Title: Using conservation science to advance corporate biodiversity accountability

Abstract

Biodiversity declines threaten the sustainability of global economies and societies. Acknowledging this, businesses are beginning to make commitments to ~~biodiversity,~~ account for and mitigate their influence on biodiversity, and report this ~~to stakeholders~~ in sustainability reports. The top 100 of the 2016 Fortune 500 Global companies' (the Fortune 100) sustainability reports were assessed to gauge the current state of corporate biodiversity accountability. ~~Our analysis revealed that~~Many c companies~~orporations~~ ~~big businesses~~ ~~are~~ acknowledged~~ging~~ biodiversity, but corporate biodiversity accountability is in its infancy. Almost half (49) of the Fortune 100 mentioned biodiversity in ~~their sustainability~~ reports, and 31 made clear biodiversity commitments, of which only 5 could be considered specific, measureable and time-bound. A variety of biodiversity-related activities were ~~described qualitatively in reports~~disclosed ~~by 49 companies~~ (e.g., managing impacts, restoring biodiversity~~, connecting people with biodiversity~~, and investing in biodiversity), but only ~~. However, only~~ 9 companies provided quantitative ~~information~~ indicators to verify the magnitude of their activities (e.g., area of habitat restored). ~~Only 1 company disclosed quantitative information about the magnitude of business impacts on biodiversity as opposed to the activities undertaken to mitigate those impacts.~~ No companies reported ~~on~~ quantitative biodiversity outcomes, ~~of their activities;~~ making it ~~. This makes it very~~ difficult to determine whether business actions we~~a~~re of sufficient magnitude to address impacts, and are achieving positive outcomes for nature. Conservation science can help ~~businesses~~ advance ~~their~~ approaches to corporate biodiversity accountability through developing science-based biodiversity commitments, meaningful indicators, and more targeted activities ~~that~~ to ~~not only~~ address business ~~business~~ impacts ~~and~~but ~~contribute to international conservation priorities~~. With the "biodiversity policy super-year" of 2020 rapidly approaching, now

25 is the time for conservation scientists to engage with and support businesses to play a critical role in
26 setting the new agenda for a sustainable future for the planet, with biodiversity at its heart.

1 Introduction

Biodiversity underpins and sustains ecosystems globally, and ~~the~~ declines in biodiversity ~~witnessed in recent decades are not only eroding the~~ threaten the resilience of nature, ~~but threatening the sustainability of~~ global economies, and societies (Duffy et al. 2017; Venter et al. 2016). International ~~biodiversity targets have~~targets ~~have been established~~ exist to direct governments and inspire society as a whole to take steps towards the conservation of biodiversity, in the broader context of global sustainable development (e.g., the Convention on Biological Diversity (CBD) Aichi targets (CBD 2011) and the Sustainable Development Goals (SDGs; United Nations 2016)). The public sector has mobilized and are~~is~~ working towards the achievement of ~~these biodiversity~~international targets; h~~.~~ ~~H~~owever, efforts to conserve biodiversity are still falling short (Butchart et al. 2010; Geldmann et al. 2013).~~Butchart et al. 2015; Butchart et al. 2010; Geldmann et al. 2013; Huwyler et al. 2016).~~

~~The international conservation community has set a~~The strategic policy goal to "mainstream biodiversity" (CBD Strategic Goal A; CBD 2011), ~~which~~ sets out a vision for shared responsibility across ~~the~~ public and private sectors for the conservation of nature balanced with sustainable development (Redford et al. 2015). The mainstreaming biodiversity agenda has predominantly been led by the public sector, where guidance, tools~~, policies,~~, standards, and regulations have been developed to both mandate and encourage the private sector to understand and manage their impacts and dependencies on biodiversity (e.g., Forest Trends 2017; TEEB 2010). Bottom-up signals of mainstreaming biodiversity are also emerging, where companies are recognizing biodiversity loss as a risk to their operations (e.g., threatening operational productivity, access to finance, regulatory compliance, or reputation; ~~Bottom-up approaches to mainstreaming biodiversity are also emerging, where the private sector~~ Dempsey 2013). ~~is beginning to recognize the importance of biodiversity and account for it in business decision-making.~~ A public signal of businesses identifying biodiversity as a material risk is when they make commitments to ~~biodiversity~~ or account for their influence on

biodiversity in , and report this to their stakeholders through sustainability reportings A public signal of this is through sustainability reports, where businesses make commitments to biodiversity, account for their influence on biodiversity, and report this to their stakeholders (Boiral 2016).

Corporate biodiversity accountability (through external disclosure of commitments, activities, and performance) is an important a vital partaspect of organizational stewardship and legitimacy, which an increasing number of businesses are undertakingand is viewed as an important way tohelping to transform attitudes and behavior within businesses (Jones & Solomon 2013). Dempsey 2013Businesses in the extractives sector (one of the morea heavily regulated sector sectors for biodiversity impact mitigation) are increasingly making biodiversity commitments (e.g., no net loss (NNL) or better) of biodiversity; and companies from a range of other sectors (e.g., food, financial services, and technology, and telecommunications) are beginning to make similar commitments (e.g., to protect the environment, or reduce impacts on the environment; Adler et al. 2017; Rainey et al. 2015; van Liempd & Busch 2013). Despite these seemingly positive moves, accounting studies suggest that corporate biodiversity accountability is very much in its infancy (Adler et al. 2017; Boiral 2016; Jones & Solomon 2013).

Redford and colleagues (2015) suggest that conservation scientists have failed to engage with the mainstreaming biodiversity agenda to date. They suggest that there is an urgent need for a "science-driven field of biodiversity mainstreaming", in whichwhere conservation scientists should critically analyze progress, to help support and improve current mainstreaming activities. In parallel, calls have been made for scientific research to develop science-based processes and tools are being called for to evaluate corporate social and environmental performance associated with businesses sustainability reports and financial statements (Vörösmarty et al. 2018). A key requirement for tracking progress towards biodiversity mainstreaming is an analysis of public corporate biodiversity accountability, as communicated through commitments, and the associated actions disclosed in

sustainability reports. Here, we carry out ~~this~~ an exploratory analysis of some of the worlds' largest companies~~, in order~~ to: i) provide a snapshot of current global corporate commitments and actions for biodiversity; and, ii) illustrate how conservation science could help inform more robust corporate biodiversity ~~commitments and actions~~~~accountability~~accountability, to support the science-driven field of biodiversity mainstreaming.

2 The biodiversity commitments and actions of the world's top 100 companies

~~In order~~T ~~t~~o ascertain the current status of current global commitments and actions for biodiversity, we turned to some of the world's largest companies – the Global Fortune 500. Every year Fortune generate an annual ranking of the largest 500 corporations worldwide as measured by total revenue, and assess~~es~~ ~~the state of large corporations in relation to their~~corporate profits, assets, and employee numbers (Fortune 2016). The analysis does not include any assessment of ~~corporate social responsibility~~sustainability reporting. ~~However, many large corporations~~companies ~~are beginning to connecting with changing stakeholder and shareholder expectations of sustainable and responsible business practice, and are publicly communicating their sustainability commitments and initiatives through sustainability reports (~~Bocken et al. 2014; Clark et al. 2015; Kareiva et al. 2015; Rainey et al. 2015~~).~~ The Fortune 500 represents an ideal opportunity to explore the extent to which ~~big business is~~companies are engaging in public disclosure of environmental and~~/or~~ social ~~sustainability commitments and initiatives~~issues, to assess the current level of corporate biodiversity accountability.

The sustainability reports of the top 100 of the 2016 Fortune 500 Global companies' (hereafter the Fortune 100; Fortune 2016) were assessed to understand how ~~seriously~~ biodiversity is being integrated into business decision-making and externally reported ~~to stakeholders and shareholders~~. We chose the top 100 companies in the Fortune 500, as these represent a cross-sector of industries that are exposed to different levels of biodiversity risk (as defined by F&C (2004); e.g., through

access to land, capital or markets, and relations with regulators). Thirty-one 31 companies are from sectors classified as high risk (e.g., energy), 32 as medium risk (e.g., finance), and 37 as low risk (e.g., health care; see SI Table 1). We investigated: i) which companies mention ~~biodiversity~~ or make ~~clear corporate biodiversity~~ commitments for biodiversity; ii) what ~~type of~~ biodiversity-related activities are disclosed; and iii) whether information about biodiversity activities is being disclosed ~~is in~~ qualitatively and/or quantitatively ~~formats~~. ~~The Fortune 100 are categorized into sectors (Fortune 2016), and we matched these with high, medium, or low 'biodiversity risk' sectors (as defined by F&C (2004); based on the biodiversity risk posed to different sectors, e.g., through access to land, capital or markets, and relations with regulators).~~

Online searches for the Fortune 100 sustainability reports were conducted using the GRI sustainability disclosure database (GRI 2016b; searching ~~for the~~by company name) or using Google ~~search engine~~ (using the search term 'sustainability', and ~~the~~ by company name). The most recent reports (dated up to 2016; searched for during September 2017) were collated (n.b., 'sustainability reports' can also be referred to as Environmental, Corporate Social Responsibility, Sustainability, Registration Reports, or Financial Reports that contain non-financial information~~, which were also included in the analysis~~). Companies made up of multiple subsidiary companies (e.g., the Exor Group), were only assessed when sustainability reporting was done for the Fortune listed company as a whole, ~~and not some of their~~not subsidiary companies. Websites were not included in our analysis when the year of biodiversity commitments/activities ~~could not be verified~~were not stated; only dated interactive online sustainability reports ~~that clearly stated year of publication~~ were ~~included in the analysis~~analyz~~s~~ed. Reports were searched for 'biodiversity' OR 'nature' OR 'species' OR 'ecosystem' (acknowledging the broad definition of biodiversity; CBD 2017). Additional search terms related to biodiversity were also used ('forest' OR 'palm' oil OR 'seafood'); these terms were commonly used in relation to nature-based ~~sustainable natural resource extraction~~commodities ~~in~~

reports, but appeared often to be mentioned without any mention ofassociation to biodiversity-related terms.

Reports were searched for concise biodiversity goals or statementscommitments made about biodiversity, which were commonly associated with a dedicated chapter or sub-chapter in the sustainability report or were listed as a goal that was reported against commitment in disclosure/materiality tables of reports (e.g., Walmart: has a goal "To conserve one acre of wildlife habitat for every acre of land occupied by Walmart U.S. through 2015"; Walmart 2016SI Table 2). We evaluated corporate biodiversity goals against a sub-set of SMART criteria used in conservation (Doran 1981), to assess whether goals were: Specific – the element of biodiversity that the goal relates to is articulated beyond simply 'biodiversity' (e.g., forest, threatened species or wetlands); Measurable – a quantifiable reduction/improvement is stated along with a defined baseline (e.g., 10% of land protected compared to 2010 levels); and, Time-bound – the goal is associated with a year or time-frame over which the company aims to achieve the goal (e.g., to achieve …by 2020). Note these criteria are a subset of the recommended SMART goals (e.g., Maxwell et al 2015); whilst A and R (ambitious and realistic) are important aspects of targets, the assessment of these aspects can be subjective and difficult when dealing with selectively reported business information in public reports, so were not assessed here.

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When biodiversity was mentioned in reports, we recorded whether this disclosure was made in relation towas in line voluntary reporting standards, such as the Global Reporting InitiativeIndex (currently the most common voluntary reporting framework used for biodiversity; Boiral 2016; Boiral & Heras-Saizarbitoria 2017) or other relevant international conventions (e.g., the Sustainable Development GoalsSDGs biodiversity related goals 14 and 15; and the Convention for Biological DiversityCBD). Search terms used included: 'GRI' OR 'Global Reporting ImitativeInitiative' OR

'Sustainable Development Goal' OR 'SDG' OR 'Convention on bio' OR 'Convention for bio' OR 'CBD'.

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To assess the types of biodiversity activities undertaken by companies, reports were open-coded to develop common themes, following an inductive category development methodology (Patton 2002). Activities were grouped into common themes once searching of all reports was complete. For each activity disclosed, we assessed whether it was described qualitatively (descriptive text provided in the sustainability report only) or quantitatively (e.g., key performance indicators or metrics presented in supporting tables or figures).

The quantitative content analysis of all reports was undertaken by the primary author, and this analysis was independently undertaken by a co-author, who coded 25% of the reports. The coders discussed the ~~categorization of information and~~ coding of the reports to assess any discrepancies. Inconsistencies were reconciled prior to data analysis, to achieve a minimum inter-coder agreement of 80% (~~following~~ similar to methods used ~~in the coding of~~recent sustainability report~~s from recent~~ studies; e.g., Boiral & Heras-Saizarbitoria 2017).

2.1 Biodiversity mentions and commitment~~goal~~s

In 2016 the Fortune 100 represented 15 sectors, and was dominated by the financial and energy sector companies (Figure 1). Their headquarters were located in 15 countries, with over half located in the USA and China. In 2016, Fortune 100 companies employed a total of 26.4 million staff, and had a total revenue of US$12.6 trillion. ~~These companies represented a cross-sector of businesses classified by their 'biodiversity risk' (F&C 2004) in high (31 businesses), medium (32 businesses) and low (37 businesses) risk categories.~~ Sustainability reporting was undertaken by the majority of the Fortune 100 companies, with 86 having publicly available sustainability reports (Figure 1; SI Table 1). These reports were predominantly from 2016 (74 company reports), otherwise were the

most recent reports available (2015 (7 reports), 2014 (2 reports), 2013 (2 reports), 2012 (1 report). See SI Table 1 for a full list of the 2016 Fortune 100 companies, including sector and biodiversity risk categories, and links to their sustainability reports.

Almost half (49) of the Fortune 100 mentioned biodiversity or related terms, and an additional 16 companies mentioned sustainable forestry or fishing (without specifically mentioning biodiversity; see SI Appendix 1 for more details). ~~There was no pattern in~~ C~~c~~ompanies from higher biodiversity risk sectors did not mak~~eing~~ greater mention of biodiversity compared to lower risk sectors (percentages mentioning biodiversity: 71% in high risk, 53% in medium risk, and 70% in low risk sectors; SI Figure 1a). This suggests that the risk biodiversity poses to business operations is ~~currently~~ not the sole driver for ~~when businesses inclu~~inclusion of~~de~~ biodiversity in ~~their~~ sustainability reports. Only 4 companies mention biodiversity and state that it is not a material risk to their operations, and therefore do not report on it any further (BMW, HSBC Holdings, Dong Feng, and Banco Santander).

The 49 companies that mentioned biodiversity all used a typical format of sustainability disclosure, which included a predominantly qualitative narrative ~~to~~ explaining the importance of biodiversity and what actions ~~or position~~ they take regarding biodiversity. Their treatment of biodiversity could be as brief as a single mention in the context of other environmental issues (e.g., climate change, water, and waste reduction), through to a dedicated biodiversity chapter, with clear biodiversity commitment(s) and disclosure of biodiversity-related activities.

Twenty-four of the 49 companies that mentioned biodiversity made links with the biodiversity-focussed ~~UN Sustainable Development Goals~~SDGs. This is far greater than the 6 companies that acknowledged the ~~Convention on Biological Diversity~~CBD. Although not intended as a reporting framework, the SDGs ~~appear to be~~ resonat~~eing~~ with the private sector and are being used to frame their sustainability commitments and activities ~~in sustainability reports~~.

Only 31 of Fortune 100 companies had clearly stated commitments relating to biodiversity (~~, See~~ SI Table 2~~)for a full list of the 2016 Fortune 100 companies with clearly stated biodiversity, or biodiversity related (e.g., forestry, palm oil, or seafood) commitments~~. Commitments most commonly related to protecting biodiversity (e.g., Volkswagen: “we promise to support the protection of species at all locations") and/or to managing impacts on biodiversity (e.g., BP: “We work to avoid activities in or near protected areas and take actions to minimize and mitigate potential impacts on biodiversity"). ~~We found no evidence that companies from higher biodiversity risk sectors~~ A higher proportion of companies from high biodiversity risk sectors made biodiversity commitments compared to lower risk sectors, but unexpectedly fewer companies from medium risk sectors made biodiversity commitments compared to low risk sectors (52%, 13%, and 30% in high, medium, and low risk sectors respectively; SI Figure 1b). This pattern is attributable to so few finance ~~sector~~ companies (classed as medium risk~~,~~ ~~and~~which include insurance, banks, and diversified financials) making biodiversity commitments (2 out of 23 companies).

Of the 23 finance sector companies, 12 were banks, and 9 of these are Equator Principles Financial Institutions (EPFIs). Eight EPFIs mentioned their adherence to the Equator Principles (which have requirements to ensure impacts on biodiversity are minimized; Equator Principles 2013), but only one company had a biodiversity commitment (BNP Paribas, which commits to ‘combating loss of biodiversity’). ~~An additional 6~~Six EPFIs mentioned biodiversity, but did not translate ~~the biodiversity requirement of~~ the Equator Principles (to minimize biodiversity impacts) into a corporate commitment. One EPFI (Banco Santander) stated that biodiversity was not of material risk to them, justifying why no biodiversity information is disclosed ~~in their sustainability report~~further. The remaining 4 non-EPFIs did not mention or make commitments for biodiversity.

~~are more likely to make biodiversity commitments than those from medium or low biodiversity risk sectors (SI Figure 1; SI Table 1).~~

Only five ~~of the 31 businesses with biodiversity commitments~~businesses (of 31) had commitments which could be classified as specific, measurable and time bound (Walmart, Hewlett Packard, AXA, Nestlé and Carrefour; Figure 1; SI Table 2). Most of these related to ~~natural resource extraction~~commodities (e.g., Hewlett Packard: "To help protect forests, in 2016 HP set a goal to achieve zero deforestation associated with HP brand paper and paper-based product packaging by 2020"). By contrast, the 12 of the 16 companies that made ~~nature-based natural resource extraction~~commodity commitments (but did not mention biodiversity) made specific, measurable and time-bound commitments (SI Table 2). The only specific, measurable and time bound biodiversity commitment made ~~by a Fortune 100 company, which was not related to natural resource extraction,~~ was Walmart's (out of date) commitment: "To conserve one acre of wildlife habitat for every acre of land occupied by Walmart U.S. through 2015". Beyond Walmart's commitment, none of the remaining Fortune 100 had adopted quantifiable biodiversity commitments (e.g., ~~no net loss~~NNL or better~~(NNL) or net positive impact (NPI) on biodiversity~~), unlike the small but rising number of corporations outside of the Fortune 100 (Rainey et al. 2015). The lack of specific, measureable or time-bound features of corporate biodiversity commitments has also been observed in other recent sector-specific and nation-specific studies (e.g., Adler et al. 2017; Boiral 2016; Jones & Solomon 2013)~~, and even for companies that make seemingly more quantifiable corporate commitments like no net loss (NNL) and net positive impact (NPI) on biodiversity (Rainey et al. 2015)~~.

2.2 What biodiversity activities were disclosed and in what format?

The 49 companies that mentioned biodiversity and additional 16 that mentioned sustainable forestry or fishing disclosed a range of ~~biodiversity related~~ activities. Activities included managing or preventing impacts, protecting and restoring biodiversity, monitoring biodiversity, engaging and connecting people with biodiversity, and investing in biodiversity (a much greater diversity of activities than the ~~areas of~~GRI areas of biodiversity disclosure ~~included in the GRI~~; Figure 2; SI Table 3). These activities were typically described qualitatively, involving short case study

narratives or general descriptions. Only 9 companies provided quantitative ~~information about their activities, which was in the form of~~ performance indicators associated with descriptions~~, presented in supporting tables or figures, about their activities~~.

The lack of ~~widely used,~~ standardized~~,~~ quantitative ~~biodiversity~~ performance indicators creates challenges for comparing performance both between companies, and for individual companies through time. Although the Global Reporting Initiative (GRI) suggest ~~some~~ performance indicators for use alongside qualitative disclosures for biodiversity, this is a voluntary framework (GRI 2016a) and not all businesses report against this for biodiversity (only 26 ~~of the 49 companies that mention biodiversity~~companies report against at least one of the GRI areas of biodiversity disclosure).

The most commonly disclosed qualitative information ~~about biodiversity activities~~ concerned habitats protected or restored, and partnerships formed (disclosed by 37 companies respectively; Figure 2). Examples of disclosed activities provided in SI Table 3 illustrate the brevity of statements made about habitats protected or restored (e.g., the reforestation of E.ON woods) and partnerships formed with NGOs and government agencies (e.g., Shell's partnerships with the IUCN). Other common activities included ~~some of the~~ GRI ~~voluntary areas of~~ biodiversity disclosure areas (GRI 2016a), including companies outlining the strategies or management approaches they use to manage impacts (33 companies; e.g., Société Générale follow the Equator Principles biodiversity standards), and how businesses manage their biodiversity impacts (e.g., Citigroup follow the International Finance Corporation Performance Standards by avoiding impacts on critical biodiversity habitats). Three companies discussed using natural capital assessments to help understand their impacts and dependencies on biodiversity (Walmart, Hitachi, and Nestlé; SI Table 2); this is likely to rise in the future with the recent release of the Natural Capital Protocol, which has gained considerable traction with the private sector internationally (Natural Capital Coalition 2016).

The most commonly disclosed quantitative biodiversity information also concerned habitats protected or restored (9 companies, Figure 2). For example, Hitachi reported the number of ecosystem preservation activities implemented. The next most commonly cited quantitative indicator for biodiversity related to the proportion of ~~natural resources~~commodities which have been sustainably sourced (e.g., Carrefour reported on the percentage increase in sales of certified seafood; SI Table 2). Other quantitative information disclosed included the GRI areas of disclosure demonstrating the avoidance of protected areas (e.g., Glencore reported on their operations which are located in, adjacent to, or that contain protected areas) and threatened species (e.g., Enel reported on the number of IUCN Red List species affected by projects in different countries of operation); but these activities are disclosed by a very small fraction of companies, suggesting the GRI areas of biodiversity disclosure are of limited relevance to the majority of the Fortune 100. ~~Very~~ F~~f~~ew companies attempted to disclose ~~comprehensive~~ quantitative information about the magnitude of their impact on biodiversity versus the magnitude of the activities they undertake which are designed to be beneficial for biodiversity (with the exception of Glencore, who disclosed the area of impacted vs rehabilitated land). Finally, no companies reported ~~on the~~ quantitative outcomes of their activities for biodiversity, which makes it very difficult to verify whether the implemented actions have any positive outcomes for nature.

3 How conservation science could ~~help~~ inform robust and impactful corporate biodiversity accountability

Our assessment of the 2016 Fortune 100 Global companies has revealed that big businesses ~~take notice of biodiversity, but most~~ are giving biodiversity limited treatment in sustainability reports. These empirical findings support ~~suggestions from the~~ accounting and accountability research ~~community~~ suggesting that corporate biodiversity accountability is in its infancy (Adler et al. 2017; Boiral 2016; Jones & Solomon 2013).

This analysis has also helped identify some critical areas where conservation science could contribute to the science-driven field of biodiversity mainstreaming (Redford et al. 2015), particularly to ~~assist in developing~~support more robust ~~approaches to~~ corporate biodiversity accountability approaches. Here we outline three critical areas where conservation science approaches, which have been successfully applied for decades to support environmental policy and management, can help businesses clarify and deepen their commitments to biodiversity, and support the international biodiversity mainstreaming agenda.

1) Developing science-based corporate biodiversity commitments

Corporate biodiversity commitments are only made by a fraction of the Fortune 100, and these commitments often lack clarity (Figure 1; Boiral 2016; Jones & Solomon 2013). In addition, many businesses disclose information about biodiversity actions without having a clearly stated biodiversity commitment (Figure 1). An absence of clearly defined corporate biodiversity commitments means that it is impossible to measure whether businesses are genuinely making progress in relation to managing their impacts and dependencies on biodiversity, and whether they are contributing to international goals to halt the loss of biodiversity and address the underlying threats to biodiversity.

By comparison, in 2015, 80% of the worlds' largest 250 companies have made science-based climate commitments, and disclosed information about carbon emission reductions in their sustainability reports (KPMG 2015). ~~Science-based climate commitments are in line with the level of decarbonization that adheres to reaching the goals under the Paris Agreement (i.e., keeping global warming well below a 2°C increase; Science Based Targets 2018).~~ The widely accepted 'science-based' commitments ~~((goals and targets~~that are specific, measurable and time bound)~~)~~ used to set corporate climate commitments are a model for the general improvement of corporate biodiversity commitments. Such commitments include clearly defined aspects of climate (e.g., greenhouse gas

emissions), baselines, and end dates, to allow for quantitative evaluation of corporate performance. However, it is much more challenging to make science-based biodiversity commitments. 'Biodiversity' is a vague and complex concept, which is impossible to capture in a single or set of indicators (Purvis & Hector 2000). The CBD's definition encompasses all living things from genes to ecosystems (CBD 2017). This is where conservation science can help, as many approaches have been successfully applied for decades to help set clear objectives to guide the management and measurement of biodiversity, informing both policy and site-level management decisions (Table 1).

Decades of conservation science have reinforced the need for ~~explicit objectives~~commitments that are specific, measurable and time bound to guide effective conservation action (Brown et al. 2015; Maxwell et al. 2015; Table 1). Decision-support frameworks, such as structured decision-making (Addison et al. 2013), adaptive management (Runge 2011), management strategy evaluation (Bunnefeld et al. 2011), and the mitigation hierarchy (Arlidge et al. 2018; Bull et al. 2013), can all be useful in guiding the development of science-based corporate biodiversity commitments (Table 1). These frameworks and their associated tools can help in developing~~:~~ clear ~~goals~~ commitments that: are ~~relevant~~ specific to business influence and impacts; ~~robust targets associated with these goals~~include quantifiable targets, ~~which~~ accounting for both biodiversity gains and losses (e.g., ~~following the principles of~~ NNL or ~~NPI~~better); ~~and~~ ~~and~~use ~~,~~ meaningful spatial and temporal frame(s) of reference; and, align with international strategic goals for biodiversity (e.g., reduce impacts, improve biodiversity status, enhance benefits to society, support and engage in knowledge sharing; CBD 2011; ~~for targets associated with biodiversity goals (~~ Table 1).

2) Developing transparent and comparable corporate biodiversity indicators to evaluate achievement of corporate biodiversity commitments

The ~~lack of enforced~~limited standards for corporate biodiversity disclosure means that there are no consistent approaches to reporting biodiversity information~~, resulting in a diverse array of information being disclosed and a general avoidance of quantitative accounting of negative biodiversity impacts~~ (Figure 2; Adler et al. 2017; van Liempd & Busch 2013). Some businesses disclosed information about the activities they undertake to address their impacts. However, few provided details of the ~~scale or~~ magnitude of these activities or quantified whether they are adequate to address the scale of the negative impacts the business is having on biodiversity (Figure 2~~; Boiral & Heras-Saizarbitoria 2017a~~). In addition, few report on the outcomes of their activities for biodiversity, that is, answering the question: is the biodiversity affected by the business's direct or indirect operations ~~or supply chain~~ improving, declining, or being maintained? The general failure to report on the magnitude of negative impacts versus beneficial activities and their outcomes for biodiversity, makes it enormously difficult for stakeholders and shareholders to obtain a complete and transparent view of a company's biodiversity performance, and at worst could be camouflaging unsustainable business practices (Fonseca et al. 2014; Vörösmarty et al. 2018).

C~~The c~~onservation approaches ~~outlined in Table 1~~ can support the development of indicators to transparently account for biodiversity gains and losses, and directly evaluate corporate commitments. Protected area management effectiveness evaluation encourages the development of indicators to address the full process of biodiversity management: from inputs (resources spent), outputs (activities undertaken), to outcomes (changes in biodiversity; Hockings et al. 2006). Approaches used in conservation science and policy like Essential Biological Variables (e.g., for measures ecosystem structure or function, or species populations; Pereira et al. 2013), global biodiversity indicators (e.g., for measures of state, pressure and response; Butchart et al. 2010), and scalable composite indicators (Burgass et al. 2017) can help businesses develop indicators that support quantitative evaluation of progress towards achieving commitments. These approaches encourage careful consideration of components of biodiversity that are fundamentally important to business

operations, directly under business control or influence, and development of indicators that account for both gains and losses of biodiversity. Lessons from the development of international-level biodiversity indicators (Nicholson et al. 2012) emphasize the necessity not only to develop and implement indicators, but also to thoroughly test the performance and sensitivity of indicators in relation to the contexts within which they are applied (e.g., correct spatial and temporal resolution, and sensitivity to change in response to policy/management interventions).

3) Expanding and deepening corporate biodiversity action

The range of actions for biodiversity which businesses disclosed (Figure 2) can help improve corporate social legitimacy, but may do little to genuinely address the magnitude of their environmental impacts ((Boiral & Heras-Saizarbitoria 2017; Jones & Solomon 2013)). Conservation decision-support approaches can be used to target activities so that they directly address support the business's biodiversity commitments, and can help businesses to predict their likely effectiveness (Table 1). Frameworks such as structured decision-making, adaptive management and management strategy evaluation, and the process models used within these frameworks, will help explicitly account for the uncertainties surrounding the effectiveness of activities (Milner-Gulland & Shea 2017). The mitigation hierarchy can guide the selection of activities to mitigate impacts and create biodiversity gains (Arlidge et al. 2018; Bull et al. 2013).

Going beyond undertaking activities to account for the direct footprint of a business's impacts, a wider question is: how are these activities contributing to global priorities for action to conserve biodiversity? The key international biodiversity targets (CBD Aichi Biodiversity Targets and the UN's SDGs (CBD 2011; United Nations 2016)) can, and should, be used to provide an overarching framework to guideguide businesses towards expanding and deepening their biodiversity activities,

so that they become part of the international community involving the public sector, civil society and private sector, that work ~~is working~~ towards a more sustainable world (Table 1). ~~Barbier et al. 2018~~

~~Conservation efforts are still falling short of maintaining even the currently impoverished global levels of biodiversity (Butchart et al. 2010). The mainstreaming biodiversity agenda is designed to engage the private sector, and encouraginge shared responsibility for nature conservation balanced with sustainable development (Redford et al. 2015).~~ S~~Barbier et al. 2018~~cientists must not underestimate the private sector's focus on risk as a reason to drive action on social and environmental issues. When business operations are threatened by biodiversity loss, then biodiversity becomes a material business risk. Only once this risk is quantified, will biodiversity become more visible to the decision-making departments of corporations that manage finance and risk, and will be truly integrated into corporate accountability and mainstreamed through the private sector (Dempsey 2013). Our study adds to the accountability literature, that biodiversity is yet to be consistently perceived as a material risk across~~in~~ the private sector ~~, particularly to those companies that are in high and medium risk sectors~~ (Adler et al. 2017; Boiral 2016). Advances in ~~critical contribution that conservation science can also make to corporate biodiversity accountability, is the development of~~ quantitative risk assessment are also needed to increase the visibility of biodiversity across business operations and across far more sectors to drive corporate action to halt biodiversity loss.

~~The approaches outlined above can support businesses in identifying how and where they can mitigate their own impacts, and contribute to international conservation efforts where it is needed most: addressing the most impactful private sector activities (Maxwell et al. 2016); protecting the most threatened species and ecosystems (Butchart et al. 2010); and conserving the last of the wilderness areas (Watson et al. 2016).~~

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4 Advancing the science-driven field of biodiversity mainstreaming in the lead up to 2020

The mainstreaming biodiversity agenda is designed to engage the private sector and encourage shared responsibility for the conservation of nature balanced with sustainable development (Redford et al. 2015). Corporate biodiversity accountability - where businesses make biodiversity commitments, disclose information about biodiversity related activities, and evaluate their corporate performance in relation to their own or international biodiversity commitments ~~–~~ remains ~~is~~ in its infancy (Adler et al. 2017; Boiral 2016; Jones & Solomon 2013). In order to genuinely contribute to the mainstreaming biodiversity agenda, businesses will need credible and robust ways to account for biodiversity throughout the supply chain, that can be reported concisely at the corporate level and acted upon.

~~Brauneder et al. 2018; Martin et al. 2015Conservation science can help businesses advance their approaches to corporate biodiversity accountability, particularly with distilling complex, dynamic, and uncertain information about biodiversity into business decision-making.~~ What would a more accountable business need to commit to and measure in order to demonstrate they are doing their bit for biodiversity? We believe corporate commitments of 'no net loss' or better for biodiversity, applied with flexibility to target the species and ecosystems that a company impacts. This commitment should be aligned with existing international biodiversity policy (CBD 2011; United Nations 2016), and couched within a global mitigation hierarchy, to help shift business activities from compensatory measures (remediation, offsets) across to preventative measures (avoidance, minimization of impacts; Arlidge et al. 2018; Bull et al. 2013). Beyond objectives, quantitative measures for biodiversity outcomes are the ideal and should be specific to a company and its biodiversity risks and impacts.

What actions should a more accountable business undertake? The expertise of conservation scientists will be vital to help target corporate action where it is needed most: helping hone attention to operations that pose the greatest impact on biodiversity (e.g., agriculture and extractives; Maxwell et

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al. 2016); and ~~contribute to~~direct corporate action in conservation priority areas by avoiding impacting the most threatened species and ecosystems (Brauneder et al. 2018; Martin et al. 2015), and helping conserve~~ing~~ the last of the wilderness areas (Watson et al. 2016).

Finally, where can conservation scientists and businesses start to tackle the complexities of business interactions with biodiversity? The approaches outlined here are all broadly applicable, but need to be tailored to ensure that biodiversity risks and impacts are captured and translated into practical advice relevant to the sector concerned. For example, some high biodiversity risk sectors like extractives (oil & gas, electricity, mining) and agriculture, have direct footprint impacts on biodiversity, and will require approaches that focus business understanding of risks and impacts at site-level operations when developing commitments, actions and performance measures. Other high biodiversity risk sectors like food retailers will require approaches that trace the biodiversity impacts of commodities through sometimes long supply chains. Finally, medium biodiversity risk sector companies, like finance and insurance firms, will require approaches that can capture indirect biodiversity impacts (e.g., through financing third parties and projects) in order to ~~ensure that~~address biodiversity performance ~~is addressed by the finance sector~~ (e.g., through risk management).

Adler et al. 2017; Boiral 2016; Dempsey 2013; World Economic Forum 2018

~~The Sustainable Development Goals, which include specific goals for the conservation of biodiversity and sustainable use of natural resources, have captured the attention of the private sector (SDG Compass 2015). Twenty-four of the Fortune 100 companies made reference to the biodiversity-focussed UN Sustainable Development Goals. In addition, businesses are convening in large numbers though initiatives such at the Natural Capital Coalition (Natural Capital Coalition 2016), which is introducing, testing and integrating natural capital approaches and biodiversity concepts into business decision-making. These new ways to frame biodiversity could help contribute to the system-level change needed to This pattern is promising, and could encourage be a sign of~~

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~~increased corporate biodiversity accountability in the future. The SDGs currently map to the CBD Aichi targets (CBD 2011), which expire in 2020. Work is underway to develop the CBD post-2020 global biodiversity framework, and links to the 2030 Agenda for Sustainable Development and the SDGs will be enhanced (CBD 2017a). In addition, businesses are convening in large numbers though initiatives such at the Natural Capital Coalition (Natural Capital Coalition 2016), which is introducing, testing and integrating natural capital approaches and biodiversity concepts into business decision-making. The annual expenditure on conservation is currently estimated at US$52 billion, and an additional US$200–400 billion is required within the next three years to address this shortfall if international biodiversity targets are to be achieved (Huwyler et al. 2016). Viewing biodiversity through a natural capital lens, could help businesses not only manage their own impacts and dependencies on biodiversity, but may also encourage business investment in biodiversity conservation helping address the substantial conservation finance shortfall.~~

Now is a critical time for conservation scientists to engage, in order to generate a science-driven field of biodiversity mainstreaming. ~~This will to help businesses to develop science-based biodiversity commitments, meaningful indicators, and activities that not only address business impacts but contribute to international conservation priorities.~~ Although our analysis highlights that the world's biggest businesses have a long way to go in developing, and reporting on, such commitments, the scene is set for rapid improvements. If these were set in place prior to the "biodiversity policy super-year" of 2020, when the international biodiversity conservation strategy will be revisited, then businesses could truly start to play a part in the new agenda for a sustainable future for the planet, which has biodiversity at its heart.

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588 **Table 1. Examples of conservation science approaches (frameworks and modeling approaches) and their potential for~~;~~ developing science-based corporate**
589 **biodiversity commitments~~;~~ transparent and comparable corporate biodiversity indicators~~;~~ and identifying additional avenues of corporate biodiversity action.**

Conservation science approach	**1) Developing science-based biodiversity commitments ~~(goals and targets)~~**	**2) Developing transparent and comparable biodiversity indicators**	**3) Expanding and deepening corporate biodiversity action**
Decision-making frameworks and associated modelling techniques (e.g., structured decision-making, adaptive management, and management strategy evaluation frameworks; Addison et al. 2013; Bunnefeld et al. 2011; Milner-Gulland & Shea 2017; Runge 2011)	– Develop specific ~~clear and robust goals~~ commitments that are relevant to business influence and impacts on biodiversity (e.g., using values-focused thinking and conceptual models in structured decision-making).	– Develop indicators to evaluate corporate commitments and activities (e.g., using objectives hierarchies and conceptual models in structured decision-making).	– Develop actions that directly address business impacts or influence (e.g., conceptual models, consequence models and cost-benefit analysis in structured decision-making or adaptive management) – Prioritize areas for biodiversity action (e.g., systematic conservation planning) – Guide the evaluation and reporting on the effectiveness of biodiversity actions in contributing to corporate biodiversity commitments (e.g., e.g., using statistical models in structured decision-making or adaptive management) – Account for uncertainty in the effectiveness of a proposed action, and help determine the

Conservation science approach	1) Developing science-based biodiversity commitments ~~(goals and targets)~~	2) Developing transparent and comparable biodiversity indicators	3) Expanding and deepening corporate biodiversity action
			magnitude of activity to be implemented (e.g., using process models within management strategy evaluation)
The mitigation hierarchy and associated principles of biodiversity management and modelling techniques (Arlidge et al. 2018; Bull et al. 2013)	– Develop measurable ~~clear and robust *targets* that are associat~~commitments ~~ed with goals, which account for biodiversity gains and losses~~ (e.g., following the principles of no net loss (NNL), or net positive impact (NPI)). – Develop meaningful spatial and temporal frame(s) of reference for commitments ~~for *targets* associated with biodiversity *goals*~~ (e.g., baseline or counterfactual development)	– Develop indicators that can account for biodiversity gains/benefits and losses/impacts.	– To guide the avoidance, minimisation, restoration and offsetting of predicted biodiversity impacts from development (i.e., applying the mitigation hierarchy). – Ensure that any activities are new contributions to biodiversity conservation, when the activity undertaken is designed to offset negative impacts (i.e., demonstrating additionalit~~l~~y) – Account for uncertainty in the effectiveness of a proposed activity, and help determine the magnitude of activity to be implemented (e.g., guided by multipliers).

Conservation science approach	**1) Developing science-based biodiversity commitments ~~(goals and targets)~~**	**2) Developing transparent and comparable biodiversity indicators**	**3) Expanding and deepening corporate biodiversity action**
Protected Area Management Effectiveness Evaluation framework and associated modelling techniques (Hockings et al. 2006)	– ~~Clear and robust *goals*~~Develop specific, measurable and time bound commitments that are relevant to business influence and impacts (e.g., using conceptual models).	– Develop indicators that address the full management process (from inputs (resources spent), outputs (activities undertaken), to outcomes (changes in biodiversity).	– To guide the evaluation and reporting on the effectiveness of biodiversity activities in contributing to corporate biodiversity commitments (e.g., expert judgement, statistical models and report cards).
SMART biodiversity commitments (Maxwell et al. 2015)	– Guide the development of specific, measurable, ambitious, realistic, and time-bound commitments.		
Essential Biological Variables (Pereira et al. 2013)		– Identify what components of biodiversity are fundamentally important, and directly under their control or influence, which relate to corporate biodiversity commitments.	
Global biodiversity indicators (e.g., Butchart et		– Develop a suite of indicators that paint a picture of both *pressures*, biodiversity *status* (i.e., *outcomes*),	

Conservation science approach	1) Developing science-based biodiversity commitments ~~(goals and targets)~~	2) Developing transparent and comparable biodiversity indicators	3) Expanding and deepening corporate biodiversity action
al. 2010; Nicholson et al. 2012)		and management *responses* to address biodiversity declines. – Testing the performance and sensitivity of indicators in relation to the business contexts within which they are applied	
Composite indicator development (e.g., Burgass et al. 2017)		– Develop indicators that can be aggregated from site to corporate level, which account for bias and uncertainty through the aggregation process.	
International biodiversity goals, e.g., CBD Aichi targets (CBD 2011) and the Sustainable Development Goals (United Nations 2016)			– Understand the types of priority biodiversity activities needed to contribute to international effort to conserve and sustainably use biodiversity, and guide more influential corporate biodiversity activity.

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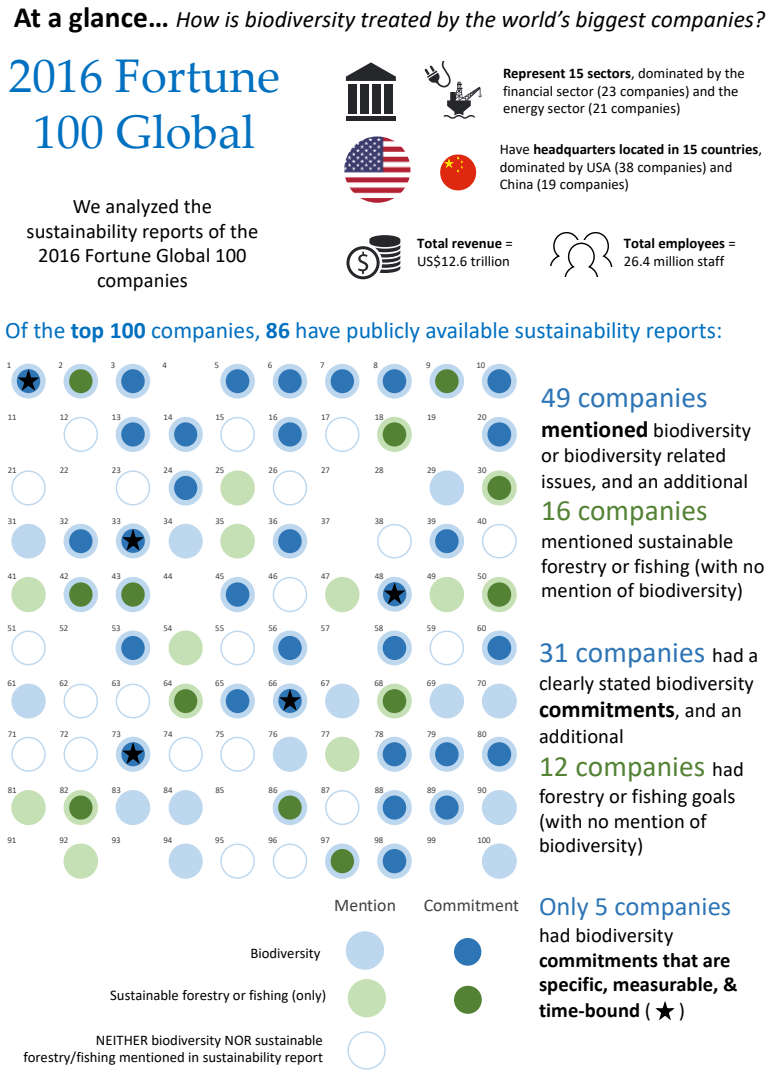
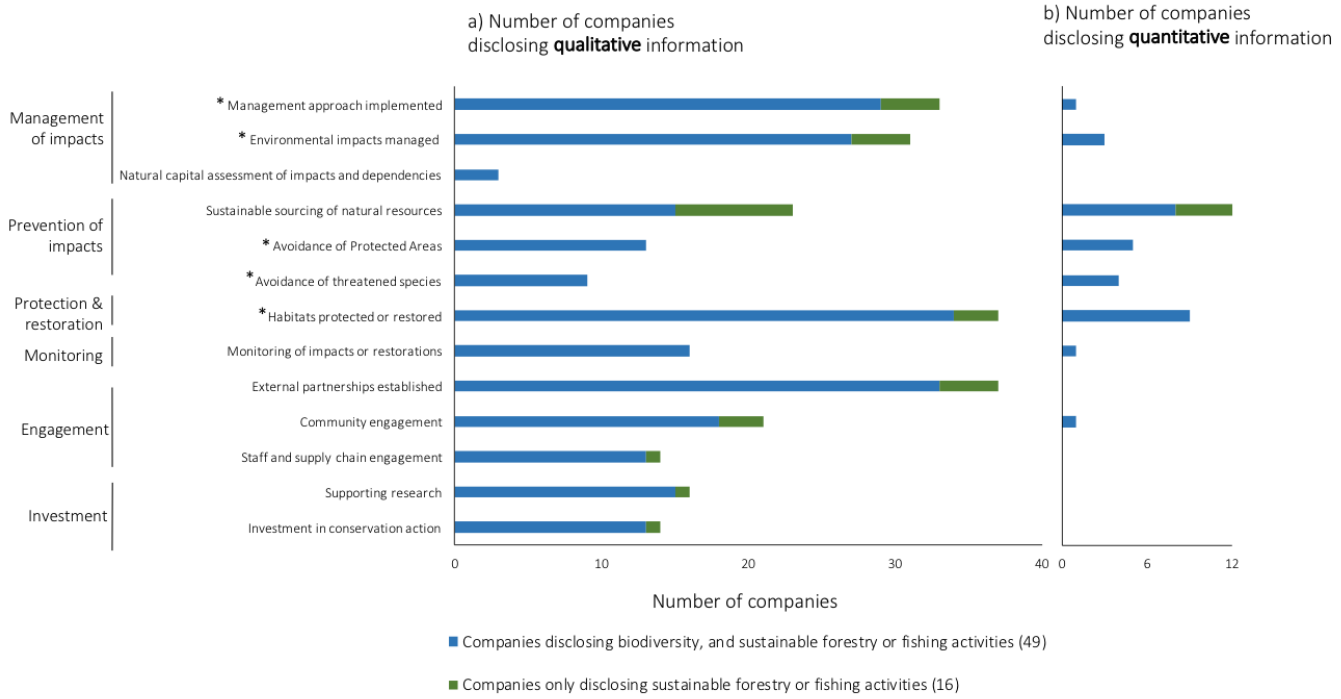


Figure 1. The Fortune 100 Global companies (with corresponding 2016 rankings), and their progress towards incorporating biodiversity into sustainability reporting – through mentions and commitments~~goals~~ relating to

biodiversity, sustainable forestry or fishery. Details regarding sector descriptions, headquarter locations, revenue and employee numbers can be found in SI Table 1 and the on the Fortune 500 Global website (Fortune 2016).



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598 **Figure 2.** The number of companies disclosing a) qualitative biodiversity information about activities, and/or b) quantitative biodiversity information about activities.
599 Companies are differentiated as those that disclose biodiversity information (including sustainable forestry or fishing information; 49 companies; shown in blue) or those
600 companies that only disclose forestry or fishing information (an additional 16 companies; shown in green). The GRI areas of disclosure are indicated with an asterisk (*).