment of whether targets have been met, it is essential that the data measure changes on a regular basis, to allow for comparisons over regular time intervals. As the Statutory Instrument outlining the species abundance targets describes the relative species abundance index as ‘an annual measure’, many of those in attendance at the stakeholder workshop considered regular data collection to support reporting on an annual basis to be an essential requirement.

How do the data compare?
All of the datasets that make up the species abundance indicator are able to produce annual indices of species abundance. Data collection efforts within a particular year vary depending on the taxa being recorded and their relative detection rates throughout the year. For example, RIS tends to record moth abundance throughout the entire year, aspiring to collect data from the various survey sites on a daily basis. On the other hand, UKBMS transects are walked weekly during a 26-week period between 1st April and 29th September each year, which corresponds with the main flight periods of many butterflies.

Despite being collected at appropriate and regular time intervals, one key bottleneck which may limit Defra’s ability to deliver timely annual reporting is the time taken for the data to progress through the quality check and analysis workflow. It is not always clear what causes delays in this aspect of the process, but often it can be related to funding and staff time.

- **Have species-level taxonomic resolution.**

Rationale and common challenges
As the target relates to the abundance of species, it is desirable that the data should be at species-level, rather than at a higher taxonomic level (e.g., genus, family). This is so the indicator can represent the change in abundance, averaged across species (likely using the geometric mean abundance). In practice, some data, such as those for species that are commonly misidentified or inconspicuous, may be recorded at an

aggregate level (e.g., species aggregate or genus level). In some cases, it may be desirable to include such data to boost the taxonomic coverage of the indicator, but it is important that the species involved are consistently recorded as such over time.

How do the data compare?

The majority of the taxa on the list set out in the statutory instrument underpinning the species abundance target are at species level (~95%). ~5% (n=65) are at genus level (e.g., *Amphinemura spp.*, spring stoneflies) – the majority of those listed at genus level are freshwater invertebrates (n=61), but there are also some plants not at species-level resolution (n=4).

As described in the targets evidence report for the freshwater invertebrate species 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. To address this, Defra considered a number of options, including 1) downgrade all records to family level, 2) retain only species-level records, 3) allocate coarse-resolution records to species in proportion to the occurrence of species in same sample, and 4) selectively exclude and downgrade 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. The latter option was considered the most appropriate due to the possibility of biases being introduced by options 1–3. The possibility of bias has not been removed completely as a result of this choice. For example, there is potential for underrepresentation of a species or genus through the removal of genus or family level records from groups where the bulk of the records were resolved to species level). Nevertheless, this method seems to be the most appropriate for retaining the greatest possible amount of data, whilst also keeping the majority of records at species level resolution.

As well as containing some genus-level taxa, there are also incidences where more than one species are listed together for the purpose of the indicator (e.g., *Bombus lucorum / terrestris*, White-tailed / buff-tailed bumblebee). In these cases, the two species listed are generally those that are often morphologically indistinguishable, so combining them allows for their inclusion in the indicator, whilst reducing potential biases and/or noise introduced by misidentification.

- **Cover different types of species within a taxonomic group.**

Rationale and common challenges

Ideally, a dataset should be based on a subset of species that adequately represents the wider community of which it is part so that status and trends in the indicator reflect status and trends in the wider community. This was considered an essential requirement in the stakeholder workshops. In practice, the inclusion of species in an indicator is often subjective or simply reflects the availability of data. As a result, status and trends are likely to be biased to some extent.

Ideally, both rare and common, migrants and residents, priority and non-priority species should be included in the indicator. There was also some discussion during the stakeholder workshops on whether both native and non-native species should be included in the indicator. Some felt that the role of the species abundance indicator is to record everything, no matter its provenance, as this reduces the subjectivity of what should be considered native given likely future range expansions due to climate change, although others felt that including ‘invasive’ non-natives in the indicator would be counterintuitive and could limit the benefits that were to be gained through achieving the species abundance targets. There was a consensus that any decision on whether to include non-native/invasive species in the indicator should be made with a clear understanding of the intended purpose of the species abundance indicator. The Environmental Improvement Plan states that "the recovery of species is critical to the restoration of diverse and healthy ecosystems which provide us with food, water, clean air, recreation, and regulate our climate." This statement is strongly anthropogenic, suggesting that functional diversity may be as if not more important than species diversity.

How do the data compare?
While some monitoring programmes manage to capture a large proportion of the targeted taxon (e.g., birds), none have 100% coverage, so there is likely to be some bias in the species that are monitored. The potential for species biases has been documented for many of the monitoring programmes. In some cases, the survey method can introduce biases in the data. For example, moth light-trap surveys by their nature are biased towards night-flying species attracted to light, and the proportion of the population attracted to the light traps may vary across species. Although this does not satisfy the ideal that a dataset should be representative of the wider community, this is not necessarily a problem if the bias is known and the proportion of the population recorded is consistent over time. In other cases, some species may be easier to survey than others due to their movement patterns or preferred habitat. For example, the most tractable species of seabird to survey are those that nest in the open at fixed locations on cliffs or islands (e.g., guillemot, northern gannet), whereas those that nest in burrows and cavities (e.g., petrels and shearwaters) are more difficult to survey, and therefore may be under-represented. Again, as long as this representation bias is known and remains consistent over time, a meaningful time series can still be generated. It is likely that for some taxonomic groups where a small proportion of the total species are recorded, there is some bias introduced. This could arise in various ways, for example, if only the most common species being recorded could lead to preferential recording of species that are more resilient to human activities. This can limit how representative the species are of others that have not been monitored.

- **Go through a quality assurance process.**

Rationale and common challenges
All individuals who complete surveys should ideally be effectively trained in the survey protocol and identification of species and the data should go through checks to identify possible mistakes. Reporting bias can occur if particular species are consistently misidentified by observers, or if particular abundances are consistently under-estimated or over-estimated by observers.

How do the data compare?
For most of the monitoring programmes that make up the species abundance indicator, there is some form of training (either mandatory or optional) provided to individuals who complete the surveys (Norris *et al.* 2016). For some monitoring programmes, specimens are also collected to be identified (e.g., Moths), so aside from occasional mis-identifications, the counts recorded are likely to be accurate and effectively quality assured.

- **Have financial security to continue into the future.**

Rationale and common challenges
Continuity of governance and financial support for the monitoring was considered an essential criterion by those who attended the stakeholder workshops. Without long term financial agreements in place, it was noted that data providers may struggle to consistently deliver monitoring and analysis at the appropriate standard for the species abundance indicator. Large scale monitoring initiatives require a significant amount of planning and preparation to undertake field campaigns, recruit citizen scientists, manage data, manage engagement and manage infrastructure. Long-term funding is therefore required by data providers to enable the planning for future monitoring with the financial security in place. Examples of this include establishing access agreements with land-owners, which may, in some cases, require up to 2 years' lead time.

How do the data compare?
There is little information on the financial security of the various monitoring programmes and subsequent statistical analysis in the public domain. In most cases, Defra do not directly fund the monitoring schemes used in the species abundance indicator. 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. Many are co-funded by the JNCC, but some are established national recording schemes. While many will have funding agreements in place, these are likely reviewed after relatively short time frames. As the species abundance indicator is reliant on the continuation of these schemes, there is a strong reliance on the coordinating bodies that undertake or manage the schemes and potentially a lack of control by Defra.

- **Ability to link trends in the data to drivers, pressures and policy actions.**

Rationale and common challenges

One key theme brought up during the stakeholder workshops was that a desirable quality for the data feeding into the indicator was an ability to link trends in the abundance data to drivers of change as this can help to separate artefactual changes from real changes in abundance and can help prioritise actions and solutions to reverse undesirable trends. Linking changes in abundance to drivers and pressures can help the user to understand causes of declines and evaluate potential policy options or management strategies. Therefore, ideally there would be integrated research programmes running alongside species abundance monitoring programmes, which monitor pressures, drivers and their associated responses in species abundance. However, this is challenging to achieve due to the wide array of potential drivers of biodiversity decline and limited resources available to be able to support such efforts. This was mostly considered a desirable characteristic, and its necessity will likely depend on the intended use of the indicator. For example, if the purpose of the index is only to summarise the state of a particular aspect of biodiversity at a given point in time, then it is not necessary to link trends in the indicator to drivers of change and policy actions. On the other hand, many of the attendees agreed that in order to effectively use the indicator to guide policy actions it was essential to be able to link the trends in the datasets to the drivers of change and understand the responses of species to specific policy actions. This would require parallel research and analysis alongside the current monitoring efforts. The cost of such research is likely to be the biggest barrier, but also the capacity and capability of organisations to conduct the research will be limiting.

How do the data compare?
Whilst there are many studies available which aim to link changes in the abundance of a single species or groups of species to pressures, drivers and policy actions, there has been little work to assess this at a scale that is relevant to the species abundance indicator (England-level, covering the species in the indicator). From the studies available it is possible to broadly describe what drivers and pressures may pose the most threat to the various groups of species present in the indicator, but many stakeholders present at the workshops suggested that further research was needed to be able to guide specific policy actions to meet the biodiversity targets.
Evidence presented within the stakeholder workshops highlighted that Natural England is in the second year of producing a species evidence base, which is a database of ecological associations for the statutory indicators. This work is not currently publicly available and the timescale for completion was not clear, but it will be publicly accessible in years to come.

The suite of datasets overall should:

- **Be representative of ‘biodiversity’.**

Rationale and common challenges
Ideally an indicator measuring change in species abundance would measure a randomly selected representative subset of taxa stratified across the main habitat types for which one would like information. Data should cover the broadest range of species

possible so that the indicator is representative of biodiversity in England. There should ideally be a fair representation of taxonomic groups (e.g., vertebrates, invertebrates, mammals, plants, fungi, etc), from a range of habitats (e.g., terrestrial, freshwater, marine), however in practice this spread of data is not available. This means that data used to monitor taxa (usually for purposes other than for use in biodiversity indicators) are used as a substitute. As a result, composite indicators of species abundance can be biased towards taxonomic groups that have greater cultural value and are relatively easy to identify or accessible to observe. There is generally an under-representation of groups that provide other types of benefits to humans and are more difficult to monitor robustly. Furthermore, remote or inaccessible locations, such as in the marine environment, are often missed by monitoring programmes, resulting in the under-representation of some habitats or ecosystems.

How do the data compare?

A thorough review of the representativeness of the species abundance indicator was completed for the evidence pack accompanying the environmental targets consultation. This review found that the composition of Version 2 of the indicator was over-representative of vertebrates and under-representative of invertebrates, considering the relative proportions of these groups in the total number of UK species. Nevertheless, it was noted that butterflies are often considered a good indicator of the abundance of a wider group of terrestrial insects, so could potentially compensate for some of the groups of insects that have been missed by monitoring schemes. The addition of plants and freshwater macroinvertebrates to Version 2 of the indicator filled some key gaps that were of concern to a number of members of the Biodiversity Targets Advisory Group (BTAG), particularly the representation of the freshwater environment, and non-animal species. The addition of bumblebees, small mammals, and fish species to the Statutory Instrument has gone further to fill in some key gaps (by adding the first non-avian marine species, additional freshwater representation, and covering other previously under-represented habitats such as hedgerows and ecosystem services such as pollinators).

Despite these efforts to increase representation, there remain some key gaps in the species abundance indicator, which imply that the metric may not be representative of species in England. Currently, only a very small proportion of marine species are included in the indicator, all of which are vertebrates (birds or fish, which may have biased representation based on the method of monitoring used). There is currently no representation of other important marine groups such as invertebrates and algae. For the freshwater environment, although the addition of some fishes has increased the taxonomic groups represented in the indicator, non-benthic invertebrates and plants are still missing. Fungi are also completely absent from the indicator.

What knowledge gaps exist?

Although a number of these datasets have already been independently assessed in earlier reviews (e.g., Norris *et al.,* 2016, Isaac *et al.*, 2016), some have not had an independent assessment. The National Plant Monitoring Scheme data and BioSYS

Freshwater Invertebrates have not yet been (independently) scrutinised; however a summary of the quality of the data, the process for species selection, rigour of analytical methods, precision and biases involved and the interpretation of outputs is laid out in some detail in the Environmental Targets Consultation Evidence Packs and the technical document for the C7 plants of the wider countryside UK biodiversity indicator. There is little information of the suitability of the bumblebee and fish data for use within the species abundance indicator, especially as the process used for species selection and analysis for the indicator is not documented in the public domain.

The analyses undertaken by Norris *et al.* (2016) and Isaac *et al.* (2016) assessed the UK-level data for UK biodiversity indicators. Whilst the majority of the data used in the UK biodiversity indicators is actually from England (Isaac *et al.,* 2016), it may be beneficial to repeat similar analyses with the England-only data as the degree to which the data was biased towards England varied between datasets. Also, the assessments of spatial and temporal bias could be repeated including the most recent years of data to ensure that the conclusions drawn from these reviews remain relevant to the datasets previously assessed.

Currently, it is unclear how the species added after Version 2 were chosen for inclusion in the final version of the indicator. Without details on the process of species selection, it is difficult to make an assessment on whether those that have been added meet the criteria outlined above. It is also currently unclear whether the species list will be reviewed in the future and if so, how frequently. Adding new data as they become available may help to address some of the gaps in the indicator, but the implications for adding extra species to the list (for example, on target achievability) will also need to be assessed.

Indicator Review

Are the indicator methods fit for purpose?
In their article on Monitoring change in biodiversity through composite indices, Buckland et al. (2005)[16] describe 6 key properties necessary for robust multi-species indicators.

They are:

1. For a system that has a constant number of species, overall abundance and species evenness, but with varying abundance of individual species, the index should show no trend.
2. If overall abundance is decreasing, but number of species and species evenness are constant, the index should decrease.

[16] Buckland S t, Magurran A e, Green R e, Fewster R m (2005) Monitoring change in biodiversity through composite indices. Philosophical Transactions of the Royal Society B: Biological Sciences 360:243–254.

3. If species evenness is decreasing, but number of species and overall abundance are constant, the index should decrease.
4. If number of species is decreasing, but overall abundance and species evenness are constant, the index should decrease.
5. The index should have an estimator whose expected value is not a function of sample size.
6. The estimator of the index should have good and measurable precision.

The species abundance indicator is based on count data and therefore is assumed to index changes in national abundance. An annual abundance estimate for each species is made by gathering source data (e.g., raw counts) annually for each species at a large number of sampling sites and converting this into temporal trends via statistical models containing 'year' effects that serve as indices of annual status. The precise way in which this is done varies between taxonomic groups for reasons of species ecology and sampling design. From these estimates a composite index of species abundance is calculated. The wording of the Statutory Instrument states that the target will be assessed using an index of geometric mean species abundance. Specifically, the method for creating the index was developed by UKCEH and is known as the "Freeman method" (Freeman *et al* 2020). The resulting index is an estimate of the geometric mean abundance, set to a value of 100 in the start year (the baseline). Changes subsequent to this reflect the average change in species abundance; if on average species' trends doubled, the indicator would rise to 200, if they halved it would fall to a value of 50. A smoothing process is used to reduce the impact of between-year fluctuations - such as those caused by variation in weather - making underlying trends easier to detect. The smoothing parameter (number of knots) was set to the total number of years divided by three. Credible intervals for the indicator are calculated based on the posterior distribution for each of the parameters within the fitted model.

Issues with summarising biodiversity data as indicators
Biodiversity data are often complex and therefore are rarely used in their raw form. Instead, they are summarised into indicators, which are simple, standardised and communicable metrics that can be used to monitor the state of a particular measure of biodiversity and track its rate of change over time. There are multiple potential issues and challenges associated with summarising biodiversity data as indicators, many of which apply to the England species abundance indicator. The issues are reviewed below and placed in the context of the species abundance indicator.

<u>Data are heterogeneous</u>

Multispecies indicators are composite indices, which combine data from a range of species. Individually, these species may have very variable trajectories. By presenting the indicator as one summarised headline value, information on the trajectories of individual species and taxonomic groups are lost. Confidence intervals, which are often presented with the indicator, capture the level of uncertainty in the status of the average species, but provide little information on the variability in the individual species or taxonomic group trajectories themselves. For example, one can imagine two highly contrasting scenarios that would result in a flat tend in the indicator: firstly, where the majority of species have low change in average abundance year after year; and secondly, where half the species are increasing rapidly but are balanced out by an equal number of species in rapid decline. This can make the indicators difficult to interpret and understand, as has been noted for other multispecies, composite indicators, such as the Living Planet Index (Puurtinen *et al.* 2022)[17]. Moreover, these two scenarios would result in very different levels of uncertainty in the indicator. If an indicator is to be used to represent the state of a particular habitat, or guide where to focus policy actions to improve the average species abundance, then it is necessary that the heterogeneity of the data feeding into it is understood and documented.

It is highly likely that the data feeding into the species abundance indicator will have high heterogeneity, as the indicator represents a very broad range of species, which are affected by a broad range of pressures and span a range of different habitat types, so it is unlikely that the monitored species will show homogeneous trends. To account for this, the stakeholders in attendance at the workshop suggested it would be beneficial to present disaggregated trends alongside the headline indicator to help capture some of the variability that may be masked by the combination of all datasets into one headline indicator. Stakeholders discussed the benefits of disaggregating the indicator and agreed that, if done in a productive way, disaggregation could help to show which groups of species are pulling the indicator in different directions. It's currently unclear whether Defra plans to present disaggregated versions of the indicator, and if so at what resolution. There are many options for disaggregation units (e.g., species, taxonomic group, habitat type, realm), so these decisions should be carefully considered so that the indicator can be used effectively to guide the most appropriate policy actions going forward.

Despite how the indicator is presented, high levels of uncertainty will likely be associated with the contributing data. This will be a result of both true variability in abundance and trajectories within and between species, and also variability arising from observation methods and observation error. However, the Statutory Instrument underpinning the biodiversity targets sets out that success of the 2030 target is determined by the change in species abundance between two concurrent years of 2029 and 2030. The high level of uncertainty, combined with the current unknowns about the final smoothing parameters to be used, therefore poses questions regarding the utility of the indicator in detecting true and meaningful changes between specific consecutive pairs of years.

Representativeness and biases

As discussed above, composite indicators of species abundance can be biased towards taxonomic groups that have greater cultural value and are relatively easy to

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[17] Puurtinen M, Elo M, Kotiaho JS (2022) The Living Planet Index does not measure abundance. Nature 601:E14–E15.

identify or accessible to observe. This can lead to a range of representativeness and bias issues. When creating a species indicator, weighting may be used to try to address biases in a dataset. Some multispecies indicators (e.g., the Living Planet Index) have introduced weighting to address biases in the data. There are a number of options for weighting. For example, if one taxonomic group is represented by far more species than another, the latter could be given a higher weight so that both taxonomic groups contribute equally to the overall indicator. It is also often argued that some species (e.g., rare or endemic species) should carry greater weight than others. The difficulty with assigning variable weights to species or taxonomic groups is that any decision of how to weight the data is subjective and value-based. Some weighting options (e.g., weighting based on the proportion of species represented in a taxonomic group) also introduces a set of assumptions about how the abundance of those species with data are capable of indicating the status of species for which there are no data available. Complicated weighting also risks make the meaning and communication of the indicator less transparent.

In the species abundance indicator, each species was weighted equally. The main bias on the data is that some taxonomic groups are not represented at all, which cannot be addressed by weighting. Some options for weighting were also discussed in the stakeholder workshop, but there was no general consensus as to which option would be the most beneficial, and many disagreed with any form of weighting. Various weighting options were considered by Defra to address some of the other forms of bias discussed in the sections above but, in the end, equal weighting for all species was used to reduce subjectivity and to ensure clarity of communication.

Inter-annual fluctuations

Often the signal of long-term changes in species abundance can be weakened by strong inter-annual fluctuations caused by ephemeral influences, such as the effect of severe weather conditions. Isolated low counts of one taxonomic group may reflect sub-optimal weather conditions in a particular year, and a drop in population that may be reversed in the following year. For example, many bird populations are known to fluctuate markedly from year to year in relation to winter weather conditions. These types of fluctuations can be particularly important to consider, as they can expose the degree to which any given change should be taken seriously. Past trends are therefore informative and can show whether populations are able to recover from one-off disturbances.

Fluctuations in annual indices could also arise as a result of sampling error, particularly for species with small populations or that occur on only a small number of plots. Smoothing processes can help to identify long-term trends and remove much of the short-term fluctuations. A number of different processes can be followed to apply smoothing to biodiversity data, each of which have various advantages and disadvantages. The concept of smoothing is very general and covers many different subtleties relating to the way averaging occurs within the smoothing process. Most elements can be encapsulated within the two main principles of smoothing: which observations to include in the average; and how should they be weighted. Furthermore, smoothing can be applied either for each species' data, and that data then combined to produce an indicator, or the species' indices can be combined in their unsmoothed form and a smoothing process applied to the resulting series.

The Freeman method (Freeman *et al.*, 2020), which was designed to include *in situ* smoothing (smoothing during the process of combining raw species indices into one index of abundance), is used to create the species abundance index. Whilst the general method of smoothing has been noted in the consultation evidence report, the details including the chosen number of knots (which control the extent of smoothing) have not yet been outlined. Measurement of the short term, legally binding target relies on calculation of the index values for only two data points (31st December 2029, and 31st December 2030) and three data points for the long-term target (31st December 2022, 31st December 2030, 31st December 2042). The degree of smoothing of the indicator is therefore critical in this assessment. Too much smoothing implies that values assigned to any two timepoints are more likely to be similar and hence less likely to be significantly different. By contrast, too little smoothing could lead to the assigned values representing inter-annual fluctuations in the data and hence make it difficult to determine whether any change observed between two time points is a true change or if it is merely a result of stochasticity of the data.

Data contain missing values

Biodiversity time series often start and end at different times, and some have missing years in between (i.e., species:year combinations where there were insufficient surveys to produce reliable data). For any measure of species abundance, a statistical model is likely to be needed in practice to impute densities for missing sites in any given year. The imputation of missing values can also help to address biases arising from site turnover.

The Freeman method used to create the species abundance index has been specifically designed to accommodate datasets with missing values.

Shifting baselines – locking in loss

It can be difficult to identify suitable baseline conditions against which changes in the state of biodiversity can be measured. Often baselines are set at the start, or close to the start, of a data time-series. However, biodiversity loss may have occurred before monitoring began. For example, most UK biodiversity data do not pre-date the 1970s, when conditions were already substantially degraded compared to the natural state. This could result in unambitious targets being set, which 'lock in the loss' that has already occurred prior to monitoring. Choosing a baseline at the beginning of time series can also result in bias and low precision if there was limited monitoring effort early on in the time series. However, choosing a later year for which there are more data (hence less bias and greater precision), increases the risk of locking in biodiversity loss.

The time series for the species abundance indicator starts in 1970, but the measurement of the legally binding targets uses 2022 as the baseline to which comparisons will be made. It is assumed that the indicator values prior to 2022 will continue to be presented alongside the more recent data.

Time taken for data to progress through the workflow

One attribute often considered necessary for an ideal biodiversity indicator is that it is timely in the reporting of changes in trends, particularly if the indicators are to inform decision making and guide policy action (Gregory et al., 2005[18]; Jones et al., 2011[19]). Timely reporting (e.g., annually), allows for timely and efficient policy responses, but this requires data to progress through the workflow at a pace that supports such reporting. Raw species indices are calculated through a variety of modelling methods, and this is done by a range of practitioners, each with varying funding underpinning the data collection and analysis.

The statutory instrument outlining the legally binding environmental targets states that the species abundance indicator is to be an annual measure. One would therefore assume that this would be accompanied by annual publication and reporting of the index value. Despite the monitoring data being collected at appropriate and regular time intervals, one key bottleneck which may limit Defra's ability to deliver timely annual reporting is the time taken for the data to progress through the quality check and analysis workflow. A delay in this aspect of the process for any of the multiple data sources can cause significant lags between data collection and indicator publication, meaning policy responses to changes in the indicator value can also be significantly delayed. It is not always clear what causes delays in this aspect of the process, but often it can be related to funding and staff time.

At the very minimum, Defra are legally required to report the value of the indicator at three data points (31st December 2022, 31st December 2030, 31st December 2042), however the reporting date for the latter two points have been set over one year after the time points (15th April 2032, and 15th April 2044). This time lag appears to be standard for the reporting of biodiversity indicators (e.g., based on the data availability reported in annual publications of indicators such as the JNCC's UK Biodiversity Indicators[20]. There is currently no published date for the expected publication of the 2022 indicator value.

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[18] Gregory RD, van Strien A, Vorisek P, Gmelig Meyling AW, Noble DG, Foppen RPB, Gibbons DW (2005) Developing indicators for European birds. Philos Trans R Soc Lond B Biol Sci 360:269–288.

[19] Jones JPG, Collen B, Atkinson G, Baxter PWJ, Bubb P, Illian JB, Katzner TE, Keane A, Loh J, Mcdonald-Madden E, Nicholson E, Pereira HM, Possingham HP, Pullin AS, Rodrigues ASL, Ruiz-Gutierrez V, Sommerville M, Milner-Gulland EJ (2011) The Why, What, and How of Global Biodiversity Indicators Beyond the 2010 Target. Conservation Biology 25:450–457.

[20] JNCC (2022) UK Biodiversity Indicators 2022. https://jncc.gov.uk/our-work/uk-biodiversity-indicators-2022/ (accessed September 29, 2023)

What else can be inferred from the species abundance indicator?

Abundance is just one measure of biodiversity, and in this case is the aspect that has been chosen to monitor progress towards legally binding biodiversity targets. Ideally the state of a larger part of an ecological system should be inferable from an indicator, even if it represents a relatively small part of the system. However, many indicators are limited in scope and lack the empirical evidence to provide wider information, although they may inform focused conservation efforts on the species or group of species they represent. Individual indicators (such as species abundance) may be used to monitor specific aspects of biodiversity, whereas multiple indicators can better represent its overall state.

The stakeholders in attendance at the workshop were asked, 'what, if anything, can the indicator tell us about the wider natural environment or drivers affecting biodiversity?'. A key message emerging from the stakeholder workshops was that the species abundance indicator cannot be used in isolation to guide effective policy actions to address biodiversity loss. Instead, it was highlighted that further information is needed on the pressures and drivers of biodiversity loss and how these link to the abundance of species underlying the indicator. Many attendees suggested that, when considered in isolation, the species abundance indicator cannot tell us much about the wider environment. Attendees agreed that it can tell us about how the species it records are faring, which could be broadened to how their specific habitats are faring. One attendee also suggested that the species abundance indicator could help to determine the level of risk of trophic collapse and the associated ecosystem services attached to abundant wildlife in England (lower species abundance could suggest higher risk of trophic collapse and could risk certain ecosystem services being unfulfilled). However, overall, there was general agreement that the species abundance indicator *alone* cannot reliably be used to infer other things about the state of the wider environment. There was general agreement that further information would be required alongside the species abundance indicator in order to make more reliable inferences about the wider state of the environment. One attendee suggested that the state of the abundance indicator could be used to prompt further questions, which would springboard users to other information or questions that can make the trend more informative.

The intended purpose of the species abundance indicator has not been clearly defined by Defra (i.e., it is not clear from the evidence available whether the abundance indicator is meant to guide policies or actions or whether it is solely meant to provide an overview of the state of biodiversity in England). If the latter, success in terms of an increase in the value of the indicator cannot necessarily be linked directly to actions and policies without more information collected alongside the indicator as trends in abundance can be influenced by many factors. In order to effectively use the indicator to measure success and take an adaptive approach to management of biodiversity, wider information will need to be used alongside the indicator to understand what actions might be met with more success.

Supporting metrics

Other metrics and the aspects of biodiversity they capture.
The species abundance indicator is not the only indicator being used to measure progress towards the legally binding biodiversity targets. There is also a target for species extinction risk, which will be measured using an England-level Red List Index. Other indicators that measure other aspects of biodiversity are also reported on annually (e.g., those within the Outcome Indicator Framework), many of which have been outlined in the EIP as being particularly relevant to the thriving plants and wildlife goal.

The workshop attendees felt that these other indicators could be used to complement the species abundance indicator as they each monitor different aspects of biodiversity. For example, while the species abundance indicator can provide a relatively reactive and sensitive measure of the state of biodiversity in England, which can potentially be used to predict the relative risk of trophic collapse, the Red List Index focusses on the risk of *loss* of biodiversity over time. Other indicators that were highlighted as important to have alongside the species abundance indicator, as complimentary metrics additional to those listed in the EIP, included indicators for invasive species and soil health, which cover aspects of biodiversity that the species abundance indicator does not.

Many of the attendees felt that useful information could be gained by disaggregating trends in the species abundance indicator and presenting these as supporting metrics. For example, by understanding how species abundance is changing within different habitats we could understand which habitats have growing populations and which are declining, which could ultimately help to focus conservation efforts. Moreover, as discussed above, the species abundance indicator has some key gaps in its coverage (particularly for the marine environment), so declines in less well represented taxa may be masked by the over-representation of others. For this reason, a separate marine index would be beneficial to consider, so that negative trends in this realm are not overlooked.

Extinction risk indicator
There are concerns about the suitability of the extinction risk indicator that will be used to measure progress towards the legally binding target for extinction risk. For example, there are concerns relating to the geographic coverage of the indicator – specifically the use of GB-level Red Lists as opposed to England-level Red Lists. Here the assumption has been made that the threat levels at England and GB scales are the same or similar. There is limited evidence to support this assumption aside from the comparisons made in the consultation evidence pack between the GB- and England-level Red Lists for plants and mammals. Although most categories for these two taxonomic groups were similar there were some key differences which risks the indicator being insensitive to changes in England. For example, the complete loss of a species in England that retained populations in Scotland or Wales, would not be accurately reflected in the

indicator, or the successful recovery of a species in England being tempered by ongoing declines elsewhere.

Appraisal of strengths and weaknesses

Based on the evidence presented above, the various strengths and weaknesses of the species abundance indicator and the data underpinning the indicator are listed below:

Wide coverage of species – The species abundance indicator has gone through various rounds of development, during which the taxonomic coverage of the indicator has been expanded. The final list of 1195 taxa is an ambitious improvement on the 670 included in Version 1 of the indicator. The species list includes birds, mammals, fish, invertebrates, and plants, and includes representatives from terrestrial, freshwater and marine environments (although not in proportion to their occurrence in nature – see below).

Taxonomic gaps in the indicator – It is widely acknowledged that the indicator is not representative of species in England; there are some big gaps. The indicator remains heavily biased towards terrestrial species and habitats, despite the recent addition of some freshwater and marine species, and misses some groups of species entirely. The marine environment, in particular, is hugely underrepresented. This representation bias means that the indicator will be less sensitive to, and representative of changes in species abundance in the environments that are poorly represented and can result in a poor understanding of how these underrepresented environments are faring. This could also have implications for the policies introduced. For example, representation bias risks policies and actions on the ground becoming imbalanced toward the overrepresented environments as that is where the knowledge will be greatest and improvements will likely have the greatest impact on the indicator value. Ultimately, underrepresentation of taxonomic groups or whole environments can risk unintended perverse consequences if the focus is on improving the *index value* rather than *species abundance* overall.

Defra’s criteria for inclusion of data – The inclusion criteria for monitoring schemes that Defra have outlined in the environmental targets consultation evidence pack (Standardised protocol delivering annual abundance indices, spatially replicated survey design with coverage across England, and taxonomic resolution ideally to species level) effectively reflect the aim to maintain a high standard of data feeding into the species abundance indicator, whilst also allowing for a broad taxonomic range of species to be included. The key essential criteria identified by the attendees of the stakeholder workshops mostly aligned with Defra’s criteria for inclusion of data.

Quality of data - There is evidence that the monitoring schemes that have been outlined in the consultation evidence pack meet many of the criteria for an ideal dataset. Often, the criteria that have not been met can be corrected for statistically. Although the monitoring schemes vary in their approaches to data collection and analysis (often necessary due to the broad range of life histories and detectability exhibited by the different species and taxonomic groups) and therefore also vary in quality, we can be fairly confident that much of the data feeding into the indicator is of sufficiently high quality to enable an accurate representation of these species' abundances in England.

The core remit of some of the data providers does not match with that of the species abundance indicator - Biodiversity monitoring schemes in the UK are usually established from the ground up by people who are directly interested in the taxonomic subjects of the monitoring programmes because of their intrinsic value to them. Whilst the data feeding into the species abundance indicator are invaluable given the length of time the monitoring schemes have been running and the extensive coverage of species, very few of these schemes were developed with the sole purpose of recording species abundance for this indicator. This has potential to introduce bias into the datasets if the aim of the monitoring programme does not match up with the aims of the indicator. For example, uneven sampling effort across space can arise if the aim of a survey is to understand whether poor quality habitats are improving as resources may be targeted into sampling in areas where there are environmental problems and there may be less impetus to consistently sample locations that have no environmental problems.

Financial security of monitoring schemes - There is little information on the financial security of the various monitoring programmes and subsequent statistical analysis in the public domain. In most cases, Defra do not directly fund the monitoring schemes used in the species abundance indicator. 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. Many are co-funded by the JNCC, but some are established national recording schemes. While many will have funding agreements in place, these are likely reviewed after relatively short time frames.

Lack of transparency – The indicator development process following the environmental targets consultation in 2022 has not been documented in the public domain. For example, the only information about what data will be included in the final version of the indicator had to be inferred from the list of species reported in the statutory instrument underpinning the environmental targets. An up-to-date technical document outlining key elements of the indicator's development such as the species selection criteria for the most recently added species and the statistical methods for calculating raw species indices for these new species were unavailable to review in detail (see section on unknowns below). There is also little information on how or if the indicator methods have been developed since the consultation, and it is not clear how the finalised index will be presented at the expected publication date.

Describe the trend, vs explaining the trend – The species abundance indicator was produced to describe the trend in species abundance in England, but on its own does not provide the information necessary to help understand how would be best to increase species abundance. Many of the stakeholders present at the workshops highlighted that if we cannot explain the trend we are seeing, then it is difficult to know how best to meet the targets that have been set. There was therefore a consensus among stakeholders that the indicator cannot be used in isolation, and that further information on pressures and drivers alongside the indicator, together with more research into how these link together will be key to allow policy makers and practitioners to effectively meet the targets.

The species abundance indicator is part of a bigger package of policy levers to achieve environmental improvement (EIP) – Defra emphasised during the stakeholder workshop that the species abundance indicator should not be considered in isolation and that the indicator should be considered in the wider landscape within which the targets exist. The indicators of species abundance and species extinction risk will be reported as part of the wider process under the Environmental Improvement Plan. If used as planned, the species abundance indicator has the potential to be a key representation of the state of environment under Government's *Thriving plants and wildlife* goal.

Unknowns – Information unavailable for review

A range of information was not available in the public domain nor made available upon request, and it was therefore not possible to include in this review. These aspects are listed below:

- It is unclear whether the species list will be reviewed in the future – if so, how frequently and if new data become available will these be added?
- There were no specific details available on how the species from the most recently added datasets (bumblebees, small vertebrates, fish) were chosen and analysed.
- There were no specific details on the species additions and removals from Version 2 of the indicator.
- There is little documented information on how and if the methods to calculate the final index value have changed since the publication of the consultation evidence document.
- It is currently unclear when the final indicator will first be ready for publication and when the 2022 baseline index value will be announced.
- It is currently unclear exactly how the indicator will be presented – e.g., will just one headline trend be presented, or will the headline trend be presented alongside disaggregated trends, if so how will the data be disaggregated?
- There is little information available on the financial security of the underpinning monitoring programmes and what commitments will be made to them to support the indicator.

- It is unclear how the marine environment will be represented as there is very low representation in the current list of species.

Opportunities and recommendations

In assessing the strengths and weaknesses of the current approach, and considering the knowledge gaps that exist, a number of opportunities have emerged.

1. The value of gathering additional information and data on other species from underrepresented taxa is clear. Whilst any such data may not be sufficient for inclusion in the indicator itself, it may provide important contextual information and greater ability for extrapolation of the indicator to the fate of species across England. This may include the opportunity for additional monitoring or focussed assessments on underrepresented taxa. Without the historical time series, this could not be formally included in the species abundance indicator but could still be useful for understanding species status and the impact of interventions.
2. As there is such a strong dependency on the data providers, long term agreements could be considered that provide commitment, stability and an ability to plan effectively. This also should mitigate any potential risk of data not being available or a key data source terminating that could then significantly affect the ability of the indicator to track trends over the 2022-2030-2042 period.
3. All key technical documentation should be presented alongside the indicator to aid interpretation and for transparency. This would include the data included and the detailed methodology of how this has been combined and smoothed to produce the indicator.
4. The limitations and representation bias should be acknowledged when the indicator is published and it should be made clear what exactly the indicator is indicative of, what can confidently be inferred from it and what cannot.
5. When the indicator is presented, key additional indicators should also be presented. The indicator should always be broken down into terrestrial, freshwater and marine domains and by taxonomic group wherever possible. Indicators of significant drivers and pressures should also be presented alongside the indicator.

3.3 B: Review of evidence used to develop targets

Defra's approach to target development and delivery

Target development

Defra's criteria for the development of biodiversity targets

In the Environmental Targets consultation evidence report for the biodiversity and freshwater targets, Defra outlined the criteria and principles that they applied in developing targets. These criteria were defined drawing on the scientific literature and best practice for global biodiversity targets. Defra highlighted that meeting all of these criteria for a complex area such as biodiversity is a challenge, and the choice of targets would need to balance the various requirements. The criteria are listed below. Biodiversity targets should:

- **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 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).
- **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.
- **Be England-focused** - 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.
- **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.
- **Have an existing baseline with a trend** - to support predicting future change in the trend. This will support setting achievable targets.
- **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.

- **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.

Target development was supported by the development of notional targets, which were used to test what was considered feasible and understand the level of intervention that would be required to reach different outcomes.

Policy Scenarios

Based on expert opinion of what was feasible, and the different types of intervention required to meet the notional targets, Defra developed five policy scenarios that were used to guide the further analysis of indicator trajectories under different policy interventions[21]. The scenarios are summarized below:

- **Scenario 1:** This scenario extrapolated existing trends where possible.
- **Scenario 2:** 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. 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:** 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: All actions in Scenario 2 plus research, partnership, spatial planning, targeted action for species.
- **Scenario 4:** This scenario includes actions identified as critical or important to the delivery of 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: All actions in scenarios 2 & 3 plus actions for water quality, planning, any changes to legislation.

[21] Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report.

- **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.

These scenario analyses were used to guide the appropriate target level. Overall, Defra reported that they considered the following four factors when proposing the target in the consultation:

- 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).

Scale and pace of delivery

The evidence report highlighted that there was a 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 consultation evidence report contained a mathematical analysis conducted by the UK Centre for Ecology and Hydrology (UKCEH), to assess what rate of change year on year would be needed to halt declines by 2030 and increase species abundance by 2042 and used a forecasting model to estimate what might happen to the indicator under Scenario 1. The mathematical analysis suggests that to bend the curve of biodiversity decline would need an increase of approximately 9.7% to 2042 compared to a 2030 baseline, whereas a continuation of the current trend would mean that by 2030 the indicator is predicted to be 41% of its 1970 value or 30% of its 1970 value by 2050.

Feasibility assessment

This included the mathematical representation of rate of change necessary to reach the targets, as well as an assessment to understand the impacts that changing the proportion of declining species would have the indicator depending on their growth rates. This analysis was undertaken using Version 1 of the indicator (670 species of birds, bats, butterflies and moths).

In addition to this, an analysis was undertaken to estimate the national level effects of agri-environment schemes on the Farmland Bird Index (FBI) using evidence on the response of birds within the FBI at the local level and an expert stakeholder workshop was held to understand the level of confidence of experts in the notional target levels being achieved.

Scenario modelling

Finally, the consultation evidence report modelled how the species abundance indicator might change under different types of interventions. The broad intervention types that were considered were (i) the uptake of higher level agri-environment scheme options, (ii) the creation and restoration of semi-natural habitat, (iii) improvements in water quality. Each of these scenarios were modelled using Version 1 of the specie s abundance indicator (670 species) A third scenario (improvement of river water quality) was also modelled, which considered the changes that could influence freshwater species.

For each intervention, the data available for modelling were compared to the ideal data requirements, and the logic behind the key assumptions were outlined using logic models, before presenting the results alongside the main assumptions.

Government's delivery plan

Defra have stated in the EIP23 that the EIP23 '*is a detailed delivery plan with policy actions allocated to different government departments, local government and the private and third sector where appropriate*'. Defra have used the 25YEP goals as the structure for the document, setting out an "*integrated and outcome focused delivery plan which recognises the interdependencies between the goals".* The EIP23 outlines a large number of actions that will feed in to delivering multiple goals, including a goal for Thriving Plants and Wildlife, which has been set as the apex goal. The actions under each goal are grouped into delivery themes. In the Thriving Plants and Wildlife chapter alone the EIP23 has set out 8 key areas of action, which list a total of 76 actions. These 8 delivery themes are each linked to a long-term target, but some actions are likely to contribute to more than one target. The 8 delivery themes are:

1. **Creating more joined up space for nature on land**
2. **Restoring our protected sites on land**
3. **Managing our woodlands for biodiversity, climate and sustainable forestry**
4. **Enhancing nature in our marine and coastal environments**
5. **Taking targeted actions to restore and manage species**
6. **Mobilising green finance and the private sector**
7. **Taking action to restore our global environment**
8. **Unlocking private and public financial finance flows**

Review of the target development process

Policy scenarios

The process of development of the legally binding biodiversity targets took place in 2021-22. The policy scenarios that were developed to inform the target ambition were developed based on expert opinion of what was feasible, and the different types of intervention required to meet the notional targets. The policy scenarios broadly described the types of interventions that would be considered for each scenario, and gave an indication of how they related to each other in terms of what resources would be necessary for their implementation. There was therefore some information on the likelihood and realism of the different scenarios but overall, there was little indication of important parameters that could be used to inform modelling such as the scale and pace of implementation that would be possible, the details of the specific types of intervention, and relative importance of the different processes. Much of this information was not available until the publication of the EIP23 (and in some cases is still lacking). There was, however, acknowledgment of potential barriers to successful implementation (e.g., the relative level of control government had over implementation). Overall, there was very little detail to inform the scenario models. This was most likely due to the time constraints the modelling was required to be completed under (i.e., in parallel to discussions around which policies would be best suited to achieve different levels of target ambition), however it likely impacted the accuracy and application of the quantitative outputs of the modelling.

Scenario modelling and feasibility assessment

Species used for modelling

The target development process occurred alongside the development of the species abundance indicator. This meant that Version 1 of the indicator, which included 670 species made up of only birds, butterflies, moths, and bats, was used for most of the scenario modelling process to inform the ambition and assessment of the achievability of the species abundance targets. This list of 670 species is almost half of that which have now been listed in the statutory instrument underpinning the biodiversity targets (n=1195).

At a first glance, it is unclear what impact including the remaining 525 species in the scenario models would have had on the outcome of the modelling, and whether this would have led to a different conclusion on the feasibility of reaching the proposed targets. However, by looking in more detail at the properties of the abundance indicator, as well as the modelling parameters and assumptions, it is possible to make some inferences about what influence adding the extra species may have had.
Firstly, it is necessary to consider the impact that adding these extra datasets will have on the value of the indicator that was most recent at the time of modelling (2018 – hereafter referred to as the modelling baseline) and the recent trajectory of the indicator. If the addition of further data would drastically change the modelling baseline value and recent trajectory, this could increase or decrease the feasibility of meeting

the targets. For example, if the addition of new datasets resulted in a large decrease in the 2018 value of the indicator and a steeper decline in the more recent trajectory of the indicator, this could increase the amount of improvement (i.e., a greater bend factor) needed in order to ‘halt the decline in species abundance’, potentially reducing the feasibility of meeting the targets (potentially resulting in an overly-ambitious target). On the other hand, if the addition of new datasets increased the modelling baseline value relative to Version 1 of the indicator and reduced the slope of the recent trajectory, the feasibility of halting the decline in species abundance may be increased (and hence the target may not be seen as sufficiently ambitious).

The consultation evidence report noted that there was a negligible difference between the 2018 indicator values and most recent trajectory of Version 1 (670 species) and Version 2 (1071 species) of the indicator[22]. This was not surprising given these extra datasets started only recently (2015 for NPMS; 2013 for EA freshwater), so their influence on the value of the indicator was likely to be small. This is also likely to be the case for the most recently added datasets (i.e., those added for Version 3 of the indicator). Therefore, providing the methodology for calculating the indicator remains the same as has been used in the evidence pack, the scenario modelling is likely to retain its utility for predicting potential impacts of these interventions on the trajectory of the indicator. However, the methodology that is to be used to calculate the final version of the indicator is currently not publicly available.

As well as understanding the impact of adding the extra species on the baseline values and recent trajectories of the indicator, it is also important to consider whether most recently added species are likely to respond in a similar way to the interventions as those that have been modelled in the consultation evidence report. The impact of these interventions were not considered for plants, fish, bumblebees, water voles and dormice as either there was insufficient time to produce a trajectory (plants), or the species had not yet been added to the indicator (fish, bumblebees, water voles, dormice). In theory, it would be possible to divide these groups of species into either habitat specialists, habitat generalists, or those that would be more likely to benefit from an improvement in river quality, so the modelling approaches may be able to be applied to these extra species. The impact that adding these extra species will have on the outcomes of the models will therefore depend on the relative proportion of the species that are classified in each category.

Recent rates of decline

It is also important to note that the modelling undertaken in the consultation evidence report used 2018 as the modelling baseline year from which the future projections were made due to the unavailability of more recent data. There is, therefore, a risk that in more recent years the decline of species abundance has accelerated, which again risks increasing the bend factor needed in order to meet the targets. A steeper rate of decline between 2018 and 2022 (compared to the average rate of 2% per year prior to 2018)

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22 Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report.

would mean that the 2030 target would be both *numerically* and *ecologically* more difficult to achieve: a greater numerical change in the index value would be needed to offset and halt the most recent declines, and it is likely to be more difficult to reduce the rate of decline for species which are in steep decline[23]. Although the impact of steeper decline between 2018 and 2022 than was predicted in the consultation evidence report would result in the 2030 target being more difficult to achieve, it could result in the 2042 target being *numerically* easier to achieve: this will likely result in a lower index value for 2030 than was predicted in the report, which requires a smaller relative numerical change to increase by 10% than would be the case if the 2030 index value was higher. Despite this, it will likely mean that ecologically the target would be more difficult to achieve: it would likely require higher levels of intervention to increase populations that are at relatively lower levels of abundance. The finalised indicator is expected to be published in May 2024, so the recent trajectory of the indicator (i.e., between 2018 and 2022) and the effect of this on the feasibility of achieving the target will likely remain unknown for some time yet.

Evidence and assumptions underpinning the methods used for scenario modelling

Various approaches to scenario modelling were used to inform the ambition level of the targets. Some of the most detailed data that was available at the time was evidence relating to the response of birds within the Farmland Bird Index (FBI) and agri-environment schemes at the local level[24,25]. Work was undertaken during the development of the targets to scale this up to a national level. Therefore, the assumption was made that the relationships observed at the local level would be maintained over larger geographical scales. Despite this assumption and the resulting simplistic model, this model was likely one of the more scientifically robust of the approaches taken to project the indicator as it was based on empirical observations for known species, which have been scaled up to a broader geographical scale (and hence has fewer assumptions that the other models used). Nevertheless, there are likely to be limitations to the modelling that are introduced as a result of the assumptions made. There is little evidence to suggest that the local observed effects on farmland bird abundance would be realised to the same extent across broader geographical scales. The research also assumed that each farm implemented nature-friendly farming actions on 10% of the farm, that actions were roughly equivalent to Higher Level Stewardship (HLS), and that from 2022 there was a steady rate of increase in coverage of nature friendly farming. In reality, specific details of the planned pace and method of delivery of ELM is unclear (although there are some clear commitments for nature friendly farming in the EIP, this is discussed further in the review of target delivery pathways). Defra’s nature friendly farming scheme polices are still in their infancy. Uptake levels are

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[23] Bane MS, Cooke R, Boyd RJ, Brown A, Burns F, Henly L, Vanderpump J, Isaac NJB (2022) An evidence-base for developing ambitious yet realistic national biodiversity targets. Conservation Science and Practice 5:e12862.

[24] Sharps E, Hawkes RW, Bladon AJ, Buckingham DL, Border J, Morris AJ, Grice PV, Peach WJ (2023) Reversing declines in farmland birds: How much agri-environment provision is needed at farm and landscape scales? Journal of Applied Ecology 60:568–580.

[25] Defra (2022) Biodiversity Terrestrial and Freshwater Targets Detailed Evidence Report.

currently on track to achieve the commitments laid out in the EIP, but this will need to be closely monitored to ensure uptake continues at the scale predicted to be necessary to reach the targets.

The remaining modelling that could be achieved was limited by the extent of empirical data on the responses of species to different types of intervention. This meant that limited interventions were considered and the models used were straightforward with many simplifying assumptions. These assumptions were necessary due to substantial evidence gaps and conceptual barriers, which limited the predictions that could be made about how species abundance might change under different policy options. Most of these assumptions are outlined and justified, and the limitations arising from the assumptions have been made clear in the report. Here we review the various assumptions of the modelling approaches.

Which species will benefit from which interventions?

One of the key assumptions underpinning the scenario models is that habitat specialists will benefit from the creation of semi-natural habitat, but are unlikely to benefit from the higher uptake of agri-environment schemes, whereas habitat generalist species are likely to respond only to higher uptake of agri-environment schemes, but not the creation of semi-natural habitat. Freshwater species were modelled separately in the improving river quality models. In reality, this separation could result in an underestimation of the predicted effects of interventions as some generalist species may benefit from creation of semi-natural habitats, and freshwater species may indirectly benefit from wider uptake of agri-environment schemes. However, there is a lack of data to suggest what scale these indirect benefits could be realized at, so the simplification seems necessary in this case.

Consideration of other pressures

The modelling undertaken to understand the impact of the creation and restoration of semi-natural habitat in England and implementation of agri-environment schemes considered scenarios both with and without the background of continuing decline, essentially giving a pessimistic and optimistic scenario for each of the scenarios. The justification for modelling scenarios with a background of decline was to take account of other pressures that will not be addressed by creating and restoring habitat or the introduction of nature friendly farming (e.g., climate change, invasive species, etc). This seems suitably precautionary, given that recent rates of decline have continued to occur despite past creation of habitat and implementation of past farming schemes. However, there is no consideration of how these pressures might change in the future, which is likely to be an oversight and could result in the underestimation of the extent of background declines caused by other pressures.

The models including mitigation of these declines does not assume that all other pressures are removed completely, but instead are mitigated to the extent that the *average* trend in the species abundance indicator absence of habitat creation is zero (i.e., some species will still be in decline, but these are offset by other species that are increasing in abundance). The results from the scenarios including mitigation are likely to be overly optimistic as this assumes that species abundance indicator background declines are halted from day 1 (in this case from 2018 onwards), whereas in reality, based on the targets and feasibility assessments, this is unlikely to be the case until 2030.

Ecological and political lags

Neither the habitat creation nor the AES scenario modelling approaches include considerations of either political or ecological lags in the models themselves, but this was acknowledged in the assumptions and limitations sections for each modelling approach.

The habitat creation modelling recognized that there are likely to be substantial ecological lags related to the creation of woodland habitat, as 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 specialize on woodland. The habitat creation models therefore ignored any benefits that might accrue from the substantial areas of woodland that are likely to be created in coming years. Ecological (e.g., colonization deficits and the time taken for the habitat to become suitable) and political (e.g., time between decision making and implementation) lags for other habitats were also mentioned, but were not accounted for in the modelling most likely due to uncertainties surrounding likely lag periods. This approach is not ideal, as this will have resulted in overly optimistic predictions of effect sizes. Ideally, the consequences of the uncertainty should be explored through sensitivity analyses to produce varying estimates of the effects of policy interventions with differing levels of ecological and political lag times.

The AES modelling assumption about lags was addressed slightly differently. In assuming that the relationship between AES option scores and abundance is the same in space and in time, and not calculating a projected ‘trend’ in species abundance (but rather a final outcome), assumptions about the rate at which the benefits of Environmental Land Management schemes might be realised were avoided. The only assumption was that the schemes will have been rolled out and the benefits realised in time for the assessment of the target in 2042. Given that ELM was in its infancy at the time of modelling, high levels of uncertainty about the rollout of Environmental Land Management schemes and biotic lags remain, and it’s difficult to know whether this assumption is suitable.

Similarly, the water quality modelling, did not model a trend in species abundance with increasing water quality, but calculated the expected change in the indicator value if all sites reached good ecological status by 2030. There was little consideration of the achievability of this within ecological and political time scales.

Policy-specific assumptions

- **Habitat creation –** The creation and restoration of semi-natural habitat models made some further assumptions specific to the scale of delivery. Specifically, the assumption was made that increases in semi-natural habitat will be evenly spread across existing priority habitat types in proportion to their current area. In reality, the scale of delivery for specific habitats has not been outlined in detail in the EIP23, so it is difficult to assess whether this assumption is likely to hold true. There is a large focus on woodland creation in EIP23, the effect of which on the species abundance indicator has not been modelled in this case.
- **Agri-environment 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. The modelling of the effects of agri-environment schemes (both on the Farmland Bird Index and the species abundance indicator) outlined that the predicted outcomes were reliant on the assumption that each farm implemented nature-friendly farming actions on 10% of the farm, and that actions were roughly equivalent to Higher Level Stewardship (HLS). This level of scheme is likely greater than SFI options being adopted by farmers at the moment.

Review of target delivery pathways

The analyses presented by Defra in the consultation evidence report make it clear that substantial action is needed to meet the species abundance targets. The EIP23 has been described as Government's delivery plan, and it outlines a large number of actions that will feed in to delivering multiple goals for the environment, including the apex goal of Thriving Plants and Wildlife.

Call for evidence responses
The responses from the OEP's call for evidence on nature recovery were key to this element of the review. The OEP received 28 responses to their call for evidence in total. The responses were from a number of different types of organisations, including Government organisations, Non-Governmental Organisations, park authorities, professional institutes, representative bodies, and research organisations. We undertook a thematic analysis on the responses to the call for evidence to highlight the key themes across responses (further details of this including the main thematic categorisations and a detailed summary of themes are presented in Annex C). Here we summarise the evidence gathered from the OEP's call for evidence and review the evidence surrounding the suitability of Government's target delivery pathways for achieving the species abundance target as laid out in the EIP23.

Achievability of species abundance targets
The scenario models presented in the environmental targets consultation evidence pack suggest that given sufficient scale of action the species abundance targets are achievable. This also relies on a pace of implementation that allows for the benefits of actions to be realized withing the timeframe of the targets. Recent analysis in Bane *et al*. (2022) shows that multiple pathways exist to achieving the species abundance targets in England. Examples include, targeting focus on a relatively small number of severely declining species, and/or creating smaller benefits for a larger number of species through landscape-scale interventions. However, some avenues to achieving the target may risk perverse consequences (e.g., focusing effort on improving the indicator value to reach the target, rather than supporting the underlying values that the targets seek to realize). Therefore, the predictions of achievability of the targets and decisions on the most appropriate delivery pathways cannot rely solely on quantitative modelling approaches and are not fully informative as to whether actions will deliver wider conservation outcomes and contribute to restoring biodiversity. Given the gaps in the indicator and potential for perverse outcomes, expert opinion on the suitability of delivery pathways and objectives is therefore essential to ensure actions will support the recovery of all species, not just those represented by the indicator.

Defra's consultation evidence pack included a summary of expert views on both the achievability of notional targets and the actions that would be required to deliver the notional targets. The OEP's call for evidence questions also covered these themes. Many respondents (64%) to the call for evidence were confident that the species abundance targets are achievable, providing policies are implemented at an appropriate scale and pace. For those that were not confident of the feasibility of the target, the assumption was made that the current trajectory of environmental policy and therefore biodiversity would continue. Respondents (from both of these groups) believed the targets to be challenging or difficult to achieve given the current state of biodiversity and that significant changes in policy and political will would be required to meet the targets.

Key actions to help achieve the species abundance targets
It is likely that a variety of actions will be required to achieve the species abundance targets. This is reflected in the EIP23, which is made up of a large number of actions, and also in the call for evidence responses, many of which listed multiple actions that would be important to contribute towards achieving the targets. Many of these actions will likely contribute to more than one goal as there are numerous interlinkages.

The consultation evidence packs and impact assessments underpinning the Environment Act biodiversity targets contain analyses that highlight the potential effects that some actions will have, and their relative contributions to achieving the targets. The modelling presented in the consultation evidence pack for the species abundance targets highlighted that agri-environment schemes are likely to provide some of the greatest impacts on the value of the species abundance indicator. This is likely because the abundance indicator is made up of a large proportion of widespread generalist species, which are more likely to benefit from improvements in farmland and the wider countryside as they have broad habitat requirements (often including habitats found on farmland). The modelling also showed that increasing water quality could constitute up to 1/3 of the change in the index required to meet the target, as freshwater macroinvertebrates make up almost 20% of the species in the indicator. The creation and restoration of semi-natural habitats would likely have the smallest contribution to the achievement of the species abundance target out of the actions modelled (again likely related to the proportion of the indicator made up by habitat specialist species). These actions are only a handful of the actions that are listed in the EIP23 but do provide some insight into which actions are likely to provide the most traction towards achieving the targets.

Although the actions modelled in the evidence pack are likely to have a positive impact on the species abundance indicator (given the appropriate scale and pace of action), it is important to remember that the indicator is not an absolute reflection of the state of species abundance in England (it is purely an *indicator*). As described in the WPA report, there remain many taxonomic gaps in the indicator. Some of the groups of species that are missing from the indicator may not accrue benefits from the modelled actions to the same extent as the monitored species. Other actions that may have not yet been considered may be more appropriate or more effective for these missing groups (but might not have as large an impact on the species regularly monitored and included in the species abundance indicator). It is therefore important that the focus for improving species abundance in England is not solely on improving the indicator but should take a holistic view and ensure that species not covered by the indicator are also considered appropriately. This is particularly the case for marine species, which are very underrepresented in the indicator. Although some marine actions have been outlined in the EIP23 compared to the actions for terrestrial and freshwater ecosystems these seem to be limited. The marine target set under the EIP to support Nature Recovery focuses exclusively on features within Marine Protected Areas (MPAs). MPAs will no doubt have an important role to play in reversing biodiversity decline, however they only cover ~40% of English waters, so cannot be the only tool used to recover biodiversity in the marine environment.

Furthermore, as highlighted in the consultation evidence packs, actions that aim to improve the quality of wider countryside or farmland habitats will be more likely to have a larger impact on the species abundance indicator as the indicator itself is dominated by generalist species. However, this does not mean that actions that target specific habitats or specialist species recovery programmes should be overlooked, as these will also be important for maintaining overall ecological integrity.

Are the areas of action outlined in the EIP23 appropriate?

Overall, the respondents to the call for evidence agreed that the eight areas of action in the EIP23 are appropriate to achieve the targets, and their responses reflected the statement made above that a range of actions will be necessary to achieve the targets. However, there were a number of concerns relating to the current scale and pace of action. Three stakeholders felt that there is also limited acknowledgment of how each of the actions listed are likely to contribute each of the targets that have been set. 18% of the respondents to the call for evidence also highlighted that the EIP23 lacks a method for prioritising these actions based on the scale of interventions required and type of outcomes they are likely to achieve. Although the EIP23 is described as a delivery plan and outlines key areas of action, it contains little detail that link the suggested actions to the planned outcomes, except where actions have been listed under the main delivery themes. These delivery themes are not explicitly linked to the long-term targets under the thriving plants and wildlife goal (although they can be broadly aligned to match up with the targets). This lack of explicit linking may or may not be intentional in acknowledgment that the listed actions could each contribute to the achievement of more than one target.

Below we outline the policies that stakeholders identified as being central to the achievement of the species abundance targets (and other targets outlined in the EIP23), along with some of the key concerns stakeholders have regarding the suitability of the policies.

Creating and restoring habitats on land

Some of the most frequently mentioned intervention types related to agri-environment schemes (AES), Environmental Land Management (ELM) and sustainable agriculture, most likely due to the significant proportion of the landscape that is dedicated to farming (70%), and the risks that unsustainable farming practices present for the state of biodiversity. All of the respondents that mentioned these types of intervention agreed that they are essential to meet the species abundance target and have great potential to make a significant contribution to improving species abundance in England. According to the EIP23, the new farming schemes are expected to contribute at least 50% of the target of bringing protected sites into favourable condition by 2042 and contribute 80 to 100% of the target to restore or create more than 500,000 hectares of wildlife-rich habitat outside of protected areas by 2042. If this expectation is realized, then it is no wonder that AES were one of the most mentioned interventions in the call for evidence responses (75% of responses mentioned this), as achieving these targets will certainly help towards increasing species abundance both within and outside of protected areas. However, these quantitative predictions of contributions to target delivery are not informative of the specific actions or schemes that will have the largest contributions to target delivery. Schemes in this category included the Sustainable Farming Incentive (SFI) and Countryside Stewardship (CS).

There were, however, criticisms of Government’s current approach to AES such as these. The criticisms mostly related to the design and delivery of the schemes as opposed to the ambition of the level of uptake of the schemes. Government set the intention to support 65 to 80% of landowners and farmers to adopt nature friendly farming on at least 10-15% of their land by 2030, which most (>50%) respondents to the call for information agreed was an appropriately ambitious level of uptake. However, some respondents, particularly NGOs and park authorities drew attention to the possible limitations of the design of the schemes, which could limit the benefits that are gained from even high levels of uptake. The consultation evidence pack was clear that successful outcomes from AES will be dependent on sufficient uptake of higher-level options (roughly equivalent to Higher Level Stewardship in past schemes) as opposed to entry level options. Respondents to the call for evidence raised the concern that the Sustainable Farming Incentive options being adopted by farmers at the moment likely fall short of the requirements necessary to see significant change in the indicator, and suggested that these options are not as economically effective as higher level options. For example, the RSPB highlighted that around 70% of farmers had previously engaged in Entry Level Stewardship (ELS) schemes at a cost of £1.5 billion, but that a large body of evidence that this did not deliver against key environmental objectives and therefore did not provide value for money[26]. There are concerns among stakeholders (particularly NGOs, researchers, and park authorities) that the free choice afforded to farmers within the SFI element of ELMs will allow farmers to select the options that they can effectively fit into their business, which will often be the easiest and generally least effective options that they may already be fulfilling. This risks absorbing much of the available budget whilst providing little additional benefit. However, this was countered by the representative bodies such as the National Farmers Union (NFU), who highlighted that free choice for farmers is important to increase popularity of the schemes and increase levels of uptake. Overall, the respondents to the call for evidence cited the need for these schemes to be backed up by sufficient funding, good advice and effective monitoring and evaluation in order for them to be able to deliver effective management for nature in the long-term.

As well as concerns surrounding the design of the schemes, most stakeholders (>50%) had concerns about the pace of delivery. Many schemes are still in their infancy or are still in their piloting phase, and currently the proportion of farmers managing at least 10% of their land under nature friendly habits are not close to the proportion required to meet the species abundance targets. Some responses to the call for evidence suggested possible mechanisms to address this could be bundling, increasing advice and support for farmers, or geographical targeting of schemes to ensure the most effective options are delivered at an appropriate density, but this needs to happen quickly in order for the benefits to be realized in the target delivery timescale.

Local Nature Recovery Strategies (LNRS) were highlighted by many stakeholders as playing a crucial role alongside ELMs. These are supported by other related legal mechanisms and policy such as the biodiversity duty, biodiversity net gain, protected area and species conservation strategies. Stakeholders recognized the opportunities that the LNRSs will bring to draw sectors together to plan how to achieve and deliver nature's recovery locally. They were described as mechanisms to enable policy delivery across sectors to be integrated to maximise benefits and provide strategic oversight.

[26] Sharps E, Hawkes RW, Bladon AJ, Buckingham DL, Border J, Morris AJ, Grice PV, Peach WJ (2023) Reversing declines in farmland birds: How much agri-environment provision is needed at farm and landscape scales? Journal of Applied Ecology 60:568–580.

However, concerns were raised surrounding the requirements for local planning authorities to ‘have regard’ to LNRSs in decision making. Many stakeholders believed that this wording in the Environment Act 2021 is too weak and could result in their potential effectiveness and benefit risks being significantly undermined in policy and decision making. There were also concerns about the availability of resources for the delivery of nature recovery actions that are to be identified thought the LNRS engagement process.

Targeted action for species

In addition to the broad scale ELM schemes and strategic oversight through policies such as LNRSs, many respondents (43%) to the call for evidence highlighted the importance of targeted actions for individual species. These targeted actions will likely also be beneficial and could help contribute towards meeting the species abundance target. Many NGOs gave examples of successful nature recovery stories stemming from targeted conservation action. For example, the Back from the Brink Project provides an example of how specific actions for individual species can help recover and protect their populations. Species focused initiatives such as tree veteranisation for deadwood specialists, pond creation and ditch management for aquatic species, as well as reintroductions and translocations, saw 96 priority species improve their conservation status and prospects, with further benefit reaching a total of 188 species[27]. Stakeholders acknowledged that actions in the EIP23 such as Species Conservation Strategies will be important to achieving similar success in targeting recovery for specific ‘at risk’ species. Despite this, stakeholders were concerned that the resources currently available for such work are inadequate to address the scale of the task and to stem the ongoing decline of species abundance in England. Others also raised the need for engagement, support, and investment in targeted actions to be ongoing, even once species have recovered, to match the scale of the need and ensure that the conditions required for those species to thrive are maintained.

Freshwater policy

18% of respondents believed that achievement of Water Framework Directive (WFD) targets will likely be central to underpin species recovery in freshwater environments, as these targets consider pollution from a wide range of sources, as well as other pressures on freshwater species such as physical habitat condition and invasive non-native species. However, the WFD target date is soon approaching (2027), and there are concerns among stakeholders that the targets set out in the Environment Act 2021 and the EIP23, do not sufficiently replace that of the WFD. There is concern that the targets in the Environment Act lack overall ambition and rely too heavily on monitoring and self-reporting. Without an overall target to act as a long-term regulatory driver of holistic action to improve the freshwater environment, stakeholders are concerned that there is a risk that improving the abundance and diversity of species in freshwater environments will not be a priority.

[27] ‘Programme Overview’, *Back From The Brink* <https://naturebftb.co.uk/> [accessed 16 November 2023].

Marine policy

The species abundance targets are primarily focused on improving terrestrial and freshwater species' abundance, with only a small number of species that can be considered truly marine included in the indicator. However, the EIP23 does include a number of marine-focused policies that will likely contribute to improvements in species abundance in the marine environment. Stakeholders suggested that improvements in marine species abundance will rely upon the availability of suitable wildlife-rich habitat and a reduction in the level of pressures experienced by species. The Marine Protected Area (MPA) targets set out in the EIP23 and the Environmental Targets (Marine Protected Areas) Regulations 2023 are to achieve favourable condition of 48% of features in MPAs by 2028, and this is increased to a target of 70% in favourable condition by 2042. Respondents who covered the marine environment in their response commented on how the targets set in the EIP focused exclusively on MPAs, and lacks clear direction on how to achieve other targets, including achieving Good Environmental Status under the UK Marine Strategy. Removing pressures such as unsustainable fishing practices within MPAs, and effective Marine Spatial Prioritization were outlined as key actions that can help to achieve these targets.

Other important actions

Other Effective Area-based Conservation Measures were highlighted by stakeholders as a potentially having an important role to play in helping complete the network of protected sites on land. However, it was suggested that criteria needs to be defined to ensure these areas are effectively delivering the aims and intentions of the 30 by 30 target.

Respondents to the call for evidence also placed a large emphasis on the importance of monitoring. Specifically, extended, targeted and invested monitoring of species, drivers and pressures, and the effectiveness of actions. Monitoring of these aspects were described as essential to delivery of the species abundance targets, as improvements in the resolution of biodiversity monitoring would allow a better understanding of the mechanistic links between species, community dynamics and drivers of change. More rapid feedback between these data and adaptive management will also help to maximise nature recovery and further develop predictive capacity.

Additionally, overarching education and awareness was highlighted as a key intervention missing from the EIP23. This included nature-based education in schools, but also for the general public and industry, to enable nature-centric decisions to be made by all.

Scale of action required

Many of the concerns raised by stakeholders about the delivery plan as laid out in the EIP23 were related to either the scale or pace of action. Stakeholders felt that there was a disconnect between Government's environmental targets and ambitions and their delivery plans. For example, some commented on the lack of integration of species into other environmental policies and were concerned that the actions were not joined up across different policy areas. There were also concerns that the ambition, and therefore the planned scale of action, was low compared to that needed to meet targets set by international agreements.

Most respondents to the call for evidence suggested that a ‘step-change’ in Government’s actions were needed in order to meet the species abundance targets and many agreed that both focused, local-scale efforts alongside landscape-scale actions would be required, with strategic oversight to ensure policy join-up across policy themes. However, the relative importance of individual actions within that are hard to determine based on the current evidence.

Pace of action required

Overall, there was little information on the planned pace of implementation of the actions outlined in the EIP23. Almost all of the respondents to the OEP’s call for evidence used the word ‘urgent’ to describe the pace of action that is required to meet the species abundance targets. However, many also noted that some of the actions are still in development or have not yet been implemented fully. Common justification for urgency from respondents was to ‘make up for lost time’, and to reduce the risk that the populations available become too low for recovery.

Enablers and barriers to improving species abundance

Respondents to the call for evidence were asked to outline what they saw as the main enablers and barriers to improving species abundance. Depending on the perspectives and approaches taken by respondents, the main themes arising from this question could be classed as either an enabler or a barrier to improving species abundance. For example, inadequate funding and resources to support species recovery work was one of the most quoted barriers to the achieving the species abundance targets. On the other hand, some stakeholders took the opportunity to highlight that longer term funding agreements would act as an enabler to encourage innovation and long-term commitment. Without such agreements there is concern that projects will not be able to challenge systemic issues but rather make smaller amounts of progress behind the ambition needed to reach the species abundance targets. For this reason, the lack of longer-term assurance of funding may generate issues for meeting the longer-term targets.

Another key theme that was covered by stakeholders related to addressing underlying pressures of biodiversity decline. If Government fail to address underlying pressures to biodiversity decline (e.g., climate change, invasive non-native species, pollution, and agricultural intensity), this could act as an important barrier to species recovery in the long term. While some benefits might be seen without addressing these underlying pressures with short-term measures, the background of continuing pressures will likely reduce the stability of ecosystems and the benefits will not continue. On the other hand, if these pressures are sufficiently addressed, this could increase the success of efforts and ensure that results are maintained in the long term.

Across all three realms (terrestrial, freshwater, marine) engagement with the general public, and stakeholders was identified as a key theme. A number of respondents highlighted that it was unclear from the EIP23 who is accountable for the outlined actions in the delivery plan, and that a continued lack of appropriate engagement and guidance could act as a major barrier to success. Alternatively, increased training and advice for those on the ground to help move towards the targets, and encouragement to the general public would act as an enabler towards achieving the targets.

Regulation and enforcement of environmental legislation was also highlighted as a key theme. Non-compliance to environmental regulation has acted as a barrier in the past. Stakeholders highlighted that while the regulations appear to be appropriate and ambitious, a lack of enforcement to ensure compliance has hindered progress. Therefore, a key enabler to achieving targets will be increased and effective enforcement.

Opportunities and recommendations

In assessing the evidence used to develop the legally binding targets for species abundance, and considering the knowledge gaps that exist, a number of opportunities have emerged.

1. The value of revisiting the scenario modelling work now that the indicator has been finalised and set into law is clear. Much of the modelling undertaken at the time of target development used Version 1 of the indicator, which contained only 670 species (56% of the final species list). This modelling work also used 2018 (the most recent data at the time of analysis) as the baseline from which future projections were modelled. Using only a small proportion of the species and an unrelated baseline year for modelling has potential consequences for both the feasibility of the targets and quantitative outputs of the models. The 2022 value of the finalised index will soon be available, so it will be possible to revisit the scenario modelling and feasibility assessments using the full suite of species and specified baseline year without needing to make assumptions about the recent (2018–2022) rates of decline in species abundance.

2. Related to the point above, there is also clear value in undertaking various sensitivity analyses on the scenario modelling to understand the significance of some of the assumptions made in the models. For example, in relation to ecological and political lags: as there was large uncertainty surrounding the likely lags that would be experienced these were not considered in the scenario models, which is unlikely to be

an accurate representation of what will occur in reality. If processes are uncertain the best approach is not to omit them, but to explore the consequences of that uncertainty through sensitivity analyses. Another example of this is in relation to the uptake of the ELM scheme. For the scenario modelling, it was necessary to make an assumption about the overall level of scheme uptake. However, no sensitivity of this assumption was made. One would expect to see repeated model runs for various plausible assumptions of uptake to enable an understanding of the importance and impact of this assumption. Such sensitivity analyses of critical assumptions can provide a formal mechanism for prioritisation by understanding which assumptions are critical in obtaining the desired response and which may be less so.

3. Also related to those opportunities outlined above is a recommendation to revisit the scenario modelling on a regular basis as more data becomes available and policies have had some time to be implemented. Government is required to produce an Environmental Improvement Plan every 5 years, so revisiting the modelled projections before future EIPs are produced will allow for an assessment of whether Government is on-track to achieve the targets, or whether an adapted approach to interventions is required. Such modelling exercises benefit from ground-based validation and therefore complimentary monitoring of actions and responses should be considered. This would provide a clear blueprint for evaluation, analysis and updating of the EIPs over time to ensure that targets are met.

4. Conclusions

Since work began to develop a legally binding target for species abundance, the species abundance indicator has significantly expanded its taxonomic coverage, now encompassing 1195 species. However, substantial taxonomic gaps remain, meaning the species abundance indicator is limited in its capacity to fully reflect the state of species abundance in England. While many of the included monitoring schemes adhere to rigorous standards, the apparent long-term financial insecurity of data collection programmes and potential biases arising from varying aims of data providers, present significant challenges. Transparency regarding the specific methodology used to calculate the indicator and information on how it will be presented is also lacking.

Despite these limitations, the legally binding biodiversity targets set by Government appear ambitious and achievable given appropriate and substantial action. The scenario modelling used to inform target levels, however, relied on many simplifying assumptions and limited data, which likely impacted the accuracy of outputs. Nevertheless, the Environmental Improvement Plan 2023 outlines broad actions, many of which are supported by stakeholders and evidence in the literature. In particular, tackling underlying pressures, engaging stakeholders, and enforcing regulations are crucial for achieving biodiversity goals. However, the plan lacks detailed timelines, prioritisation, and clarity on responsibilities for those working on-the-ground, which ultimately may hinder progress towards achieving targets if not addressed in the future.

Overall, given the time and data constraints during the development process, evidence suggests the indicator is based on robust monitoring of species abundance, and has the potential to be a key representation of the state of environment under Government's *Thriving plants and wildlife* goal. However, evidence suggests the indicator should not be used in isolation to guide policy decisions but can instead be used to help identify whether collective actions are achieving intended biodiversity outcomes. The process undertaken to set the ambition level of the targets, although based on limited evidence and therefore reliant on many simplifying assumptions, was based on the best available quantitative evidence at the time, resulting in targets that are ambitious yet likely achievable. Nevertheless, opportunities exist to improve both the utility of the indicator and likelihood of target achievement. Expanding monitoring and presenting accessory indicators for underrepresented taxa and key drivers/pressures of biodiversity decline would help to address biases and improve the utility of the indicator for informing policy action. Fully documenting the indicator development process and acknowledging key limitations in technical documentation will increase transparency, build trust and aid interpretation. Importantly, securing long-term funding for monitoring schemes would futureproof the indicator. Finally, there are also opportunities to enhance the scenario modelling to improve utility and accuracy. For example, revisiting the models with the finalised species list along with analyses of sensitivity of key assumptions and regular updates with new data and policy implementation progress could enhance their effectiveness and help determine if an adapted policy approach is needed.

5. Annexes

5.1 Annex A – Stakeholder workshop: meeting structure and findings.

One key component of our evidence gathering process was a series of stakeholder workshops, which were focused on understanding the monitoring schemes and data that feed into the species abundance extinction risk indicators. In particular, the workshops sought to understand the limitations, barriers and technical challenges associated with providing robust, consistent and reliable data with which to compose indices of change in species abundance and extinction risk. The objective of the meetings was to explore the extent to which the assessment and monitoring of species abundance provides a comprehensive, accurate and precise understanding of the state of species abundance, as well as how well this sits within the broader context of biodiversity monitoring.

Meeting Structure

Session 1: Exploring the data that underpin the species abundance indicator

In this first session of the workshop, we aimed to understand what delegates see as the essential criteria for data feeding into species abundance or extinction risk indices, and what the main technical challenges and barriers are to achieving this.
Following the issues discussed in Buckland and Johnston (2017)[28] and Buckland et al., (2005)[29] , and along with the UK Statistics Authority Code of Practice[30], we see the key principles are for an ideal data standard to be based on monitoring that constitutes:

- Representative sampling over space, time and of the species in the community of interest
- Sufficient sample size to ensure trends and effects can be detected with reasonable precision

And more generally that data should conform to trustworthiness, quality and value considering key issues such as data governance, orderly release of data, quality assurance procedures, consistent protocols, and accessibility. For the purposes of this workshop, we were not seeking to evaluate any particular monitoring programme and

[28] Buckland ST, Johnston A (2017) Monitoring the biodiversity of regions: Key principles and possible pitfalls. Biological Conservation 214:23–34.

[29] Buckland S t, Magurran A e, Green R e, Fewster R m (2005) Monitoring change in biodiversity through composite indices. Philosophical Transactions of the Royal Society B: Biological Sciences 360:243–254.

[30] https://code.statisticsauthority.gov.uk/the-code/

accept that any operational monitoring programme may not meet such criteria for myriad reasons.

Finally, the first session ended by considering what were the major risks associated with monitoring species abundance.

<table>
<tr><th>Item</th><th>Theme to explore</th><th>Specific questions to consider</th></tr>
<tr><td>A</td><td>What is the ideal standard for data contributing to an abundance indicator?</td><td>What considerations should there be for:
Survey design (e.g., spatial, temporal replication)
Field methods used
Taxonomic resolution
Targeted species
Security of continued monitoring
Analytical method
Do these requirements vary according to the taxa being monitored? If so, how?
Which of these requirements are <u>essential</u>?</td></tr>
<tr><td>B</td><td>What are the technical challenges data providers face in meeting these <u>essential</u> data requirements?</td><td>What confidence do data providers have in their data being used to track progress towards legally binding targets?
How well are uncertainties in the data communicated? Is the magnitude of uncertainty versus the scale of change considered?
What are the key sources of bias in the data? Have these been accounted for?
Robustness of monitoring programme in lieu of pressures from climate change, invasive species etc? Does the impact of these pressures affect the bias
Are there any issues with species detection that impact the quality/robustness of the data collected?</td></tr>
<tr><td>C</td><td>(considering questions A-B) What are the main concerns with data that do not fulfil these requirements?</td><td>How might the interpretation of the data be affected – now and in the future?</td></tr>
</table>

Session 2: Application of the indicator to monitor progress in species abundance

In the second session of the workshop, we considered the species abundance indicator as a whole. In recognising that there are multiple potential issues with summarising biodiversity data as indicators, we hoped to understand how these issues relate to the presentation of the England abundance index, and the assessment of the species abundance targets.

Specifically, we are looking to understand (i) the different ways in which the indicator could be interpreted, (ii) the different factors that can affect the interpretation of the indicator, and (iii) what other information about the natural environment can potentially be inferred from the indicator.

Abundance is just one measure of biodiversity - there are a multitude of different metrics that capture various aspects of biodiversity. In the second part of this session, we considered other measures of biodiversity and how they can complement the species abundance index. We were particularly interested in understanding how an indicator for species extinction risk can complement the species abundance index.

Item	Theme to explore	Specific questions to consider
A	**What are the key challenges and risks related to interpreting the species abundance indicator?**	• What, if anything, can the indicator tell us about the wider natural environment? • Is there anything else that can be inferred from the species abundance indicator (e.g., about the state of drivers/pressures affecting biodiversity, or the impact that declines/increases in abundance will have on the natural environment)? What are the risks of making these inferences? • Will the indicator be sensitive enough/too sensitive to detect 'significant' change? Lags between a change in the pressure and a change in the value of the indicator? • What influence does the choice of baseline year have on the interpretation? • How could the indicator be updated and what are the risks and opportunities associated in doing so?
B	**What other measures of biodiversity would most complement the species abundance indicator? And why?**	• Consider those published in the JNCC biodiversity indicators[31] and those reviewed in the OEP monitoring report[32]

[31] https://jncc.gov.uk/our-work/uk-biodiversity-indicators-2022/

[32] https://www.theoep.org.uk/report/progress-improving-natural-environment-england-20212022

		• There is also a legally binding target for species' extinction risk – how can an extinction risk indicator complement the species abundance indicator?

Attendees?

Thirteen organisations attended the workshops in total. This included a mixture of NGOs, Government agencies, arms-length bodies, research institutes and individuals. Some of the organisations that attended collect, analyse and provide data for the species abundance indicator, and others were involved in the development of the indicator. The following organisations attended the workshops:

British Trust for Ornithology (BTO)	Defra
Royal Society for the Protection of Birds (RSPB)	Biodiversity Targets Advisory group (BTAG) Members
Rothamsted Research (Rothamsted Insect Survey)	Forestry Commission
Queen Mary University London	Marine Management Organisation (MMO)
Bumblebee Conservation Trust	DAERA
Environment Agency	National Trust
Joint Nature Conservation Committee (JNCC)	

Main findings

What is the ideal standard for data contributing to an abundance indicator?

Below is a summarised list of the ideal standards for data contributing to an abundance indicator as suggested by the workshop attendees:

- Formal standardised sampling strategy - standardised protocol for data collection or a common data and assessments standards framework that is peer reviewed and repeatable.
- Data collected at regular time intervals to support annual reporting – aspiring to record daily with continuity and integrity of data and observations through time to aid inference.
- Comprehensive geographical spread of data collection – which can help to minimise geographical biases. The ideal standard would be to require a random or stratified random sampling design to help deliver representative data. This required overcoming land access issues by working with land owners to allow sampling on their land, and working with citizen scientists to generate encouragement to sample more remote locations.

- Other biases reduced by appropriate sampling design – e.g., data from each environmental domain, consistency through time, detectability, seasonality, apparency, identifiability.
- Ideally a mixture of different types of species should be recorded – generalists and specialists, pests and non-pests, rare and common (invasive and native?).
- Data collected needs to be a measure of species abundance, not a surrogate of abundance such as occupancy or percentage cover.
- Data should ideally be collected at species-level resolution.
- Data should go through verification/validation process to ensure high quality and to minimise mistakes. Could potentially be achieved by having an archive of samples to revisit.
- There should be a commitment to long-term monitoring via consistent long-term funding agreements.
- Ideally the monitoring should allow new methods to be used without damaging the statistical legitimacy of the indicator.
- Sampling design and analysis should incorporate a measure of error and allow quantification of uncertainty.
- Inclusion of citizen scientists in data collection.
- Adequate repetitions to allow sufficient power to detect real changes in abundance.
- Ability to aggregate and disaggregate data to highlight trends in different groups of species (e.g., Freshwater vs marine vs terrestrial).
- Flexibility – taxonomy seldom sits still.
- Should conform to FAIR data principles – 5* linked open data.

Which of these requirements are essential?
Below is a summary of the criteria that were considered essential by those in each of the breakout sessions of the workshop. Similar criteria between breakout groups have been grouped in rows where possible. There is a high degree of overlap in the essential criteria outlined between groups of stakeholders:

Breakout 1	**Breakout 2**	**Breakout 3**	**Breakout 4**
Standardised protocols	Standardised protocol with continuity of observations	Consistency and repeatability year to year	Consistency (robust) and continuity of monitoring methods. BUT needs to be flexible (keep in mind improving technology)

Spatially representative of England (geographic/geoclimatic gradients)	Comprehensive geographical spread	Limitation of bias – good representation (ecosystem, geographic)	Representation of different habitats
Repeated surveys at appropriate temporal intensity	Repeated at regular time intervals to support annual reporting	Good coverage with appropriate temporal monitoring regime across taxonomic groups	consideration of the ecology of species, so the distribution, climate change, invasive non-native species. migration/ life stages are IDable/ lifestage is surveyable.
Replication (enables uncertainty quantification)	Transparent and consistent uncertainty and error assessments in the analysis of the data across all monitoring programmes	Sufficient/appropriate sample size to have confidence in what data is telling us	Quantified measure of uncertainty
Sensitive to real change (sample sizes large enough to capture change)	Sample sizes large enough to confidently capture anticipated change	Continuity of data providers – future proofing data collection	
Representative but separable of different environments, groups.	Ability to aggregate /disaggregate with other datasets for producing a composite indicator and identifying specific trends.		Breadth of species - suited to the spirit of the target. Need to account for what purpose the indicator needs to fulfil
	Continuity of data providers – future proofing data collection	Secure long term monitoring regime (funding, capacity etc)	Long term reliability of monitoring
Consistency in measuring real abundance	A measure of species abundance – not a surrogate		
Species-level recording	Species-level resolution		
		Robust QA and QC process (appropriate training and accreditation – includes citizen scientists).	Peer review and expert opinion (e.g., taxonomic resolution).
			Consider data in terms of the code of practice for statistics

What are the technical challenges data providers face in meeting these essential data requirements?

Below is a list summarising the main challenges data providers face in meeting the essential data requirements. The challenges are broadly separated into the key themes identified:

- Drivers of monitoring
  - Where data are taken from existing programmes driven for other needs, the scope for targeting /reducing spatial bias is limited.
  - This could mean that the core remit of the data provider may not be perfectly aligned with that of the indicator requirements.
  - Data may be collected for a different reason.
  - E.g., EA Taxonomic resolution: The data we collect are done to a defined and constrained list of taxa depending on the monitoring method. Therefore not all species present within a sample / survey / site are captured.

- Long term and existing data meets only some of the essential criteria. Do we give up and start again or repair by design or analysis?
  - Comparability between repeat surveys with changing and improving technology.
  - Insufficient data of a taxon group to be of use.
  - Recording large enough numbers of less-abundant species to generate trends.
  - Accessibility of sites - Spatial/geographic constraints - the willingness of the landowner to host a sampling event/trap.
  - Methods (EA) the methods we use are often based on legacy techniques and understanding and so limited in the resolution they can supply. Newer technology and techniques (molecular based) could help overcome this.
  - How to update methodologies without causing issues to the long-term datasets.

- Embrace new technology, but need to understand what it is telling us first - and how that relates to the other methods - running the methodologies in parallel, but that requires time and money.

- Capacity in the market for surveyors, volunteers, etc to do the field work.
  - Acts of public good (volunteering etc) are compromised by overworked workforce with little time.
  - Time/availability of recorders, especially for long-term surveys or those with complex methodologies.

    - Ensuring that volunteers do correctly identify all species that appear in the sample.
    - Consistent surveyor effort over time & area (i.e., volunteer numbers from year to year)

- Species biases and other biases.
    - Charismatic insects attract recorders. Ugly or cryptic groups often have just a few recorders (e.g., compare soil inverts, like worms, with butterfly recording).
    - Link taxonomic resolution and skills available - e.g., easier to identify grass families, harder to identify grass species- so should we focus on monitoring families?
    - From an aquatic perspective our data availability depends on existing programmes so favours particular taxonomic groups and ecosystem types.
    - Some species are technically difficult to identify and therefore require higher levels of expertise and resource.
    - Monitoring species migration - need either flexibility to move monitoring sites or good spatial coverage to start with.
    - Hard to survey some habitats. So there is a bias towards those easy to access and/or survey.
    - Even within places/sites, land access limitations or simply 'paths of least resistance' can lead to potentially unintended biases e.g., using transect based methodologies will lead to a bias towards linear features etc.
    - Monitoring data includes pollution tolerant species, therefore increase in abundance needs expert interpretation.

- Data mobilisation can be very difficult with different organisations wanting ownership of the data.
    - Communication/sharing of protocols between/within networks and other researchers.
    - Government Statistics Protocols. Some data collected may fall under this, which then limits who can see data and when. Might these timing constraints limit the use of data, especially where a question involving a more immediate timeframe is being asked.

  - Fragmented data landscape - knowing what is out there to make use of is challenging.

- Additional monitoring that needs to be done in order to link changes to drivers.
  - Linking biotic data to data on the drivers of biodiversity loss (invasive species, parasitic infection, pathogens, exotoxins, nutrient and organic pollution etc as well as habitat loss).
  - Lack of physico-chemical monitoring (in freshwaters, chemical monitoring in particular) paired with the biotic monitoring, which is robust and fit-for-purpose. UK water quality monitoring is not fit for purpose (space, time, contaminants).

- Lack of a coherent monitoring strategy and monitoring community with a common purpose.
  - The distribution of surveyors can mean that some places are over-sampled and others are under-sampled.
  - Health & Safety. It limits what recorders can do (understandably).

- Lack of funding and political will to support technical advances.
  - There is inadequate resource (staff and money) provided by Government to allow the level of monitoring, quality assurance, replication, biotic groups environment types and training required.
  - Cost/funding availability, esp. long-term - training, verification/validation (expertise), etc

- Staff expertise especially taxonomic is generally shrinking nationally.
  - ID ability - cryptic species, hidden species, recorder abilities, taxonomic confusion. Especially for less-known species, smaller, etc.
  - Resilience and geographical distribution of technical expertise for some taxonomic groups.
  - Species detection- need skilled botanists, entomologists, etc, for manual surveys. Need robust data for ground truthing novel technologies that do not require species identification skills e.g., remote sensing, acoustic devices. Also- skills in handling large datasets e.g., DNA - need highly trained specialists

    - Skill gaps: We struggle to develop and maintain the skill sets required to provide the resolution in the data needed for this indicator. This is in part down to the boom / bust funding regime we have been in, in recent times.
    - Limits to capacity and expertise relating to particular species groups, habitats, survey methods, Code of Practice for Statistics, etc.
    - Expert opinion to understand interconnections - trends and their wider context

- Long-term and consistent resourcing for monitoring schemes.

- Spatial grain affects standardised protocols. E.g., compare soils which vary over just a few metres, to aerial fauna which vary over 50m>km

- Limitations of scientific knowledge is an unavoidable bias. Can't measure what we don't know exists (which might otherwise impact survey design).

- Robustness to climate change - e.g., changes in phenology with changing climate. How to correct for this, should we correct for it?

What are the main concerns with data that do not fulfil these requirements?
Below is a list summarising the main concerns with data that does not meet the essential data requirements outlined above. The concerns are broadly separated into the key themes identified:

- Data collected outside a standardised framework is susceptible to changes driven by changes in the recording framework rather than changes in the species abundance/occupancy.
    - The data may not sufficiently sample species abundance so change in the index would not reflect genuine species abundance change.
    - An 'inadequate' dataset may be altering the true abundance trajectory and/or magnifying uncertainty around the trend.
    - The data could mask or make it more difficult to detect change.
    - The amount of statistical error around the composite index could swamp out any genuine change.

    - Data uncertainty / quality: If these two aspects are not maintained and kept consistent, then the end data may have so much noise in them as to make any trends in them meaningless or masked.
    - Decisions being made on the basis of unreliable understanding. This can lead to reputational risk/lack of credibility

- The data may not be sufficiently representative to ensure the indicator represents changes in “species abundance in all England”.
    - Some environments and biotic groups are excluded or masked within the indicator, if they are not sampled in a robust and representative way – e.g., rolling freshwater ecosystem indicators in with terrestrial indicators (dominated by moths/butterflies has masked freshwater biodiversity decline and allowed it to continue.
    - If all taxonomic groups are not adequately represented, you will not get the whole picture e.g., one grouping apparently doing well may mask decreases in other groups.
    - If we don't include all different habitats , we might just fund improvements to improve the species abundance of those that we are surveying.
    - Not including groups that require more resource and/or expertise to identify will also skew results.
    - Skewed results could result in funding for some groups being cut.
    - E.g., data collected by the EA might be collected to help us understand a pressure rather than give an accurate reflection of the state of the environment. So sites that are heavily impacted are over-represented. Or it could be vice versa for access reasons. However, the methodologies need to reflect that data collection might not be for the purpose of monitoring species abundance.
    - Taxonomic coverage - including data on undesirable or negative indicator species might cause the indicator to go in the direction we want, but for the wrong reasons

- The main concerns are how the evidence is then used to influence policy, funding and management. Does it recognise that the data is a proxy. does it reflect that our ecology will change under climate change.
    - Risk of misinterpretation and misuse (especially for political end).

- Wasted time/effort- if data cannot be used, what was the point in collecting it? If a citizen science project, citizens may be upset if their data is not used, bad PR, fuels scepticism, decline in motivation.
    - Wasted resource - wasted investment - if data cannot be shared.
    - Indicators may not be as trusted, e.g., by policy makers and the public.
    - Unusable by government if not up to standards of code of practice.
    - Risk of dis-engagement (perhaps only relevant in a citizen science context): If a scheme is inappropriately sold as trying to achieve a particular objective (e.g., informing government policy) but doesn't end up meeting these requirements, it does risk future engagement and/or credibility.

- We could prevent monitoring from developing methodologies as they a required to use an older methodology. But on the other hand - combining data of differing quality might cause trends from poor quality data to mask the more reliable trends from better quality data

- Without study of drivers, trends alone offer no indication of the solutions needed.

What, if anything, can the indicator tell us about the wider natural environment or drivers affecting biodiversity?

- It can tell us that there is a change. But not very much about what it is driven by.
- The indicator can tell us very little, as there are too many conflicting drivers. We need to be monitoring for these drivers in parallel with biological monitoring to link the two.
- Provides a broad-brush measure of biodiversity change in the environment and hence ecosystem function and health.
- Provide a sign that we need to do more / invest more / have more focus.
- Tells us about what is happening to the species/groups included - not necessarily whether this is good/bad (e.g., invasive/thug species increasing). Not necessarily representative of whole system.
- Very broad trends. if looking at group of species it can start to give you an indication on trends for those species.. It is more of a sign post. You would need to look at the specific species or trend more closely to understand what the indicator is telling you.
- Indictor D4a can be used to provide an assessment of the general condition of the English environment. It cannot be used, with confidence, to assess specific drivers.

- The indicator could tell us about broad environmental quality on average, if species abundance goes up it is probably safe to assume that is because environmental quality has gone up, but would not be informative for specific habitats or drivers.
- The indicator can tell us if the target been met - in terms of what it can tell us beyond that it depends on how it is presented
- There is a simple assumption that if there are more individuals of a species (on average) present than before then the environment (on average) is improving.
- There is the potential for creating sub- abundances indices that are proven to respond to certain drivers.
- With associated research to disaggregate and analyse trends against drivers, one would begin to understand drivers, i.e. why things are changing.
- Comparison to progress in other countries.
- Linked to the Apex target - can't interpret one target without looking at the others. Need to understand interdependencies between the targets. Important to work out the "so what".

What are the key challenges and risk related to interpreting and making these inferences from the species abundance indicator?

- Top-level figure hides lots of changes for individual taxa/sites/etc, even if the mix of species/sites is wholly representative.
    - Improvement on average may hide deteriorations in specific instances, and thus draw attention away from areas which need it.
    - Risk of headline taken as gospel - despite nuances of individual species/groups.
    - Some species groups more variable with year - year weather patterns.
    - Simple bias from unweighted taxonomic groups (nos. of species).
    - Communicating this aggregated indicator will be very tricky. It is likely to be used by organisations to back up points that might not be accurate.
    - Explaining subtleties in the data in a clear and non-technical way.
    - Some species doing well could mask significant declines in other key species.
- Trade-off between representativeness, incorporating more data sets, vs 'blunting' of the responsiveness of the indicator
- Are we confident that the indicator will detect the change that the target requires - and on what timescale?

- The species will be responding to multiple stressors that vary in time and space, including but not only climate change. Drivers of species loss for one species may be different that those driving other species (relative risk and sensitivity to different drivers).
    - Key risk is misattribution of drivers of biodiversity loss across biotic groups/environments/time periods, and therefore misdirection of biodiversity loss mitigation efforts.
    - Key challenge is to revise national monitoring of drivers so that it is fit for purpose and captures the range of drivers of biodiversity loss across all environment types.
    - Many explanatory factors affecting different species make it difficult to disentangle causation - e.g., one species could be more affected by air pollution, another more by temperature - and monitoring abiotic factors.
    - We don't know everything behind what creates increase in species abundance - species interactions will change - e.g., through succession/ lags in change, hard to make inferences on what actions did what.
- Being aware of the gaps in coverage, so being clear on the scope of coverage.
- Maintaining long term monitoring/data sets is a challenge/risk.
- 2030 abundance goal is 2030 vs 2029 - risk of how trends until then will be interpreted - we're basically expecting declines to continue for another 5 years.

What other measures of biodiversity would most complement the species abundance indicator and why?

- Need to breakdown indicator into component parts – e.g., terrestrial, freshwater, marine taxa
    - Habitat-specific abundance reporting would be useful to show which habitats we need more of (and which less of).
    - Species abundance broken down different ways - regionally, habitat, functional groups perhaps
- Very dependent on the question! E.g., habitats, north vs south, protected vs unprotected sites, etc
- Indicators of distribution
- Other environmental change
    - such as land use, PA area, agri-env area, habitat creation and restoration statistics, weather variables etc

    - other indicator trends including non-wildlife e.g., pollution.
    - A number that describes the magnitude of relationships between biodiversity and different explanatory factors e.g., temperature, LUC, air pollution, etc, and indicators of change in explanatory factors, in different habitats/regions - then map drivers of change.
    - Linking species data to habitats as a measure of habitat/ecosystem health and condition.
    - Looking at the habitats alongside species, would help to describe represent that their trends are linked. so for water looking at the morphology of the river alongside the species gives a much better understanding of the state of the environment.
    - Measurement and reporting on pressures on species to provide proxy measure while species take longer to respond positively.
    - Invasive species - a decline of these could be a good indicator.
    - Soil health - inter relationship between species abundance and soil health.
    - % of protected sites in favourable condition.
    - Naturalness of physical processes/function - links to species diversity and abundance.
- Species Extinction Risk e.g., a RLI provides a useful complement to Abundance, reflecting both aspects of biodiversity crisis. There is some overlap in the use of data however. Red listing uses a range of criteria including abundance and PVA, but also range data.
- State of Nature uses other species indices which may be useful corroboration/otherwise.
- WFD good ecological status - could explain patterns based on environmental pressures.
- The England Priority Species indicators may help provide additional perspective as covers both abundance and range.
- Adopting environmental omics approaches to enrich the information on 'who is or was there' - eDNA and 'who is active/alive/functioning and not dormant' – eRNA.

5.2 Annex B - Methods to generate raw species indices

Table B1 & Table B2

Table provide a summary of the abundance datasets included in the indicators. They show the analytical methods used to generate the species' time-series in each dataset.

Table B1: Summary of the analysis methods and criteria for species selection for bird datasets

Monitoring Scheme	Time period	Data Type	Species selection method	Analysis method
Seabird Monitoring Panel (SMP) and Seabird censuses	1986-2018	Unsmoothed index	Very small colonies and colonies where counting error is known, or suspected, to exceed 5% are excluded from SMP time-series. The accuracy of time-series obtained using the SMP sample was assessed by comparing them with data from 2 complete censuses of all breeding seabirds in the UK. A time-series was rejected as inaccurate where a discrepancy of more than 15% occurred between the SMP estimate and the census figure (Thompson *et al*. 1997).	For the majority of species, a combination of SMP and census data is used. The 2 census estimates are used, with linear interpolation for the intervening years. The SMP time-series is anchored to the 2nd census estimate and used in all subsequent years. For a small number of species, the census data alone is used.
Time-series used in England breeding bird indicators	Various	Unsmoothed index		Various, depending on the original dataset, all those used are described below
Statutory Conservation Agency and RSPB Annual Breeding Bird Scheme (SCARABBS)	Various	Population estimates from 2 or more national surveys	These surveys are designed to be in depth surveys for a particular species and so have sufficient data to allow population trends to be robustly estimated.	Linear interpolation was used to estimate annual values for years between national surveys.
Common Bird Census/Breeding Bird Survey (BBS) joint trends	1970-2018	Unsmoothed index		Unsmoothed population time-series were generated from a log-link linear regression with Poisson errors fitted to site x year data (BTO 2014a).

Breeding Bird Survey (BBS)	1995-2018	Unsmoothed index	Data from the BBS surveys were only included for species for which the BBS methodology is appropriate, and which are recorded in on at least 30 BBS squares per year of the survey period.	Unsmoothed time-series are estimated using a similar procedure to the CBC/BBS joint trends described (BTO 2014a).
Rare Breeding Birds Panel (RBBP)	Various, ~1970 - 2017	Annual estimate	Species were removed where survey effort was thought insufficient to generate a reliable trend. Additionally, species where individuals were only infrequently present in the UK (taken as species where the maximum count was 10 or less and the median was three or less), were removed.	Linear interpolation was used to estimate any missing data.
England Wintering Waterbird indicator	1968-2017	Unsmoothed index	Derived from the Wetland Bird Survey (WeBS). For core species observers record quality of visit (visibility, areas missed) and poor-quality site visits are excluded. Only sites with a good level of coverage are used (≥ 50% of possible visits undertaken) Further details of analytical methods are published (BTO 2017; Maclean & Ausden 2006).	As for BBS time-series

Table B2: Summary of the analysis methods and criteria for species selection for other taxonomic groups

Group	Dataset and provider	Time period and Data Type	Species selection method	Analysis method
Moths	English moth trends from Rothamsted Insect Survey light trap network (1968 to 2016)	1968-2016, TRIM annual index.	Data for 766 moth species were analysed using data from Rothamsted Insect Survey light trap network (Harrower *et al*. 2019). The 766 species that were analysed are mostly macro-moths as the majority of micro-moths had to be excluded due to inconsistencies in their recording over the time period. Of the species analysed 423 species produced reliable trends based on expert assessment of the underlying data and the analysis results.	The Generalised Abundance Index (GAI) methodology proposed by Dennis *et al.* (2006) was used to produce English abundance trends. This methodology involves estimation of standardised annual flight periods curves for each species. These flight curves are used to estimate the annual total abundance for each site whilst correcting for gaps in the surveying. Poisson regression models, with site and year explanatory variables, are then fitted to the estimated annual total abundance values to determine the abundance trends and also yearly abundance indices. Confidence intervals were produced by bootstrapping (1,000 samples).
Moths	Butterfly Conservation	~2000-2016. TRIM annual index.	Expert opinion (Mark Parsons – Butterfly Conservation) was used to judge whether the number of sites monitored was sufficient to represent the national time-series, given each species' distribution.	Site x year Log-linear Poisson regression models in TRIM (Pannekoek and van Strien 1996) were used.
Bats	National Bat Monitoring Programme (Bat Conservation Trust)	1997-2018 Unsmoothed index.	A power analysis determined that across all surveys, a sample size of 30-40 repeat sites (surveyed for more than one year) would give sufficient data to calculate robust species time-series. This would provide 90% power to detect a decline of 25% over 25 years (0.1 sig. level). Borderline cases are judged based on the quality of the time-series, primarily from the confidence limits (Walsh *et al*. 2001, Bat Conservation Trust 2013).	As BBS time-series (Barlow *et al.* 2015). In addition, mixed models are used to investigate factors that could influence time-series (e.g., bat detector make, temperature). Over dispersion is a problem for bat detector surveys, where a single bat repeatedly flying past the observer may give rise to a large count of bat passes. Based on the results of simulations a binomial model of the proportion of observation points on each survey where the species was observed is used.
Terrestrial Mammals	Breeding Bird Survey (BTO)	Unsmoothed index	Data from the BBS surveys were only included for species for which the BBS methodology is appropriate, and which are recorded in on average 30 BBS squares per year of the survey period.	Unsmoothed time-series are estimated using a similar procedure to the CBC/BBS joint trends described (BTO 2014a).

Freshwater Invertebrates	Environment Agency BioSYS	2013 – Unsmoothed index	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. Taxa that were very rare (< 100 records) were excluded.	The data are counts with repeats across the season. Converted the sample counts into annual indices of abundance using linear mixed effects modelling framework. For each taxa, model with log10(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 were fitted. The year effects from each model are estimates of the annual abundance for the taxon in question.
Vascular Plants	National Plant Monitoring Scheme	2015 – Unsmoothed index	Unclear	Unclear

5.3 Annex C – Call for evidence summary data

The OEP launched a call for evidence in May 2023 to establish whether government's plans and delivery methods will achieve the species abundance targets, and whether they detail and address the major barriers, enablers, synergies, and trade-offs within and across policy areas.

The key questions asked were:

- Considering the government's species abundance targets, to what degree do you consider these achievable in England's terrestrial, freshwater, and marine environments? What assumptions affect your consideration of feasibility?
- Considering the 8 areas of action set out in EIP23 and other actions, what are the main interventions, or types of interventions, required to achieve the species abundance targets in England's terrestrial, freshwater and marine environments. Regarding these interventions, what scale and pace of deployment is required to achieve success?
- What are the enablers and barriers to improving species abundance in the terrestrial, freshwater, and marine environment, and achieving the species abundance targets?
- What are the synergies and trade-offs in improving species abundance in the terrestrial, freshwater, and marine environments, and achieving the species abundance targets?
- What are the key uncertainties and knowledge gaps in assessing the achievability of the targets?

For each question, specific sub-questions were also developed (outlined in Section 2) to help draw out the key information (detailed in the Methodology section of the report). Where these sub-questions had been answered, responses were categorised based on these answers. In some cases the respondents did not explicitly answer the questions set out, so the sub-questions and categorisations were key to helping pull out the key themes from the responses.

The OEP received 28 responses to their call for evidence in total (Table 2). The responses were from a number of different types of organisations, including Government organisations, Non-Governmental Organisations (Non-Governmental Organisations), park authorities, professional institutes, representative bodies, and research organisations. The most represented group by far was NGOs (60% of responses), some of which represent particular groups of species (e.g., Amphibian and Reptile Conservation, Bat Conservation Trust, Butterfly Conservation, Seal Research

Trust), while others represent the wider environment (e.g., Green Alliance, National Trust, Wildlife Trusts). The focus of the responses from the organisations that represent particular groups of species tended to focus not only on the relevance of the questions to the groups of species they represent, but also commented on the suitability of the indicator, targets and delivery plan more generally.

Table 2: Number of responses in from each type of organisation.

Government Organisation	NGO	Park Authority	Professional Institute	Representative Body	Research
3	17	2	2	2	2

Question 1

Overall 18 out of the 28 (64%) responses explicitly stated that the 2030 species abundance target is achievable. Those remaining, either assumed that the current trajectory of policy would continue, and political will would remain insufficient to generate the change needed to meet the target, or did not explicitly say whether they thought the target was achievable or not achievable (instead highlighting that the target would be challenging or difficult to achieve). In most cases a number of assumptions were made, which enabled the respondent to come to the conclusion. Some of the most mentioned themes for these assumptions were the level of political will (29% of responses mentioned this as an assumption), level of funding/resources (29%), pace of action (25%), and ecological lags/response time (21%). A complete list of themes used for categorisation for this sub-question is shown in Table 3.

Table 3: Themes of the assumptions respondents made to come to the conclusion of whether the 2030 target is achievable, and number of responses that mentioned each theme.

Theme	Number of responses	Theme	Number of responses
Level of political will	8	Political lags/response time	3
Level of funding/resources	8	Scale of change	3
Pace of action	7	Tipping points	2
Ecological lags/ response time	6	Compliance	2
Current trajectory	4	Interim targets	1
Climate change impacts	4	ELM uptake	1
Enforcement	3	Habitat health	1
Business as usual	3	Emission rates of nitrogen	1
Evidence gaps/needs	3	Invasive species	1

Question 2

The interventions mentioned by respondents were categorised (if possible) into the areas of action outlined in the EIP23. Although there are 8 areas of action set out in the

EIP23, two did not directly relate to England, so only 6 were considered. The frequency with which each area of action was mentioned is outlined in Table 4.The most discussed area of action was ‘creating more joined up space for nature’ (89% of respondents discussed this area), followed by 54% who mentioned restoring protected sites on land. The areas of action that were discussed the least were ‘managing our woodlands for biodiversity, climate, and sustainable forestry’ (25%) and ‘enhancing nature in our marine and coastal environments’ (29%). This generally reflects the types of organisations that responded – i.e. there were fewer organisations that have a marine/woodland remit, resulting in fewer answers that talked about these actions in detail.

Table 4: Areas of action in the EIP23 relating to England and the number of responses that mentioned each area as a type of intervention required to meet the 2030 species abundance target.

Area of Action	Number of responses
1) Creating more joined up space for nature on land	25
2) Restoring our protected sites on land	15
3) Managing our woodlands for biodiversity, climate, and sustainable forestry.	7
4) Enhancing nature in our marine and coastal environments	8
5) Taking targeted actions to restore and mange species	12
6) Mobilising green finance and the private sector	10

Within action area 1 ‘creating more joined up space for nature’ 75% of all 28 respondents discussed agri-environment schemes (AES)/ELMs as an intervention that was required to meet the 2030 species abundance target. Some of these responses went into the finer details of the different schemes (e.g., Countryside Stewardship, Landscape Recovery, Sustainable Farming Incentive etc) – see section 3.3 for detailed points, but the majority discussed AES more broadly. The second-most mentioned intervention type within this theme was local nature recovery strategies (57% of all respondents believed this intervention would be required to meet the target).
The two most mentioned options under action area 2 ‘restoring our protected sites on land’ were the Protected Landscapes Outcomes Framework, and Protected Sites Strategies (27% of respondents that discussed action area 2 mentioned these), but most responses that considered this area of action in their response talked about it broadly, without reference to specific interventions.

The majority (>50%) of respondents that discussed action area 4 ‘Enhancing nature in our marine and coastal environments’ believed that highly protected marine areas (HPMAs) and improved MPA measures were required to meet the species abundance target. Other interventions such as Fisheries Management Plans (FMPs), Marine

Spatial Prioritisation, and Restoring Meadow Marsh and Reef habitats were also important (38% of respondents that discussed action 4 mentioned these).

Of those that discussed ‘targeted actions to restore and manage species, 67% highlighted Species Conservation Strategies and the Species Survival Fund as being important interventions.

A list of interventions that could not directly be linked to any of the areas of action listed in Table 4 are presented in Table 5. Reducing pressures and drivers of biodiversity decline included reducing intensive agriculture (39% of all 28 respondents), tackling pollution (36%), tackling invasive non-native species (29%), tackling climate change (21%), and Reducing sewage in waters (7%). Funding and resources covered both economic resources and investment in skilled personnel. Monitoring not only included the monitoring of species, but also the monitoring of pressures/drivers, actions and evaluation of outcomes.

Table 5: of interventions that could not directly be linked to any of the EIP areas of action and the number of responses that mentioned them

Intervention Type	Number of responses
Reducing pressures and drivers of biodiversity decline	19
Funding and resources	14
Monitoring	12
Maintaining current legislation (including EU-derived regs)	10
Advice for farmers and land mangers	9
Enforcement	9
Other Effective area-based Conservation Measures (OECMs)	5
Planning	4
Rewilding	2
Education and awareness	1

In total 22 out of the 28 responses (79%) used the word ‘urgent’ to describe the pace of action required for the interventions they discussed in order to meet the 2030 target for species abundance. There were no other themes identified for the pace of action. There was a range of themes for the scale of action. These generally depended on how the respondent had interpreted the question – some considered spatial scales (e.g., landscape-scale actions vs local-scale actions), while others considered temporal scales (e.g., long-term measures, supported by multiple interim targets), or political scales (e.g., joined-up/strategic/cross-departmental action, or actions that were coherent with international commitments). The most important theme for the scale of action required, where > 50% of responses agreed, was ‘joined-up/cross-departmental/strategic action’ (57%). 46% of responses wrote that a ‘step-change in policy’ was needed to meet the targets.

Question 3

The main enablers and barriers listed by respondents are presented in Table 6. The most mentioned theme was resources. Having sufficient resources was seen as an enabler, whereas a lack of resources was discussed as a barrier. There were sub-themes within the resources category (economic and skills). While all of the 17 responses that mentioned resources talked about the implications of not having enough economic resources, only 5 also talked about what influence this has on the skills capacity of the work force and volunteers conducting monitoring. This is related to the second most popular theme of monitoring and research. Increased monitoring and research was seen as an enabler as it increases understanding about species and their responses to drivers. Discussions about monitoring and research were not limited to species only, many also considered the benefits of environmental monitoring alongside species monitoring.

Table 6: Key themes of enablers and barriers mentioned in response to Question 3 and the number of responses that mentioned each theme.

Theme	Number of responses
Resources (including economic and skills capacity)	17
Monitoring and research	14
Engagement with stakeholders	11
Addressing underlying pressures	10
Governance	7
Planning	7
Regulation and enforcement	6
Willingness and motivation	4

Question 4

The identified themes of synergies and trade-offs in improving species abundance and achieving the species abundance target are presented in Table 7

Table 7: Themes of synergies and trade-offs in improving species abundance and achieving the species abundance target and the number of responses that mentioned each theme.

Synergies		Trade-offs	
Theme	**Number of responses**	**Theme**	**Number of responses**
Cross-environment benefits	9	Competing land users	6
Healthy ecosystems (including increased ecosystem services/ resilience)	8	Tree planting	6

Increased human health and wellbeing	7	Converting habitat types	5
Tackle climate change	7	Species priorities	3
Healthy economy	5	Resource security (e.g., timber, food)	3
Productivity and soil health of farmland	5	Prioritising outcomes/objectives	2
Help to meet other targets	4	Popular non-native species	2
Cross-species benefits	3	Competing users in the marine environment	1
Reduce need for chemicals on farmland	3	Disturbance of species by humans	1

Question 5

The identified themes of knowledge gaps and uncertainties in assessing the achievability of the species abundance target are presented in Table 8.

Table 8: Themes of knowledge gaps and uncertainties in assessing the achievability of the species abundance target and the number of responses that mentioned each theme

Theme	Number of responses
Monitoring data	16
Climate change data	10
Governance	7
Enough funding	4
Which species will benefit	4
Which actions should be prioritised	3
Scale required	2
How the indicator will be presented	2
Species baselines	1
Mechanistic understanding of action and response	1
How to integrate biodiversity with other policy	1
Outcomes	1
Quality and access to data	1
Subjectivity of ‘good’ and ‘successful’	1
Who is responsible for actions	1

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