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The making of imperfect indicators for biodiversity: A case study of UK biodiversity performance measurement

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Abstract

This paper seeks to understand the process by which biodiversity performance indicators can be developed. In doing so, this paper examines how biodiversity performance measurements are inherently imperfect and reflects on the implications of that imperfectness. Using document analysis and semi-structured interviews, this research outlines the case of the UK Department for Environment, Food and Rural Affairs and their work in developing biodiversity indicators. Based on the concept of imperfect measurements, this paper outlines the conditions under which imperfect biodiversity indicators can be productive measurements leading to fertile debate and constant improvements, rather than flawed measurements that actors 'make do' with. This paper concludes the biodiversity indicators construction process requires a collaboration between a broad set of diverse organisations, including NGOs and research centres. Lastly, this paper outlines the need for ongoing and rigorous review of adopted measurements to reduce the potentially harmful nature of imperfect biodiversity performance measurement.

KEYWORDS
biodiversity accounting, biodiversity indicators, imperfect measurements, performance measurement, sustainability accounting and reporting

1 | INTRODUCTION

In 2019, a report published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) identified a 47% decline in the condition and extent of natural ecosystems compared to the earliest estimates available. The report also stated that more species on earth are now threatened with extinction compared to any other time in human history (IPBES, 2019). Thus, the IPBES report concludes that global biodiversity[1] can only be saved through 'transformative changes across economic, social, political and technological factors' (IPBES, 2019, p. 6), including businesses and organisations.

While many organisations are aware of the importance of measuring and understanding their biodiversity performance, challenges exist in developing decision-useful biodiversity indicators that enable organisations to measure and report their impacts on biodiversity and the environment more general (Addison, Carbone, & McCormick, 2018). When assessing the sustainability reports of the top 100 out of the 2016 Fortune 500 companies, Addison, Bull, and Milner-Gulland (2018) found that less than half of the reports mentioned biodiversity and only a third made clear biodiversity commitments. Furthermore, only five reports included biodiversity

LIST OF ABBREVIATIONS/ACRONYMS: CBD, Convention on Biological Diversity; DEFRA, Department for Environment, Food and Rural Affairs; GRI, Global Reporting Initiative; IPBES, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services; JNCC, Joint Nature Conservation Committee; NGOs, non-governmental organisations; SDGs, Sustainable Development Goals.

commitments that were time-bound and measurable, and only nine companies included any form of quantitative biodiversity indicator. The limited extent of corporate and public sector biodiversity disclosure has been consistently found within a broad range of literature (see, e.g., review of Cuckston, 2018a and Skouloudis et al., 2019), suggesting that private and public organisations may face difficulties when developing and implementing a meaningful biodiversity performance measurement system.

Various accounting scholars have considered how to take biodiversity into account when designing and implementing calculative organisational practices. Within that literature, accountants are presented as having a particular skillset to support conservation, such as 'independence, professional scepticism, information design, and communicational expertise' (Jones, 1996, p. 286). As such, Russell et al. (2017) argued that accountants have knowledge in measuring and reporting data necessary for biodiversity accounting. As a result, issues around biodiversity are becoming increasingly prominent within the accounting literature, with a growing amount of accounting scholars recognising the significance of accounting practices for biodiversity (Jones, 2014). Still, Gaia and Jones (2017) and Gibassier et al. (2019) pointed out that accounting for biodiversity is, up to this point in time, an understudied area with the accounting literature more generally focusing on sustainability accounting or reporting issues rather than biodiversity concerns.

Most of biodiversity accounting literature rests on the underlying assumption that accounting can be a 'productive force' (Miller & Power, 2013, p. 558). Subsequently, accounting is not just a passive practice which records reality, but instead, accounting has the potential of reshaping reality by influencing human behaviour (Hines, 1988). By translating qualities into quantities, phenomena are rendered calculable and comparable (Miller, 1992; Power, 2015), and accordingly, issues are made visible or are kept hidden. Thus, accounting constructs a condition that influences the perception of people about their possibilities (Espeland & Sauder, 2007), making accounting 'the calculative practice that delineates the playing field and defines the rules of the game' (Kornberger & Carter, 2010, p. 340). Hence, how biodiversity is measured and accounted for has significant implications for organisational decision-making, and as such, any biodiversity performance measurement system has to be carefully designed in order to minimise the risk of adverse and harmful effects on biodiversity conservation and nature protection.

Sobkowiak et al. (2020) argued that rather than relying on generic top-down biodiversity accounting indicators, such as those provided by the GRI framework, organisations should focus on developing their own specific bottom-up biodiversity performance measurement system, focusing on the specific circumstances of their organisations and its particular impacts on biodiversity. And while the work of Sobkowiak et al. (2020) has focused on public sector rather than private sector organisations, numerous studies of corporate sustainability reporting in line with top-down standards such as GRI have found this reporting to be almost always inadequate to discharge meaningful biodiversity information (see, e.g., review of Cuckston, 2018a and Skouloudis et al., 2019). Even further, corporate sustainability reports often declare the particular reporting standards on biodiversity to be irrelevant for their operational context and as such do not report on biodiversity issues at all (Adler et al., 2018; Atkins et al., 2014).

As a result, it seems like both public and private organisations struggle to report meaningful biodiversity measures and as such potentially face similar challenges in constructing appropriate biodiversity indicators. However, and while various articles have studied how organisations can choose or prioritise certain pre-existing sustainability indicators (see, e.g., Keeble et al., 2003; Whitehead, 2017), the process of how organisations can develop and construct their own set of biodiversity indicators has been understudied within the literature so far. Therefore, the aim of the following paper is to explore the construction process of biodiversity performance measurements. In doing so, this paper will outline how biodiversity indicators are inherently imperfect and incomplete and reflect on the implications of the incompleteness on the ability of the performance measurement system to support or potentially hinder biodiversity conservation efforts. For this purpose, this paper will examine two different biodiversity indicators construction processes by the UK Department for Environment, Food and Rural Affairs (DEFRA), using the examples of the Indicator on Habitat Connectivity and the Indicator on the Status of Pollinating Insects. In doing so, this paper contributes to the emerging literature on biodiversity performance measurement by outlining practical implications for organisations interested in constructing and implementing biodiversity indicators. Additionally, this paper contributes to the literature on imperfect performance measurements by reflecting on conditions necessary during the construction process of biodiversity indicators that could enable incomplete biodiversity performance measurements to be productive rather than potentially problematic.

This paper is structured as followed. First, the extant literature on biodiversity indicators is outlined before the conceptual framework of imperfect performance measurements is introduced. Afterwards, the research methodology is explained. Following, the empirical findings are presented before the implications of these findings as well as areas for further research are discussed.

2 | LITERATURE ON BIODIVERSITY INDICATORS

Motivated by the fact that 'the erosion of the world's biodiversity is widely recognised as one of the greatest current threats to the planet' (Jones & Solomon, 2013, p. 1), a wide range of emerging biodiversity accounting practices have been discussed within the extant literature on biodiversity accounting. These practices include ideas of corporate biodiversity reporting (Adler et al., 2018; Atkins et al., 2014; Atkins & Maroun, 2018; Boiral, 2016; Hassan et al., 2020; Rimmel & Jonäll, 2013; van Liempd & Busch, 2013), biodiversity offsetting (Cuckston, 2019; de Silva et al., 2019; Ferreira, 2017; Sullivan & Hannis, 2017; Tregidga, 2013), stewardship accounting (Jones, 1996, 2003; Siddiqui, 2013), biodiversity certifications (Boiral et al., 2017;

Cuckston, 2013; Elad, 2014) and biodiversity indicators (Sobkowiak et al., 2020; Thomson, 2014).

The aim of a broad range of these papers has been to evaluate how these different accounting practices were able to measure and communicate organisational biodiversity performance. Performance measurement within this setting has often been understood as the ability to measure and judge 'how well' actors were performing in whatever work they might be doing (Hopwood, 1992; Miller & Power, 2013). Applied to the context of biodiversity, Cuckston (2017), for example, analysed efforts by a water utility company and a nature conservation charity to deploy an array of devices to enable them to organise and manage a project aimed at restoring a degraded blanket bog habitat. Their actions were informed by the establishment of calculative infrastructure (such as remote sensors and periodic surveys) measuring numerous aspects of the performance of this socio-ecological system against specified standards for this type of habitat. These included aspects such as water quality, water table level, abundance and diversity of desirable species, as well as absence of various undesirable species. These measures of performance guided the restoration work as these actors sought to move the habitat from an 'unfavourable' to a 'favourable' condition. Moreover, Cuckston (2018-b) conceptualised the Red List of Threatened Species as a calculative device that, by creating a kind of ranking of species extinction risk, enables numerous different forms of accounting for conservation performance.

And while biodiversity reporting seems to be the most broadly discussed practice to communicate organisational biodiversity performance within the accounting for biodiversity literature, only a few accounting publications have looked at biodiversity indicators as biodiversity performance measurement tools (Sobkowiak et al., 2020; Thomson, 2014). Thomson (2014) aimed to analyse the relationship between biodiversity indicators and biodiversity strategies in order to examine the representation of the governing vision and rationalities within these strategies by the indicator sets. Based on the theoretical framework of governmentality, Thomson (2014) examined the development of biodiversity indicators in the United Kingdom as a powerful governmental tool for the establishment of norms defining an 'acceptable' behaviour or to draw a line between positive and negative actions for biodiversity conservation. Indicators are seen as a technique to facilitate governance from a distance and to achieve visibility. Thomson (2014) pointed out the risk that the wrong indicators could distort the implementation of biodiversity into normal practice, by suppressing knowledge or areas of visibility, which would be essential to biodiversity conservation. Consequently, the design of the basket of biodiversity indicators seems to be key to support biodiversity conservation as an inappropriate basket may lead to the invisibility of biodiversity issues for intervention or interventions being incorrectly classified as positive towards biodiversity conservation. On the other hand, Sobkowiak et al. (2020) aimed to problematise the indicator framework agreed on under the UN Sustainable Development Goals (SDGs) and the underlying expectations within that framework assuming that accounting for national biodiversity should be globally comparable and commensurable. Instead, they highlight how national biodiversity indicators have to be policy relevant and applicable to local biodiversity differences and priorities and as such require a bottom-up construction process, rather than the generic top-down approach implemented through the SDG indicator framework.

Within the wider area of sustainability indicators, a broad range of papers have examined the question of what sustainability indicator should be chosen or prioritised (see, e.g., Keeble et al., 2003; Whitehead, 2017); however, the indicator development process remained largely hidden within this research. An exception to this trend has been the work by Searcy et al. (2008). Focusing on the case of a Canadian utility organisation, they outline the process of identifying and prioritising sustainable development indicators and highlight the need for external stakeholder engagement and the need to integrate any indicators into the existing business infrastructure. However, their research only focused on the initial indicator implementation stage, without any analysis of the adjustments within the indicators after the initial development, as well focused largely on the process of identifying key sustainable development issues, rather than the indicator construction process. As a result, a gap in understanding the challenges faced within the construction process of biodiversity indicators within the extant biodiversity indicator literature is visible.

Moreover, sustainability indicators have often been criticised for attempting to measure 'the immeasurable' (Bell & Morse, 2012). Similarly, Gray (2010) argued that indicator approaches for sustainability concerns lack value as they require key issues to be simplified leading to them not providing a full narrative of the issue they are trying to represent. In contrast, a number of studies have explored the enabling function of imperfect performance measurement systems and highlighted how imperfect representation should not be seen as a fault, but rather as a positive as they enable debate and reflections (Busco & Quattrone, 2015, 2018; Chenhall et al., 2013).

The question therefore becomes whether the incompleteness of biodiversity indicators is potentially problematic for biodiversity conservation or whether it might provide a positive area for debate that can actually support biodiversity conservation actions. This paper argues that by understanding the construction process of individual biodiversity indicators, conditions that can contribute to the productive nature of biodiversity indicator can be identified. Moreover, by distinguishing between imperfect measurements that involved actors accept versus imperfect measurements that encourage deliberate considerations and ongoing improvements, this paper argues for a more nuanced understanding and engagement with imperfect environmental performance measurements.

The next section will outline the previous work on imperfect performance representations in more detail and introduce this notion as the conceptual framework deployed within this paper.

3 | CONCEPTUAL FRAMEWORK

A range of studies have looked at the incompleteness of performance measures and accounting numbers (e.g., Busco & Quattrone, 2018;

Chenhall et al., 2013; Dambrin & Robson, 2011; Jordan & Messner, 2012; Wouters & Wilderom, 2008). Within that stream of literature, earlier publications examining the 'imperfectness' of performance measurement systems have often investigated how organisational members dealt and 'made do' with flawed or 'imperfect' accounting numbers and performance measurements (Briers & Chua, 2001; Dambrin & Robson, 2011; Jordan & Messner, 2012). For example, Jordan and Messner (2012) examined two ways in which actors responded to imperfect performance measures, first by trying to fix these measurement systems or second, by distancing themselves. Moreover, Briers and Chua (2001) described the compromises taken by managers to extrapolate 'best guesses' and more reliable figures and the necessity for consent within the actors involved in order to 'make do' with the incomplete measurements.

In contrast to the 'make do' approach, Chenhall et al. (2013) argued that organisational actors do not just accept imperfect measurements but that it is actually the incompleteness of the performance measurements that provided a 'fertile arena' for debate and discussion. By providing different perspectives and evaluative criteria, Chenhall et al. (2013) concluded that imperfect performance measurements can prompt deliberate discussions and considerations about existing measures and provide a 'fitting answer to a problem of common interest' (p. 31). Moreover, Busco and Quattrone (2015) outlined how the Balance Scorecard enables engagement, debate and use within the organisation due to its ambiguity and incompleteness while Busco and Quattrone (2018) concluded that the incompleteness of accounting visualisations drives a continuous search for perfection. And while this perfection can never be achieved, Busco and Quattrone (2018) argued that it is that generative power of incomplete representations that makes these accounting visualisations valuable.

And while these papers conclude that imperfection is necessary for debate and thus a positive aspect of performance measurement, incomplete measurements and representation of nature have often been critiqued within the environmental accounting discipline. This is due to the risk of creating areas of invisibility and providing incomplete representations of nature (see, e.g., Gray, 2010; Russell & Thomson, 2009). Thus, environmental accountants have warned that imperfect environmental measurements can distort efforts of biodiversity conservation and provide further harm to the natural environment.

Using the theoretical concept of imperfect performance measurements, this paper will highlight how any measurement of biodiversity performance is inherently imperfect and incomplete. However, by using the distinction outlined within the conceptual framework between flawed measurements that actors just deal and 'make do' with versus imperfect measurements that provide fertile areas for debate and constant improvements, this paper will examine to what extend imperfect environmental performance indicators are either problematic due to their flawed nature or potentially productive due to their ability to facilitate discussion and enable collaboration. In doing so, this paper will also discuss conditions necessary during the indicator construction process that could contribute to the productive nature of biodiversity indicators while decreasing the risk of potentially problematic consequences of imperfect biodiversity performance measurement.

4 | METHODOLOGY

This research is based on a case study research design, focusing on the UK Biodiversity Indicators construction process. Focusing on document analysis and semi-structured interviews, the aim of this research methodology was to get an in-depth understanding of how DEFRA has been able to construct and implement their national set of biodiversity performance indicators. This case was chosen for the following reasons. The United Kingdom has a long history of measuring and reporting its national biodiversity performance, and as such, DEFRA has published its UK Biodiversity Indicators Report annually since 2007, with the 2018 report containing 24 indicators. Therefore and contrasting other organisational biodiversity accounting attempts, this case allowed access to a broad range of knowledge and material surrounding biodiversity indicators and allowed the tracing of biodiversity indicators over a 10-year period. As such, this case study enabled the researcher to analyse the construction process of biodiversity indicators over a decade long process, identifying and examining the challenges faced and solutions found during the construction process of these particular indicators.

The research project used document analysis and semi-structured interviews as the main data collection tools. Starting with document analysis of the UK Biodiversity Indicators Reports between 2005 and 2018 as well as all publicly available UK biodiversity policy documents and strategies, Biodiversity Indicators Forum meeting protocols and presentations, as well as international biodiversity frameworks, themes for the following interviews were identified. These themes—including historical developments and changes within the UK biodiversity indicators, the use of these indicators, benefits and challenges and the influence of national and international organisations on these indicators—were then followed up with 19 semi-structured interviews with actors involved in the UK biodiversity indicators construction process. The interviews were conducted between February and August 2018, and interviewees were identified using a purposeful sampling method (Patton, 1990) and a snowball sampling approach. As such, interviewees were identified based on their involvement in the UK biodiversity indicators process, and all interviewees were asked to identify further potential interviewees afterwards. Given that the United Kingdom has a highly complex biodiversity indicators governance structure, comprising a small Project Group[2]—putting together the final UK Biodiversity Indicators Report, a Biodiversity Indicators Steering Group[3]—deciding on the indicators to be included in the final report, a Four Countries Group[4]—determining the overall strategic and political direction and a Biodiversity Indicators Forum[5]—providing expert advice on potential indicators and reviewing existing biodiversity indicators, potential interviewees from all four groups were identified and approached. An overview of the indicator development process can be found in Figure A1.

Additionally, and also due to the structure of the UK Biodiversity accounting process comprising a multitude of nearly 100 (DEFRA, 2018) government and non-governmental organisations, interviewees came from 12 different organisations including DEFRA, JNCC, environmental agencies, devolved governments, NGOs, research centres and academia. Overall, nine interviewees came from government institutions, four interviewees came from non-governmental organisations, two interviewees worked in academia and four interviewees came from research institutions.[6] Interviews were between 30 min and 2.5 h long, depending on the level of involvement in the process and time availability of the interviewee, and all interviews were recorded and transcribed. Eight interviews were done face-to-face while 11 interviews were done over Skype or phone based on the preferences of the interviewee.

The interview data were then analysed using NVivo and a thematic data analysis process as described by Braun and Clarke (2006). Following Boyatzis (1998, p. 63) definition of a code as being 'the most basic segment, or element, of the raw data or information that can be assessed in a meaningful way regarding the phenomenon', any parts of the interview data that appeared helpful in understanding the indicator development process, as well as the challenges and solutions within that process, were coded. In order to avoid the omission of certain ideas, the entire data set and as many potentials elements as possible were coded resulting in 516 codes. These codes were named as close as possible to the actual wording of the participants in order to minimise researcher's bias. In order to refocus the analysis at a broader level, initial codes were then reviewed and collated into themes based on common similarities. Overarching themes were identified, and relationships between the initial codes and the themes were drawn out before the themes were revised and reviewed. An overview of the themes identified can be found in Figure A2.

This process allowed for an iterative analysis between the interview transcripts as well as the documents analysed, which also allowed for triangulation between these two data sources. From this structure, the two indicators—for example, Habitat Connectivity and the Status of Pollinating Insects—were identified as good representations of the various problems faced during the construction process of biodiversity indicators and as such were used to analyse the challenges faced and potential solutions developed in order to enable the construction of these indicators. The following section will present these findings.

5 | FINDINGS

In 2007, DEFRA made the first decision to adopt standardised biodiversity performance measures in order to report on UK biodiversity performance. This decision was taken due to a shift within the international biodiversity framework signed up by the United Kingdom—the UN Convention on Biological Diversity (CBD)—towards a more outcome orientated governance process requiring countries to calculatively capture biodiversity. The 2010 Biodiversity Targets agreed on in 2005 and the Aichi Biodiversity Targets under the Strategic Plan for Biodiversity 2011–2020 (SCBD, 2010) agreed on in 2010 positioned biodiversity accounting and indicators as a principal part of the UN biodiversity conservation strategy. Due to the shift within the UN CBD programmatic, national biodiversity performance had to be accounted for by national governments using standardised calculative measures, making biodiversity conservation a fundamental part of national political governance and accountability practices.

This change towards standardised biodiversity performance measures was adopted in the United Kingdom in 2007 with the publication of the first Biodiversity Indicators in Your Pocket (BIYP) report. Preceding the BIYP, biodiversity had not been cohesively accounted for within the UK Government as reporting on biodiversity issues took place in a range of policy documents, reports, or annual reports of different governmental agencies. Biodiversity reporting was fragmented and not systematically framed. For example, the reporting and accounting practice on biodiversity was characterised in the first UK Report to the UN CBD as 'biodiversity information, however, remains scattered across the country in many different and incompatible forms; from modern, computerised databases to scraps of paper kept in shoe boxes' (DETR, 1998, p. 26, cited in Thomson, 2014).

Since 2007, DEFRA has published its Biodiversity Indicators Report annually, and in 2018, the report contained 24 indicators, including information about individual species and habitats, ecosystem services and mainstreaming. Additionally, all indicators are grouped according to the five Aichi Strategic Goals and aligned with the international CBD framework. An overview of the indicators included in the report in 2007 and in 2018 can be found in Table A1.

In order to be able to design and publish the first Biodiversity Report, DEFRA decided to hold a multi-stakeholder workshop aimed at identifying easily available and pre-existing indicators to be included in the report. Invited stakeholders included members of different parts of DEFRA, the JNCC, devolved administrations, devolved environmental agencies, research centres, academia and NGOs.

> So in probably about 2006, there was a decision taken through DEFRA […] that we should try to develop a set of metrics to measure progress towards what was then the 2010 Biodiversity Targets […]. And to do that, what we did was to pull together a workshop of a number of interested stakeholders to try and identify what sort of metrics we might need and what sort of metrics would be available – what was easily available. […]. That lead into a first publication of what we call at that point Biodiversity Indicators in Your Pocket […]. That's the latest version which has now become called UK Biodiversity Indicators […] and we've published pretty much annually ever since. (Interviewee 5, Project Group)

As a result of these multi-stakeholder workshops—also labelled Biodiversity Indicator Forum Meetings—over a 4- to 5-year period, as well as meetings of the Biodiversity Steering Group, the Four Countries Group and the work of the Project Group, the first BIYP report contained 18 different biodiversity indicators, four of which, however,

labelled as experimental statistics with no data presented. One of those experimental indicators was the indicator of habitat connectivity, which will be outlined below. It is one of the indicators that interviewees described as one of the hardest indicators to construct and one of the indicators that underwent significant changes over the last 10 years. Additionally, it is one of the indicators that was not already pre-existing within DEFRA and therefore had to be constructed from scratch.

5.1 | Indicator on habitat connectivity

The first indicator on habitat connectivity[7] was introduced within the first UK BIYP report in 2007 as an indicator 'under development'. At that point in time, only a narrative outline of how this indicator could look like was proposed, without any quantified assessment.

> This indicator is under development, therefore no data or assessments are presented. The following text outlines the development work underway to produce an indicator by 2008. (DEFRA, 2007, p. 28)

The habitat connectivity indicator stayed 'under development' until 2010, when an indicator on 'Change in habitat connectivity for selected broad habitats in the wider countryside, 1990 to 2007' measuring 'Broad-leaved, mixed and yew woodland' and 'Neutral grassland' was included in the BIYP 2010 report. Within subsequent publications, neither the indicator nor the underlying data set was updated, resulting in the BIYP report in 2013, still publishing the indicator based on the 2007 data set. And while the actors' involved made do with the outdated data set collected in 2007 in the biodiversity reports between 2010 and 2013, the indicator was seen as being scientifically problematic by 2013. As a result, actors involved in the UK Biodiversity Indicators Steering Group—including members of DEFRA, JNCC, devolved administrations, devolved environmental agencies and one NGO—made the decision to remove the indicator from the report.

> A measure of connectivity has been published previously within the biodiversity indicators set […]. The measure required further analysis to better explain the causes of the changes in connectivity and, as a result, the information available was insufficient for an assessment of change to be made, despite the statistically significant increase seen in connectivity in neutral grassland habitat observed. It has not been possible to undertake the analysis required and, given the latest data available for the indicator is from 2007, it has been decided by the UK Biodiversity Indicator Steering Group that this indicator is now too out-of-date to be retained within the indicator set, and the previous data and analysis has been moved to the background. […] It is hoped that a new interim measure can be published in 2015. (DEFRA, 2014, p. 27)

As a result of the removal of the existing indicator, the Biodiversity Steering Group was now responsible to develop a new habitat connectivity indicator, however, lacked access to an already existing internal alternative indicator. Thus, the Group decided to ask the UK Biodiversity Indicators Forum—consisting of members of research institutes, academia and NGOs—for expert advice on new indicator developments that could potentially be used within the UK Biodiversity Indicators Report.

> The existing UK indicator of habitat connectivity […] has been viewed as too constrained in its application […], too reliant on expert judgement and too complex. The UK Biodiversity Indicators Steering Group (BISG) has, therefore, identified that there remains a need to develop alternative options that address these issues or that replace the indicator. (JNCC, 2012b, p. 6)

Thus, the previous imperfect indicator on habitat connectivity was used in order to start and facilitate a close and ongoing discussion and collaboration between a broad range of organisations and experts. To begin with, 'leading experts' (JNCC, 2012b, p. 2) from the research field proposed three possible new indicators on habitat connectivity to members of the Forum and representatives of DEFRA, JNCC, devolved administrations and devolved environmental agencies at the sixth UK Biodiversity Indicators Forum (BIF6) taking place in 2012. The summary report of that meeting concluded that 'habitat connectivity as an indicator is very context-specific, and therefore finding a generic option is a challenging task' (JNCC, 2012a, p. 7).

Nonetheless, the UK Biodiversity Indicators Forum recommended that one of the three proposed indicators—the indicator of functional connectivity—was the 'most suitable choice to take forward at this stage' (JNCC, 2012a, p. 8). The Biodiversity Steering Group followed the advice of the Forum and began to commission the development work of this particular indicator. In that case, the Project Group worked closely with NGOs, research centres and academia in order to identify appropriate pre-existing data sources and to develop novel data analysis methodologies allowing the construction of this particular indicator. Though, and in contrast to the early predictions of the Steering Group and the Project Group, it took 6 years to develop an indicator on functional connectivity to be included in a UK Biodiversity Indicators Report.

Finally, in 2018, a new indicator on habitat connectivity—the indicator on functional connectivity of butterflies—was published within the UK Biodiversity Indicators set. However, this indicator was labelled as an 'experimental statistic', with the Project Group asking for feedback on the methodology of the indicator within the report. In that case, rather than constructing the indicator methodology and deciding on a data set straight away, efforts were made to get a broader range of input and feedback from outside actors to be subsequently incorporated into the indicator. This decision was taken by DEFRA and JNCC to ensure the indicators appropriateness, academic rigour and usefulness for all actors involved.

> Experimental statistic: The UK biodiversity indicators project team would welcome feedback on the novel methods used in the development of this indicator. (DEFRA, 2018, p. 29)

At the point of data collection for this research project in 2018, interviewees made clear that this indicator is still under development and that this indicator is especially difficult to develop.

> We don't currently have an indicator of connectivity we'd like to have. One of the difficulties is that there isn't an obvious simple indicator. One of the difficulties is perhaps to get one costs money. So that's a practical difficulty that we have to have the budget. […] Some of the things we want to measure are just not obvious tangible things to measure. I mean it's not difficult to measure the relative change in abundance of birds because people go and count them. It's more difficult to measure something like connectivity because how do you do it. (Interviewee 6, Project Group)

As a result, the United Kingdom is continuously working on constructing a biodiversity indicator on habitat connectivity as the current indicator is seen as imperfect and incomplete. However, rather than just to accept the imperfectness of the current indicator, active work is going into the continuous improvement of the current indicator approach. Additionally, the difficult nature of that particular indicator seems to have prompted ongoing debate and discussion particularly within the Project Group and the research centre involved in its construction.

To conclude, this section highlighted the extensive work taken place to develop a UK indicator on habitat connectivity. Besides the first version of an indicator on habitat connectivity being proposed in 2007 and included in the UK Biodiversity Indicators Report in 2009, this indicator was considered too labour intensive and outdated—and thus too imperfect—and was subsequently removed from the report. As a result, the decision was made to develop a new indicator, a process that resulted in close collaboration and ongoing debate between the actors involved within the indicator construction. In detail, the construction process included getting options for possible indicators proposed by outside experts, which were then discussed within the UK Biodiversity Indicator Forum in 2012 before one option was approved and commissioned by the Biodiversity Steering Group. However, up to this date, the indicator on habitat connectivity is labelled as being under development, with interviewees highlighting how the difficult nature of biodiversity connectivity and the funding constraints placed upon them make it difficult to construct a perfect habitat connectivity indicator. As such, this indicator also highlights how the perceived imperfectness of the existing indicator is driving an ongoing search for perfection. And while this perfection will most likely never be achieved, the indicator on habitat connectivity has highlighted how the engagement of DEFRA within the self-constructed governance structure of the UK Biodiversity Indicators Forum has led to ongoing improvements, as well as deliberate discussions and considerations about the scientifically most appropriate way of measuring habitat connectivity.

5.2 | Example of Status of Pollinating Insects

Following, the construction process of another biodiversity indicator—the indicator on the Status of Pollinating Insects—will be described. This indicator was predominantly developed in order to comply with the UN CBD Aichi targets, and as such, the development of this indicator was politically supported and funded. The 20 international Aichi Biodiversity Targets were agreed on by the parties of the UN CBD in 2010 under the Strategic Plan for Biodiversity 2011–2020. These targets represented a shift away from a species and habitat focus within the international biodiversity framework towards a more natural capital and ecosystem services focused approach (Shepherd et al., 2016). As a result, DEFRA and JNCC made the decision to review the existing indicators in light of these new international targets in order to identify potential gaps.

After the existing UK Biodiversity Indicators were mapped against the CBD Aichi targets in 2011, the Project Group felt that the current set of biodiversity indicators was incomplete, particularly within the new Aichi Strategic Goal D: 'Enhance the benefits to all from biodiversity and ecosystem services'. Thus, and in order to improve the current perceived incompleteness of the indicator set, the Biodiversity Indicators Steering Group and the Project Group tried to identify possible indicators to fill that gap. Given a lack of pre-existing and internally available indicators, the Project Group again decided to engage in outside collaboration, and thus, external research centres were commissioned to explore potential indicator options. This work was funded by DEFRA and led to various indicator options being explored aimed at constructing appropriate biodiversity indicators to measure ecosystem services.

> When we moved from 2010 to doing the 2020 indicators, we identified that we got a number of gaps. And DEFRA actually came up with some research money to try and fill those gaps. And that was on a number of topics, one of them was ecosystem services. (Interviewee 5, Project Group)

This development process started with the Project Group, together with external stakeholders—such as research centres—reviewing already existing indicators that could potentially be repurposed to be used as a UK Biodiversity Indicator. Afterwards, these indicators were discussed within three specialist workshops before being presented to the seventh UK Biodiversity Indicators Forum—and therefore a wider audience of NGOs, researchers, government officials and environmental agencies—in 2013.

> The process of indicator development started by compiling a preliminary list of potential indicators. […] UK

> specialists in the field of ecosystem services then met at a series of three workshops to tackle issues surrounding definitions, refine indicator suggestions, and develop indicator options that would be possible for implementation within a short timeframe. [...] Three indicator options were short-listed for development, and were reviewed through the 7th UK Biodiversity Indicators Forum. (JNCC, 2013, p. 9)

However, again, the final indicator decision had to be made by the Steering Group—thus by government officials—rather than within the specialist group or the Indicators Forum. Subsequently, the UK Biodiversity Indicators Steering Group reviewed the proposed indicators, rejecting some for being too simplistic or having insufficient underlying data (DEFRA, 2014). Others were put forward for inclusion in the UK Biodiversity Indicators Report in 2014, however only after they had undergone change in accordance with the recommendations made by the Biodiversity Steering Group. One of the proposed indicators was the indicator on the Status of Pollinating Insects.

> The measures on pollinators were considered by the Forum to be the most sound, and to complement each other well. At the UK Biodiversity Indicators Steering Group in July 2013, it was noted that there is insufficient data for the first measure (bumblebee abundance), which is based on information obtained from bee-walks, to be published in 2013, although it may be possible to publish this measure after an additional year of data has been collected, in 2014. The second measure (species richness of hoverflies and solitary bees) is to be incorporated within other work assessing trends in species distribution data to ensure the methodology being employed is consistent with that being used for other species indicators. Work assessing trends in species distribution data is on-going, and it is hoped a new measure based upon it will be published in 2014. (JNCC, 2013, p. 43)

As described by the interviewee below, one of the biggest problems actors were facing during the development of this particular indicator was the identification of appropriate data sets. As a result of this lack of data, the development process of this indicator was complicated, with involved actors meeting for three times in person in order to discuss the issue and potential data sources to be used for this assessment and one of the final proposed indicators still being rejected by the Steering Group due to data issues. As such, the construction of that particular indicator again provided a 'fertile arena' for debate and collaboration between a broad range of different organisations and actors.

> We started off having a workshop going 'Ok what are we after?', 'What can we do?'. And we ended in a circle somewhat. We ended up having a second workshop, but we still weren't really getting there. So, we ended up having a third workshop – which sort of was banging heads together saying, 'look come on guys we need to come up with some metrics here'. And part of the issue around this was we could think of really important things that we ought to measure, but where the hell are the data to measure them. And that's why we've ended up actually with only three ecosystem services indicators within the set. So we've got the pollinators one that we've been able to do which is measuring change in distribution of pollinators. (Interviewee 5, Project Group)

Nonetheless, the interviewee described that the actors involved in these development workshops were not able to come up with the ideal indicators hoped for by the Biodiversity Indicators Steering Group. Given that the Steering Group was not willing to make do with any of the proposed imperfect indicators, pragmatic solutions and compromises between the actors involved were required. As a result, more realistic indicators had to be developed, one of which has been the indicator on the Status of Pollinating Insects.

> To take an example of that for the pollinators indicator [...] which is about the ecosystem benefits for pollination. Ideally what we'd like to be able to measure is the pollination service. But actually that's really quite difficult. So what we're able to do is to measure the number of bees and hoverflies through people actually submitting observations. (Interviewee 5, Project Group)

Given the difficulties in developing this indicator and the perceived imperfectness of the indicators due to the compromises necessary, a decision was made to again publish this indicator as an experimental statistic in order to get feedback on the indicator and being able to improve and further develop the indicator in subsequent years.

> We started off with what we would call an experimental statistic where we didn't assess it. We come up with something, we put it out there to say 'Ok guys does this work for you? Can we get some feedback on it?' and then over the following couple of years we were able to improve the modelling techniques. We were able to increase the number of species that we could put within that indicator and we've then said 'Ok that's good enough, we can assess it'. (Interviewee 5, Project Group)

Additionally, DEFRA commissioned an independent Academic Review Panel in 2015–2016 in order to review certain existing biodiversity indicators. One of the indicators reviewed, included the indicator on the Status of Pollinating Insects, with the panel recommending

improvements to the data quality, the rigour of the analytical method, the precision and bias of the indicator, as well as the proposed interpretation. As a result, the data fed into the indicator was continuously updated and the underlying methodology improved, resulting in significant changes to the indicator over time. Consequently, the UK Biodiversity Indicators Report in 2017 highlighted how the version of the indicator included within that year cannot be compared to the indicator published in previous years. As such, this indicator cannot be described as consistent. However, as these changes were perceived as improvements, actors seem to be acceptant of the lack of consistency within this particular indicator.

> The [indicator on the] status of pollinating insects (indicator D1c) [has] benefited from methodological improvements to the underlying modelling techniques, which have allowed many more species to be brought into these measures. As such [the indicator is] not directly comparable with the indicators previously published. (DEFRA, 2017, p. 9)

Additionally, interviewees measured the success of the indicator by tracing how this indicator has been used within the political space and as such became relevant to policymakers and public figures including the UK Prime Minister—at the time of data collection—Theresa May. Thus, the calculative outcome—a pollinators' decline of 10%—became a separate entity outside of the UK Biodiversity Indicators Report. And while the underlying indicator methodology was based on pragmatic compromises, the fact that this imperfect indicator was able to spark debate within the policy space was seen as a big success for conservation work. As such, interviewees preferred to publish indicators that are able to pragmatically demonstrate trends and developments in UK biodiversity—even if imperfect—over not publishing any indicators at all.

> Now, of course, the indicator will carry on and we'll deviate from it over the time, but at the moment [it] is quite widely known that the pollinating insects have declined by 10% roughly over that period. […] I was lucky enough to go to the launch of the 25-year plan and that was one of the two statistics that Theresa May mentioned. That was very gratifying to be in there, the room, and she said, 'Pollinating insects have declined by 10%'. (Interviewee 1, Biodiversity Indicators Forum)

This example of the Status of Pollinating Insects indicator highlighted an example in which a gap between the current biodiversity indicator set and the strategic biodiversity goals signed up to by DEFRA was identified. As such, the Project Group concluded that the current set of UK Biodiversity Indicators was incomplete and needed pragmatic adjustments. The process of the indicator development was guided by the identification of pre-existing indicators, three expert workshop sessions shortlisting these indicators and a discussion with government and non-governmental organisations within the UK Biodiversity Indicators Forum. However, upon review, a gap between the desired and practically possible indicators became visible and compromises had to be made. This agreed on indicator—the Status of Pollinating Insects—was then published as an experimental statistic with feedback being sought and incorporated, thus changing the indicator over the years and rendering in incomparable to the older versions. Thus, this indicator might be described as imperfect. However, this indicator also highlights how a broad governance structure, an external academic review panel and ongoing collaboration and improvements can reduce the risks associated with imperfect environmental indicators and provide the potential for these indicators to generate traction that can potentially support biodiversity conservation efforts.

6 | DISCUSSION AND LIMITATIONS

This paper uses the example of two UK Biodiversity Indicators—namely, the Habitat Connectivity Indicator and the Indicator on the Status of Pollinating Insects—to outline the UK Biodiversity Indicators construction process. In doing so, this paper highlights the challenges faced and the solutions adopted in order to render UK national biodiversity performance measurable within a set of standardised performance indicators. This paper also argues that given these challenges and the need for pragmatic compromises in order to overcome them, any set of biodiversity indicators will be inherently imperfect and incomplete. Given this imperfect nature of biodiversity indicators, this paper also reflects on the conditions that could contribute either to the productive or to the potentially problematic nature of biodiversity performance measurement.

The following section will first summarise the individual challenges faced on a UK level and the solutions agreed (visualised in Table 1), before discussing the conditions that can contribute either to the productive nature or the potentially problematic nature of imperfect biodiversity indicators.

First, a boundary around what to include or exclude within the indicators had to be drawn, thus defining the margins of biodiversity. To do so, the United Kingdom aligned their own set of biodiversity indicators with international biodiversity goals and targets, such as the CBD Aichi targets. Within that international framework, DEFRA faced the challenge of developing context-specific indicators that are policy relevant, applicable at multiple scales and focused on UK biodiversity priorities. As a result, and as discussed by Sobkowiak et al. (2020), DEFRA solved that challenge by developing bottom-up biodiversity indicators rather than relying on any pre-defined top-down indicator framework. Particularly, given earlier research findings highlighting how the majority of current corporate sustainability reports declared existing, top-down biodiversity reporting standards to be inappropriate for their operations (Adler et al., 2018; Atkins et al., 2014), this paper suggests that a bottom-up approach might be a useful approach to organisations aiming to measure their biodiversity performance. This recommendation is in line with Searcy et al.'s (2008) suggestion that '[s]imply adopting existing indicator

TABLE 1 Overview of indicator development challenges and solutions

Challenge	Solution
• Drawing boundaries around biodiversity	• Orientation on international goals and targets such as the UN CBD Aichi targets
• Developing context-specific indicators	• Focus on constructing bottom-up indicators rather than relying on pre-existing top-down indicator frameworks
• Meeting the needs of decision-makers	• Collaboration between policymakers, environmental agencies and DEFRA statisticians aimed at identifying decision-making needs • Constant feedback on indicators and subsequent improvement to the indicator set
• Resource constraints such as funding, time or labour	• Alignment of indicators with strategic goals in order to achieve high-level support • Relying on pre-existing research, infrastructure and data sets
• Identifying appropriate data sets and indicator methodologies • Dealing with out-of-date indicators, lack of available data for desired indicator	• Collaboration with outside organisations including NGOs, research centres and academia • Formalised structure of that collaboration with regular meetings of all actors • Specialist workshops aimed at indicator development • Repurposing of already existing data sets and indicator methodologies developed by outside organisations
• Inability to construct 'perfect' indicators	• Publication of experimental statistic for feedback before a final assessment of indicator • Willingness for compromises and pragmatic indicator solutions • Iterations and ongoing improvements to the indicators • Acceptance of lack of indicator consistency

packages will likely not provide the commitment necessary to integrate the indicators with existing business system' (p. 148).

However, this case also highlighted how constructing bottom-up indicators was time and labour intensive and thus costly, hence, opening up challenges in terms of resources such as funding constraints (similar findings have been made by Barman et al. (2021) in the context of entrepreneurial innovation). As outlined in the empirical findings above, that meant that high-level funding support was only available if the focus of the biodiversity indicators was aligned with the strategic goals signed up to by DEFRA, and as a result, all existing indicators were mapped onto these international frameworks in order to identify gaps and argue for additional resources. Still, and even when funding for the indicator development was available, the Project Group ongoingly faced the challenge of identifying appropriate data sets and data methodologies to be used within the biodiversity indicators set. As a result, a decision was made to repurpose already existing data sets and indicator methodologies collected and developed by outside organisations for their own conservation work, rather than to collect own data only for the purpose of being used within this particular indicator set.

Additionally, collaborating with outside organisations including research centres, academia and NGOs became a main focus of DEFRA in order to access this outside knowledge and this collaboration was formalised through the UK Biodiversity Indicators Forum and regular Forum meetings discussing potential indicator developments and reviewing already existing indicators. It is this collaboration that allowed scientific developments to be considered during the biodiversity indicators construction process, thus internalising scientific and academic knowledge and research data into the final indicators.

As a result, this paper suggests that constructing biodiversity indicators requires collaborations with outside organisations, particularly research centres and local conservation NGOs that can support the identification of appropriate data sets and indicator methodologies. This finding extends the suggestion made by Searcy et al. (2008) to involve key stakeholder throughout the indicator development process by highlighting the necessity for active collaboration and a formalised structure for regular meetings and engagements with a broad range of organisations—not just key stakeholders—that can actively support the indicator development process and supply valuable data infrastructures. Based on the findings of this paper, it is highly doubtful that any organisation will be able to construct meaningful biodiversity performance indicators without a broad governance structure, given the breath of the concept of biodiversity and the challenges included in collecting appropriate data sets. Additionally, biodiversity science is constantly evolving, and thus, the definition and understanding of biodiversity is ongoingly progressing. A broad governance structure will also ensure that the biodiversity indicators are relevant and updated and thus useful for decision-making.

However, even with this scientific and academic support, it was impossible to construct all desired biodiversity indicators within the case presented in this paper. As a result, compromises had to be made and pragmatic indicator solutions had to be agreed on. Consequently, the agreed on indicators might not be the indicators that the actors involved would have liked to construct but rather the indicators that were felt possible to develop and measure by the actors involved. Thus, interviewees were aware of the imperfectness and incompleteness of their own biodiversity indicator set. However, being able to publish indicators that are able to pragmatically demonstrate trends and developments in UK biodiversity—even if recognised as imperfect—was seen as preferable by interviewees over not publishing any indicators at all. In that sense, publishing any form of acceptable—to the actors involved—indicators was preferable over a

complete absence of any calculative measures. As such, this case demonstrated how actors did not just accept the existence of imperfect performance indicators (Briers & Chua, 2001; Dambrin & Robson, 2011; Jordan & Messner, 2012) but rather preferred imperfection over a complete lack of performance measurement.

Given the challenges faced when constructing biodiversity indicators (see Table 1), it is to be expected that any proposed biodiversity performance measurements will most likely be imperfect and that measuring biodiversity perfectly is a myth (similar findings have been made by Gibassier et al., 2018 about integrated reporting). Thus, this paper argues that the focus should not be on whether a particular indicator is flawless, but rather whether it supports or potentially hinders biodiversity conservation efforts. This finding is in line with York's (2009) argument about the need for a pragmatic approach to environmental ethics, while extending his recommendation to go beyond concerns of competitive advantage and to refocus on the impact of a particular business decision on the environmental concern in question. Additionally, this finding is in line with the suggestion made by Baker and Schaltegger (2015), arguing that the philosophy of pragmatism can motivate positive forms of social and environmental change by enabling new ways of thinking of and making sense of current social and environmental issues.

One way in which interviewees aimed to ensure the usefulness and appropriateness of these indicators was through continual improvement and adaptations as well as ongoing collaboration and reviews. As a result, new indicators were often published as experimental statistics first, asking for feedback on the indicator methodology before making any final assessment of the indicator. Additionally, even already agreed on and published indicators often went through multiple iterations (similar to the findings by Barman et al., 2021), and ongoing changes aimed at improving the indicator methodology and indicators were regularly reviewed by outside experts. As such, it was the awareness of imperfections within the existing indicators that was driving ongoing improvements and the search for better representations of biodiversity (Busco & Quattrone, 2018).

However, and while this productive debate initiated by imperfect performance measurements (Busco & Quattrone, 2015, 2018; Chenhall et al., 2013) enabled experimentations and improvements of the indicators, the incompleteness of the indicator set does not come without its risks. For example, the ongoing change within the indicator set often resulted in inconsistency within these indicators and older versions of the same indicator were not comparable to the newer versions published. Yet it was the interviewees understanding that inconsistencies were ok as long as they were published transparently and they were even preferred over publishing a consistent, yet outdated and perhaps scientifically flawed indicator. Also, data availability often influenced the indicator selection and as such created invisibilities for species or biodiversity concerns not monitored within traditional data collection work. Additionally, the need to set boundaries will always exclude certain aspects of biodiversity. However, aligning the scope of the indicators with international frameworks might be able to reduce the risks of distortion and potentially harmful invisibilities.

In order to moderate the potentially negative effects of incomplete biodiversity measurements (see, e.g., the discussions by Gray, 2010 and Russell & Thomson, 2009), this paper highlights the benefits of more experimentation during the biodiversity indicator development process (in line with the recommendation made by York, 2009), as well as the acceptance of feedback and ongoing indicator improvements. In doing so, this paper argues that there is the potential for imperfect biodiversity indicators to open up productive areas for discussion (Busco & Quattrone, 2015, 2018; Chenhall et al., 2013) and to have generative power (Busco & Quattrone, 2018). However, organisations should be aware of the risks of adverse and harmful effects due to imperfect biodiversity measurements, and as such, precautionary steps should be taken. Particularly, having a broad governance structure comprising NGOs and research centres might reduce these potential negative outcomes, especially if organisations are willing to engage in regular and open conversations, as well as open and honest feedback and ongoing external reviews of their biodiversity indicator set. Under these conditions, the risks of imperfect biodiversity indicators might be reduced and the potential for constructive and productive debates supporting biodiversity conservation can be enhanced. Thus, this paper contributes to the literature on imperfect performance measurements by reflecting on the conditions necessary for incomplete performance measurements to be productive rather than potentially problematic.

7 | CONCLUSION

To conclude, this paper has explored the construction process of biodiversity indicators, using the examples of the UK Indicator on Habitat Connectivity and the Indicator on the Status of Pollinating Insects. In doing so, this paper has outlined the types of problems likely to be encountered during the indicator construction process and discussed possible ways to work through these challenges. This paper has argued that organisations should focus on developing their own bottom-up biodiversity indicators, taking into account their organisational context and decision-making needs. In addition, this paper suggests that organisations have to actively decide on the boundaries drawn around the issue of biodiversity and their operational priorities. To do so, this paper recommends the use of international biodiversity frameworks—such as the UN CBD targets, or the recommendations made by the IPBES—as long as these targets are translated into the individual setting in which the organisation operates. As a result, this paper argues that any biodiversity performance measurement system has to be aligned with the organisational strategic goals in order to be sufficiently supported and funded as well as generate high-level commitment.

Moreover, this paper has argued that it will be impossible to construct any form of perfect biodiversity indicators. By using the distinction outlined within the conceptual framework between flawed measurements that actors 'make do' with versus imperfect measurements that provide fertile areas for debate and constant improvements, this paper discussed conditions necessary to reduce the risk of

potentially problematic biodiversity indicators. One approach presented within this paper has been the publication of experimental indicators, aimed at being critiqued before any analysis and open to multiple iterations and improvements. Additionally, this paper argues for ongoing reviews and constant improvements to any biodiversity performance measurement system, given ongoing scientific development, changes in national and international biodiversity governance and possible operational adjustments. In doing so, this paper contributes to a more nuanced understanding of imperfect environmental performance measurements.

Nevertheless, these findings do not come without their limitations. First of all, this research has only explored a single-case study within a public sector setting in the United Kingdom. While it is expected that other organisations will face similar challenges, further research would be needed to explore the construction process of biodiversity indicators within this setting. As such, the findings presented within this paper might not be straightforwardly generalisable to all types of organisations. Additionally and given the disparity in resources and capacity between different countries and governments, the findings of this paper might not be generalisable to other countries. Finally, the paper prompts areas where further research might be useful. For example, exploring the biodiversity indicator construction process within private sector organisations could help establish whether the framework and the findings of this paper can be translated to different organisational settings. Likewise, further research outside Western countries such as the United Kingdom could explore additional challenges faced within this setting, enriching the framework employed and the findings presented within this paper.

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ENDNOTES

[1] The most broadly accepted definition of biodiversity has been the definition agreed at the UN Convention on Biodiversity (CBD) in 1992. It states that biodiversity is 'the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems' (CBD, 1992, p. 3).

[2] The UK Biodiversity Indicators Project Group consists of one Biodiversity Indicators Manager from the Joint Nature Conservation Committee (JNCC) and three Statisticians from DEFRA.

[3] The UK Biodiversity Indicators Steering Group consists of representatives of DEFRA, JNCC, the four devolved administrations, the four devolved environmental agencies and one NGO link.

[4] The Four Countries Group consists of representatives of DEFRA, JNCC and the four devolved administrations.

[5] The UK Biodiversity Indicators Forum consists of representatives of statutory and non-governmental organisations, research centres and academia.

[6] In order to maintain the confidentiality of interviewees, individual organisations or interviewee names are not listed here.

[7] The notion of habitat connectivity refers to the degree to which detached parts of a habitat are connected. This connectivity is particularly important given the need for exchange of organisms, information and material between these separated patches to maintain the functionality and integrity of the ecosystem. As such, habitat connectivity might be relevant to entities who (by their nature) govern central parts of possibly connected habitats.

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APPENDIX A.

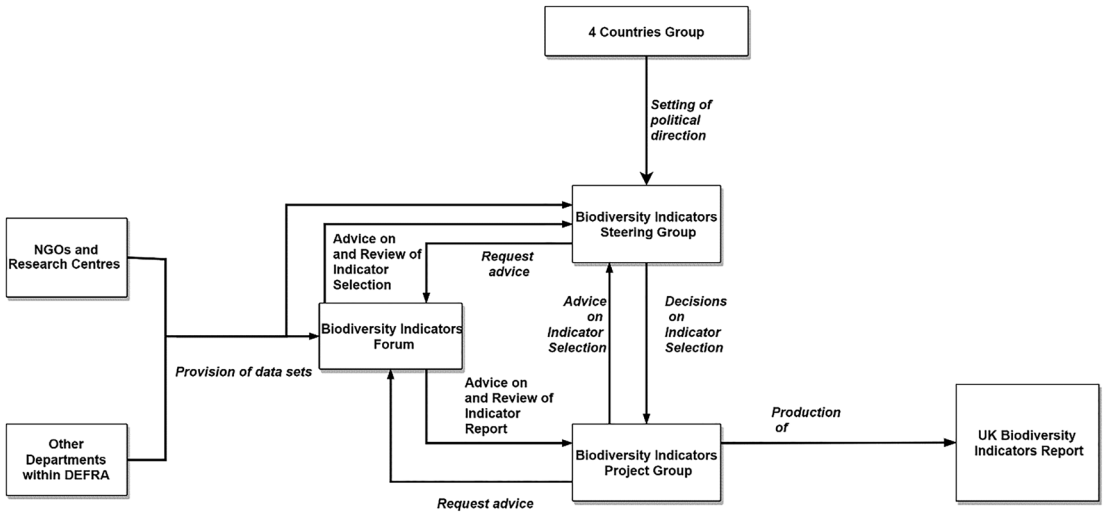

FIGURE A1 Overview of the indicator development process

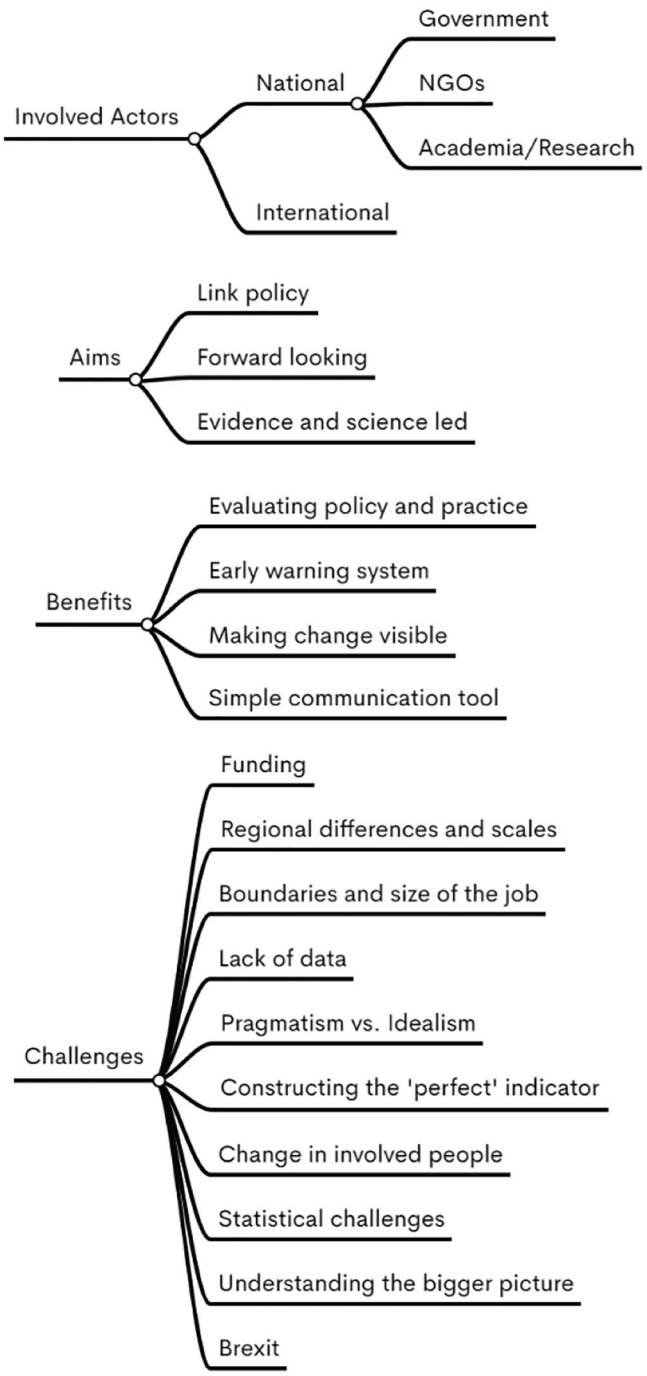

FIGURE A2 Overview of coding themes

TABLE A1 Overview indicators included in 2007 and 2018

2007		2018		
Indicator	**Measure(s)**	**Indicator**	**Measure(s)**	
1a. Trends in populations of selected species (birds)	Farmland birds	A1. Awareness, understanding and support for conservation		
	Woodland birds	A2. Taking action for nature: volunteer time spent in conservation 2000–2016 2011–2016		
	Seabirds	A3. Value of biodiversity integrated into decision making Under development		
1b. Trends in populations of selected species (butterflies)	Butterflies of the wider countryside	A4. Global biodiversity impacts of UK economic activity/ sustainable consumption		
	Specialist butterflies	A5. Integration of biodiversity considerations into business activity	A5a. Environmental management systems	
2. Plant diversity	Open habitats		A5b. Environmental consideration in supply chains	
	Woodlands	B1. Agricultural and forest area under environmental management schemes	B1a. Area of land in agri-environment schemes	
	Boundary habitats		B1b. Area of forestry land certified as sustainably managed	
3. UK BAP Priority Species		B2. Sustainable fisheries	B2a. Proportion of fish stocks harvested sustainably	
4. UK BAP Priority Habitats			B2b. Biomass of stocks at full reproductive capacity	
5. Genetic diversity		B3. Climate change adaptation		
6. Protected areas	Extent of protected areas	B4. Pressure from climate change		
	Condition of species and habitat features	B5. Pressure from pollution	B5a. Air pollution	B5a(i). Area affected by acidity
7. Sustainable woodland management				B5a(ii). Area affected by nitrogen
8. Area of agri-environment land			B5b. Marine pollution	
9. Sustainable fisheries		B6. Pressure from invasive species	B6a. Freshwater invasive species	
10. Ecological impacts of air pollution	Area affected by acidity		B6b. Marine (coastal) invasive species	
	Area affected by nitrogen		B6c. Terrestrial invasive species	
11. Invasive species		B7. Surface water status		
12. Spring Index				
13. Marine Trophic Index		C1. Protected areas	C1a. Total extent of protected areas: on-land	
14. Habitat connectivity			C1b. Total extent of protected areas: at-sea	
15. River quality	Biological		C1c. Condition of Areas/Sites of Special Scientific Interest	
	Chemical	C2. Habitat connectivity		

TABLE A1 (Continued)

2007		2018		
Indicator	**Measure(s)**	**Indicator**	**Measure(s)**	
16. Expenditure on UK biodiversity		C3. Status of European habitats and species	C3a. Status of UK habitats of European importance	
17. Expenditure on global biodiversity			C3b. Status of UK species of European importance	
18. Conservation volunteering		C4. Status of UK priority species	C4a. Relative abundance	
			C4b. Distribution	
		C5. Birds of the wider countryside and at sea	C5a. Farmland birds	
			C5b. Woodland birds	
			C5c. Wetland birds	
			C5d. Seabirds	
			C5e. Wintering waterbirds	
		C6. Insects of the wider countryside (butterflies)	C6a. Semi-natural habitat specialists	
			C6b. Species of the wider countryside	
		C7. Plants of the wider countryside		
		C8. Mammals of the wider countryside (bats)		
		C9. Genetic resources for food and agriculture	C9a. Animal genetic resources—effective population size of Native Breeds at Risk	C9a(i). Goat breeds
				C9a(ii). Pig breeds
				C9a(iii). Horse breeds
				C9a(iv). Sheep breeds
				C9a(v). Cattle breeds
			C9b. Plant genetic resources—Enrichment Index 1	
		D1. Biodiversity and ecosystem services s	D1a. Fish size classes in the North Sea D1c. Status of pollinating insects	
			D1b. Removal of greenhouse gases by UK forests	
			D1c. Status of pollinating insects	
		E1. Biodiversity data for decision-making	E1a. Cumulative number of records	
			E1b. Number of publicly accessible records at 1 km^2 resolution or better	
		E2. Expenditure on UK and international biodiversity	E2a. Public sector expenditure on UK biodiversity	
			E2b. Non-governmental organisation expenditure on UK biodiversity	
			E2c. UK expenditure on international biodiversity	