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Review

Are corporate biodiversity commitments consistent with delivering 'nature-positive' outcomes? A review of 'nature-positive' definitions, company progress and challenges

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ABSTRACT

There are growing calls for businesses to implement 'nature-positive' strategies. Convergence around a precise definition is now needed. We review definitions of 'nature-positive', highlight differences between 'nature-positive' and previous iterations of organizational biodiversity strategies (e.g. net positive impact) and propose four key elements for 'nature-positive' strategies: 1) demonstrating positive biodiversity outcomes across the entire value chain ("scope"); 2) buy-in throughout the entire organization ("mainstreaming"); 3) integrated consideration of different components of nature (e.g. both biodiversity and climate; "integration"); and 4) measurable outcomes against a fixed baseline aligned with overall societal goals (e.g. post-2020 Global Biodiversity Framework; "ambition"). We analyse trends in biodiversity commitments of the Global Fortune 100 companies and firms that have made recent 'net impact' commitments, evaluating alignment with these elements and where possible assessing their evolution since 2016. Uptake of biodiversity commitments has increased since 2016, but with limited progress towards adopting measurable, time-bound commitments (an increase from 5 to 10/100 Fortune 100 firms from 2016 to 2021). We review barriers to business implementation of strategies that can deliver socially equitable and 'nature-positive' outcomes. Major improvements are needed in data availability and transparency, regulation and sector-wide coordination that creates level playing fields and prevents impact leakage. Transformative action is required to create production and consumption systems that actively enhance nature.

1. Introduction

Whilst economic progress has historically been coupled with improvements in human welfare, there is widespread concern that current and future welfare is now being undermined by excessive resource consumption and waste generation, at a scale sufficient to destabilise the Earth system (Daly and Farley, 2011; Díaz et al., 2019; Steffen et al., 2015). Recent global assessments have highlighted that the loss of nature represents a fundamental risk to the functioning of our societies and economies, and have called for systemic transformations to address biodiversity loss (Dasgupta, 2021; Díaz et al., 2019; Mace et al., 2018; World Economic Forum, 2019). The post-2020 Global Biodiversity Framework (GBF) of the Convention on Biological Diversity (CBD), currently in negotiation, is expected to commit the global community to goals to halt and reverse biodiversity loss: the first draft called for 'no further human-driven extinction of known threatened species' and '[restoring] the abundance and distribution of depleted populations of species' (CBD, 2021b).

Businesses have a key role to play in these systemic transformations, as explicitly identified in the first draft of the post-2020 GBF. Biodiversity loss is now widely considered one of the largest macro-scale business risks (Moody's, 2021; WEF, 2022). The flow of ecosystem

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services provided by nature underpins core operations in many business sectors (van den Belt and Blake, 2015; Watson and Newton, 2018). Others are vulnerable to transition risks such as stranded assets from increasingly stringent environmental policies (Cahen-Fourot et al., 2021). The goods and services that impact biodiversity are predominantly produced, procured or delivered by businesses, so business actions are central to determining society's impacts on nature and the future of the biosphere (Folke et al., 2019; Österblom et al., 2015). Business has potential to lead systemic improvements, for example through those with large market power working in partnership with or demanding higher standards from suppliers and partners (Cassol and Sellitto, 2020), and those with leading environmental practice lobbying governments for regulatory reforms (Lambin et al., 2020).

Despite decades of international agreements aiming to halt biodiversity loss, none of the global Aichi targets for biodiversity were fully achieved by the target date of 2020 (CBD, 2020). Recognising the shortfalls of past agreements, conservation and business forums are now converging on a goal of 'nature-positive', with the aim by 2050 not only to halt but to reverse biodiversity loss (Locke et al., 2021). Increasing commitment to the nature-positive concept has stimulated a range of conservation and industry initiatives to drive transformative change, such as the Science-based Targets for Nature, Taskforce for Nature-related Financial Disclosures, and the Conservation Hierarchy approach (Milner-Gulland et al., 2021). However, consensus on a clear definition of what 'nature-positive' actually means for business, and how to measure it, is now needed (Milner-Gulland, 2022). This is essential to ensure accountability, enable evaluation of progress towards overarching biodiversity policy goals, and prevent potential use for greenwashing (Boiral, 2016).

In this study we examine the emerging trend of 'nature-positive' in business and large organisations. We review definitions and propose key criteria to distinguish 'nature-positive' approaches from previous iterations of business biodiversity strategies, such as 'net positive impact on biodiversity' or 'no net loss'. We then analyse company sustainability reports to investigate to what extent current corporate biodiversity commitments (a commonly used but imperfect proxy for biodiversity performance) reflect these criteria. For criteria where there are comparable time-series data, we examine progress from 2016 to 2021.

2. Theoretical framework for achieving nature-positive outcomes

2.1. Existing definitions of nature-positive

With origins in public pollution and wetland trading policies in the USA in the 1970s, 'no net loss' (NNL) or 'net positive impact' (NPI) corporate commitments have expanded in the last two decades (Damiens et al., 2020; de Silva et al., 2019; Rainey et al., 2015). In business contexts, NNL/NPI commitments have typically focused on applying the mitigation hierarchy ('avoid, minimize, restore, offset'; Bull et al., 2013) to direct operational impacts only (i.e. not supply chain impacts or the embodied impacts of the organisation's material consumption), with many of the foundational concepts implemented and refined in the extractives sector.

The recent shift in discourse from 'no net loss/net positive impact' to 'nature-positive' emerges from several trends. These include growing recognition of the economic and financial risks of biodiversity loss mentioned above (WEF, 2020). Additionally, footprinting assessments across companies' entire value chains are showing that direct operational impacts are a relatively small part of total biodiversity impacts for many large organisations (Bull et al., 2022b; Kering, 2020a; Puma, 2011), with biodiversity impacts often embedded in supply chains and production systems (Lambin et al., 2018; Poore and Nemecek, 2018).

A 'nature-positive' framing is becoming pervasive throughout the business and political communities. A major coalition of organisations including the World Wildlife Fund (WWF) and the World Business Council for Sustainable Development (WBCSD) argues for a 'nature-positive global goal for nature', aiming to bend the curve of biodiversity loss by 2030 and achieve a full recovery of nature by 2050 (Locke et al., 2021). The leaders of the G7 agreed on the need for 'Global system change … our world must not only become net zero, but also nature-positive … ' (G7 Summit, 2021, p. 7). The UK government recently announced a strategy for a 'nature-positive 2030' including nearly 100 companies as 'supporters' (JNCC, 2021, p. 202). 'Nature--positive' as a framing benefits from similar rhetorical properties as 'zero deforestation' commitments: a positive, intuitively simple message which masks a staggering complexity of measurement, and operationalisation (Lyons-White et al., 2020).

While there is already a wealth of recent initiatives and resources relating to the concept of 'nature-positive' (WBCSD, 2021b), there is no consistent definition (Milner-Gulland, 2022), and often little distinction from previous 'no net loss' or 'net positive' approaches. We reviewed definitions of 'nature-positive' by searching the websites of high-profile industry initiatives working on organizational biodiversity performance and target-setting, and a supplementary internet search (Table 1). We classified definitions into categories: process-based, which highlight the operational steps required without defining explicit criteria for success (Business For Nature, 2021; WBCSD, 2021b); outcome-based, referring to specific biodiversity outcomes, such as reversing biodiversity declines by 2050 (Locke et al., 2021); and conceptual, referring to aspirational, general concepts such as a 'regenerative' economy.

'Nature-positive' represents a new concept for business and will naturally evolve as key stakeholders adopt and operationalise the term. However, if the approach remains vaguely defined and variably interpreted there is a high risk that it could be misleading, and used to 'neutralise' criticism of companies' environmental practices (Boiral, 2016), without driving genuine action to achieve global biodiversity goals. The definitions and descriptions in Table 1 encompass a number of elements that should underpin our understanding of 'nature-positive'. These include viewing outcomes not just at the organisational level but in the context of wider systems, recognising interconnections between different nature goals (e.g. climate and biodiversity), and delivering outcomes consistent with wider social goals and targets (such as a full recovery of nature by 2050). Building on these elements, we propose that 'nature-positive' organisational strategies need to advance on previous biodiversity commitments across four key dimensions: scope, mainstreaming, integration, and ambition (Table 2) in order to deliver outcomes consistent with global biodiversity goals such as the GBF (Locke et al., 2021).

2.2. Scope

To date, NNL/NPI goals have typically been applied to firms' direct operational footprint and have rarely scoped in supply chain impacts or impacts at the point of consumption (IUCN, 2016). Such goals are anchored in the analytical framework of the mitigation hierarchy (avoid, minimize, restore, offset), applied and implemented mainly in sectors with impactful direct operational footprints, such as extractives. However, for many companies the majority of impacts occur beyond their direct operational footprint (Bull et al., 2022b; Kering, 2020a; Puma, 2011), requiring the scope of actions to be expanded to reverse biodiversity loss. This expansion is needed in two directions: vertically, to achieve positive biodiversity outcomes along the entire value chain (end-of-life impacts might be particularly large in sectors like consumer goods); and horizontally, through working towards transformative sector-wide improvements in sustainability practices.

It remains challenging for many companies to understand and address their supply chain impacts (Lyons-White and Knight, 2018). However, opportunities to do so are rapidly improving as high-resolution supply chain data and better measurement methods become increasingly available (Gardner et al., 2019; Lambin et al., 2018). A further challenge is a company's steps to address supply chain

Table 1
Review of the definitions or uses of 'nature-positive' adopted by key organisations attempting to operationalise the concept.

Institution	Type of definition	Description of 'nature-positive'
Science-based targets network (SBTN)	Conceptual	Discusses the "elements of … nature-positivity": collective action to avoid and reduce pressures on nature and contribute towards nature regeneration, and judging success not only by the outcomes of the individual actor but also the wider ecosystem in which it is embedded (SBTN, 2021a)
UK Council for Sustainable Business	Conceptual	"A nature-positive approach puts nature and biodiversity gain at the heart of decision-making and design. It goes beyond reducing and mitigating negative impacts on nature as it is a proactive and restorative approach focused on conservation, regeneration, and growth." (CSB, 2022)
UNEP	Conceptual	"A Nature-positive Economy [is] an economy that is regenerative, collaborative and where growth is only valued where it contributes to social progress and environmental protection" (UNEP, 2021)
World Economic Forum	Conceptual	"A nature-positive built environment shares space with nature, putting whole ecosystems rather than humans alone at the centre of design" "Nature-positive extractive processes have the potential to minimize destructive land management practices and enhance conservation efforts to offset biodiversity impacts that cannot be either avoided or mitigated" "A nature-positive energy transition has the potential to further both global climate and nature goals" (WEF, 2020)
Global goal for nature	Target-based	"Zero Net Loss of Nature from 2020, Net Positive by 2030, and Full Recovery by 2050" (Locke et al., 2021)
IUCN	Target-based	"… an equitable, nature-positive and net zero world [would] ensure there is more nature globally in 2030 than there was in 2020, by halting and reversing the loss of nature to put nature on a path to recovery for the benefit of all people and the planet by 2030, as well as tackle climate change, achieve the Sustainable Development Goals, and enable people and communities to thrive in a healthy and stable future" (IUCN, 2020)
Natural England and UK Joint Nature Conservation Committee	Target-based	"Becoming Nature-positive means reversing the current declines in biodiversity, so that species and ecosystems begin to recover" (JNCC, 2021)
Nature-positive Universities network	Target-based	"Nature-positive means restoring species and ecosystems that have been harmed by the impacts of a university and its activities and enhancing the university's positive impacts on nature" (Nature-positive Universities Network, 2022)
Taskforce for Nature-related Financial Disclosures	Target-based	"A high-level goal and concept describing a future state of nature (e. g. biodiversity, ecosystem services and natural capital) which is greater than the current state" (TNFD, 2022a)
Business for Nature	Process-based	Does not define nature-positive, but outlines how to achieve nature-positive outcomes via a process of "assess, commit, act, advocate" (Business For Nature, 2021)
World Business Council for Sustainable Development	Process-based	Does not define nature-positive, but outlines how to achieve nature-positive outcomes via the procedural building blocks of "assess and prioritise, commit, measure and value, act, transform, disclose and report" (WBCSD, 2021b)

impacts could be undermined through the actions of others, e.g. through displacement to other sites ('spillover' or 'leakage': Meyfroidt et al., 2020) or re-routing through less discriminating purchasers. Companies seeking to deliver nature-positive outcomes therefore need to expand actions into driving transformational improvements horizontally throughout industry, reflected in the 'transform' and 'advocate' steps to implementing a nature-positive approach adopted by WBCSD and Business for Nature (Table 1).

2.3. Mainstreaming

The need to mainstream biodiversity considerations into business practices has been increasingly discussed (Milner-Gulland et al., 2021), but there remain barriers to implementation (Addison et al., 2019; Smith et al., 2019). Traditionally, achieving NNL/NPI goals has been the domain of ecological managers responsible for operational impacts at project sites. However, a necessary precursor to embedding nature-positive principles throughout an organisation's strategy is the buy-in and proactive engagement of employees across the entire business and at board level (Boiral et al., 2019). One useful emerging set of criteria for gauging how far nature considerations are mainstreamed into organisations comes from the Taskforce for Nature-related Financial Disclosures (TNFD). The TNFD recommends that organisations disclose nature-related risks and opportunities affecting their governance and strategy, including specifying their management's role in managing them (TNFD, 2022b). They also recommend companies report on how they identify and manage nature-related risks. These disclosure recommendations speak to the material importance of having senior employees approaching all executive business activities through the lens of understanding the impacts and dependencies on nature, and recommend that it should be of material interest to investors to know the degree of engagement with nature loss at board level. Key to mainstreaming is setting organizational biodiversity targets that galvanise efforts across the entire business, and holding different business areas accountable for their contributions to the organization's overall targets. The best kinds of organizational biodiversity targets are SMART (specific, measurable, accepted, realistic and time-bound), enabling tracking of progress towards, and incentivizing achievement of overarching biodiversity goals (Addison et al., 2019; Maron et al., 2021).

2.4. Integration

Business activities have impacts on multiple dimensions of nature and social systems, from the climate to biodiversity, to communities in production landscapes. Organisations often address these dimensions independently (e.g. climate and biodiversity strategies are typically stand-alone), but that brings the risks of actions across different dimensions that undermine rather than reinforce each another. For

Table 2
Summary of the authors' perspectives on the key differences between nature-positive and net positive impact/no net loss of biodiversity corporate strategies.

Key elements	No Net Loss/Net Positive Impact	Nature-positive
Scope	The framing of NNL/NPI commitments is rooted in the mitigation hierarchy, which has traditionally been applied to firms' direct physical operational footprints	Extends beyond the traditional mitigation hierarchy and encompasses the operational footprint, supply chain and end-of-life impacts (vertical scope); and engagement in sector wide efforts to improve industry sustainability (horizontal scope). Proposed frameworks include the Science-based Targets Action Framework (SBTN, 2021b) and the Mitigation and Conservation Hierarchy (Milner-Gulland et al., 2021), which both emphasise additional steps to be taken on top of compensating for harms, including "transforming" or "renewing" systems to drive sector-wide improvements
Mainstreaming	Mainly the domain of ecological managers responsible for operational impacts at project sites	Review and transformation of business processes to ensure that all decisions (and business models) are aligned with nature-positive goals. Nature embedded in organizational decision-making via governance, strategy, risk management and measurement (TNFD, 2022)
Integration	Biodiversity typically addressed separately from other dimensions of nature. Social outcomes dealt with via safeguards to reduce harm.	An integrated approach across relevant dimensions of nature (e.g. biodiversity, climate, water, soil) to promote synergies and minimize trade-offs. Further integrated with social considerations to ensure social justice and positive social outcomes
Ambition	Commonly applied to a subset of projects and biodiversity features, and anchored in the mitigation hierarchy at project level. For organisations, assessed as the aggregate of commitments across projects. Project commitments may be assessed against declining baseline and are not set with reference to overall jurisdictional targets or global goals.	Scaling against overarching societal goals (global and/or jurisdictional), including a contribution to restoring historical impacts, and delivering absolute, rather than relative, gains for biodiversity. Commitments should be SMART and progress towards them reported publicly to ensure public accountability (Addison et al., 2019)

example, international concern is growing that decarbonization strategies have the potential to inflict serious harm on biodiversity (Pörtner et al., 2021): plantation-based carbon offsets, increased biofuel consumption and production of the raw materials needed for the renewable energy transition could all conflict with biodiversity goals (Sen and Dabi, 2021; Sonter et al., 2020). Delivering a nature-positive strategy involves contributing to environmental improvement across the dimensions relevant to a business (e.g. biodiversity, carbon and water), using an integrated approach that addresses impacts coherently without exacerbating other environmental or social risks (WBCSD, 2021a). This might manifest in businesses investing in solutions that contribute to multiple goals simultaneously (e.g. green infrastructure, nature-based solutions focusing on the restoration of natural ecosystems) or combined target-setting (Bull et al., 2020). For example, fashion giant Kering's recent biodiversity strategy commits to regenerating one million hectares of productive land in their supply chain and protecting an additional million hectares of critical habitat outside their supply chain by 2025, emphasizing the carbon co-benefits of their strategy (Kering, 2020b).

2.5. Ambition

Commitments to NNL or NPI have typically involved applying the mitigation hierarchy to direct impacts alone, and often to a subset of high-priority projects and/or biodiversity features. Aligning with broader societal targets for nature recovery will require an increase in the ambition of company biodiversity strategies, beyond merely compensating for impacts and towards delivering active biodiversity improvements in line with global biodiversity goals (Locke et al., 2021). This implies improvements in nature relative to a static baseline (Milner-Gulland, 2022; Simmonds et al., 2022). Previous corporate NNL goals have often been assessed against a declining counterfactual where biodiversity loss would be more intense in the absence of the company's intervention (e.g. Temple et al., 2012). This can produce demonstrable NNL outcomes for a particular project while the overall state of nature continues to decline. For example, Rio Tinto's flagship commitment to achieving a NPI for its ilmenite mine in Madagascar assumed that forest loss from the mine's operations could be compensated for by slowing the rate of forest loss elsewhere (Temple et al., 2012). This was a ground-breaking level of ambition at the time, but such commitments do not collectively deliver the absolute improvements aligned with nature-positive. For most organisations, delivering measurable net improvements in nature relative to a static baseline will require fundamental transformations in their organizational consumption and production systems that both radically reduce their organizational material impacts on nature and increase the ambition of their investments in nature improvement (Bull et al., 2022b).

To operationalise higher levels of ambition it is key to define what an organisation's biodiversity goals should be (Milner-Gulland, 2022). Assessing and fairly allocating responsibility across economic actors for past impacts remains a major challenge both scientifically and politically (Hickel et al., 2022; Irwin et al., 2022; Pinero et al., 2019). This is actively being explored by key target-setting institutions such as the SBTN, which anticipates publishing further guidance in 2023 (SBTN, 2020).

2.6. Measuring progress towards nature-positive

How far have companies progressed towards implementing 'nature-positive' approaches? Frameworks and standards for business disclosure of biodiversity outcomes are rapidly progressing (e.g. TNFD, 2022b), but at present assessing firms' actual biodiversity impacts and performance relies on largely inaccessible information and is highly challenging (e.g. zu Ermgassen et al., 2020). An approach commonly taken in practice (e.g. the Forest 500 assessment, https://forest500.org/) and the literature is to analyse information in firms' public sustainability reports and stated commitments (Carvajal et al., 2022; Haque and Jones, 2020; Skouloudis et al., 2019), whilst acknowledging that this is an imperfect reflection of actual biodiversity performance (Smith et al., 2019; zu Ermgassen et al., 2020). Robust biodiversity commitments are a key foundation of nature-positive approaches (Milner-Gulland, 2022), explicitly identified by process-based definitions of nature-positive and key initiatives such as the SBTN (Table 1).

We assessed companies' public biodiversity commitments and strategies to as far as possible assess alignment with the four key elements identified for nature-positive approaches (Table 2). As the empirical basis, in 2021 we updated two datasets from previous studies that provide a 2016 baseline for corporate biodiversity commitments from two key samples of businesses: leading adopters of biodiversity targets (de Silva et al., 2019; Rainey et al., 2015) and the world's largest listed companies in the Global Fortune 100 (GF100) (Addison et al., 2019).

Rainey et al. (2015) documented corporate net positive impact biodiversity commitments in 2011, while de Silva et al. (2019) assessed changes in these to 2016 and found severe limitations in the use of scientific principles to set and measure targets. Addison et al. (2019) quantified the extent and quality of biodiversity commitments used by firms in the GF100 in 2016. They again identified severe deficiencies, with only 5/100 of the world's largest firms having specific, measurable and time-bound targets.

3. Methodology

We updated the two existing databases of biodiversity commitments and references mentioned above last sampled in 2016 using identical search protocols. We reviewed the 2021 commitments of firms in both the 2016 GF100 and 2021 GF100 (73 firms overlap between both sampling periods). In total, we analysed the public biodiversity documentation of 167 firms: all 100 of the 2016 GF100, an additional 27 firms from the 2021 GF100, and an additional 40 firms from the 2016 'net impacts' commitment tracker. A detailed methodology is in the Supporting Information. The firms in the 2021 GF100 encompass revenues in excess of $14.5trillion, equivalent to >15% of global GDP.

We used these two samples to explore subtly different questions. The 'net impacts' commitment tracker captures changing commitments of companies at the forefront of biodiversity target-setting over the last decade, representing a sample of firms that have historically represented best-practice. This sample is defined by the types of biodiversity targets they set rather than any other business criteria, so it spans a wide variety of sectors and company sizes. The GF100 sample includes the world's biggest publicly-listed companies. The GF100 represents firms from a wide set of industries, including higher representation of firms from sectors commonly (but not necessarily correctly) perceived to have less direct materiality of biodiversity risk and smaller direct operational impacts on nature (e.g. health and financial services).

To replicate the Addison et al. (2019) sampling method we analysed the most up-to-date sustainability reports of the firms in the 2016 GF100, and the 2021 GF100. We noted whether biodiversity was mentioned in the text, then compiled any clear biodiversity commitments in the text (Table 3), and evaluated whether these commitments were SMART (defined a specific component of biodiversity, provided a measurable target, and set a clear time goal). Repeating the Addison et al. (2019) sampling method for 2021 allows us to approximate changes in the quality of corporate biodiversity commitments over time: firms are categorized as having 1) no mention of biodiversity; 2) mentioning biodiversity but having no formal commitment; 3) having a formal commitment but not a SMART commitment (i.e. the firm's performance towards their commitment cannot be held accountable or measured); and 4) having a SMART commitment (which enables accountability towards their commitments). We did not distinguish between SMART commitments that applied to the whole organisation's biodiversity actions or a subset of their business activities (e.g. a zero deforestation commitment applying to a specific commodity could enable a firm to be categorized as SMART). We can therefore evaluate changes between categories for those firms present in both the 2016 and 2021 GF100.

De Silva et al. (2019) conducted a systematic search to identify all of the corporations with net outcome-type biodiversity commitments. We did not repeat their systematic search protocol but constrained our analysis to the firms included in the 2016 update of the database, and updated their commitments for 2021 (Supporting Information).

As well as repeating the sampling methods for both datasets, we extracted additional information from company reports for the 2021 update to attempt to evaluate the degree to which firms' publicly-reported actions addressing biodiversity loss were consistent with the principles of nature-positive highlighted in the introduction (ambition, scope, integration, mainstreaming). The categories used to classify company's biodiversity publicly-reported biodiversity actions

Table 3
Examples of the type of language identified in corporate biodiversity reports categorized across our proposed elements required for nature-positive alignment.

Elements for nature-positive alignment	Categories	Examples of relevant text	Firm
Scope	Entire value chain	"ENGIE will also supplement its strategy by carrying out an in-depth analysis of the impacts and reliance of its activities on its value chain, raising employee awareness of biodiversity issues and setting up a platform for the exchange of good practices."	ENGIE
	Operations and supply chain	"As a member of the One Planet Business for Biodiversity (OP2B) coalition, we are working to preserve biodiversity. At the same time, by collaborating throughout our supply chains, we are scaling up regenerative agriculture and eliminating deforestation."	Nestlé
	Operational footprint	"Wherever its industrial activities have an impact on biodiversity (e.g. when building a new site or extending an existing one), the Company is engaged with local partners on conservation and remediation projects to preserve the affected flora and fauna and ensure they are not adversely affected by the Company's activities."	Airbus Group
Ambition	Biodiversity conservation actions scaled with reference to societal targets	No firms identified in our sample.	
	Biodiversity conservation actions scaled with reference to company footprint	"In 2020, we committed to permanently protect and restore more land than we use company-wide by 2025, using approaches like land acquisition, conservation easement, national park creation, and community or indigenous-led conservation. While we do not have a particularly large footprint, Microsoft does directly operate on approximately 11,000 acres of land globally"	Microsoft
	Arbitrary scaling of biodiversity conservation actions	"We are committed to minimizing the impact of our operation on biodiversity. In particular, we have consistently undertaken ecosystem protection activities, including the identification of endangered species near our worksites and protection of their	Samsung

(continued on next page)

Table 3 (*continued*)

Elements for nature-positive alignment	Categories	Examples of relevant text	Firm
		habitats." Companies under this categorization often presented a set of CSR case studies but without reference to the magnitude of the benefits relative to the organizational footprint.	
Integration	Mention biodiversity co-benefits	In a section of their climate strategy 2021 report: "Conservation of old growth forests or other areas of high conservation value are at the same time very important. These forests often have a significant amount of carbon stored in them and provide irreplaceable services in terms of biodiversity, soil protection and many others"	IKEA

commitments are shown in Table 3 (further description in the Supporting Information). As categorization based on text analysis is partially subjective, the database was independently validated by a second author on the authorship team. Following the validation process agreement across all classification judgements between the authors was 84%, in line with that from similar studies (Addison et al., 2019; Boiral and Heras-Saizarbitoria, 2017; Supporting Information).

We acknowledge some methodological limitations. To standardize our method and ensure consistency with the sampling methods of the past databases, it was necessary to constrain our GF100 analysis to corporate biodiversity reports, which means our dataset would not include commitments made on company websites or other documentation, or their participation in industry platforms associated with their own set of commitments (e.g. the Equator Principles). In addition, our search was conducted only in English. Given these limitations, as with other similar analyses the results should be interpreted as an indicative global snapshot of the robustness and depth of corporate biodiversity goals.

4. Results

Our analysis shows some advance since 2016 in the overall uptake of biodiversity commitments in company sustainability documentation and depth of corporate engagement with biodiversity, and modest improvement in the uptake of specific, time-bound commitments that are a necessary precursor for nature-positive objectives, allowing for public accountability and measuring progress towards goals (Fig. 1). From 2016 to 2021, there were increases in the number of 2016 Global Fortune 100 (GF100) companies mentioning biodiversity (from 50 to 70) and specifying biodiversity commitments (from 31 to 53; Fig. 1). The number of firms implementing SMART biodiversity targets increased from 5 to 10 over five years. Three firms (Verizon, Microsoft and Tesco) moved from not mentioning biodiversity in 2016 through to having SMART biodiversity targets in 2021 (although Tesco's commitment applies only to deforestation in their soy supply chain). In the 2021 GF100 (76 firms overlap between the 2016 and 2021 league tables), the distribution is similar – 61 mention biodiversity in their corporate reports, 46 have some form of biodiversity commitment, and nine firms have SMART commitments.

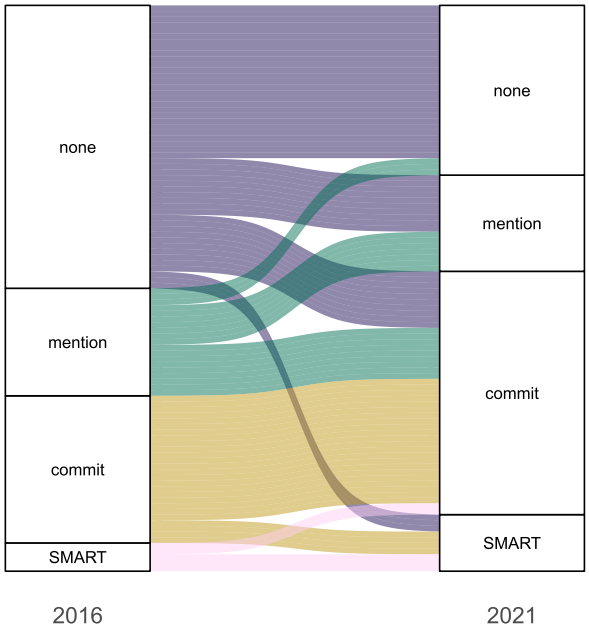

Fig. 1. Alluvial chart showing changes in the quality of corporate biodiversity commitments in firms in the 2016 GF100 from 2016 to 2021. "None" indicates no mention of biodiversity in the company public sustainability documentation, "mention" indicates biodiversity being mentioned in the text but not associated with any formal commitment, "commit" indicates firms that have a recognizable biodiversity commitment but unassociated with SMART criteria that would allow for accountability and tracking progress towards a defined target, and "SMART" indicates firms that have SMART biodiversity commitments.

Reductions in the quality of biodiversity commitments over the five-year period were less common than improvements, indicating a gradual advance in the quality of corporate engagement with biodiversity in company reports over this time (Fig. 1). However, there were also commitment retractions observed. Of the five firms recorded as having SMART targets in their sustainability documentation in 2016, two no longer reported SMART targets in their sustainability reports in 2021 (Carrefour, and AXA - they had previously set SMART zero deforestation commitments by 2020, but no new SMART targets were found in their 2021 biodiversity reporting). Although biodiversity commitments increased overall, three companies moved from mentioning biodiversity to no longer mentioning it in their reports.

Biodiversity commitments were as expected more robust in our sample of best-practice firms from the 'net impacts' tracker, with 11/41 firms implementing SMART biodiversity targets, and an additional five with targets that had some SMART elements (e.g. time-bound but not specific). On the other hand, 7/41 firms no longer had biodiversity commitments or had not renewed their biodiversity commitments since 2016. These seven commitment extinctions contained both firms that no longer exist in their previous form (e.g. Solid Energy New Zealand), and firms whose online sustainability information appears to not have been updated since the last survey (e.g. Tradition Green, Pinepac Group).

However, our sample suggests that corporate biodiversity actions are falling short of aiming for transformative improvements consistent with long-term nature recovery: the elements needed for nature-positive alignment were frequently not explicitly mentioned in company documentation (Fig. 2). The majority of firms did not specify the scope of their nature conservation actions, and of those that did, most commitments relate to the firms' direct operational impacts rather than their supply chains or entire value chain. No firms in our samples explicitly aimed to achieve biodiversity outcomes aligned with a defined overarching global or national policy target, with 40/167 firms explicitly

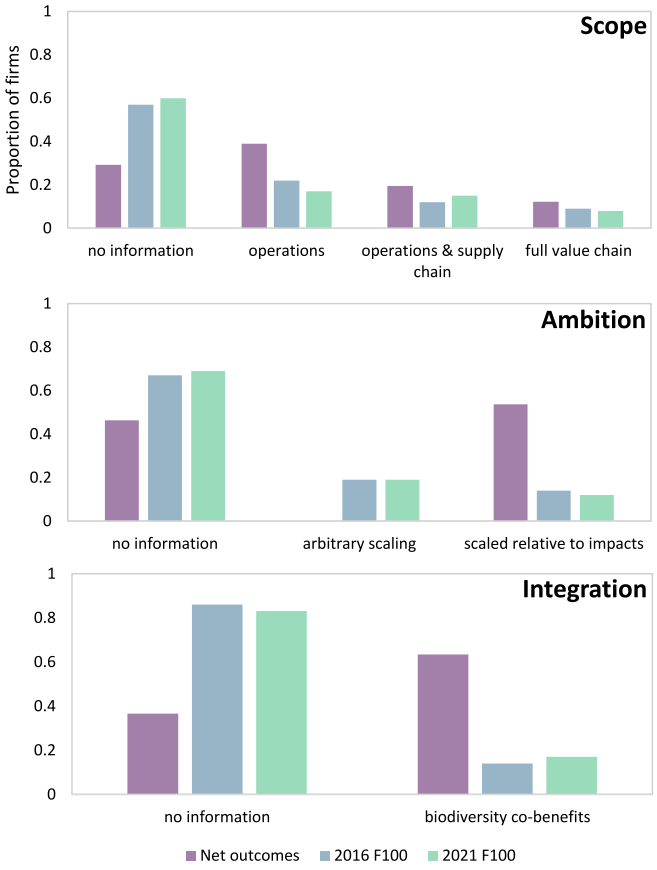

Fig. 2. Quantifying the degree to which corporate biodiversity actions reported in 2021 sustainability reports are consistent with elements required for nature-positive alignment across three samples of companies. Top panel) Scope of biodiversity actions, capturing whether firms explicitly mentioned how far along their value chains they address biodiversity impacts; Middle panel) Ambition of biodiversity actions, capturing whether firms scaled their positive biodiversity actions with respect to the firm's overall impacts, present various case studies of their biodiversity initiatives but with an arbitrary connection to their overall impacts, or whether the scale was undefined; Bottom panel) Integration of commitments, assessing whether companies mentioned biodiversity when discussing their climate strategy. Companies in the 2016 F100 and 2021 F100 overlap (76 companies in both samples), and 1/41 companies in the sample of companies with historical 'net outcomes' commitments is also in the F100 samples. Insufficient information was available to assess alignment with 'mainstreaming' of biodiversity.

aiming to deliver biodiversity outcomes to compensate for the biodiversity impacts of the company, mostly operationalized via the application of the mitigation hierarchy at operational sites. The firm that came closest to committing to biodiversity actions consistent with nature-positive was Microsoft, which set SMART targets ("committed to permanently protect and restore more land than we use company-wide by 2025"), discussed the biodiversity co-benefits of their climate strategy, and committed to mitigating the negative impact of their business on biodiversity. Firms with historical net-outcomes commitments outperformed the GF100 with regards to explicitly scaling their biodiversity conservation activities relative to their company's impacts (as this is implicit in net-outcomes type approaches), and mentioning the biodiversity benefits of their climate strategies (61% of firms in the sample).

The sectors with the most firms on the 2021 GF100 were energy (14), financial institutions (19), automobile firms (13), and healthcare and technology firms (10 each). There was considerable variation in the penetration of biodiversity commitments between well-represented (>5 firms) sectors, varying from a high of 71% of energy companies having some form of biodiversity commitment, to a low of 25% and 26% for retail and financial firms respectively (although some are signed up with industry commitment platforms such as the Equator principles which are not captured in this study).

5. Discussion

Whilst business and policy rhetoric about the role of business in addressing biodiversity loss has intensified, there is evidence of limited progress in the extent and robustness of biodiversity commitments among the world's largest listed firms from 2016 to 2021. Progress is substantially slower for biodiversity than for climate commitments: 10% of firms from the 2021 GF100 had some form of measurable and time-bound biodiversity targets, compared with 21% of the world's largest publicly-listed firms having net zero targets (Black et al., 2021). The changes could be generally interpreted as firms moving towards increasingly acknowledging their biodiversity impacts, but at a slower rate than that required to be consistent with global biodiversity goals embedded in the GBF. A few companies have failed to renew their previous biodiversity commitments. On the other hand, some firms have substantially increased the quality of their biodiversity commitments. There are also firms outside the sampling frame of our study that have adopted principles closely aligned with the nature-positive approach outlined here, such Kering, one of the world's largest fashion companies, which has committed to nature restoration through and beyond their entire supply chain, with time-bound targets scaled well in excess of their own land footprint (Kering, 2020b).

Based on their reports, many service-based firms still consider biodiversity of limited materiality to their core operations, and downplay their operational impacts on nature (Addison et al., 2019). For example, insurance giant Allianz (>150,000 employees) explicitly choose not to report their biodiversity and land use impact, explaining that 'as a financial services company, our operational impact on nature loss is limited' (Allianz, 2020). Within the GF100 sample, we found much higher rates of biodiversity commitments in sectors with significant direct operational impacts such as energy than in service-based sectors. However, a recent biodiversity footprinting analysis for Oxford University, another large research- and service-based organization, identified the majority of their biodiversity impacts were embedded in the materials required for everyday core operations (Bull et al., 2022b). The reports of service-based businesses generally did not acknowledge the consequential environmental footprints of the metabolism of large organisations, such as the biodiversity impacts embedded in the consumption of office supplies, energy, food and construction materials (Bull et al., 2022b; Södersten et al., 2020; Torres et al., 2022), which impose pressure on biodiversity that should be addressed through organizational strategy.

Nature-positive is a relatively new and poorly defined concept, so it is unsurprising that most firms' commitments do not yet reflect the elements that we argue are necessary if businesses are to align with global biodiversity goals. That notwithstanding, some aspects, such as the need to address supply chain impacts, have been known and understood for decades, yet uptake has been slow. Ultimately, our data demonstrate the vast gap between what is biophysically required to bend the curve of biodiversity loss and reduce the associated risks, and what is currently being delivered or promised through company strategies. Here, we summarise the challenges facing firms implementing nature-positive business strategies, and highlight practical steps that firms, sectors and institutions can take to move closer towards nature-positive outcomes (Table 4).

5.1. Metrics and measurement

Metrics are needed across all components of nature, but here we focus on biodiversity. Robustly measuring biodiversity and its responses to business impacts is key to enable nature-positive aligned action by

Table 4
Summary of key challenges and potential solutions to the implementation of nature-positive business strategies.

Theme	Challenges	Potential solutions
Metrics and measurement	Need metrics that can capture positive and negative biodiversity impacts along the whole value chain, based on high-quality spatially-explicit data on biodiversity	Innovation in biodiversity metrics designed to track business impacts and further improvements in the underlying biodiversity data base
Information	Large gaps in biodiversity reporting	Governments moving towards mandatory disclosure of biodiversity impacts and dependencies
	Opacity of supply chain impacts	Innovative methods for enhancing supply chain transparency (e.g. https://www.trase.earth/)
	Misleading or incomplete biodiversity reporting	Standards (e.g., TNFD, IUCN Nature-based Solutions Standard, Global Biodiversity Standard), combined with independent third-party evaluation of biodiversity reporting/disclosure
Financial and political	Nature-positive requires reductions in material throughput	Collectively agreed policies for forgoing specific high-impact commercial opportunities
		Preventing leakage by levelling the playing field
	Resistance from firms implementing ecologically damaging activities	Minimizing vested interests in policymaking
Skills	Skills barriers, lack of basic engagement	Biodiversity-related training and senior management buy-in
Coordination	Landscape-scale coordination	Improved spatial and land use planning delineating areas
	Business Equity – allocation of fair share of responsibility between businesses	firms are responsible for
		Legitimate fora (where power imbalances between firms are minimized) for debate on equity issues
		Appropriate metrics to make allocation decisions transparent and enable debate
		Draw on climate precedents where appropriate
Social equity	Positive for whom?	Explicit recognition of local nature priorities through equitable local consultation
		Assess and mitigate identified people-nature trade-offs to maintain and where possible enhance local human wellbeing

business. Biodiversity is intrinsically complex and local, and cannot be fully assessed in a single metric. This has resulted in a proliferation of metrics and measurement approaches. There are over 250 biodiversity-related indicators proposed for monitoring various aspects of the post-2020 Global Biodiversity Framework (CBD, 2021a), and at least 40 different biodiversity measurement tools or frameworks developed for use by business (Lammerant et al., 2021). Different metrics and measurement approaches are suitable for different purposes, have different strengths and drawbacks, and typically demonstrate trade-offs between desirable features such as granularity, feasibility, scalability and validity. Indicators for monitoring business biodiversity impacts have been extensively reviewed elsewhere (Stephenson and Carbone, 2021), accompanied by numerous methodological guides to applying metrics (Addison et al., 2020; UNEP-WCMC et al., 2022). We review desirable properties of biodiversity metrics for business in the Supporting Information (Table S1).

It will not be practical for business to adopt targets – and associated metrics – relating to all the elements of biodiversity. A relatively simple approach that can rapidly scale up, yet credibly covers key components of biodiversity, is likely be the most effective. Though still in development, the TNFD, SBTN and Align frameworks appear largely convergent in recommending an ecosystem extent and condition metric (an approach already adopted by the UN-SEEA for national ecosystem reporting; https://seea.un.org/ecosystem-accounting), and a metric related to species extinction risk such as the Species Threat Abatement and Restoration metric (STAR; Mair et al., 2021). These two metric types have complementary features, meet the general criteria outlined above, and together appear to have potential to support a practical, credible and effective approach to nature-positive alignment. Since biodiversity is local and place specific, these broad metrics may need to be complemented by supplementary site-specific metrics. A lack of metrics should no longer be an excuse for businesses to delay taking ambitious action to measure and address their biodiversity impacts and dependencies.

5.2. Informational barriers

Providing public information on company biodiversity performance is key to mainstreaming biodiversity and to demonstrating nature-positive outcomes. As yet, a large minority of firms in our samples do not even mention biodiversity in their sustainability documentation. The main theory-of-change of emerging disclosure initiatives such as the TNFD is to increase the standardized information available for stakeholders (primarily investors) to judge how exposed firms are to risks relating to biodiversity loss, so this should incentivise stronger biodiversity reporting in future, although a mandatory approach is ultimately likely required.

There are other informational barriers. Knowing the location of business activities is key to understanding biodiversity risks, impacts and opportunities. However, there is often a dearth of reliable, fine-grained information on the location of assets and of supply chain sources (World Bank & WWF, 2020). This is a particular issue for finance, and especially for investments in companies or portfolios, but also for many industries reliant on raw material supply chains. For example, despite increasing efforts to enhance transparency and develop high-resolution understanding of the ecological impacts of agricultural supply chains (Gardner et al., 2019; zu Ermgassen et al., 2020), large sections of these supply chains remain hidden from view because end-users purchase from indirect suppliers, making it much harder to trace the commodities to source (zu Ermgassen et al., 2022).

A range of initiatives have the potential to incentivise improved understanding of supply chain biodiversity impacts. On the policy side, innovations such as the EU's proposed zero deforestation law aiming to end the EU importing commodities associated with deforestation will require high-resolution data in order to monitor and enforce. France has introduced new legislation requiring French financial institutions to disclose their nature-related risks from 2022 onwards (Global Canopy, 2021). On the business reporting side, TNFD's beta framework emphasizes the need for location-specific information about businesses interactions with nature; if this gains traction it has potential to improve the informational basis for nature-positive strategies by making an expectation of traceability in supply chains the norm rather than an exception. Where business-led efforts do not encourage rapid disclosure improvements, this will need to be addressed through regulation, with governments replicating mandatory climate disclosures for nature-related risks (Griffin and Jaffe, 2021). To ensure good quality reporting, regulations could require biodiversity disclosures to be third-party audited in a similar way to financial accounts.

5.3. Financial and political barriers

The World Economic Forum recognizes that one key component of achieving a nature-positive future is: "… a reset of how we live, produce

and consume to … halt biodiversity loss by 2030. This reset needs both to decouple our well-being from resource consumption to reduce the amount of resources we need … and to decouple resource extraction from negative impact on ecosystems" (WEF, 2020). This bold statement reflects a growing realization that continued dematerialization of resource consumption will not, at current rates, be enough to shrink society's impacts on natural systems within our 'safe-operating space' (Jackson, 2016; Steffen et al., 2015). Not merely relative decoupling but absolute reductions in material consumption are required (Jackson and Victor, 2019). Large reductions in throughput are required even for service-based industries that perceive themselves as having limited direct biodiversity impacts. For example, Bull et al., 2022b found that even if the University of Oxford eliminated all its biodiversity impacts which were not mission critical (e.g. flights and meat consumption), the organisation would still need to acquire offsets equivalent to 32% of the University's biodiversity footprint to achieve a net positive impact on biodiversity.

A key component of reducing businesses' material consumption will be forgoing business activities that are inconsistent with nature-positive outcomes (equivalent to the 'avoidance' step of the mitigation hierarchy or conservation hierarchy; Bull et al., 2022a; Milner-Gulland et al., 2021). Such restrictions are already implemented by many businesses and financing institutions: e.g. some technology firms have signed up to the deep-sea mining moratorium (Reuters, 2021), and the main principles behind zero deforestation commitments are to forgo the consumption of agricultural commodities that are responsible for forest loss. However, such restrictions have so far been adopted by a small number of companies and institutions, generally apply in narrow and specific circumstances, or have been ineffectively implemented. Delivering outcomes consistent with nature-positive will require broader exclusions spanning both biodiversity- and climate-damaging activities, and much greater uptake. Some industries and organisations with business models predicated on large material impacts on nature will require fundamental transformations away from business models that maximise short term economic returns whilst externalising losses (which currently are financially and politically supported). For example, it has been estimated that globally the agricultural sector generates environmental externalities in excess of the value of food production (Trucost & FAO, 2015), demonstrating that the need for sector-wide transformation.

Firms that have historically benefitted from being able to socialize environmental harms tend to resist the internalization of those costs (Kapp, 1950). There is often political resistance to legislation that could incentivise these transformations by increasing the costs of damaging activities or restricting usage of environmental resources (e.g. protected area expansion; Lindenmayer et al., 2018). More subtly, firms may deprioritise environmental actions to address the drivers of loss when these appear costly. Research demonstrates clear discrepancies between firms' stated commitments to addressing biodiversity loss and the reality of where biodiversity falls within company priorities. For example, in Chile companies in the salmon farming and forestry sectors outwardly accepted their responsibilities to address biodiversity impacts, while deploying tactics to delay the fundamental and costly reforms needed (Smith et al., 2019). Reducing the influence of vested interests in environmental policy design and implementation is likely to be a necessary enabling step for nature-positive outcomes.

5.4. Skills shortages

Numerous studies show that a key barrier to the uptake of biodiversity initiatives in firms is a lack of employee skills or capacity (Boiral et al., 2019; Krause et al., 2021; WWF & TBC, 2021). Previous NNL/NPI strategies have been focused primarily on a company's operational impacts, requiring appropriate capacity in environmental management, impact assessment and mitigation in the business units involved in operations. However, delivering nature-positive outcomes requires development and implementation of biodiversity strategy that affects all business units, especially executive functions and procurement. Additionally, there are barriers to the use and implementation of evidence-based biodiversity-promoting practices that could be addressed through targeted training and improved disclosure practices (White et al., 2022). The solution to skills gaps is clearly upskilling throughout all the key business units whose decisions impact on nature, including executive-level training in the material risks posed by biodiversity loss.

5.5. Coordination

The overarching goal of a nature-positive economy is for the sum total of all economic actors' activities to deliver net improvements in nature. To achieve this it will be necessary to seek the achievement of nature-positive outcomes at the level of individual firms, nested within national or sectoral strategies that seek to do the same whilst also providing some degree of global coordination. Metrics for monitoring progress towards overall nature-positive outcomes would be consistent and mandatory where appropriate (e.g. for large corporations) but more flexible elsewhere (e.g. for areas owned and managed by Indigenous communities; Bull et al., 2020). However, there are many coordination challenges. One is the issue of leakage, with firms with higher sustainability standards potentially forgoing activities that are then taken up by firms with weaker standards, with no positive biodiversity outcome overall.

Agreeing principles for inter-business equity is also a major coordination and political challenge (Clift et al., 2017; Maron et al., 2020). There is a huge variation in firms' historical and current responsibility for nature loss, and equitably allocating responsibility is essential to delivering nature-positive outcomes in the aggregate. Bjørn et al. (2021) compared seven different methodologies for setting firms' science-based carbon reduction targets, encompassing a wide range of responsibility-allocation mechanisms, and found that under several methodologies there were severe discrepancies between the aggregate of firms' science-based emissions reduction targets and the cumulative global emissions cap.

Predefined spatial plans that identify targets and priority areas for restoration or habitat protection over large spatial scales can form a framework for allocating responsibilities, helping to ensure that in aggregate firms' nature-positive commitments contribute effectively to global biodiversity goals (Simmonds et al. 2019). Methods are being developed to estimate the land-use impacts of firms' commodity supply chains, which could help define a spatial area that each firm is directly responsible for (e.g. using metrics such as the Biodiversity Impact Metric, lifecycle assessment models like LC-Impact, and guidance such as the GHGP Land Sector and Removals Guidance). Resolving inter-business equity issues for nature is a deep ethical challenge, for which there has not yet been any universal agreement in the far more developed policy area of tackling climate change. Fora like SBTN are emerging to enable development and piloting of appropriate allocation principles, but both broader and more local fora will be required to achieve sufficient legitimacy for wider adoption. Precedents developed in the climate space, for example by the Science-based Targets Initiative, may be adaptable to other components of nature.

5.6. Nature-positive and socially equitable – positive for whom?

The impacts of business actions on nature are experienced differently by local, regional and international social actors. For example, protection of nature around production sites to conserve biodiversity, sequester carbon and mitigate climate change may benefit remote international actors. But this protection of nature may limit access to natural resources, negatively affecting local human wellbeing (Bidaud et al., 2017). Local actors consist of diverse and distinct groups whose wellbeing is related in different ways to nature, from direct reliance on nature for daily livelihoods such as fishing or farming, provision of wild

foods and shelter, to recreational and spiritual benefits (Loveridge et al., 2020; Woodhouse et al., 2015). Therefore business actions that have a positive impact on nature may result in unequal social outcomes due to the varying dependence of social groups on aspects of nature and its associated value to them, raising the question: positive for whom?

To address social equity concerns future nature-positive business strategies will need to: 1) recognize and respect the contrasting values that different local groups ascribe to nature, and given these values, understand what nature-positive means for diverse local actors through processes of equitable consultation; 2) assess how business activities will impact the differing ways in which local actors use and depend on nature; and 3) put in place processes to address identified unequal impacts with particular attention given to marginalized and highly nature dependent groups (Dawson et al., 2018). Nature-positive business strategies should at a minimum maintain the wellbeing of people affected by business activities (through direct operations or supply chains) through mitigating people-nature trade-offs (Griffiths et al., 2019). Where possible actions should be taken to enhance place-based nature values to increase local human wellbeing (Jones et al., 2019). In the few studies that have rigorously assessed the impacts of international supply chain initiatives on both nature and social outcomes, no schemes were identified that simultaneously improved both nature and local livelihoods, demonstrating huge room for improvement (Garrett et al., 2021).

6. Conclusion

In this study we have synthesized the working definitions of nature-positive, proposed key elements of a nature-positive approach, and where possible evaluated corporate progress towards more effective commitments that are a necessary precursor of measurably nature-positive business strategies. Our overall empirical finding was that from 2016 to 2021 there has been progress towards addressing biodiversity issues, but insufficient progress towards adopting SMART biodiversity commitments against which firms can be held accountable. Ultimately, a much faster transition towards sustainable business practices is required if business is to play its part in meeting global biodiversity goals consistent with the GBF.

The low levels of adoption of nature-positive practices is not surprising given that the concept is new, has been subject to numerous definitions, and little operational guidance has yet been provided. We make the case that firms that do not address biodiversity impacts along their supply chain, set robust and measurable biodiversity targets aligned with global goals, meaningfully engage with biodiversity at board level, and address single environmental issues in isolation cannot credibly be considered nature-positive, and call for more specific and careful use of the term in order not to dilute its transformative potential (Milner-Gulland, 2022).

However, there are significant, credible business benefits from taking steps towards delivering nature-positive outcomes now, such as improved risk management (Addison and Bull, 2018). The pace of innovation is rapid, with numerous influential frameworks, policies and measurement tools being developed for implementation in the near future (e.g. TNFD, SBTN, EU deforestation policy, post-2020 GBF), which will increase the incentives towards better environmental stewardship and reporting.

Achieving nature-positive outcomes will need concerted, transformative action and coordination between firms and governments to create systems of production and consumption that actively enhance nature. Enabling nature-positive outcomes requires huge improvements in spatial information and data availability and transparency, regulatory improvements to level playing fields and prevent leakage, and improved spatial planning and landscape-scale coordination. Progress in these areas is urgently needed if businesses are to begin actively contributing to the regeneration of nature, and playing their part in securing nature's recovery into the future.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data included in the supporting information.

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Appendix A. Supplementary data

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