Received: 11 May 2023 | Revised: 20 August 2023 | Accepted: 1 September 2023

DOI: 10.1002/bse.3570

RESEARCH ARTICLE

Business Strategy and the Environment

WILEY

Short-term solutions to biodiversity conservation in portfolio construction: Forward-looking disclosure and classification-based metrics

Hannah Layman[1] | H. Resit Akçakaya[2] | Amanda Irwin[3] | Sophus zu Ermgassen[4] | Prue Addison[5] | Mark Burgman[6,7]

[1]FTSE Russell, London Stock Exchange Group, London, UK

[2]Department of Ecology and Evolution, Stony Brook University, New York, New York, USA

[3]School of Physics, University of Sydney, Sydney, Australia

[4]Interdisciplinary Centre for Conservation Science, Department of Biology, Oxford University, Oxford, UK

[5]Berkshire, Buckinghamshire, and Oxfordshire Wildlife Trust, Oxford, UK

[6]Centre for Environmental Policy, Imperial College London, London, UK

[7]Department of Zoology, Cambridge University, Cambridge, UK

Correspondence
Mark Burgman, Centre for Environmental Policy, Imperial College London, Room 101, Weeks Building, 16-18 Prince's Gardens, Imperial College, South Kensington, London SW7 1NE, England.
Email: mburgman@ic.ac.uk

Funding information
EU Horizon 2020 project SUPERB, Grant/Award Number: GA 101036849

[Correction added on 27 September 2023, after first online publication: Article title has been corrected in this version.]

Abstract

Demand is increasing among investors to create portfolios that encourage positive outcomes for biological diversity. The evolution of investment strategies for transitions to zero carbon over the last two decades provides insights that will assist in shaping strategies for biodiversity-positive investments. Many emerging approaches to capture company impact and dependence on biodiversity focus on nature-related threats to an organisation by assessing ecosystem integrity. Other approaches focus on minimising an organisation's contribution to risks of species extinction by using data sets such as the IUCN's Red List of Threatened Species. However, while these approaches are useful for assessing threats to and from biodiversity for individual companies, to be effective for investment portfolio construction, metrics need to be comparable across companies in an investment universe. Many of the threat assessments that could link corporate activities to impacts are incomplete and omit critical information. If the investment community focuses on biodiversity without sufficient forethought, there is a risk of entrenching metrics with significant flaws. In this paper, we suggest that interim approaches are needed to support investors in understanding the approaches being taken by potential investee companies. To that end, we present and discuss a disclosure-based Biodiversity Management Quality and a classification-based Biodiversity Revenues metric for biodiversity-related investing.

KEYWORDS
biodiversity metrics, biodiversity revenues, carbon, forward-looking metric, green revenues, management quality, nature-positive investment, sustainable finance

Abbreviations: BMQ, Biodiversity Management Quality; BR, Biodiversity Revenue; ESG, Environmental, Social and Governance; EU, European Union; FTSE100, Financial Times Stock Exchange 100 Index; GDP, Gross Domestic Product; GHG, Greenhouse Gas Protocol; IUCN, International Union for the Conservation of Nature; STAR, Species Threat Abatement and Restoration; TCFD, Task Force on Climate-Related Financial Disclosures; TPI, Transitions Pathway Initiative; UNEP, United Nations Environmental Program; WCMC, World Conservation Monitoring Centre; WWF, World Wide Fund for Nature.

1 | INTRODUCTION

Climate change is inextricably linked with ecological, economic and social well-being (Otero et al., 2020) and is currently the primary motivation of transitions to sustainable economies (Dikau et al., 2021;

Rosenbloom et al., 2019). Yet, human impacts on species and ecosystems driven by many factors in addition to climate change are substantial and accelerating (IPBES, 2019). Biological diversity, or biodiversity, means 'the variability among living organisms', including 'diversity within species, between species and of ecosystems' (CBD, 1992). The Convention on Biodiversity's *Strategic Plan for Biodiversity 2011–2020* created 20 Aichi Biodiversity Targets that promised (among other things) to address the underlying causes of biodiversity loss by, for instance, halving the rate of loss of all natural habitats (CBD, 2010). None of the targets was fully met by the 2020 deadline (CBD, 2020). A suite of global biodiversity indicators has been approved for use to assess fulfilment of the Convention's targets by 2030 (CBD, 2022a).

From the perspective of climate change, the Greenhouse Gas (GHG) Protocol, the most widely used approach to carbon emissions reporting globally, was adopted because it offered relatively low transaction costs, first-mover advantage, enhanced reputation (Green, 2010), consistent methodology and a basis for comparing sectors, regions and asset classes (Simmons et al., 2022). Voluntary corporate carbon reporting frameworks (Envizi, n.d.) aim to ensure consistency, reliability and compliance with the GHG Protocol. Prominent examples include the Task Force on Climate-Related Financial Disclosures (TCFD) (CDSB, 2022), which has formed the basis for legislation in many countries,[1] the Global Reporting Initiative standards, the Sustainability Accounting Standards Board standards and the International Integrated Reporting scheme (Klaaßen & Stoll, 2021). Among the carbon metrics, forward-looking assessments of corporate intent (Dietz et al., 2018) deployed by investment companies could be adapted usefully to guide biodiversity investment. Several groups have emerged that orchestrate emissions reporting, data collation and participation by companies, providing a basis (albeit imperfect) for investments in renewable energy, carbon capture and storage, and in companies that have sound policies and track records for reducing carbon emissions. More than $649bn was invested worldwide in environmental, social and governance-focused funds in 2021 (Reuters, 2021).

Biodiversity underpins most economic activity, either as nature-related inputs to production or through the provision of ecosystem services (UNEP, 2023). Threats to and impacts upon biodiversity are a substantial and often unacknowledged financial and business risk (Agarwala et al., 2022; Kraemer & Volz, 2022). The World Economic Forum (2020) classified biodiversity-related financial risks to include transition (to economies that sustain biodiversity), physical (arising from damage to infrastructure, business assets and supply chains), litigation and systemic risks (arising from the depletion of natural capital and ecosystem services, such as the loss of pollinators from agricultural systems; Capitals Coalition, 2020). These risks expose investors to losses through defaults, reputational harm and changes in the market value of investments. The risks are significant, with about 75% of the market capitalisation of the FTSE100 Index, for example, associated with nature-dependent production processes (Natural Capital Finance Alliance, 2019, in EDIE, 2019). The Banque de France found that 42% of the market value of securities held by French financial institutions comes from issuers (non-financial corporations) that are highly or very highly dependent on at least one ecosystem service (Svartzman et al., 2021). Similarly, the World Economic Forum (2020) report found that more than half of global GDP has moderate to high dependency on nature and its services.

As with carbon emissions, the sizes of investments and the speed of change needed to halt human-induced extinctions (Target 4); protect 30% of Earth's lands, oceans, coasts and inland waters by 2030 (Target 3); and restore 30% of degraded ecosystems (Target 2, COP15, 2022) may exceed the resources or willingness of individual governments (Deutz et al., 2020); institutional and private investors will play a central role. We have begun to see estimates of the required size of investment, with the Paulson Institute's (Deutz et al., 2020) analysis suggesting that reversing the decline in biodiversity by 2030 globally will require spending between US$ 722–967 billion each year between 2020 and 2030. Yet, until recently, limited attention has been paid to how financial investors might encourage positive biodiversity outcomes in the 2030 Agenda for Sustainable Development and the post-2020 Convention on Biological Diversity Global Strategy Framework (COP15, 2022; Moranta et al., 2022).

Reliable biodiversity metrics are an essential element in supporting the investment community to engage with biodiversity outcomes. Developing metrics for biodiversity is especially challenging because measuring biodiversity is difficult, its links to business are complex, and there is no consensus on appropriate trade-offs with potential adverse social impacts (Bishop et al., 2009). Some metrics report the state of biodiversity at a given location, or within a given area, others assess the significance of a location, the priority of implementing (or excluding) action at that location, or the probability of species or habitat decline. Thus, some biodiversity metrics operate only at a local level whereas others report on biodiversity over any spatial extent (a business enterprise, country, region) by accounting for spatial interactions and complementarities within that system (Leclère et al., 2020; Rosa et al., 2020).

It is further complicated by the need to consider the 'double materiality' of impacts, including both the impacts of businesses on nature and the impacts of nature on business performances (UNEP, 2023). Faced with this complexity, COP15 (2022) did not reach agreement on detailed targets for global impacts on species or ecosystems. Instead, it stipulated the need to encourage business, especially large and transnational companies and financial institutions, to monitor, assess and disclose risks, dependencies and impacts on biodiversity, provide information and report on compliance to reduce negative impacts, increase positive impacts and reduce biodiversity-related risks (Target 15). However, such initiatives may not be

[1]The TCFD (2022) is the basis for many legislated carbon regulations: see, for example

- US: SEC.gov | SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors
- EU: Guide on climate-related and environmental risks (europa.eu)
- AUS: 22-161MR ASIC encourages submissions to the International Sustainability Standards Board consultation on global baseline climate and sustainability disclosures | ASIC
- NZ: Mandatory climate-related disclosures | Ministry for the Environment

implemented soon enough to stem imminent global biodiversity loss (Addison et al., 2019; Business for Nature, 2022; de Silva et al., 2019), especially for impacts linked to distant elements of value chains (Beck-O'Brien & Bringezu, 2021; Crenna et al., 2020; Farsan et al., 2018). This creates an urgent need to develop transparent, cost-effective approaches to biodiversity impact reporting to guide investment that could be adopted internationally, using the resources and data currently available.

While the Taskforce on Nature-related Financial Disclosures Report (TNFD, 2021, 2022) has begun to offer direction, there are no broadly accepted methods, indicators, or guidelines for the financial valuation of biodiversity impacts or risks (Stephenson, 2019), without which investors cannot assess biodiversity management performance or practices (Addison et al., 2020; de Silva et al., 2019; zu Ermgassen, Howard, et al., 2022). Metrics published by Soto-Navarro et al. (2020) and more recently by WWF (2023) and UNEP (2023) were developed in line with TNFD (2022) recommendations. They aim to minimise impacts on local ecosystem composition, structure and function through concepts including ecosystem intactness (the average number and abundance of species remaining at a given location; Leclère et al., 2020), ecosystem and landscape integrity, Potential Disappeared Fraction and Mean Species Abundance (see Prescott et al., 2023, for a comprehensive guide). Other metrics which we outline below provide insight into biodiversity impact performance in terms of species extinctions.

Substantial research is needed to create new data or uplift/combine existing data so that they are fit for the purpose of guiding investments and to design asset-based biodiversity metrics that are appropriate for portfolio construction. The mitigation hierarchy provides a framework for implementing biodiversity-positive investment strategy (Arlidge et al., 2018; Milner-Gulland et al., 2021). However, investments in avoiding, mitigating, or offsetting impacts on biodiversity are likely to move before such metrics can be sufficiently tested (CPIC, 2021). If the investment community focuses on biodiversity without sufficient forethought, there is a risk of treating the symptoms of biodiversity decline without addressing underlying causes (Obura et al., 2021), entrenching metrics with significant flaws that at best create unnecessary portfolio turnover and at worst result in perverse outcomes for biodiversity because the system fails to penalise companies, or even rewards them, for behaviours and decisions that impact adversely (Simpson et al., 2021).

The investment community includes large institutional investors who look for guidance on how to invest in line with their climate and ethical policies, while satisfying expectations on financial risk and return. These investment decisions rely on a comprehensive and comparative evaluation of all potential investments, and often the investor does not have the time or resources to assess individual operations and so they will defer to metrics produced by data and rating providers. Data and rating providers use 'forward-looking' metrics to evaluate management intent, together with 'backward-looking' metrics that measure impact and opportunities to date (Hassan et al., 2022; Hassanein et al., 2019).

In this study, we explore ways in which, in the short term, investors could leverage off existing data frameworks and collection processes to include a biodiversity signal in their portfolio, bridging the gap until more sophisticated metrics are fully developed, challenged and tested. In the longer term, these metrics could form part of a broader dashboard of biodiversity metrics. The tools we propose are not a solution to the problem of inadequate biodiversity metrics, nor are they intended to replace those currently being used. Rather, they aim to address the problem of how to get started with identifying which companies are taking biodiversity impacts seriously. These proposed metrics are easy to implement in a standardised way across a universe of potential investments, potentially helping to overcome data gaps and biases.

Our goal is to encourage private capital investment that slows and reverses biodiversity declines through businesses acting to mitigate their impacts and taking proactive steps towards nature-positive goals (Milner-Gulland, 2022). We stress that such actions are a complement, and not a substitute, for more rigorous public policy to conserve biodiversity and to restrict financial flows into activities that damage biodiversity (Kedward et al., 2023).

We first describe the development of global carbon investment indices, their essential features and limitations. We then summarise the current state of investment tools that encourage effective biodiversity outcomes. We outline approaches to assessing positive business impacts on biodiversity based on those developed for carbon emissions. Specifically, 'Green Revenues' provide a template for a classification-based approach for identifying opportunities, and the Transition Pathway Initiative's Management Quality (Dietz et al., 2018) provides a disclosure-based approach for evaluating a company's planned or expected future performance. We describe the essential elements of new metrics, the Biodiversity Management Quality metric, based on the carbon metric by Dietz et al. (2018), and the Biodiversity Revenues metric, which could add to the current range of options for assessing biodiversity investments, providing an interim solution until reliable data and comprehensive metrics for biodiversity investment are available and vetted. We provide examples of applications and discuss challenges and opportunities for implementation.

2 | THE CARBON MODEL

The Greenhouse Gas Protocol Corporate Standard, published in 2001, was motivated by a need to establish standardised reporting and monitoring for disclosure and compliance with regulations (Green, 2010). This allowed for the calculation of portfolio-level metrics such as carbon intensity and the ability to measure a portfolio against targets. The concept of Green Revenues (Bassen et al., 2023) signalled a change in focus towards opportunities associated with transitions to sustainable business activities. More recently, the investment community has developed a focus on measuring the intent of companies, which has led to the creation of 'forward-looking' metrics that document how companies are planning to move

towards sustainability goals. It is unlikely that a single performance metric will fully describe the position of a product, company, or investment strategy. Bocquet et al. (2021) recommended a dashboard of performance indicators and forward-looking metrics that reflect trends, targets, management quality and climate-related financial risk exposure.

The emergence of effective guidance for responsible investment in carbon transitions depends on three critical elements: (1), standardised disclosures and appropriate incentives for reliable monitoring and reporting, (2) agreed targets for unacceptable impacts and the allocation of responsibility for meeting the targets among jurisdictions and activities and (3) reliable measures of progress towards achieving the agreed targets (Smith et al., 2020).

Pattberg (2017) highlighted the importance of standardised disclosure to create incentives for investment to close the gap between current emissions and those required to limit global temperature increases. Disclosure depends on measuring and reporting greenhouse gases emitted or sequestered, together with an assessment of their monetary value (as assets and liabilities), so that investors can evaluate market risks and opportunities. Several initiatives have emerged to encourage voluntary, consistent and transparent climate-related financial disclosures and provide companies with technical guidance to meet their emissions objectives. For example, the Transition Pathway Initiative (TPI, n.d.) Management Quality metric uses questionnaires to evaluate the quality of company management and planning, compared to international targets and national pledges made as part of the Paris Agreement. The impact of these disclosure initiatives is substantial and growing; in 2021, 10,400 companies globally responded to the Carbon Disclosure Project questionnaire and more than 680 financial institutions managing more than US$130 trillion in assets requested the data (CDC, 2022). In the same year, nearly one thousand organizations worldwide set emissions reduction targets through the Science Based Targets Initiative, primarily in Europe and Asia (SBTi, 2021).

Indicators such as GHG footprints and emissions covered by carbon pricing schemes are called lagging indicators because they are static and reflect past performance. In contrast, forward-looking (or leading) indicators provide insights on where a company's performance is heading. Examples include commitments to climate targets (CDC, 2022) and the Task Force on Climate-related Financial Disclosures (TCFD, 2022). The evolution of metrics to guide investment in carbon has lessons for the development of indices to guide nature-positive investment. It has emphasised the need to thoroughly test metrics before they are deployed, to create structures for standardised disclosure, to ensure the requisite data to support reliable assessments are available, to utilise a dashboard of backward and forward-looking metrics to suit different circumstances and to provide transparent metrics that can be assessed by third parties and fully understood by the investment community.

3 | BIODIVERSITY CONSIDERATIONS IN EXISTING TOOLS

Here, we discuss several existing tools including procedures, metrics and data bases. Most investment agencies have biodiversity as one of several inputs into higher level Environmental, Social and Governance (ESG) scores. For example, land-use change (forest loss and regeneration) is part of FTSE-Russell's models for ESG calculations (FTSE, 2022). Most established metrics for a company's biodiversity impact assessments focus on individual company activities. They can be used to guide performance, set biodiversity goals and targets, deploy mitigation actions and monitor outcomes (FTSE, 2022). However, they are granular, focusing on internal company modelling to assess impacts specific to a business (Addison et al., 2019, 2020). Importantly, businesses report their biodiversity impacts across a very narrow range of categories, underestimating their true negative impacts (Smith et al., 2018). As with carbon intensity, investors require a consistent approach that can be used across industries and investment universes by third-party assessors.

There are several nascent, industry-led initiatives on broader biodiversity impact assessment that aim to guide disclosure and develop standardised metrics to assess how nature may impact an organisation and how an organisation impacts nature (F4B, 2022a, 2022b; NGFS, 2022; TNFD, 2021). Other metrics have been defined that assess impacts on global and local biodiversity, based on life-cycle analysis of activities, integrating carbon, water, land and material impacts on terrestrial and marine systems (Soto-Navarro et al., 2020, ClubB4B, 2021, CBF, 2022, GBS, 2022, NEC, 2022, UNEP, 2023, WWF, 2023; Table 1). These have tended to be asset-based approaches. For example, the Biodiversity Footprint for Financial Institutions (BFFI, 2021) ascribes biodiversity footprints to industry sectors, split by drivers of loss (climate change, land use and so on). HSBC (2022) introduced their World ESG Biodiversity Screened Equity in 2021. It contains biodiversity and ESG screening criteria, aiming to guide investments in ways that mitigate biodiversity risk. HSBC assigns a Corporate Biodiversity Footprint (based on Mean Species Abundance and capital employed). Most recently, WWF (2023) and UNEP (2023) have developed methods that focus on nature-related risks and rely in part on metrics of intactness (Table 1). The metrics in Table 1 are a subset of those that potentially may be deployed effectively to assess corporate impacts; many others have been suggested (see, e.g., Di Marco et al., 2019; Ferrier et al., 2020; Marques et al., 2021; Mokany et al., 2019; UNEP-WCMC, 2016). They are used for assessing corporate impacts on species (Marques et al., 2021) and illustrating the different ways that investee companies can assess their impact and dependency on biodiversity and the variation in approaches and datasets used to carry out those assessments.

Metrics of species richness and abundance remaining in an area such as Mean Species Abundances, Potentially Disappeared Fraction or Biodiversity Intactness (Newbold et al., 2016) can be used to account for both direct and indirect (supply chain) impacts when spa-

TABLE 1 Some important biodiversity initiatives, summarised in part from Lammerant et al. (2021).

Initiative		Proposed metric to assess biodiversity footprints		Proxy linking activity to impact
BFFI (2021)	Biodiversity Footprint for Financial Institutions	Potentially Disappeared Fraction (PDF)	Approximated by calculating the proportion of species in an area that would be eliminated by company activities, compared to species richness in undisturbed conditions.	Land use
CBF (2022)	The Corporate Biodiversity Footprint	Mean Species Abundance (MSA)	The average of native species abundances in each ecosystem compared to their estimated abundance in its original (pre-impact) state.	Land use
GBS (Club B4B+ 2021)	The Global Biodiversity Score	Mean Species Abundance	As above	As above
NEC (2022)	Net Environmental Contribution	Relative harm	Measures impact on biodiversity, climate and air quality, placing activities on a scale from −100%, for the most damaging, to +100% for the least harmful environmental solutions that fulfil the same function.	Land use, soil pollution
OP (Huijbregts et al., 2017; e.g., Bull et al., 2022)	The Oxford Protocol	ReCiPe, local species loss per year	Estimates the relative species loss resulting from corporate activities.	Land use, GHG emission, water use, water and air pollution
ENCORE (2022)	Exploring Natural Capital Opportunities, Risk and Exposure	Mean Species Abundances and IUCN Red List	Assists businesses to assess risks arising from climate and land use change and the alignment of their portfolios with global and regional biodiversity targets, using mean species abundances and extinction risk estimates.	Land use and species extinction risk
WGBI (Bourne et al., 2020)	World Government Bond Index	IUCN Red List and other metrics	Assesses biodiversity impacts with several biodiversity-related metrics, one of which is the proportion of species in a country that are classified as threatened, based on IUCN categories.	Species extinction risk and land use
STAR (2022a)	Species Threat Abatement and Restoration	IUCN Red List	Calculates the contribution an investment in each location can make to reducing extinction risk.	Species extinction risk
nSTAR (Irwin et al., 2022)	Non-normalised Species Threat Abatement and Restoration	IUCN Red List	Connects to economic activity which allows quantification of extinction risk by sector/company.	Species extinction risk
WWF (2023)	Biodiversity risk filter	33 biodiversity risk metrics	A combination of the locationof corporate activities and the importance and state of biodiversity integrity.	Many
UNEP (2023)	Nature risk profile	Ecosystem Integrity Index (EII)	A measure of the extent to which ecosystem structure, function and composition fall within a natural range of variation.	Land use

tially explicit information is available. They are relatively simple to apply and can be disaggregated into impacts of individual companies, industry sectors and jurisdictions using land use as a proxy. They all measure slightly different things. None have yet been accepted by the finance sector as a standard way to measure the biodiversity impacts and dependencies of investments.

The Species Threat Abatement and Restoration (STAR, 2022a) metric focuses on minimising the risk of extinction and builds on the IUCN Red List Index (IUCN, 2022) to estimate the effects of investments to reduce extinction risk (Mair et al., 2021). It is based on the scope (proportion of the global population impacted), severity (rate of decline driven by the threat within its scope) and timing (past, ongoing, or future) of threats. Mair et al. (2021) used the STAR metric to identify opportunities for threat abatement and restoration in a global context, and Chaudhary et al. (2022) and Mair et al. (2023) used it at a national scale. Strassburg et al. (2020) used the Red List data to calculate 'Area of Habitat' to identify priority areas for conservation. Irwin et al. (2022) modified the STAR methodology to create the nSTAR metric, which connects adverse impacts on species to global supply chains. While the STAR methodology produces a value for each species, it is currently only available as aggregated assessments for specified locations, nor does it yet provide coverage for biodiversity in marine or freshwater ecosystems (STAR, 2022b). These biodiversity metrics are asset-based, requiring site-specific information for detailed assessment of company operational impacts and options to reduce biodiversity impacts, while the nSTAR metric can be used for value chain assessments due to its connection into global supply chain data.

The IUCN Red List is currently the most complete data source for the development of a biodiversity metric focused on species extinctions. The Red List provides an assessment of the extinction risk category of each species, linked to an evaluation of the threats affecting them. The Red List of Threatened Species has been used by businesses to identify and avoid impacts on locations with high conservation values, to mitigate impacts on priority species and to tailor activities to minimise impacts of infrastructure development (Bennun et al., 2018).

The Red List Index was developed to determine meaningful trends in the status of biodiversity. It shows trends in the status of species based on genuine improvements or deteriorations in status for groups in which all species have been assessed at least twice (Butchart et al., 2005, 2007), currently including birds, mammals, amphibians, corals and cycads (IUCN, 2022; Rodrigues et al., 2006). The STAR score is the sum of the risks of extinction of species weighted by their threat status (Mair et al., 2021; STAR, 2022a). For global assessments, the threats noted in the Red List are not tied to specific corporate activities (IUCN, 2021). nSTAR methodology circumvents this problem by using input–output analysis to connect an investment portfolio to an extinction-risk footprint for that portfolio.

However, the information on threats (i.e., human activities causing the threatened status) contained in the Red List assessments is incomplete in many cases (Irwin et al., 2022). Many assessments lack detailed reasoning that links specific human or company activities to increases in the extinction risk of species, and many omit information on the location, scope and relative severity of threats (see, e.g., the assessment of the European Sturgeon; IUCN, 2023; eight threats are listed but their scope and severity are unknown. This is the case for most listed species). While there is potential for the development of a more sophisticated metric based on the Red List, applicable across industries and investment universes, significant work is needed to ensure comprehensive data are fit for use in a biodiversity metric for portfolio construction. Given the millions of species still to be assessed, in addition to those hundreds of thousands of species whose assessments are incomplete, the challenge is daunting.

In parallel, other metrics are being developed that focus on the composition of local ecosystems and sustaining ecosystem services. In the wake of TNFD (2021, 2022), these types of metrics have made significant advances, with various designs mapping from companies to activities to asset locations to impacts by leveraging off geospatial data and measures of intactness. For example, the Red List of Ecosystems (Keith et al., 2014) establishes a spatially explicit, globally consistent set of assessments of threatened ecosystems. However, to provide a comprehensive assessment of impacts on and exposure to biodiversity loss, these approaches will need to incorporate the threats to ecosystem persistence arising from corporate activities, together with local variation in ecosystem condition and community composition (Weiskopf et al., 2022). This work is far from complete (e.g., Dhyani et al., 2022; Prescott et al., 2023).

Like metrics focusing on risk of species extinction, these approaches have significant limitations. There is no body of academic research that verifies the mapping from geospatial corporate activities onto ecosystem intactness or that provides a reliable guide to the likelihood of ecosystem collapse as a result of a company's or sector's activities (GBS, 2022).

While many of the metrics in Table 1 are used to measure the impact of a company's actions on biodiversity, to guide planning and investment in the future, they are backwards looking indicators in the context of financial reporting, in the sense that they use data up to the present, without explicit forecasts or predictions. Some of these (e.g., those based on the IUCN Red List) are leading indicators of species extinctions (Keith et al., 2014; Stanton et al., 2015) and are useful for tracking progress against targets. However, they are designed to assess a company's impact on biodiversity at a point in time and they provide limited insights into the intentions or future impacts of company activities.

Given the growing investment appetite for ethical and nature-positive portfolios, and the undervalued, imminent risks associated with biodiversity loss, there is a need to provide measures of corporate activities that can be applied readily to all companies using existing data such as company reports that reflect current activities that generate positive biodiversity outcomes, as well as metrics that reflect the intentions and future behaviour of companies towards biodiversity.

4 | INTERIM SOLUTIONS

Investments with poorly designed metrics have rightly been criticised for 'green washing' (Tuhkanen & Vulturius, 2022), potentially misleading investors and creating the appearance of socially and environmentally responsible investment without encouraging effective outcomes (Kedward et al., 2023). Both providers of metrics and managers of portfolio construction and design who use these metrics have significant discretion in creating and adjusting their models, with limited oversight (Bloomberg Law, 2022). They require metrics that are informative and thoroughly tested, that generate appropriate investment behaviours leading to beneficial biodiversity outcomes. If investments are ready before metrics can be developed and tested, there is risk that inappropriate metrics may become embedded in financial operations so that investments do not generate the intended nature-beneficial outcomes. This prospect creates a need to provide robust alternatives that can bridge the gap until more suitable and effective tools are ready. In the longer term, these can be used as part of a broader dashboard of biodiversity tools, which, if operating effectively, will converge over time. Below, we outline two options that build on existing carbon reporting metrics and existing data, one a forward-looking metric based on Dietz et al. (2018) and the other, a classification for investment that builds on 'Green' revenues classifications in broad use in the financial industry. We provide succinct and deliberately incomplete outlines, to encourage development by data and rating providers who will ultimately be responsible for their testing and deployment.

4.1 | Biodiversity Management Quality—A forward-looking (leading) metric based on company disclosures

Commitments to biodiversity impact mitigation are unevenly distributed among companies, even within the same business sector (Narain et al., 2020; zu Ermgassen, Howard, et al., 2022). The benefit of a disclosure-based metric for portfolio construction designed in line with the Transitions Pathway Initiative (TPI; Dietz et al., 2018) is that data can be collected from company disclosures, and companies can be given the chance to respond. Rewarding biodiversity-positive management outlook and priorities should encourage businesses to develop appropriate systems and to disclose activities that avoid, mitigate, or offset negative biodiversity impacts or that enhance biodiversity (Milner-Gulland, 2022).

Our objective is to outline a potential design for a globally relevant, robust metric for portfolio construction that encourages activities that use the mitigation hierarchy (Arlidge et al., 2018; Milner-Gulland et al., 2021) to create positive biodiversity contributions. Management quality and commitments to net-zero carbon transitions are important elements of forward-looking assessments. These issues may translate straight-forwardly to assessments of commitments to reducing impacts on biodiversity.

The TPI Management Quality framework assesses company management (Dietz et al., 2018) against a series of indicators related to transition to a low-carbon economy, covering issues such as company policy, emissions reporting and verification, targets, strategic risk assessment and executive remuneration. Based on their performance against these indicators, companies are placed on one of five levels. This approach can be translated to a focus on biodiversity via a Biodiversity Management Quality Metric, an example structure of which is presented in Table 2. It omits several of the questions that are part of the equivalent carbon assessment process because it is merely an example of what might be done. A fully fledged questionnaire-based approach would need to be based on an analysis of company disclosures, adjusting questions to ensure they discriminate effectively among companies within and across sectors and geographies and providing much more detailed guidance for assessors. The risk management and disclosure framework for nature-related risks under development by the Taskforce on Nature-related Financial Disclosures (TNFD, 2022) addresses many of the same concepts.

We discuss the strengths and weaknesses of a questionnaire-based leading metric below. The approach is presented here only as an example of the kind of assessments that may be undertaken, reflecting the path taken for carbon emissions assessments. Many of the questions could be further developed to include, for example, targets that address the level of impact that the company is having on biodiversity and time-bound, quantitative targets. The attainment of levels in this index is just one way of aggregating company disclosure. It may turn out that companies can be discriminated better within a sector or universe by allocating points and adding over a company's range of activities. Alternatively, this kind of information may be evaluated better using a decision tree or fuzzy logic, given the linguistic uncertainties that arise inevitably in language-based analyses.

4.2 | Biodiversity Revenues—A classification-based biodiversity metric to identify opportunities for financial investors

The development of so-called 'green revenues' data sets was motivated by investor interest in the opportunities arising from the transition to a low carbon economy, rather than exclusively by interest in risk mitigation. The methodology looks at assessing positive impacts, allowing investors to identify opportunities for potential revenue growth from nature-positive market outcomes.

One such data set, FTSE-Russell's (2020) Green Revenues data model, aims to help investors and financial markets to identify companies with green products and services. It is based on a classification of activities identified as generating green revenue, mapped onto one 10 subsectors, 64 subsectors and 133 microsectors, aggregated at the company level (FTSE-Russell, 2020). Company activities are assessed against seven environmental objectives (climate change mitigation and adaptation, pollution, healthy ecosystems, sustainable water and marine resources, circular economy and sustainable agriculture [FTSE-Russell, 2022]). They are

TABLE 2 A purposefully incomplete example for a Biodiversity Management Quality Metric (based on an excerpt of questions in the TPI framework; Dietz et al., 2018).

Level 0: Unaware of (or not Acknowledging) Biodiversity Loss as a Business Issue
Question 1 Does the company acknowledge biodiversity loss as a significant issue for the business?
Notes If the company does not acknowledge biodiversity loss as a significant issue for the business, it is placed on Level 0. Companies are assessed as Yes if they: 1. Explicitly recognise biodiversity loss as a relevant risk and/or opportunity for the business (Q2); or 2. Have a policy or an equivalent statement committing them to act on biodiversity loss (Q3); or 3. Have set biodiversity impact reduction or enhancement targets (Q4); or 4. Have published information on their operational biodiversity impacts (Q5).
Level 1: Acknowledging Biodiversity Loss as a Business Issue
Question 2 Does the company explicitly recognise biodiversity loss as a relevant risk and/or *opportunity for the business?*
Notes Companies are assessed as Yes if they demonstrate recognition of biodiversity loss as a relevant risk and/or opportunity to the business. …
Level 2: Building Capacity
Question 4 Has the company published information on its operational positive and negative biodiversity impacts?
Notes Companies are assessed as Yes if they report on their direct (operational) impacts. Indirect (supply chain) impacts are included in other Questions.
Level 3: Integrating into Operational Decision-Making
Question 6 Has the company nominated a board member or board committee with explicit responsibility for oversight of biodiversity impact policy?
Notes Companies are assessed as Yes if they provide evidence of clear board or board committee oversight of biodiversity impact, or if they have a named individual/position responsible for biodiversity impact at board level.
Question 9 Has the company had its operational positive and negative biodiversity impact data verified?
Notes Companies are assessed as Yes if their operational biodiversity impact data have been independently verified by a third party, or if they state the international assurance standard they have used and the level of assurance.
Question 10 Does the company support domestic and international efforts to mitigate negative or enhance positive biodiversity impacts?
Notes Companies are assessed as Yes if they demonstrate support for mitigating negative or enhancing positive biodiversity impacts through membership of business associations that are supportive of nature-positive outcomes, and if they have a clear company position on public policy and regulation.
Level 4: Strategic Assessment Question
Question 13 Has the company set long-term quantitative targets for reducing its negative biodiversity impacts and/or enhancing its positive impacts?
Notes Companies are assessed as Yes if they have set quantified, long-term targets (i.e., more than 5 years in duration) negative and positive biodiversity impacts in relative or absolute terms (direct and indirect impacts). This question is more demanding than Question 7, as the targets must not only be quantitative, they must also be long-term.
Question 14 Has the company incorporated positive and negative biodiversity impact issues into executive remuneration?
Notes Companies are assessed as Yes if executive remuneration incorporates biodiversity impact performance.
Question 15 Does the company incorporate biodiversity risks and opportunities in their strategy?
Notes Companies are assessed as Yes if they detail how they incorporate biodiversity risks and opportunities in their strategy (mitigation, R&D, etc.), and if they disclose the impact of biodiversity risks and opportunities on financial planning (OPEX, CAPEX, M&A, debt).

Note: To apply the metric, the analyst addresses the questions sequentially. If the answer to a given question is 'no', the assessment stops at that level. If it is 'yes', they progress to the next level's questions. Where there is more than one question for a given level, the analyst must answer each question 'yes' to be assessed successfully at that level. The question numbers relate to analogous questions in the TPI framework.

classified as Tier 1 if the environmental benefits are 'clear and significant', Tier 2 if they are 'net positive' and Tier 3 if the environmental benefits are 'limited'. Activities have been assessed for more than 16,000 securities in 48 markets. A Tier 1 activity is, for example, revenue from the operation and supply of power generation where the primary source is renewables-based, and where the waste heat is utilised for large-scale heating and/or cooling purposes. Tier 3 activities that result in environmental benefits and potential environmental harm include, for example, revenue-generating activities related specifically to the mining, processing, handling, or owning of lithium, a key input into advanced batteries.

The EU Commission (2020) classifies sustainable business activities and FTSE Russell's Green Revenues Classification System aligns as closely as possible to it, quantifying the share of revenues that is likely to qualify as generated by sustainable activities under the EU Taxonomy (FTSE Green Revenues 2.0 data model). The Green Revenues classification does not deal explicitly with biodiversity impact avoidance, minimisation, or remediation (Milner-Gulland et al., 2021). Rather, biodiversity is considered as an implicit element of the seven environmental objectives, including healthy ecosystems. The risk of not having explicit biodiversity goals means that biodiversity losses will accumulate when other objectives are in conflict and outweigh biodiversity considerations.

There is an opportunity to develop an analogous classification for Biodiversity Revenues, designed to capture activities that are directly related to enhancing biodiversity outcomes, consistent with the EU Sustainable Finance Taxonomy (EU Commission, 2020), which identified the protection and restoration of biodiversity and ecosystems as one of six environmental objectives (EU Commission, 2022). A Biodiversity Revenues metric would be based on an expansion of the classification that currently has a limited list of relevant activities. Once developed, alongside identifying opportunities, revenues arising from activities that harm biodiversity (analogous to Brown Revenues) and ratios (such as Green to Brown Revenues) may also be useful. The benefits of this are the potential for an overlapping classification with existing Green Revenues data models, the potential to leverage off data collection and quality procedures designed for Green Revenues and the market's relative familiarity with the structure of the metric.

In the even shorter term, subsectors of the Green Revenues model that relate to biodiversity outcomes could be selected to form the kernel of a Biodiversity Revenues classification. Some examples are outlined in Table 3, where we present some potential options for this purpose that illustrate how the classification may be developed and applied.

Table 3 provides just two of many possible examples, and these are not fully developed. For example, smart city design would include campaigns to encourage people to use native plant species in their backyards, as well as propagating and providing native plants for larger restoration projects.

5 | DISCUSSION

It is generally agreed that assessing biodiversity impacts is more complex than carbon assessment, which has proven to be challenging enough. Nevertheless, acquiring the data and designing the metrics to encourage investment portfolio design to avoid or alleviate biodiversity loss is achievable. Several important lessons from the development of carbon portfolio metrics have implications for the development and deployment of biodiversity metrics. As we have seen from the evolution of carbon investments, these include the need for meaningful target setting, incentives for the investment

TABLE 3 Options for enhancing the Green Revenues Classification System to focus on beneficial biodiversity outcomes, so-called 'Biodiversity Revenues', from the perspective of reduced risks of species extinctions.

Sector **Environmental support services**		**Revenue generating activities from environmental support services relating to consulting, investment or urban design that enable or indirectly contribute to activities resulting in positive biodiversity outcomes.**	
Subsector	**Micro-sector**	**Green tier**	**Description**
Environmental consultancies	Environmental consultancies (general)	Tier 1	Revenue generating activities related specifically to companies that provide advice and/or support regarding biodiversity impact avoidance, minimisation and remediation.
Finance and investment	Sustainable investment funds	Tier 1	Revenue generating activities related specifically to investment vehicles that specialise in biodiversity enhancement.
Smart city design and engineering	Smart city design & engineering (general)	Tier 1	Revenue generating activities related specifically to urban design and to the development, manufacture or installation of products and services that allow cities to develop and maintain biodiversity focused green spaces, transport systems and related design options specifically focused on maintaining populations of threatened species.
Sector **Food and agriculture**		**Revenue generating activities from products that reduce threats to species without compromising yield, productivity and sustainability in agriculture, silviculture, aquaculture and food production or distribution.**	
Subsector	**Micro-sector**	**Green tier**	**Description**
Agriculture	Agriculture (general)	Tier 1	Revenue generating activities related specifically to companies that provide advice and/or support regarding biodiversity enhancement activities in agricultural landscapes specifically focused on maintaining and enhancing threatened species and ecosystems.
Logistics	Logistics (general)	Tier 1	Revenue generating activities related to the operation of efficient logistics systems in the transportation stage of food production, especially focused on local distribution and consumption, minimising transportation and reducing food waste, resulting in reduced threats to species.

Note: Many other sectors could be added such as tourism, with micro-sectors devoted to ecotourism.

community, short-term vs. long-term solutions and the importance of transparency and data quality.

The usefulness of point-in-time metrics is limited without targets. The Paris Agreement allowed targets to cascade through countries and sectors to companies. Targets for biodiversity can be in terms of loss reduction or restoration, essentially representing a consensus on acceptable loss, analogous to the acceptable levels of carbon emissions that will limit climate warming to below 1.5°C, and in terms of restoration, representing a consensus on the levels to which to increase the species. The latest international agreement on biodiversity, the Kunming-Montreal Global Biodiversity Framework (CBD, 2022b), includes both of these, with one goal set as:

> Human induced extinction of known threatened species is halted, and, by 2050, extinction rate and risk of all species are reduced tenfold, and the abundance of native wild species is increased to healthy and resilient levels.

As with carbon, such deliberations about biodiversity targets will result in discussions about the equitability of the geographical and social distribution of the burden for avoiding unacceptable biodiversity impacts and enhancing positive impacts. This is particularly relevant given much of the world's biodiversity is in emerging economies (particularly in tropical climates). It will involve discussions about shareholder interests, as businesses seek to balance climate objectives with traditional financial objectives. This issue has been brought into focus for carbon investments, particularly in the face of the recent oil and gas movements that has seen the investment community examining priorities between climate risks and traditional financial risk, including the importance of monitoring tracking error, concentration risk and traditional factor exposures. The investment community is also becoming increasingly aware of the need to test metrics thoroughly to account for evolving data, changing contexts and novel outcomes, through stress and scenario tests. These insights will also be important for the development and deployment of biodiversity metrics.

Given the current investment interest in biodiversity, there is a need a create interim solutions that can be used to encourage biodiversity outcomes before more sophisticated metrics can be sufficiently tested and understood. Ideally, these short-term solutions can leverage off existing data and data structures. We have suggested two possible metrics to bridge the gap. Exact measurements of the current state and changes in biodiversity may not be essential for encouraging behaviour change in businesses. While the two metrics of business impacts on biodiversity we have outlined here offer possibly crude approximations for biodiversity impacts, they give companies and more importantly, investors, an opportunity to respond quickly to make changes, hence influencing behaviours to reduce biodiversity negative impacts and enhance positive impacts, as crude metrics of carbon emissions have encouraged businesses to respond to climate change. Solutions such as those described here will be complemented by detailed assessments of impacts and eventually work together as part of a broader biodiversity dashboard.

The issue is not that companies cannot use biodiversity metrics such as ecological intactness or the STAR metric, but that to support investment portfolios, metrics need to be applied to all companies within each sector of an investment 'universe'. BMQ and BR may be estimated for all companies by third parties using publicly available data. Therefore, the BMQ may ask whether a company has published information on its operational positive and negative biodiversity impacts. For a company to be able to do this, it needs to have a measure of the state of biodiversity in the places the company's operations or value chains have impacts. If the company has not published this information, it scores zero. These provisions should create incentives for companies to disclose information consistently regarding biodiversity and extinction risk, which currently is lacking (Hassan et al., 2020, 2022). Equivalent questions are used currently to evaluate carbon metrics. Thresholds for investment decisions will be in the hands of investors, who may use the metric to undertake comparative assessments of companies within industry sectors or subsectors.

The Biodiversity Management Quality metric, if operating effectively, should correlate with lagging indicators developed in the longer term, allowing investors to anticipate the impacts of company activities. The data can be collated from company disclosures and companies may have opportunities to respond and clarify. This approach also has the advantage that it leverages off existing data collection practices and quality assurance processes and so will be relatively readily implemented. Insomuch as the questions address a company's ability to adapt and manage risks, and their ability to measure their impacts on the environment, it is consistent with evaluations of double materiality. Many companies currently do not report data of biodiversity-relevant activities in sufficient detail to score highly. The Biodiversity Management Quality metric will create an incentive to develop governance and policy for biodiversity, report transparently and act effectively.

The Biodiversity Revenues metric is intended to encourage companies to engage in activities with clear and important biodiversity-positive impacts. Like the Biodiversity Management Quality metric, it could be designed to be collated from company disclosures, giving it the advantage that it would leverage off existing data collection practices and quality assurance processes and so be relatively readily implemented. This will encourage companies to disclose sufficient financial information that their Biodiversity Revenues can be clearly assessed, especially if the system provides an opportunity for companies to respond to third-party assessments. Issues of subjective assessment may arise for Green Revenues, as they do for forward-looking questionnaires. Like them, transparent third-party assessments and detailed guidelines should provide comfort for investors that the data are a meaningful guide to effective investment.

These metrics have limitations (Table 4). Inevitably, the interpretation of questions and the categorisation of revenue streams involve a degree of subjectivity. zu Ermgassen, Howard, et al. (2022) assessed sustainability reports of the Global Fortune 100 companies, effectively addressing many questions in Table 2. They found that, for instance,

TABLE 4 Challenges and solutions for the Biodiversity Revenues and Biodiversity Management Quality metrics.

Metric	Potential challenges	Potential solutions
Biodiversity Management Quality	Becomes a box-ticking exercise	Use independent (third party) assessment (see zu Ermgassen et al., 2020, in the context of monitoring corporate zero-deforestation commitments), monitor assessments over time to identify unjustified changes, ensure data are verified.
Biodiversity Management Quality	Links to the state of biodiversity are assumed but not empirically established.	Monitor management quality and biodiversity impacts over time.
Biodiversity Management Quality	Introduces size bias into portfolios—larger companies have greater capacity to respond adequately to questionnaires and have the resources and corporate cultures that support high quality sustainability reporting, leading to concentration issues.	Adjust portfolio construction to mitigate reporting size bias.
Biodiversity Management Quality	The categorical nature of questionnaires leads to unhelpful distributions, particularly in regional contexts.	Monitor the distribution of the metric within investment universes and adjust the questions to ensure the metric differentiates meaningfully between companies within a sector, particularly in regional or more concentrated universes.
Biodiversity Management Quality and Biodiversity Revenues	If methodology changes, the metric may be sensitive to changes in data distribution, generating portfolio turnover.	Stress test the methodology thoroughly before release.
Biodiversity Management Quality and Biodiversity Revenues	The interpretation of questions and the categorisation of revenue streams involves a degree of subjectivity, leading to inter-rater variability (e.g., zu Ermgassen, Howard, et al., 2022).	Use multiple, independent (third party) assessors (see zu Ermgassen et al., 2020), compare the independent judgements made by two or more independent assessors and provide detailed guidelines to support assessments.
Biodiversity Management Quality and Biodiversity Revenues	As for all metrics, it may be difficult to assess the impact of indirect supply chains, especially where the origin of a product cannot be traced (zu Ermgassen, Lima, et al., 2022; c.f., nSTAR, Irwin et al., 2022).	Provide detailed guidelines to support assessments (zu Ermgassen, Lima, et al., 2022). See the approach used in nSTAR (Irwin et al., 2022)
Biodiversity Management Quality and Biodiversity Revenues	Setting meaningful targets will be challenging.	Work with international bodies (such as TNFD) to set global targets.
Biodiversity Management Quality and Biodiversity Revenues	The lack of a history of biodiversity data in financial markets and portfolio development presents challenges for adequate backtesting	Ensure comprehensive scenario and stress testing.
Biodiversity Management Quality and Biodiversity Revenues	Relevant data may be difficult to access or assess.	Ensure only publicly available and verifiable data are used in support of claims (e.g., Deitz et al., 2021).

companies report biodiversity mitigation efforts, but the threshold regarding what counts as a 'substantial' commitment may vary between assessors. Likewise, for Question 15, some companies report risk materiality matrices in which biodiversity loss counts as one of the points in a risk matrix—it may be subjective to decide whether this would be enough to count as being incorporated in a company strategy. Each one of these potential challenges could be debilitating, were it not anticipated and managed appropriately. In that sense, they are equally important. The insights for their management come from our experience in the management of similar issues in the assessment of carbon emissions and the development of investment portfolios.

It will be challenging to set meaningful targets for both Biodiversity Management Quality and Biodiversity Revenues because they entrain judgements about social priorities and subjective value trade-offs. Ideally, the metrics would be fully designed and tested before implementation. This will be a longer-term project that should include both estimated and reported data points, to minimise changes and avoid unnecessary portfolio turnover.

As is the case with carbon assessments, end users of biodiversity investment data are sensitive to single stock positions and so the ability to understand, communicate and justify a portfolio position is particularly important, especially when carbon and biodiversity outcomes are in conflict (Caparros & Jacquemont, 2003; Soto-Navarro et al., 2020). The lack of a history of biodiversity data in financial markets and portfolio development presents challenges for adequate backtesting, so scenario and stress testing become more important. These circumstances create a need for increased transparency (such as in the Transition Pathway Initiative; Dietz et al., 2018; TPI, n.d.), with methodologies being made publicly available.

Alongside this, there is a need to upskill the investment community on biodiversity metrics and targets and their use in portfolio and index construction. When ESG metrics were introduced to financial markets, it created a need for a new set of specialisations. Analysts who understand financial data, quality assurance and sustainable investment data were needed. The deployment of biodiversity metrics for portfolio construction will require the sustainable investment community to understand the strengths and limitations of different kinds of biodiversity data, as well as conventional financial analysis. For example, the approaches we advocate will require companies to have quantitative methods for assessing impacts on biodiversity and for setting, and measuring progress towards achieving, biodiversity targets (e.g., questions 4, 9 and 13 in Table 2). To satisfy this requirement, companies may employ metrics of the types evaluated above, though they are not yet fit-for-purpose. The details of these deficiencies may remain largely hidden behind the categorical/qualitative responses to questionnaires unless the independent assessors can evaluate critically the underlying data and systems.

Perhaps the greatest challenge in creating metrics for positive and negative biodiversity impacts is data quality and coverage. Above, we noted that the IUCN Red List data, while being relevant for assessing impacts in terms of species risk status, are limited by the lack of explicit reasoning that links threat assessments to the extent and severity of a company's activities. In addition, the frequency of data collection will concern investors, particularly when a portfolio rebalances more frequently than metrics update, generating turnover in portfolios and correcting for price drift with no new information. This issue still plagues carbon investments, where emission data are often updated once a year and significantly lag financial reporting. Updates on biodiversity data in the IUCN Red List can be slower still; updates on individual species occur every 5 years or even longer, depending on the taxa involved, although the Red List data are recompiled two to three times per year. All biodiversity metrics are biased taxonomically and may lack the spatial resolution necessary for effective application to site-level business activities. It is likely that a range of impact metrics will emerge to provide a holistic perspective for investors (Burgass et al., 2018). It is also important to understand the limitations of asset location data. While the rapid development of geospatial data has the potential to provide independent assessment of a company's assets and infrastructure, the World Bank (2020) warned that to generate insights with sufficiently wide coverage to meet most use cases, asset data and the supporting information on company trends needs to be dramatically improved. If the data are not sufficient, there is a risk a company's biodiversity impacts results will be artefacts of different levels of reporting between companies rather than a real signal.

A lack of consistency between data providers will erode investor confidence and make it difficult to report consistently across different portfolios. For carbon metrics, Bocquet et al. (2021) compared forward-looking metrics for 135 companies from three data providers: the correlations among them ranged from 0.4 to 0.65, denoting only modest agreement between the assessments. They comment that investors may be reluctant to use potentially inaccurate data to avoid liabilities arising from miscalculations. The creation of biodiversity metrics will face the same challenges and will be enhanced by careful consideration of the criteria that will encourage consistency between data providers, a strong argument for the process-based approach such as those we advocate.

As for carbon emissions indicators, no single biodiversity metric will be able to describe fully the position of a product, company, or investment strategy. The data necessary to support a comprehensive set of indicators are limited by the fact that critical assessments of the links between company activities and their impacts on species are incomplete. In the interim, tools such as the forward-looking metric and classification approaches outlined above, if used in concert, may provide adequate guidance for financial investments to help avoid, minimise, or remediate biodiversity impacts. The tools proposed are not a solution to the problem of inadequate biodiversity metrics but to the problem of how to get started on understanding how to identify which companies are taking biodiversity impacts seriously.

ACKNOWLEDGEMENTS

We thank Astrid Sofia Flores Moya, Florian Gallo, Weihui (Lily) Dai, Claire Hugo, Simon Ferrier, Nick Dulvy, E.J. Milner-Gulland and three anonymous reviewers for constructive discussions and many helpful comments. S.O.S.E.z.E. is supported by EU Horizon 2020 project SUPERB (systemic solutions for upscaling of urgent ecosystem restoration for forest related biodiversity) [Grant Ref: GA 101036849].

CONFLICT OF INTEREST STATEMENT

H.L. is employed by FTSE-Russell. A.I. is employed by FairSupply in a part-time capacity.

ORCID

Amanda Irwin https://orcid.org/0000-0001-8374-9284
Mark Burgman https://orcid.org/0000-0003-0435-4829

REFERENCES

Addison, P. F., Stephenson, P. J., Bull, J. W., Carbone, G., Burgman, M., Burgass, M. J., Gerber, L. R., Howard, P., McCormick, N., McRae, L., & Reuter, K. E. (2020). Bringing sustainability to life: A framework to guide biodiversity indicator development for business performance management. *Business Strategy and the Environment*, *29*(8), 3303–3313. https://doi.org/10.1002/bse.2573

Addison, P. F. E., Bull, J. W., & Milner-Gulland, E. J. (2019). Using conservation science to advance corporate biodiversity accountability. *Conservation Biology*, *33*, 307–318. https://doi.org/10.1111/cobi.13190

Agarwala, M., Burke, M., Klusak, P., Kraemer, M., & Volz, U. (2022). Nature loss and sovereign credit ratings. In *Finance for biodiversity*. SOAS University of London and Cambridge University.

Arlidge, W. N., Bull, J. W., Addison, P. F., Burgass, M. J., Gianuca, D., Gorham, T. M., Jacob, C., Shumway, N., Sinclair, S. P., Watson, J. E., Wilcox, C., & Milner-Gulland, E. J. (2018). A global mitigation hierarchy for nature conservation. *Bioscience*, *68*(5), 336–347. https://doi.org/10.1093/biosci/biy029

Bassen, A., Shu, H., & Tan, W. (2023). Green revenues and stock returns: Cross-market evidence. *Finance Research Letters*, *52*, 103550. https://doi.org/10.1016/j.frl.2022.103550

Beck-O'Brien, M., & Bringezu, S. (2021). Biodiversity monitoring in long-distance food supply chains: Tools, gaps and needs to meet business requirements and sustainability goals. *Sustainability*, *13*(15), 8536. https://doi.org/10.3390/su13158536

Bennun, L., Regan, E. C., Bird, J., van Bochove, J. W., Katariya, V., Livingstone, S., Mitchell, R., Savy, C., Starkey, M., Temple, H., & Pilgrim, J. D. (2018). The value of the IUCN Red List for business decision-making. *Conservation Letters*, *11*(1), e12353. https://doi.org/10.1111/conl.12353

BFFI. (2021). Biodiversity footprints for financial institutions. In *Exploring biodiversity assessment*. Netherlands Enterprise Agency.

Bishop, J., Kapila, S., Hicks, F., Mitchell, P., & Vorhies, F. (2009). New business models for biodiversity conservation. *Journal of Sustainable Forestry*, *28*(3–5), 285–303. https://doi.org/10.1080/10549810902791481

Bloomberg Law. (2022). *Market indexes seen as new targets in SEC's greenwashing fight. Bloomberg Law*, August 1, 2022. New York: Bloomberg. Retrieved December 5, 2022, from https://news.bloomberglaw.com/securities-law/market-indexes-seen-as-new-targets-in-secs-greenwashing-fight

Bocquet, R., Georgieva, A., & Metrotra, S. (2021). Untangling the confusing landscape of forward-looking climate metrics. *Responsible Investor*. https://www.responsible-investor.com/untangling-the-confusing-landscape-of-forward-looking-climate-metrics/

Bourne, D., Clements, L., Emin, G., & Lorans, T. (2020). *How to build a climate-adjusted government bond index*. Index Insights, FTSE Russell. https://content.ftserussell.com/sites/default/files/how_to_build_a_climate-adjusted_government_bond_index_final_v02.pdf

Bull, J. W., Taylor, I., Biggs, E., Grub, H. M., Yearley, T., Waters, H., & Milner-Gulland, E. J. (2022). Analysis: The biodiversity footprint of the University of Oxford. *Nature*, *604*(7906), 420–424. https://doi.org/10.1038/d41586-022-01034-1

Burgass, M. J., Arlidge, W. N., & Addison, P. F. (2018). Overstating the value of the IUCN Red List for business decision-making. *Conservation Letters*, *11*(3), e12456. https://doi.org/10.1111/conl.12456

Business for Nature. (2022). *Business for nature's position on Target 15*. https://www.businessfornature.org/target-15

Butchart, S. H., Resit Akçakaya, H., Chanson, J., Baillie, J. E., Collen, B., Quader, S., Turner, W. R., Amin, R., Stuart, S. N., & Hilton-Taylor, C. (2007). Improvements to the red list index. *PLoS ONE*, *2*(1), e140. https://doi.org/10.1371/journal.pone.0000140

Butchart, S. H., Stattersfield, A. J., Baillie, J., Bennun, L. A., Stuart, S. N., Akçakaya, H. R., Hilton-Taylor, C., & Mace, G. M. (2005). Using red list indices to measure progress towards the 2010 target and beyond. *Philosophical Transactions of the Royal Society, B: Biological Sciences*, *360*(1454), 255–268. https://doi.org/10.1098/rstb.2004.1583

Caparros, A., & Jacquemont, F. (2003). Conflicts between biodiversity and carbon sequestration programs: Economic and legal implications. *Ecological Economics*, *46*, 143–157. https://doi.org/10.1016/S0921-8009(03)00138-1

Capitals Coalition. (2020). Capitals Coalition and Cambridge Conservation Initiative. In *Integrating biodiversity into natural capital assessments*. (Online) www.capitalscoalition.org

CBD. (1992). *Convention on biological diversity* (p. 3). United Nations. https://www.cbd.int/doc/legal/cbd-en.pdf

CBD. (2010). Aichi biodiversity targets. In *Convention on biological diversity, strategic plan for biodiversity* (pp. 2011–2020). United Nations Environment Programme. https://www.cbd.int/sp/targets/

CBD. (2020). *Secretariat of the convention on biological diversity, global biodiversity outlook 5*. United Nations Environment Programme. https://www.cbd.int/gbo/gbo5/publication/gbo-5-en.pdf

CBD. (2022a). *Draft decisions for the fifteenth meeting of the conference of the parties to the convention on biological diversity. COP/15/2 section 9B* (pp. 14–67). UNEP and CBD. November 2022. https://www.cbd.int/doc/c/c9de/d8ef/7225d7bb822f39ad3426c52b/cop-15-02-en.pdf

CBD. (2022b). *the Kunming-Montreal Global Biodiversity Framework. Nations adopt four goals, 23 targets for 2030 in landmark UN biodiversity agreement*. UNEP and CBD. https://prod.drupal.www.infra.cbd.int/sites/default/files/2022-12/221219-CBD-PressRelease-COP15-Final_0.pdf

CBF. (2022). Guide on biodiversity measurement approaches. Finance for biodiversity. In *Corporate biodiversity footprint* (2nd ed.). Finance for Biodiversity. https://www.financeforbiodiversity.org/wp-content/uploads/Finance-for-Biodiversity_Guide-on-biodiversity-measurement-approaches_2nd-edition.pdf

CDC. (2022). *The carbon disclosure project. Criteria and challenges*. Greenly Institute. https://www.greenly.earth/blog-en/carbon-disclosure-project-criteria-and-challenges

CDSB. (2022). Climate disclosure standards board. In *Task force on climate-related financial disclosures*. Climate Disclosure Standards Board. https://www.cdsb.net/what-we-do/task-force-climate-related-financial-disclosures#:~:text=The%20TCFD%20is%20an%20industry,transparent%20information%20to%20global%20markets

Chaudhary, A., Mair, L., Strassburg, B. B., Brooks, T. M., Menon, V., & McGowan, P. J. (2022). Subnational assessment of threats to Indian biodiversity and habitat restoration opportunities. *Environmental Research Letters*, *17*(5), 054022. https://doi.org/10.1088/1748-9326/ac5d99

Club B4B+. (2021). *Measuring the contributions of business and finance towards the post-2020 global biodiversity network*. BioDiv'2050 Outlook. Club B4B+. http://www.mission-economie-biodiversite.com/wp-content/uploads/2020/09/N15-TRAVAUX-DU-CLUB-B4B-GBS-UK-MD-WEB.pdf

COP15. (2022). *Convention on biological diversity. Meeting documents*. UNEP and CBD. https://www.cbd.int/meetings/COP-15; https://www.cbd.int/article/cop15-cbd-press-release-final-19dec2022

CPIC. (2021). Conservation finance 2021: An unfolding opportunity. In *Coalition for private investment in conservation*. http://cpicfinance.com/the-conservation-finance-market-is-growing-fast-but-investors-lack-access-to-investable-deals/

Crenna, E., Marques, A., La Notte, A., & Sala, S. (2020). Biodiversity assessment of value chains: State of the art and emerging challenges. *Environmental Science & Technology*, *54*(16), 9715–9728. https://doi.org/10.1021/acs.est.9b05153

de Silva, G. C., Regan, E. C., Pollard, E. H. B., & Addison, P. F. E. (2019). The evolution of corporate no net loss and net positive impact biodiversity commitments: Understanding appetite and addressing challenges. *Business Strategy and the Environment*, *28*(7), 1481–1495. https://doi.org/10.1002/bse.2379

Deitz, S., Bienkowska, B., Jahn, V., Hastreiter, N., Komar, V., Scheer, A., & Sullivan, R. (2021). TPI methodology and indicators report. Version 4.0. November 2021. Transition Pathways Initiative. https://www.transitionpathwayinitiative.org/publications/90.pdf?type=Publication

Deutz, A., Heal, G. M., Niu, R., Swanson, E., Townshend, T., Zhu, L., Delmar, A., Meghji, A., Sethi, S. A., & Tobin-de la Puente, J. (2020). *Financing nature: Closing the global biodiversity financing gap*. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability. https://www.paulsoninstitute.org/wp-content/uploads/2020/10/FINANCING-NATURE_Full-Report_Final-with-endorsements_101420.pdf https://www.paulsoninstitute.org/conservation/financing-nature-report/

Dhyani, S., Sivadas, D., Basu, O., & Karki, M. (2022). Ecosystem health and risk assessments for high conservation value mountain ecosystems of South Asia: A necessity to guide conservation policies. *Anthropocene Science*, *1*, 211–225. https://doi.org/10.1007/s44177-022-00010-8

Di Marco, M., Harwood, T. D., Hoskins, A. J., Ware, C., Hill, S. L., & Ferrier, S. (2019). Projecting impacts of global climate and land-use scenarios on plant biodiversity using compositional-turnover modelling. *Global Change Biology*, *25*(8), 2763–2778. https://doi.org/10.1111/gcb.14663

Dietz, S., Byrne, R., Gardiner, D., Gostlow, G., Jahn, V., Nachmany, M., & Sullivan, R. (2018). TPI methodology and indicators report. Version 2.0. May 2018. Transition Pathways Initiative. www.transitionpathwayinitiative.org/publications/20.pdf?type=Publication

Dikau, S., Robins, N., & Volz, U. (2021). *Climate-neutral central banking: How the European system of central banks can support the transition to net-zero*. Grantham Research Institute on Climate Change and the Environment. https://eprints.soas.ac.uk/35168/1/Climate%20Neutral%20-Central%20Banking.pdf

EDIE. (2019). Three-quarters of UK FTSE all-share firms 'highly dependent' on natural capital. https://www.edie.net/three-quarters-of-uk-ftse-all-share-firms-highly-dependent-on-natural-capital/

ENCORE. (2022). *Exploring natural capital opportunities, risks and exposure*. Natural Capital Finance Alliance and UNEP-WCMC. https://encore.naturalcapital.finance/en/about

Envizi. (n.d.). *Guide to ESG reporting frameworks*. IBM. https://envizi.com/a-guide-to-esg-reporting-frameworks/

EU Commission. (2020). *EU sustainable finance 2020. Financing a sustainable European economy. Technical report. Final report, technical expert group on sustainable finance*. Commission to the European Parliament. https://finance.ec.europa.eu/system/files/2020-03/200309-sustainable-finance-teg-final-report-taxonomy_en.pdf

EU Commission. (2022). *EU taxonomy. Draft commission notice*. Commission to the European Parliament. https://ec.europa.eu/finance/docs/law/221219-draft-commission-notice-eu-taxonomy-climate.pdf

F4B. (2022a). *Finance for biodiversity initiative*. Finance for Biodiversity. https://www.f4b-initiative.net/aboutus

F4B. (2022b). *Finance for biodiversity, guide on biodiversity measurement approaches* (2nd ed.). Finance for Biodiversity. October 2022. https://www.financeforbiodiversity.org/wp-content/uploads/Finance-for-Biodiversity_Guide-on-biodiversity-measurement-approaches_2nd-edition.pdf

Farsan, A., Chang, A., Kerkhof, A., Cserna, B., Yan, C., Villasana, F. R., & Labutong, N. (2018). *Value change in value chain: Best practices in Scope 3 greenhouse gas management, version 3.0. SBTi*. Science Based Targets Initiative.

Ferrier, S., Harwood, T. D., Ware, C., & Hoskins, A. J. (2020). A globally applicable indicator of the capacity of terrestrial ecosystems to retain biological diversity under climate change: The bioclimatic ecosystem resilience index. *Ecological Indicators*, *117*, 106554. https://doi.org/10.1016/j.ecolind.2020.106554

FTSE-Russell. (2020). *Green revenues classification system 2.0. December 2020*. London Stock Exchange Group. https://content.ftserussell.com/sites/default/files/ftse_russell_green_revenues_2.0_classification_system_grcs_12-2020.pdf

FTSE-Russell. (2022). *Green Revenues 2.0 data model*. London Stock Exchange Group. https://content.ftserussell.com/sites/default/files/ftse-russell-green-revenues-2.0-data-model-2022_1.pdf

GBS. (2022). *Measuring the biodiversity impact of your portfolio. Carbon4Finance, biodiversity impact analytics*. Carbon for Finance. https://www.carbon4finance.com/files/BIA_Launch_Presentation_1.pdf

Green, J. F. (2010). Private standards in the climate regime: The greenhouse gas protocol. *Business & Politics*, *12*, 1–37. https://doi.org/10.2202/1469-3569.1318

Hassan, A., Roberts, L., & Rodger, K. (2022). Corporate accountability for biodiversity and species extinction: Evidence from organisations reporting on their impacts on nature. *Business Strategy and the Environment*, *31*, 326–352. https://doi.org/10.1002/bse.2890

Hassan, A. M., Roberts, L., & Atkins, J. (2020). Exploring factors relating to extinction disclosures: What motivates companies to report on biodiversity and species protection? *Business Strategy and the Environment*, *29*, 1419–1436. https://doi.org/10.1002/bse.2442

Hassanein, A., Zalata, A., & Hussainey, K. (2019). Do forward-looking narratives affect investors' valuation of UK FTSE all-shares firms? *Review of Quantitative Finance and Accounting*, *52*, 493–519. https://doi.org/10.1007/s11156-018-0717-6

HSBC. (2022). *World ESG biodiversity screened equity UCITS ETF*. Retrieved October 31, 2022, from https://www.assetmanagement.hsbc.co.uk/en/intermediary/investment-expertise/etfs/world-esg-biodiversity#openTab=0

Huijbregts, M. A. J., Steinmann, Z. J. N., Elshout, P. M. F., Stam, G., Verones, F., Vieira, M., Zijp, M., Hollander, A., & Van Zelm, R. (2017). ReCiPe2016: A harmonised life cycle impact assessment method at midpoint and endpoint level. *The International Journal of Life Cycle Assessment*, *22*, 138–147. https://doi.org/10.1007/s11367-016-1246-y

IPBES. (2019). In S. Díaz, J. Settele, E. S. Brondízio, H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, et al. (Eds.), *Intergovernmental science-policy platform on biodiversity and ecosystem services. Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services*. IPBES Secretariat.

Irwin, A., Geschke, A., Brooks, T. M., Siikamaki, J., Mair, L., & Strassburg, B. B. N. (2022). Quantifying and categorising national extinction-risk footprints. *Scientific Reports*, *12*, 5861. https://doi.org/10.1038/s41598-022-09827-0

IUCN. (2021). *Reasons for changing category*. Retrieved December 23, 2021, from https://www.iucnredlist.org/assessment/reasons-changing-category

IUCN. (2022). *The IUCN red list of threatened species*. https://www.iucnredlist.org/

IUCN. (2023). *European Sturgeon*. https://www.iucnredlist.org/species/230/137215851

Kedward, K., zu Ermgassen, S. O. S. E., Ryan-Collins, J., & Wunder, S. (2023). Heavy reliance on private finance alone will not deliver conservation goals. *Nature Ecology and Evolution*, *7*, 1–4. https://doi.org/10.1038/s41559-023-02098-6

Keith, D. A., Mahony, M., Hines, H., Elith, J., Regan, T. J., Baumgartner, J. B., Hunter, D., Heard, G. W., Mitchell, N. J., Parris, K. M., Penman, T., Scheele, B., Simpson, C. C., Tingley, R., Tracy, C. R., West, M., & Akçakaya, H. R. (2014). Detecting extinction risk from climate change by IUCN Red List Criteria. *Conservation Biology*, *28*, 810–819.

Klaaßen, L., & Stoll, C. (2021). Harmonizing corporate carbon footprints. *Nature Communications*, *12*,6149. https://doi.org/10.1038/s41467-021-26349-x

Kraemer, M., & Volz, U. (2022). *Integrating nature into debt sustainability analysis*. Finance for Biodiversity and SOAS University of London CBD (1992).

Lammerant J., Driesen, K., Vanderheyden, G., Starkey, M., De Horde, A., Bor, A. M., Kisielewicz, J., & Müller, L. (2021). *Assessment of biodiversity measurement approaches for businesses and financial institutions, update report 3, EU business @ biodiversity platform*. European Commission. Retrieved March 1, 2021, from https://ec.europa.eu/environment/biodiversity/business/assets/pdf/EU%20B@B%20Platform%20Update%20Report%203_FINAL_1March2021.pdf

Leclère, D., Obersteiner, M., Barrett, M., Butchart, S. H., Chaudhary, A., De Palma, A., DeClerck, F. A., Di Marco, M., Doelman, J. C., Dürauer, M., & Freeman, R. (2020). Bending the curve of terrestrial biodiversity needs an integrated strategy. *Nature*, *585*(7826), 551–556. https://doi.org/10.1038/s41586-020-2705-y

Mair, L., Amorim, E., Bicalho, M., Brooks, T. M., Calfo, V., de Capellão, T. R., Clubbe, C., Evju, M., Fernandez, E. P., Ferreira, G. C., Hawkins, F., Jiménez, R. R., Jordão, L. S. B., Kyrkjeeide, M. O., Macfarlane, N. B. W., Mattos, B. C., de Melo, P. H. A., Monteiro, L. M., Lughadha, E. N., … McGowan, P. J. K. (2023). Quantifying and mapping species threat

abatement opportunities to support national target setting. *Conservation Biology*, *37*(1), e14046. https://doi.org/10.1111/cobi.14046

Mair, L., Bennun, L. A., Brooks, T. M., Butchart, S. H., Bolam, F. C., Burgess, N. D., Ekstrom, J. M., Milner-Gulland, E. J., Hoffmann, M., Ma, K., & Macfarlane, N. B. (2021). A metric for spatially explicit contributions to science-based species targets. *Nature Ecology & Evolution*, *5*(6), 836–844. https://doi.org/10.1038/s41559-021-01432-0

Marques, A., Robuchon, M., Hellweg, S., Newbold, T., Beher, J., Bekker, S., Essl, F., Ehrlich, D., Hill, S., Jung, M., Marquardt, S., Rosa, F., Rugani, B., Suarez-Castro, A. F., Silva, A. P., Williams, D. R., Dubois, G., & Sala, S. (2021). A research perspective towards a more complete biodiversity footprint: A report from the world biodiversity forum. *The International Journal of Life Cycle Assessment*, *26*, 238–243. https://doi.org/10.1007/s11367-020-01846-1

Milner-Gulland, E. J. (2022). Don't dilute the term nature positive. *Nature Ecology and Evolution*, *6*, 1243–1244. https://doi.org/10.1038/s41559-022-01845-5

Milner-Gulland, E. J., Addison, P., Arlidge, W. N. S., Baker, J., Booth, H., Brooks, T., Bull, J. W., Burgass, M. J., Ekstrom, J., zu Ermgassen, S. O. S. E., Fleming, L. V., Grub, H. M. J., von Hase, A., Hoffmann, M., Hutton, J., Juffe-Bignoli, D., ten Kate, K., Kiesecker, J., Kumpel, N. F., … Watson, J. E. M. (2021). Four steps for the earth: Mainstreaming the post-2020 global biodiversity framework. *One Earth*, *4*, 75–87. https://doi.org/10.1016/j.oneear.2020.12.011

Mokany, K., Harwood, T. D., & Ferrier, S. (2019). Improving links between environmental accounting and scenario-based cumulative impact assessment for better-informed biodiversity decisions. *Journal of Applied Ecology*, *56*(12), 2732–2741. https://doi.org/10.1111/1365-2664.13506

Moranta, J., Torres, C., Murray, I., Hidalgo, M., Hinz, H., & Gouraguine, A. (2022). Transcending capitalism growth strategies for biodiversity conservation. *Conservation Biology*, *36*(2), e13821. https://doi.org/10.1111/cobi.13821

Narain, D., Maron, M., Teo, H. C., Hussey, K., & Lechner, A. M. (2020). Best-practice biodiversity safeguards for belt and road initiative's financiers. *Nature Sustainability*, *3*(8), 650–657. https://doi.org/10.1038/s41893-020-0528-3

NEC. (2022). *The net environmental contribution initiative*. NEC Initiative. https://nec-initiative.org/

Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., Hill, S. L., Hoskins, A. J., Lysenko, I., Phillips, H. R., & Burton, V. J. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. *Science*, *353*(6296), 288–291. https://doi.org/10.1126/science.aaf2201

NGFS. (2022). Central banking and supervision in the biosphere: an agenda for action on biodiversity loss, financial risk and system stability. In *Final report of the NGFS-INSPIRE study group on biodiversity and financial stability*. *Network for greening the financial system, occasional paper*. NGFS, Central Banks and Supervisors. https://www.ngfs.net/sites/default/files/medias/documents/central_banking_and_supervision_in_the_biosphere.pdf

Obura, D. O., Katerere, Y., Mayet, M., Kaelo, D., Msweli, S., Mather, K., Harris, J., Louis, M., Kramer, R., Teferi, T., & Samoilys, M. (2021). Integrate biodiversity targets from local to global levels. *Science*, *373*(6556), 746–748. https://doi.org/10.1126/science.abh2234

Otero, I., Farrell, K. N., Pueyo, S., Kallis, G., Kehoe, L., Haberl, H., Plutzar, C., Hobson, P., García-Márquez, J., Rodríguez-Labajos, B., & Martin, J. L. (2020). Biodiversity policy beyond economic growth. *Conservation Letters*, *13*(4), e12713. https://doi.org/10.1111/conl.12713

Pattberg, P. (2017). The emergence of carbon disclosure: Exploring the role of governance entrepreneurs. *Environment and Planning C: Politics and Space*, *35*(8), 1437–1455.

Prescott, G., Bennun, L., White, T., Stephen, W., Turner, J., Bang, A., & Starkey, M. (2023). *Additional guidance on use of ecosystem condition metrics in the TNFD LEAP approach*. The Biodiversity Consultancy.

Reuters. (2021). *Analysis: How 2021 became the year of ESG investing*. Retrieved December 23, 2021, from https://www.reuters.com/markets/us/how-2021-became-year-esg-investing-2021-12-23/

Rodrigues, A. S., Pilgrim, J. D., Lamoreux, J. F., Hoffmann, M., & Brooks, T. M. (2006). The value of the IUCN red list for conservation. *Trends in Ecology & Evolution*, *21*(2), 71–76. https://doi.org/10.1016/j.tree.2005.10.010

Rosa, I. M., Purvis, A., Alkemade, R., Chaplin-Kramer, R., Ferrier, S., Guerra, C. A., Hurtt, G., Kim, H., Leadley, P., Martins, I. S., & Popp, A. (2020). Challenges in producing policy-relevant global scenarios of biodiversity and ecosystem services. *Global Ecology and Conservation*, *22*, e00886. https://doi.org/10.1016/j.gecco.2019.e00886

Rosenbloom, D., Meadowcroft, J., & Cashore, B. (2019). Stability and climate policy? Harnessing insights on path dependence, policy feedback, and transition pathways. *Energy Research & Social Science*, *50*, 168–178. https://doi.org/10.1016/j.erss.2018.12.009

SBTi. (2021). *Science based net-zero*. SBTi progress report, version 1.2 – Updated June 2022. https://sciencebasedtargets.org/reports/sbti-progress-report-2021; Chang, A., Anderson, C. and Aden, N. 2021. Pathways to net-zero. SBTi technical summary, version 1.0. October 2021. SBTi.

Simmons, J., Kooroshy, J., Bourne, E., Jain, M., & Clements, L. (2022). Mind the gaps: Clarifying corporate carbon. In *Market navigation*. FTSE Russell 2022.

Simpson, C., Rathi A., and Kishan, S. (2021). *The ESG mirage. Bloomberg UK edition*. London: Bloomberg. Retrieved December 10, 2021, from https://www.bloomberg.com/graphics/2021-what-is-esg-investing-msci-ratings-focus-on-corporate-bottom-line/

Smith, T., Beagley, L., Bull, J., Milner-Gulland, E. J., Smith, M., Vorhies, F., & Addison, P. F. (2020). Biodiversity means business: Reframing global biodiversity goals for the private sector. *Conservation Letters*, *13*(1), e12690. https://doi.org/10.1111/conl.12690

Smith, T., Paavola, J., & Holmes, G. (2018). Corporate reporting and conservation realities: Understanding differences in what businesses say and do regarding biodiversity. *Environmental Policy and Governance*, *29*, 3–13. https://doi.org/10.1002/eet.1839

Soto-Navarro, C., Ravilious, C., Arnell, A., De Lamo, X., Harfoot, M., Hill, S. L. L., Wearn, O. R., Santoro, M., Bouvet, A., Mermoz, S., Le Toan, T., Xia, J., Liu, S., Yuan, W., Spawn-Lee, S. A., Gibbs, H., Ferrier, S., Harwood, T., Alkemade, R., … Kapos, V. (2020). Mapping co-benefits for carbon storage and biodiversity to inform conservation policy and action. *Philosophical Transactions of the Royal Society B*, *375*(1794), 20190128.

Stanton, J. C., Shoemaker, K. T., Pearson, R. G., & Akçakaya, H. R. (2015). Warning times for species extinctions due to climate change. *Global Change Biology*, *20*(3), 1066–1077.

STAR. (2022a). *Species threat abatement and restoration (STAR) metric*. IUCN. https://www.iucn.org/resources/conservation-tool/species-threat-abatement-and-recovery-star-metric

STAR. (2022b). Business user guide. https://www.ibat-alliance.org/pdf/star-business-user-guidance.pdf. Accessed October 13, 2022. See also, the science based target network, a large group of diverse organisations, developing targets for biodiversity for land, water and oceans. Science Based Targets Network. http://sciencebasedtargetsnetwork.org/earth-systems/biodiversity.html

Stephenson, P. J. (2019). The holy grail of biodiversity conservation management: Monitoring impact in projects and project portfolios. *Perspectives in Ecology and Conservation*, *17*(4), 182–192. https://doi.org/10.1016/j.pecon.2019.11.003

Strassburg, B. B., Iribarrem, A., Beyer, H. L., Cordeiro, C. L., Crouzeilles, R., Jakovac, C. C., Braga Junqueira, A., Lacerda, E., Latawiec, A. E., Balmford, A., & Brooks, T. M. (2020). Global priority areas for

ecosystem restoration. *Nature*, *586*(7831), 724–729. https://doi.org/10.1038/s41586-020-2784-9

Svartzman, R., Espagne, E., Julien, G., Paul, H. L., Mathilde, S., Allen, T., Berger, J., Calas, J., Godin, A., & Vallier, A. (2021). A 'silent spring' for the financial system? Exploring biodiversity-related financial risks in France. In *Banque de France, working paper no. 826*. https://publications.banque-france.fr/en. https://doi.org/10.2139/ssrn.4028442

TCFD. (2022). *Taskforce on climate-related financial disclosures. Overview*. Taskforce on Climate Related Financial Disclosures. December 2022. https://assets.bbhub.io/company/sites/60/2022/12/tcfd-2022-overview-booklet.pdf

TNFD. (2021). *Proposed technical scope. Recommendations for the TNFD*. Taskforce on Nature Related Financial Disclosures. https://tnfd.global/publication/proposed-technical-scope-for-tnfd/

TNFD. (2022). *Introducing v0.3 of the TNFD framework*. Taskforce on Nature Related Financial Disclosures. https://framework.tnfd.global/introducing-the-tnfd-framework/

TPI. (n.d.) *The transition pathway initiative. Supporting the global transition to a low-carbon economy*. The Transition Pathway Initiative. www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2020/03/TPI_overview_-brochure_v9.1_FInal.pdf

Tuhkanen, H., & Vulturius, G. (2022). Are green bonds funding the transition? Investigating the link between companies' climate targets and green debt financing. *Journal of Sustainable Finance and Investment*, *12*, 1194–1216. https://doi.org/10.1080/20430795.2020.1857634

UNEP. (2023). *United Nations environment programme. Nature risk profile: A methodology for profiling nature related dependencies and impacts*. https://resources.unep-wcmc.org/products/WCMC_RT496/access?option=9&endpoint_id=425540

UNEP-WCMC. (2016). *Exploring approaches for constructing species accounts in the context of the SEEA-EEA*. United Nations Environment Program - World Conservation Monitoring Centre.

Weiskopf, S. R., Myers, B. J., Arce-Plata, M. I., Blanchard, J. L., Ferrier, S., Fulton, E. A., Harfoot, M., Isbell, F., Johnson, J. A., Mori, A. S., & Weng, E. (2022). A conceptual framework to integrate biodiversity, ecosystem function, and ecosystem service models. *Bioscience*, *72*(11), 1062–1073. https://doi.org/10.1093/biosci/biac074

World Bank. (2020). *Spatial finance: Challenges, and opportunities in a changing world*. The World Bank. https://www.wwf.org.uk/sites/default/files/2020-12/Spatial%20Finance_%20Challenges%20and%20Opportunities_Final.pdf. https://doi.org/10.1596/34894

World Economic Forum. (2020). Nature risk rising: Why the crisis engulfing nature matters for business and the economy. In *World economic forum and price waterhouse coopers*. New Nature Economy Series. World Economic Forum. https://www3.weforum.org/docs/WEF_New_Nature_Economy_Report_2020.pdf

WWF. (2023). *WWF biodiversity risk filter methodology documentation*. World Wide Fund for Nature. Retrieved January 2023, from https://cdn.kettufy.io/prod-fra-1.kettufy.io/documents/riskfilter.org/BiodiversityRiskFilter_Methodology.pdf

zu Ermgassen, E., Lima, M. B., Bellfield, H., Dontenville, A., Gardner, T., Godar, J., Heilmayer, R., Indenbaum, R., Dos Reis, T., Ribeiro, V., Itohan-Osa, A., Szantoi, Z., & Meyfroidt, P. (2022). Addressing indirect sourcing in zero deforestation commodity supply chains. *Science Advances*, *8*, eabn3132. https://doi.org/10.1126/sciadv.abn3132

zu Ermgassen, E. K., Ayre, B., Godar, J., Lima, M. G. B., Bauch, S., Garrett, R., Green, J., Lathuillière, M. J., Löfgren, P., MacFarquhar, C., & Meyfroidt, P. (2020). Using supply chain data to monitor zero deforestation commitments: An assessment of progress in the Brazilian soy sector. *Environmental Research Letters*, *15*(3), 035003. https://doi.org/10.1088/1748-9326/ab6497

zu Ermgassen, S. O., Howard, M., Bennun, L., Addison, P. F., Bull, J. W., Loveridge, R., Pollard, E., & Starkey, M. (2022). Are corporate biodiversity commitments consistent with delivering 'nature-positive' outcomes? A review of 'nature-positive' definitions, company progress and challenges. *Journal of Cleaner Production*, *379*, 134798. https://doi.org/10.1016/j.jclepro.2022.134798

How to cite this article: Layman, H., Akçakaya, H. R., Irwin, A., zu Ermgassen, S., Addison, P., & Burgman, M. (2023). Short-term solutions to biodiversity conservation in portfolio construction: Forward-looking disclosure and classification-based metrics. *Business Strategy and the Environment*, 1–16. https://doi.org/10.1002/bse.3570