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Principles for using evidence to improve biodiversity impact mitigation by business

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Abstract

There is an increasing expectation on the private sector to address biodiversity impacts and contribute towards global conservation goals. Appropriate evidence use can help businesses avoid biodiversity losses and realise gains, reduce ineffective or suboptimal action, whilst minimising biodiversity-related risks and securing opportunities from engaging with biodiversity.

We review the status of evidence-based action in the private sector, where previous studies have identified concerning trends, and explore the barriers that may currently be hindering practice.

To learn from this, and improve the status quo, we propose a set of principles for evidence-based biodiversity impact mitigation. We outline tools and resources that can help businesses move towards evidence-based practice and achieve each of these principles.

Meeting these principles would improve the biodiversity outcomes from businesses' biodiversity related actions. However, for business action to contribute more fully to global conservation goals, broader political and socio-economic issues also need addressing.

KEYWORDS
biodiversity, effectiveness, efficiency, environmental management, evidence-based biodiversity management, mitigation hierarchy

Abbreviations: CBD, Convention on biological diversity; CSR, Corporate social responsibility; ESIA, Environmental and social impact assessment; ESMS, Environmental and social management systems; GBIF, Global biodiversity information facility; IFC PS6, International finance corporation performance standard 6; NNL, No net loss; RoW, Right-of-Way; TNFD, Taskforce for nature-related financial disclosures.

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1 | BUSINESS ACTION TO ADDRESS BIODIVERSITY LOSS

Biodiversity is in large-scale global decline (Diaz et al., 2019; WWF 2020), largely driven by the increasing consumption of materials and commodities to support our modern-day societies. This is compounded by the systematic undervaluing of natural ecosystems in decision making, including the decisions made in businesses, which can further negatively impact biodiversity (Dasgupta, 2021; IPBES, 2019). Negative impacts of business on nature can be diverse and complex and expressed through various pathways, such as land use change, overexploitation of wildlife, urban development, pollution and the spread of invasive species. These negative impacts also occur at different stages of the business value chain (e.g. direct operations, upstream supply chains, downstream supply chains and investments), affecting a variety of different species and habitats, which differ depending on threatening pathways and location.

Consequently, there have been many calls for businesses, including the finance sector, to assess their business models and help deliver the transformative change required to address the biodiversity crisis (Dasgupta, 2021; Leclère et al., 2020; Mace et al., 2018). In fact, the Convention on Biological Diversity has recently set a global target calling on businesses and financial institutions to "*regularly monitor, assess, and transparently disclose their risks, dependencies and impacts on biodiversity, including with requirements for all large as well as transnational companies and financial institutions along their operations, supply and value chains and portfolios*" (CBD, 2022).

This expectation is now mirrored by increasing business engagement and commitments surrounding biodiversity loss, which is being recognised as a systemic risk to society and economies (WEF, 2020a). Just like wider society, businesses depend upon nature and its services for their operations (e.g. clean water and air, and functioning supply chains) so the continued degradation of nature represents operational risks to businesses (ENCORE, 2022; Global Canopy & Vivid Economics, 2020; WEF, 2020a, 2020b). At the same time, the responses of governments, investors and wider society (e.g. shareholders and consumers) to the risks posed by biodiversity loss create risks to businesses if they fail to keep up with these changing expectations (Boiral & Heras-Saizarbitoria, 2017; Smith et al., 2020). Governments are increasingly asking businesses to disclose and address remaining impacts (GIBOP, 2018) while the G7 governments have recently endorsed the Taskforce on Nature-related financial disclosures, which will require companies to report on their nature-related risks and opportunities. Similarly, several large finance bodies have developed safeguarding principles requiring businesses to measure and address negative biodiversity impacts (Equator Principles, 2020; IFC, 2012). An increasing number of businesses are now pledging, and setting targets, to address biodiversity loss (de Silva et al., 2019; zu Ermgassen, Howard, et al., 2022), often as part of industry groups such as Finance for Biodiversity, Business for Nature and Act4Nature. Much work is now being channelled into helping develop appropriate targets and strategies (Maron et al., 2021; science-based targets for nature), as well as metrics and indicators to measure the impact of business activities on biodiversity (Addison et al., 2020; Lammerant et al., 2018).

For sectors with large direct impacts, the Mitigation Hierarchy, whereby impacts are first avoided and minimised, before steps are taken to restore and offset impacts, has emerged as a best-practice approach to achieve biodiversity goals (CSBI, 2015). Offsets entail actions taken to protect and restore biodiversity, resulting in quantified biodiversity gains that compensate for residual impacts (BBOP, 2012). The use of the mitigation hierarchy, including offsets, is often required as part of financier or regulatory requirements (IFC, 2012; GIBOP, 2018) to reach well-defined goals, such as 'No Net Loss' or 'Net Gain' for biodiversity (BBOP, 2012; de Silva et al., 2019; IFC, 2012). In these sectors, management plans (and associated actions) are often internalised as part of environmental and social management systems (ESMS), pulling data from environmental and social impact assessments. This can include environmental management plans as well as specific biodiversity management plans, where quantified offset actions are specified.

More recently, companies have been setting out 'nature positive' goals which are deployed in a wider array of sectors with less tangible impacts on biodiversity (zu Ermgassen, Howard, et al., 2022). This momentum has been built upon by the science-based targets network, which have expanded the Mitigation Hierarchy framework to help address impacts across value chains, and includes proactive conservation actions (termed transformative actions) that business can take to restore biodiversity (Milner-Gulland et al., 2021; Science Based Targets Network, 2020). This framing is inclusive of actions supportive of conservation but not necessarily linked to impact and may not lead to quantified gains in the same manner as offsets (e.g. educational programmes and advocating for improved standards in sector-wide biodiversity initiatives; Wolff et al., 2018). Given that the majority of negative biodiversity impacts may be through the organisations' value chains and investments, this expansion of the mitigation hierarchy is a useful step for developing whole organisation strategies to meet ambitious biodiversity goals (Kering, 2020; Bull et al., 2022).

However, despite this increased interest and action, biodiversity remains low on the agenda of many companies, with actions taken to address biodiversity impacts missing or negligible in sustainability strategies (Addison et al., 2019; Bhattacharya & Managi, 2013; Ecogain, 2021). Although action is taken across the mitigation hierarchy in some companies, the avoidance stage is often poorly implemented (Bigard et al., 2017; Sahley et al., 2017; Treweek et al., 1993), and action taken as part of strategies can be supportive of biodiversity conservation but not materially linked to the negative impact of business activities (Driesen et al., 2022). This risks substantial negative impacts on biodiversity being masked by some positive but limited action (Wolff et al., 2018). A range of barriers currently prevent businesses from fully engaging with biodiversity, including insufficient awareness, capacity, willingness to use or knowledge of tools that can help measure and address impacts (e.g. Feger & Mermet, 2022; White et al., 2023). There can also be limited political support and inadequate existence or enforcement of regulation that asks businesses to

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address biodiversity issues (e.g. Phalan et al., 2018; Treweek, 1996). Lastly, economic outcomes are prioritised, with biodiversity being seen as an externality, limiting opportunities to address the issue without sacrificing profits (Cuckston, 2018).

To achieve ambitious biodiversity goals, businesses will need to upscale efforts and take a diverse range of actions to transform their impacts on biodiversity throughout their direct operations and value chains, and at different stages of the mitigation hierarchy (see Table S1). However, it is becoming increasingly clear that, even when businesses start to engage with biodiversity as part of their sustainability work, their biodiversity impact mitigation is not always based on appropriate evidence.

Here we first discuss the benefits of evidence-based practice from a business and conservation perspective, learning from the literature on conservation science. We then explore the state of evidence use in business practice and, based on this review, develop principles for evidence-based impact mitigation. Finally, we identify pragmatic opportunities to improve businesses' engagement in evidence-based decision-making.

2 | THE BENEFITS AND STATUS OF EVIDENCE-BASED ACTION

Evidence is a broad term, defined in the conservation literature as 'The relevant data, information, knowledge, and wisdom used to assess an assumption.' (Salafsky et al., 2019, 2022). This can include documented scientific, local, expert and indigenous knowledge. The design of a biodiversity strategy will involve making many assumptions about the status of biodiversity, the scope and severity of impacts as well as the expected effectiveness and efficiency of actions taken (Esmail et al., 2022; Salafsky et al., 2022). Evidence is thus needed to reveal the confidence we can have in assumptions, and therefore the likelihood that mitigation and conservation strategies will be effective at achieving biodiversity goals. For example, what is the evidence that a particular species is, or is not, present? What information is there to back up, or refute, the level of negative impact stated from business activities? What data is there to back up the assumption that a given action will be effective at minimising impact and has acceptable trade-offs?

In the wider discipline of conservation science, much progress has been made to improve evidence use. In the early 2000s, there were calls to move conservation towards evidence-based practice, having already been shown to be successful in improving the effectiveness and efficiency of other disciplines, such as health care (Pullin & Knight, 2001; Sutherland et al., 2004). Indeed, even before then there were calls for mitigation actions to be based on sound ecological data and science (e.g. Treweek, 1996). From a conservation perspective, using evidence to inform the application and design of biodiversity strategies has two major benefits: (i) a higher likelihood of achieving positive conservation outcomes and stated biodiversity goals (Sutherland et al., 2004), and (ii) it avoids wasting resources on suboptimal or ineffective conservation actions (Cook et al., 2017), particularly as resources for conservation are often severely limited (Deutz et al., 2020; McCarthy et al., 2012). From a business and financial perspective, evidence use can help lower the direct cost implications of mitigation by ensuring only the most cost-effective measures are implemented to reach a given biodiversity target. In addition, by increasing the likelihood of effective and cost-effective action, a company can also reduce the operational, regulatory and reputational transitional risks associated with negative biodiversity impacts, which can translate into financial risks for companies if unaddressed (Boiral & Heras-Saizarbitoria, 2017; Macellari et al., 2018; White et al., 2023). Therefore, taking evidence use seriously helps businesses due to their due diligence and avoids costly mistakes.

Despite these benefits, there are concerning trends that indicate current practice is not always using the best available information to guide decisions (Table 1). There are examples of continued application of mitigation measures known to be ineffective (e.g. Sutherland & Wordley, 2017), or where the evidence for the effectiveness of commonly used actions is limited, mixed or ambiguous. This includes actions to minimise the impact within value chains (Morgans et al., 2018; Tscharntke et al., 2015), actions to minimise the impacts of development projects (Hunter et al., 2021), actions to restore habitat or offset impacts (Josefsson et al., 2021; Tischew et al., 2010), and proactive actions taken through CSR initiatives and wider biodiversity strategies (e.g. tree planting programmes and habitat restoration; Fleischman et al., 2020; Coleman et al., 2021). Moreover, in environmental impact assessments, multiple measures are put forward to mitigate development impacts, but few assessments detail the likely success of recommended actions based on available evidence (Bigard et al., 2017; Drayson & Thompson, 2013), and a lack of monitoring of mitigation outcomes is a frequently identified challenge (Drayson & Thompson, 2013; Lewis et al., 2016; Treweek & Thompson, 1997).

Actions taken by business are often informed by guidance and consultants (many of whom rely on guidance themselves) or adherence to standards (e.g. IFC PS6), certifications, principles or policy (White et al., 2023). However, reviews of guidance documents for management and mitigation in the UK and Ireland have identified poor use of scientific evidence to support recommendations: many documents commonly used for development projects are out-of-date, based on circular referencing of other guidance publications, and show limited use of primary empirical literature to support claims (Downey et al., 2022; Hunter et al., 2021). These results are of particular concern given Europe's comparatively strong research and information base, regulations, exceptional biodiversity monitoring, and relatively low species diversity compared to many other regions of the globe, which should mean that evidence can be more easily put into practice in development projects (Moussy et al 2021).

Whilst there are examples of successful, evidence-based mitigation (Table 2), the poor evidence use and uncertainty of nature-positive outcomes for many commonly used actions, calls into question the quality, effectiveness and efficiency of private sector action in conservation. The lack of evidence use does not mean conservation actions are necessarily ineffective, but without appropriate evidence

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TABLE 1 Examples of limited use of evidence to guide mitigation action.

Issue	Examples
Limited evidence for the effectiveness of some commonly used, often legally required, mitigation measures.	Hunter et al. (2021) reviewed the mitigation measures recommended for a sample of UK housing developments—identifying 65 mitigation measures related to eight taxa. In doing so, they found that over half of these measures were not supported by the available scientific evidence.
	Biodiversity offsets are increasingly required around the world, but there is limited evidence available on their ecological success (zu Ermgassen et al., 2019; Josefsson et al., 2021). Where evidence is available, only one third of policies and offset projects reported that NNL targets were achieved, with no evidence of NNL being achieved in forested ecosystems (zu Ermgassen et al., 2019).
Continued application of mitigation measures known to be ineffective, or where evidence is mixed or ambiguous.	There is mixed evidence for the conservation effectiveness of some certification schemes commonly used by businesses to reduce the biodiversity impacts in supply chains (Morgans et al., 2018; Tscharntke et al., 2015).
	Some measures have evidence showing they are ineffective, yet are still deployed. Bat gantries were still constructed in the UK, even after studies showed they did not successfully mitigate the impacts of roads on bats (Sutherland & Wordley, 2017).
	Reptile translocation is commonly carried out to mitigate the impacts of development, yet the success of these measures is highly uncertain (Sullivan et al., 2015; Nash et al., 2020).
	Corporate reforestation programmes are often communicated as biodiversity enhancing, but the conservation outcomes of such programmes are ambiguous (Coleman et al., 2021; Fleischman et al., 2020).
Guidance documents have limited consultation of the evidence base.	A review of guidance documents in the UK and Ireland identified that only 9% of documents provided a reference to justify the actions that were recommended (Downey et al., 2022). For the UK housing sector, 56% of mitigation actions were justified by citing guidance documents, but <10% of the cited texts within these guidance documents looked at evidence of effectiveness. Concerning patterns of circular referencing between guidance documents was also identified (Hunter et al., 2021).
Few documents detail the evidence of the success of actions when proposed.	Reviews of environmental and ecological impact assessments in England and France have identified that only 6.4% and 4.8% of documents included evidence on the likely success of mitigation actions proposed, respectively (Bigard et al., 2017; Drayson & Thompson, 2013).
Monitoring and evaluation of outcomes from mitigation is often poor.	Drayson and Thompson (2013) identify that only 40% of impact assessments proposed monitoring measures for actions, and only 20% provided information on who would conduct it.
	A review of project files for Great Crested Newt mitigation in England and Wales identified that only 9% of licensing files contained post-development population monitoring data (Lewis et al., 2016).

use in decision-making, we risk ineffective or suboptimal biodiversity outcomes and misallocated resources.

Once a business commits to taking action on biodiversity, the likely drivers of poor evidence use can be split broadly into two categories: intrinsic factors as part of institutions and processes (e.g. knowledge, capacity, decision-making structures and priorities) and extrinsic factors resulting from the quality and extent of the available information (see Rose et al., 2018; Walsh et al., 2019). Intrinsic factors that hinder evidence-based practice can include organisational, political or socio-economic barriers. Businesses and consultants may lack sufficient awareness of the data and resources available to them, have limited capacity (time, skills and money), face a limiting management structure, or they may rely too heavily on single sources of information, for example, expert opinion, experience or previous projects (e.g. Cook et al., 2010; Walsh et al., 2019; White et al., 2023). There may also be limited drivers for transparently reporting effective action from governments and financiers, and priority placed on economic agendas (e.g. Rose et al., 2018; White et al., 2023).

The above text assumes that businesses will be striving towards effective practice to address operational and transition risks. But, where scrutiny is limited, reputational risks can possibly be managed without generating biodiversity benefits, leading to perverse incentives around the action needed and information required. Some companies may seek to 'neutralise' messages to manage stakeholder impressions, where claims are made on the success of actions without evidence of ecological outcomes and negative impacts are denied or down-played (Boiral, 2016; Thompson, 2018). Other businesses may be interested in meeting minimum requirements, and not in

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TABLE 2 Examples of scientific evidence applicable across the mitigation hierarchy for a development project.

AVOID	**MINIMISE**
Numerous databases now provide access to information on species and habitat status and threats which can be used to guide avoidance actions (Stephenson & Stengel, 2020).	There is a growing evidence base on the effectiveness of different techniques to minimise the impact of development on biodiversity (Berthinussen et al., 2019, 2021; Littlewood et al., 2020).
For example, the integrated biodiversity assessment tool (IBAT) provides evidence on areas of high biodiversity risk that can help be avoided early in project planning. Sensitivity maps can also be used to locate infrastructure in areas of lowest biodiversity risk.	For example, bird flight divertors are commonly used to minimise the number of bird collisions with power line infrastructure. Recent meta-analyses have shown that these measures can be effective at reducing risk but vary depending on the design of the markers, as well as the species at risk (Bernardino et al., 2019).
Jones et al. (2022) exemplify how global datasets can be used to help design avoidance measures in infrastructure planning through both site selection and changes in project design.	New and innovative technologies are also being tested. Dwyer et al. (2019) show that collision risk for sandhill cranes was reduced by 98% from the introduction of UV lights that illuminated the power lines.
RESTORE	**OFFSET/PROACTIVE ACTION**
Several platforms provide summaries of the available evidence on the effectiveness of restoration techniques (e.g. conservation evidence, conservation effectiveness, IUCN panorama). Some specific examples below:	Globally, offsets suffer from a limited evidence base supporting their effectiveness (Josefsson et al., 2021; zu Ermgassen et al., 2019), but specific studies are available that test the effectiveness of the offset programmes.
Russell et al. (2005) compared traditionally mowed grasslands, to areas where a dense scrub is restored under the right of way (RoW). They find significantly more bee species in areas managed as scrub, which can also be a less costly management technique for vegetation management under the RoW.	For example, a robust analysis of an offset implemented to compensate for the impacts of a mine in Madagascar was successful in reaching biodiversity goals to avert the loss of habitat occurring outside the offset area (Devenish et al., 2022).
Derhé et al. (2016) show that tropical forest restoration projects in NE Queensland, Australia had high potential to mitigate prior losses. They show that the functional diversity, species richness and abundance of dung beetle species increased with the age of restoration areas, with an increasingly similar community composition to natural rainforest sites over time.	zu Ermgassen et al. (2021) test the ecological outcomes of biodiversity net gain pilot schemes in England and identify offsets lead to a net loss of habitat area, where losses are largely compensated for by smaller patches of habitat adjacent to the development area. These gains are poorly connected to other habitats and are difficult to govern and enforce.

environmental outcomes. For example, Smith et al. (2019) showed that the impacts reported by business and the reporting required by reporting frameworks can be different from what is likely to be their main impact on biodiversity. Such businesses can tick all the right boxes required by financiers, regulatory agencies and shareholders, yet side-step needed actions from a biodiversity perspective. In these situations, there may be limited incentives for businesses to look at the evidence base, as the biodiversity box has been ticked, and no one follows up or asks to see the underlying information. In fact, being transparent and open about impacts, and the effectiveness of actions, may be seen as a risk to some businesses—opening them up to unwanted scrutiny that is avoided by competitor firms. Collectively, these intrinsic barriers can hinder uptake of an evidence-based approach to impact mitigation and have meant that evidence use can often be overlooked.

Whilst there is a growing body of literature relevant to business-biodiversity action, poor availability of, or access to, the appropriate evidence base can be an extrinsic barrier for business evidence use (Walsh et al., 2019). For example, in the conservation literature, there is limited scientific evidence available that tests the effectiveness of many actions, with many species groups and habitats under-represented, particularly in the biodiverse Global South (Christie et al., 2020; Christie, Amano, et al., 2021; Williams et al., 2020). This applies for many measures relevant to business impact mitigation such as biodiversity offsets (Josefsson et al., 2021; zu Ermgassen et al., 2019). Similarly, whilst there are improvements in data availability, data on the localities and impact of sourcing in complex supply chains can be sparse. This is true even within the most well understood supply chains, such as agricultural commodities, particularly when commodities are sourced indirectly (zu Ermgassen, Bastos Lima, et al., 2022).

Even when data exist, using such evidence to decide upon possible mitigation actions can also be problematic where available information has varying relevance to the specific socio-economic context,

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and must be judged alongside information on costs, stakeholder values and feasibility (Adams & Sandbrook, 2013; Buxton et al., 2021; Christie, Downey, et al., 2021; Evans et al., 2017; Treweek & Thompson, 1997). In practice, using evidence in decision-making will require appraisal of different sources, and difficult trade-offs between multiple environmental, economic, and social outcomes of actions (Brownlie et al., 2013).

3 | PRINCIPLES FOR EVIDENCE-BASED BIODIVERSITY STRATEGIES

In Figure 1, we outline principles to assist businesses in developing an evidence-based approach for the management of biodiversity. They will help increase the likelihood that when strategies are planned and actions are taken by businesses or consultants, those actions lead to effective conservation gains that can contribute to global biodiversity goals (e.g. CBD Target 15). Using these principles also helps reduce risks associated with ineffective practice and counter accusations of negligence in strategy design.

We hope that such principles can be embedded within frameworks for developing biodiversity strategies, setting targets and disclosure frameworks. For example, the Science-based Targets for Nature Initiative could integrate these principles into their 'measure and set', 'act' and 'track' steps to ensure the transparent use of evidence to guide biodiversity management decisions and improve outcomes (Science Based Targets Network, 2020). Lastly, such principles could be promoted by industry bodies or coalitions of businesses, as a core condition of membership to signal commitment to transparent, evidence-based business-biodiversity action.

The principles were developed and refined by the author team, representing both experts in the use of evidence and the interface between business and biodiversity. They build upon the existing literature, and required core skills, for evidence-based decision-making in conservation (e.g. Downey et al., 2021). We discuss these principles below, including resources and tools available that can help address each principle.

3.1 | Evidence use is mainstreamed across business operations

The use of evidence needs to be embedded across business operations, with a cultural shift required to expect and deliver on evidence-based practice, and address some of the intrinsic barriers. Placing these principles within current processes for environmental management and business decision-making will be key. For example, during ESIAs, Biodiversity Action Plans and risk screening, the evidence base behind statements of impact or proposed mitigation actions should be regularly reviewed by project teams. Similarly, when developing organisational environmental strategies, assumptions made should be routinely scrutinised, particularly for claims made that are critical for the

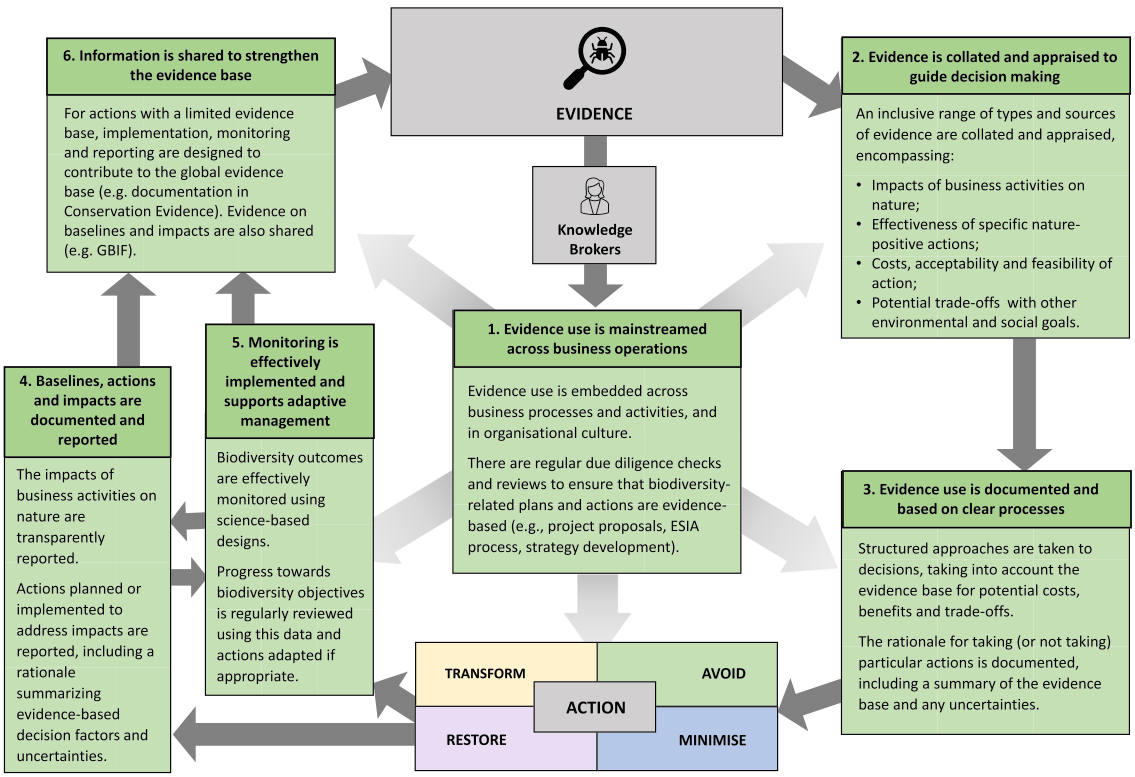

FIGURE 1 Principles for using evidence to improve biodiversity impact mitigation by business.

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success of the strategy (e.g. Salafsky et al., 2022). There should be specific due diligence steps put in place to ensure evidence use in these processes. The steps needed to embed evidence into operations will vary by organisation but could range from developing checklists to ensure that project teams have appropriately assessed evidence, including evidence as a criteria in decision-making protocols and project proposals, as well as integrating it into procurement processes (e.g. reviewing the practice of hired consultants and screening financed projects to ensure they are conducting effective mitigation). Creating the necessary culture may also benefit from providing capacity for staff to assess evidence, training programmes, as well as creating responsibilities and buy-in at the senior leadership level to drive change across the organisation (Frick et al., 2022).

There may be opportunities to use 'knowledge brokers' who can help access the relevant information and integrate evidence-based practice across the organisation (Rose et al., 2018). This could be a staff member hired internally, or working with skilled consultants or 'evidence-bridge' organisations that can help break down some of the barriers described above (Kadykalo et al., 2021).

3.2 | Evidence is collated and appraised to guide decision-making

Actions taken to mitigate impacts should be guided by an appropriate collation and appraisal of the evidence base (see Table 2 for examples). We discuss different subjects and sources of evidence needed at different stages of the mitigation hierarchy to assess assumptions made in the design of a strategy:

3.2.1 | Subjects of evidence

The actions that can be taken at each step of the mitigation hierarchy will vary depending on the components of biodiversity covered (i.e. species, habitats and biological processes); the types of threat being addressed (e.g. land-use change, invasive species, pollution etc.); the stage of the businesses value chain where the impacts occur (e.g. direct operations, upstream supply chain, downstream supply chain and investments) and the level of traceability of those impacts. The information required to assess possible actions differs depending on these factors (see Table S1).

Avoidance measures can be guided based on the best available evidence of the location and status of species, threats and habitats and the likely impact of different business activities (Figure 2). For example, for a road infrastructure project, measures may include rerouting the road around areas designated as irreplaceable or of high value to biodiversity. This requires testing of the assumptions of species and ecosystem presence, condition and distribution, and evidence on the impact of different construction scenarios to calculate the impacts that can be avoided. Minimisation measures (e.g. building a wildlife crossing) will also require data on the effectiveness of different actions in minimising those impacts.

The same is true when considering value chains and investments. For example, a cosmetics company aiming to avoid and minimise deforestation impacts in their supply chain requires baseline information on the status of biodiversity in different sourcing locations and the potential biodiversity impacts of comparable commodities or alternative sourcing locations, as well as data on the effectiveness of any certification schemes they may be complying with to minimise

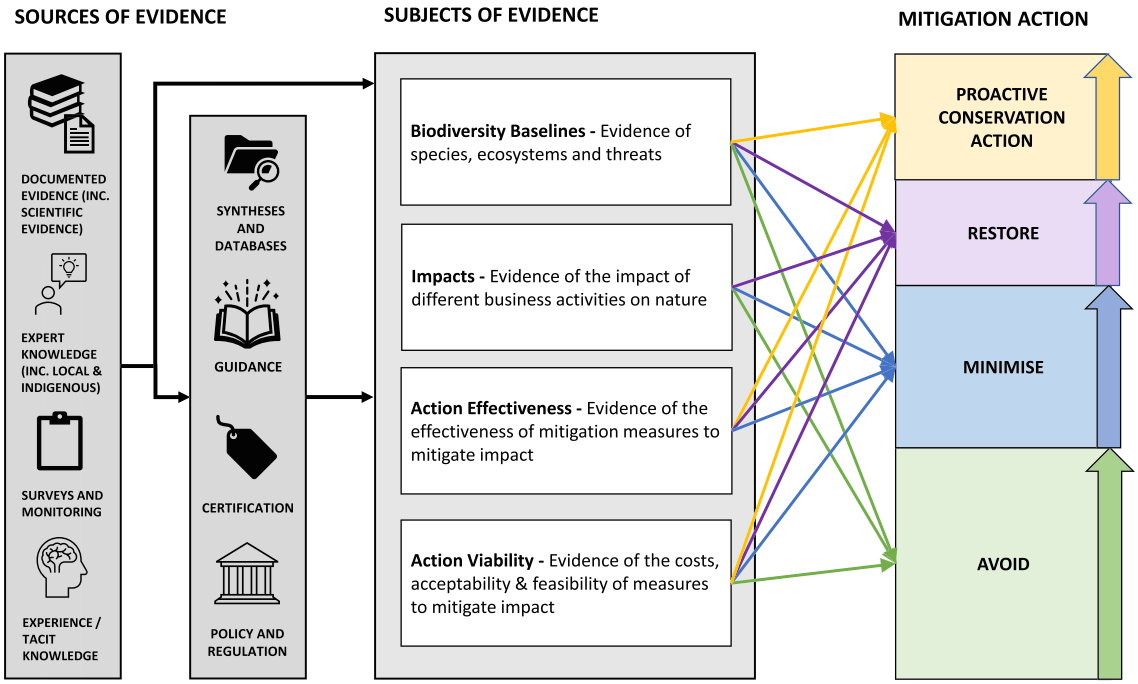

FIGURE 2 Where can evidence help inform actions to mitigate impacts on biodiversity?

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deforestation risks. When designing restoration and offset measures, the evidence required would include information on species and habitats present to help guide restoration action, the likely impacts that necessitate restoration, and the effects of proposed actions (Figure 2).

Across the hierarchy, evidence may also be required on the acceptability of actions to local stakeholders (i.e. stakeholder values), the feasibility of implementing actions in specific contexts, and of other environmental and social outcomes (Treweek & Thompson, 1997). For example, careful consideration should be given to the economic costs and benefits of different actions, including costs that are avoided as a result of mitigation and the distribution of costs and benefits between stakeholders (Iacona et al., 2018; White et al., 2022).

3.2.2 | Sources of evidence

There are many direct sources of evidence that can be consulted by businesses to guide action (Salafsky et al., 2022; Figure 2). In conservation science, there are an increasing number of publications on the effectiveness of biodiversity management actions (Cadotte et al., 2020; Sutherland et al., 2019) and a growing number of databases with information on biodiversity state, threat and action data (Stephenson & Stengel, 2020). In addition, specific tools for the private sector exist to assess risks, impacts and dependencies on nature that can be used to guide action in direct operations (e.g. IBAT, ENCORE) and supply chains (e.g. TRASE). There are also technologies to help access and collect data on species, habitats and threats (Jones et al., 2022; White et al., 2021) and databases that synthesise the available quantitative and qualitative information on the effectiveness of different actions (e.g., Collaboration for Environmental Evidence; Conservation Evidence; Nature-based Solutions Initiative, IUCN Panorama; Evidensia; Conservation Effectiveness; Metadataset). Primary data can also be collected through baseline surveys (e.g. through the ESIA process) and through follow-up monitoring to inform the effectiveness of particular actions.

Some types of evidence, particularly experiential information, local and expert knowledge (including indigenous knowledge) may be difficult to access, yet are vital for designing interventions within complex socio-ecological systems that deliver biodiversity gains in the long-term, and which respect local stakeholders' knowledge and values. Appropriate consultation of relevant stakeholders is important for designing appropriate conservation actions consistent with stakeholder values and for respectfully engaging local communities (Evans et al., 2017). Local knowledge can also help to understand the relevance or transferability of scientific knowledge to local contexts and may fill important gaps in the scientific evidence base. Expert elicitation can be used to gather information and is particularly useful where data gaps have been identified (Martin et al., 2012). There are various techniques available that can improve the reliability information obtained (e.g. IDEA protocol; Hemming et al., 2018).

Where indirect sources are used to guide decision-making (e.g. guidance documents, standards and expert consultants; Figure 2; White et al., 2023), quality control checks should be put in place to ensure that sources are evidence-based wherever possible. For example, when using guidance documents or standards to guide action, effort should be made to ensure they are up-to-date, and meet best practice principles on evidence use (Downey et al., 2022). Good guidance documents will, for example, refer to sources of evidence used and provide information on the review process that led to the synthesis and recommendations (e.g. Bennun et al., 2021; Cruickshanks, 2018). Similarly, businesses can check the evidence base behind certifications used by searching the literature or databases for information on effectiveness (e.g. Carlson et al., 2018; Morgans et al., 2018; Santika et al., 2021).

3.2.3 | Evidence quality

Wherever information and evidence is compiled, it will vary in its reliability and relevance, and this needs to be accounted for when making decisions (Salafsky et al., 2019). This includes examining the reliability of the source of the evidence and the information provided (e.g. are there biases and uncertainties associated with the data or source?), how relevant the evidence is to the businesses' decision context, as well as the degree of support for the evidence provides for a claim or assumption, for example, how much does the evidence support a particular course of action? (Salafsky et al., 2022). Careful consideration should be placed on these factors to allow evidence to appropriately feed into business decision-making.

To enact this principle, evidence should be collated and assessed wherever key assumptions are made in the design of biodiversity strategies or management plans. For example, in Environmental Impacts Assessments, data are needed to back up statements of negative impacts, as well as the effectiveness, feasibility and costs of proposed actions.

3.3 | Evidence use is documented and decisions based on clear processes

Businesses should record the information assessed and the sources of evidence used to guide decisions. Information on the likely effectiveness of each action should be explicitly stated in biodiversity strategies, including where there is limited evidence backing up an action. If no convincing argument can be made that given actions will be effective, then the feasibility of the mitigation should be brought into question. Actions may have multiple benefits (e.g. enhancing carbon storage and improving water quality) and trade-offs (e.g. reducing carbon storage and opportunity costs to local communities) that need to be considered as part of wider environmental strategies, and these trade-offs should also be recorded. The rationale for taking (or not taking) particular actions should be documented along with any uncertainties, including where decisions have been made based on the costs, acceptability based on stakeholder values and feasibility of actions (Christie, Downey, et al., 2021).

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Structured decision-making approaches can help integrate evidence into decision-making and clearly lay out the available information, making trade-offs and uncertainties explicit and transparent. This is particularly important as using evidence to inform policy and mitigation action is complex and dependant on socio-economic context, political considerations, and diverse stakeholder viewpoints (Adams & Sandbrook, 2013; Evans et al., 2017). In situations where the consequences of failure or uncertainty are high, or a large investment is being made, decision making tools, such as structured decision-making (e.g. using consequence tables) or multi-criteria decision analysis can help combine diverse sources of information to inform a strategy (see Knight et al., 2019). Other tools have been developed to document the evidence base and reasoning behind decisions on strategies or actions more quickly, enabling the generation of reports that promote due diligence and scrutiny over whether decisions were made based upon the best available relevant evidence (www.evidence2decisiontool.com; Christie, Downey, et al., 2021; Salafsky et al., 2022).

3.4 | Baselines, actions and impacts are documented and reported

A recent evaluation has demonstrated that there has been little progress in the quality and robustness of businesses' biodiversity commitments from 2016 to 2021, with the number of firms from the Global Fortune 100 reporting specific, measurable and time-bound biodiversity targets rising from just 5 to 10 over that time (Addison et al., 2019; zu Ermgassen, Howard, et al., 2022). The lack of scientific robustness in biodiversity target setting prevents firms being held accountable for their biodiversity performance, so vastly improved target setting and reporting principles are required. Companies should be explicit about the biodiversity baselines they are measuring their impacts (both positive and negative) against and then document the actions they are taking to attempt to achieve their targets. This should include information on the evidence base underpinning those actions, and how that was compiled. Transparent and regular reporting is necessary to avoid accusations of greenwashing and to identify where successes or failures have occurred so that firms can learn and undertake adaptive management where necessary. To enact this principle, individual businesses should compile this information across their operations and value chains, and make the information freely available as part of sustainability reporting, so allowing negative and positive impacts to be scrutinised, and progress towards targets (if they have been set) to be tracked.

3.5 | Monitoring is effectively implemented and supports adaptive management

The biodiversity outcomes of mitigation actions need to be effectively monitored, using science-based designs, as a key component of evidence-based practice (Ferraro & Pattanayak, 2006). This is particularly important when there is high uncertainty over the likely outcomes of an intervention, where data gaps exist or where there are major risks associated with impact and mitigation requirements. The monitoring information ideally feeds into reviews of biodiversity objectives and is deployed with adaptive management and evaluation to help identify successes and rectify failures at an early stage. Adaptive management, based on monitoring, is a standard feature of biodiversity action plans for development projects and can be required through national legislation or financier standards (e.g. Equator Principles, 2020; IFC, 2012).

Lack of monitoring, where high-quality information is collected and used to inform future practice, is a frequently identified challenge in the business-biodiversity community. This is often due to the costs of monitoring combined with weak enforcement of monitoring requirements or unclear responsibilities for implementation (Lewis et al., 2016; Stone et al., 2013). However, this is also a problem for the wider conservation sector where detailed evaluations, particularly at project or programme scales, can be limited and poorly designed (Ferraro & Pattanayak, 2006; Dickson et al., 2022).

Designing high-quality monitoring programmes, and prioritising effort, can be technically complex and may require expert input. It may include, for example, consideration of appropriate controls and counterfactual assumptions, as well as the choice of indicators and monitoring techniques. There are also an increasing number of technologies available to business that can provide high-quality monitoring data at lower cost (White et al., 2021). The Open Standards for the Practice of Conservation provide helpful guidance on designing monitoring programmes, using standardised techniques, that link to objectives. If designed at an early project stage, monitoring data can help address key uncertainties and transition between baseline, implementation and adaptive management (CMP, 2020). To enact this principle, individual businesses should carefully design monitoring and evaluation programmes to ensure they are achieving biodiversity objectives. This should include information on responsibilities, funding and timescales.

3.6 | Information is shared to strengthen the evidence base

There is a specific opportunity for business to share the data collected during baseline and monitoring surveys with relevant local, national or global biodiversity databases, such as the Global Biodiversity Information Facility (White et al., 2021). National databases may also be available (e.g. the UK National Biodiversity Atlas, Biodiversity Atlas Kenya). This can provide access and prevent duplication of costly survey and monitoring work, whilst providing data useful to the wider community that can guide the implementation of appropriate mitigation measures. Whilst the sharing of data is rare in many cases, some sectors are taking steps in this direction. For example, the Equator Principles Financial Institutions are obliged to share data collected during project surveys (Equator Principles, 2020).

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Businesses will often be deploying interventions in new contexts, with some uncertainty over the relevance of the evidence base to a specific geographical, biological or socio-economic context. Monitoring data from these interventions can help expand the evidence base and better determine the likely effectiveness of interventions in new contexts or the feasibility of implementation. If an intervention is designed and tested in an appropriate way (e.g. controls, replication and randomisation; see Ockendon et al., 2021) the data collected can contribute more reliably and transparently to the global evidence base through publication in the scientific literature. This should include a consideration of counterfactual analyses, which carefully assess what would likely have happened in the absence of the intervention. It is worth noting that there can be differences in the availability of data to academic and business/practitioner audiences, particularly when data are published in scientific journals. Open access journals or databases that provide transparent access to data should therefore be prioritised. The Open Standards of Conservation provide helpful guidance on the sharing of data collected when evaluating and monitoring actions (CMP, 2020).

Alongside the sharing of data, businesses, or industry groups, are encouraged to test and report on the effectiveness actions through collaboration with researchers or 'evidence bridge' organisations (Kadykalo et al., 2021) that may be able to reduce the time and cost investment required by conducting monitoring, analysis and writing up of results. Sharing commercial data may be a barrier to some businesses for fear of providing competitive advantages or unwanted scrutiny, but anonymising data before sharing could help address this issue.

4 | WIDER CONTEXT AND CHALLENGES

Where the scale of, or incentives for, effective action are lacking, using evidence (and these principles) to guide decision-making might improve outcomes of specific actions but not address the root drivers of biodiversity loss. This is a real concern. Currently, only a minority of companies take sufficient action to address their impacts on biodiversity (Addison et al., 2019; Bhattacharya & Managi, 2013), and actions are often criticised as a result of perverse incentives, poor implementation or greenwashing (Boiral, 2016; Drayson & Thompson, 2013). Since many socio-economic factors are outside businesses' control, there are concerns that these can lock society and business into situations of ineffective action to address biodiversity loss. For example, failings in the regulatory structure surrounding some offsetting schemes can allow biodiversity targets to be met on paper, whilst leading to negative biodiversity outcomes overall (Maron et al., 2018; zu Ermgassen et al., 2021). Similarly, influential lobbying groups exert political pressure to maintain the expansion of road networks, fossil fuel infrastructure and housebuilding, and consequently, projects often fail to contemplate the possibility of true avoidance (e.g. not building roads or houses, or producing the product) (Brauers & Oei, 2020; Mattioli et al., 2020; zu Ermgassen, Drewniok, et al., 2022). Additionally, there are issues when a level-playing field is not created as evidence use can be disincentivised due to competition. For example, one firm applying appropriate evidence to reduce their impacts might have higher costs, or open themselves up to scrutiny, that is not felt by a competitor who is ignoring the possible risks of biodiversity impacts. Similarly, in complex systems such as agricultural supply chains, a company using evidence to mitigate impact may have no overall impact if there is leakage (i.e. where another firm with weaker standards sources in areas that the more conscientious firm chose to avoid). It is essential therefore that alongside these principles that can improve actions when taken, businesses move towards a genuinely regenerative model that fully engages with and accounts for biodiversity impacts. There is a particularly important role for regulation to prevent firms with weaker standards, or those not using evidence, undercutting others who are trying to improve biodiversity practice. This is reflected in the aims of emerging policies such as the EU's new proposed legislation aiming to eliminate imported deforestation.

To ensure better engagement with biodiversity (and the associated evidence base) by businesses, a wide range of stakeholders need to push for a political environment where effective mitigation strategies are expected and valued, and evidence use is seen as standard to help achieve biodiversity goals. Promising leverage points to achieve this include the growing field of biodiversity litigation (Phelps et al., 2021) and pushes for disclosure frameworks to be broadly applied that account for, and monitor, real impacts and biodiversity outcomes (e.g. TNFD). Disclosure frameworks could be extended to require reporting of the evidence base behind a company's activities so investors can judge not just what companies choose to disclose but also the quality of the evidence underpinning it. There are also approaches to develop strong and appropriate biodiversity objectives and targets that account fully for impacts to help achieve nature positive outcomes (Maron et al., 2021; Science Based Targets Network, 2020). Transparent and standardised reporting and target setting approaches can allow proper comparison of negative and positive biodiversity impacts between companies, limit opportunities for greenwashing, and highlight where practice adopted is not evidence based.

A facilitating environment also requires greater civil society awareness of biodiversity loss and the available evidence base that can be used to hold businesses to account as well as increased capacity and awareness among lenders and regulators, and a willingness to transparently report efforts and learn from failure. Such a transition will not happen on its own, and therefore, it requires proactive action from business to start embedding biodiversity throughout their operations and taking evidence-based action to address impacts.

5 | CONCLUSION

As the private sector increases its engagement with biodiversity conservation, it will need to demonstrate robust evidence-based decision-making to counter sceptics and appeal to shareholders. However, their involvement itself represents an important step in the right direction for our current economic system. With biodiversity impacts

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seen as a growing risk to businesses and investors and with increasing attention on how to address those risks, businesses have a chance to contribute towards global goals to avert declines in biodiversity that are linked to their activities. Evidence-based practice is imperative if we are to realise the conservation potential from businesses engaging with the conservation sector. We hope that these principles will facilitate and transparently improve this transition.

AUTHOR CONTRIBUTIONS

All authors contributed to the conceptualisation and development of the principles. The investigation and writing of the initial draft was led by TBW. All authors contributed to the review and editing of the manuscript. The project was supervised by SOP and WJS.

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CONFLICT OF INTEREST

TB and LB work for organisations that receive income from paid consultancy related to private sector biodiversity assessments and management. BJ's work supports paid services for private sector biodiversity management. All other authors declare no competing interests.

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