European Commission

Recommendations for a standard on corporate biodiversity measurement and valuation

Align

Aligning accounting approaches for nature

UNEP-WCMC, Capitals Coalition, Arcadis, ICF, WCMC Europe (2022) Recommendations for a standard on corporate biodiversity measurement and valuation, Aligning accounting approaches for nature

Project consortium

The Align project - Aligning accounting approaches for nature - came into being with the objective to co-develop recommendations for a standard on corporate biodiversity measurements and valuation. Align is a three-year project aiming at providing businesses and financial institutions with principles and criteria for biodiversity measurement and valuation. The Align project was funded by the European Commission, and led by UNEP-WCMC, the Capitals Coalition, Arcadis, and ICF, with the support of WCMC Europe.

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Foreword

It is well established now that businesses and the financiers of their activities are highly dependent on nature, and that they have a key role to play in reversing the decline of biodiversity and contributing to a nature positive future. Businesses are therefore facing a multitude of policy drivers to assess and disclose their environmental performance, creating an urgent need for more effective measurement and valuation of their nature related impacts and dependencies. Biodiversity, ecosystems and their services are all highly complex, but many biodiversity measurement and valuation approaches have evolved to meet this need. These vary in their suitability and application for different decision contexts, creating challenges related to comparability, consistency, and uptake. I therefore welcome these recommendations from the Align project, which provide much needed clarity on the 'what' and the 'how' of corporate biodiversity measurement and valuation. Their development, through a consensus building process with many of the leading experts on the topic, provide the technical basis to support many evolving policies and standards. They are an important step towards more harmonized approaches of natural capital accounting within Europe and beyond.

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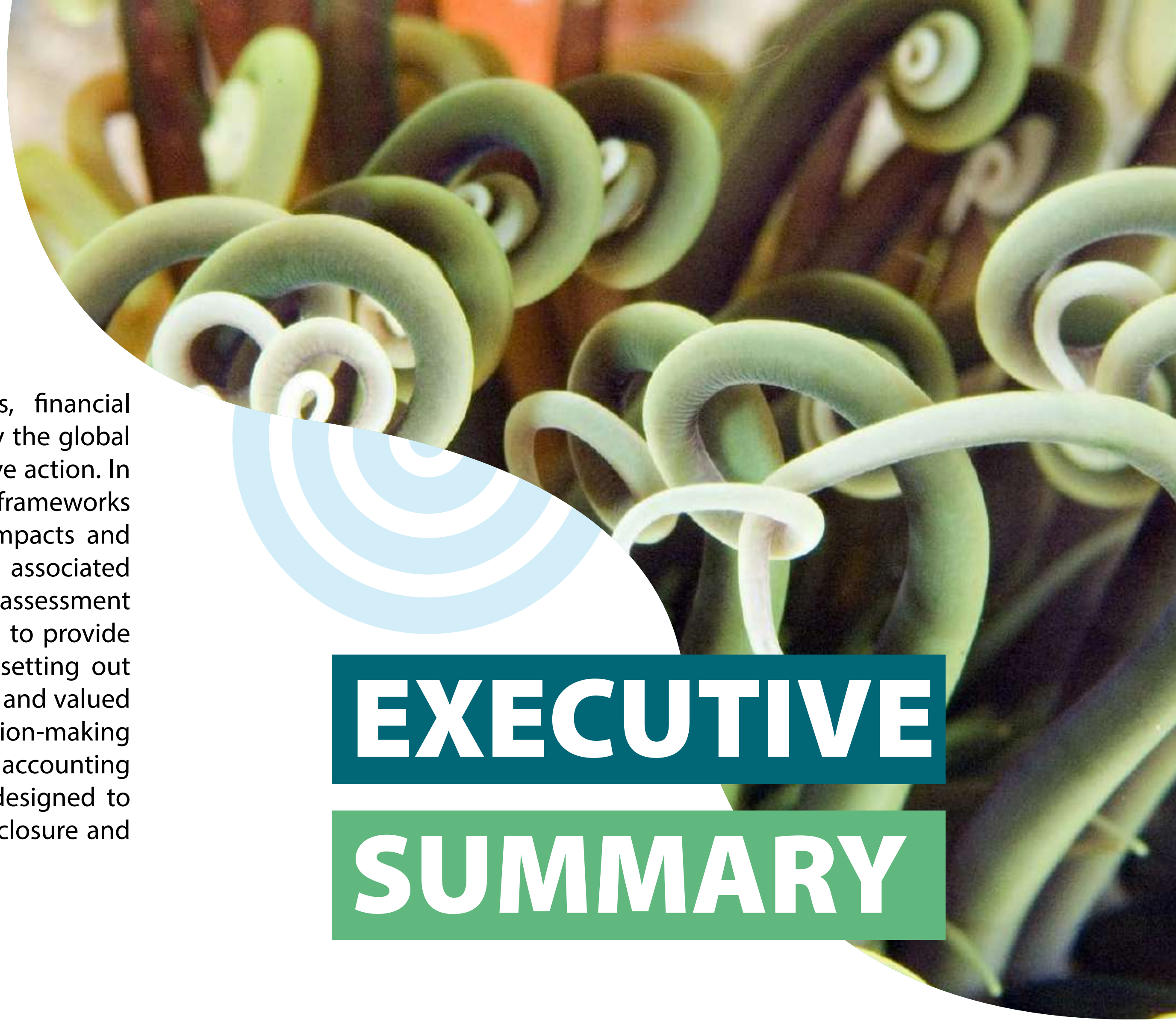
EXECUTIVE SUMMARY

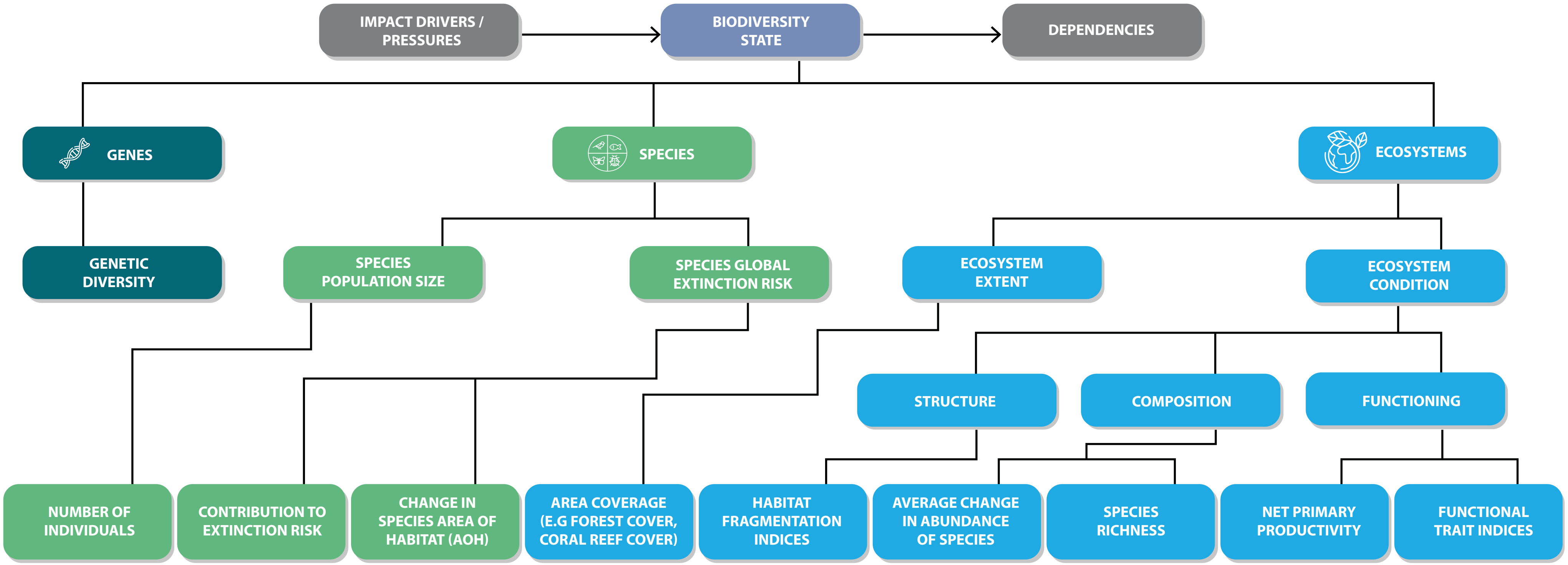


There is growing awareness among businesses, financial institutions and policy-makers of the risks posed by the global decline of biodiversity, and opportunities for positive action. In response, a complex landscape of metrics, tools and frameworks has been developed to measure and value the impacts and dependencies of business on biodiversity and associated ecosystem services, as part of wider natural capital assessment and accounting processes. There is an urgent need to provide an agreed set of principles and technical criteria setting out 'what' elements of biodiversity should be measured and valued and 'how' this should be done in different decision-making contexts. These recommendations from the Aligning accounting approaches for nature (Align) project have been designed to address this need and support wider reporting, disclosure and target setting initiatives and standards.

Summary of recommendations:

- **The business context is important to determine appropriate measurement methods.** Broadly speaking, measurement approaches include those used to screen risks relating to a business's impact and dependencies on biodiversity, and opportunities for mitigation, and those for measuring realised biodiversity impacts/performance. Methods will also differ for direct (site) and value chain (upstream and downstream) impacts given the differences in level of spatial information available to businesses, and the level of a business' influence.
- **The concept of 'double materiality' should be used to prioritise effort and attention.** Companies and investors need to focus on activities and associated biodiversity impacts and dependencies that are most relevant or 'material'. 'Double materiality', which considers the societal value of biodiversity alongside business value, will provide a more comprehensive view of the relationship between a company, biodiversity, and ecosystem services as well as a more comprehensive understanding of potential risks and opportunities.
- **Indicators of ecosystem extent and condition should form the core of assessments of impact and dependencies.** Biodiversity is multifaceted and difficult to capture in a single metric (Figure E1). Ecosystem condition gives insight to the capacity of ecosystems to deliver ecosystem services on which business and society depend and allows changes in biodiversity to be effectively valued. For a more comprehensive assessment that captures risks associated with individual species loss, species level measurement should also be considered, including extinction risk and population size. Genetic diversity is also a key aspect of biodiversity, but the application of genetic diversity metrics and tools for measuring business impacts and dependencies is under-developed and species level metrics will capture aspects of genetic diversity.

Figure E1. Components of biodiversity and example measurement indicators.



- **Factors to consider in selecting a measurement approach include spatial precision, accuracy, responsiveness to change and feasibility to apply at scale**. The extent to which these different factors are addressed within a measurement approach determines which business contexts they are appropriate to use within. 'Footprinting' approaches that apply globally modelled pressure-state responses can produce scalable measurements across value chains, and facilitate a comprehensive screening process of biodiversity risks. However, they can lack the accuracy and spatial precision required for robust impact measurement at site level compared to indicators based on direct measurements from surveys and spatial data layers.

Figure E2. Good and best practice measurement criteria for site and supply chains

SITE & PROJECT LEVEL

GOOD PRACTICE | BEST PRACTICE

Practice / Level	WHAT TO MEASURE	CHARACTERISTICS OF MEASUREMENT APPROACH	MOST APPLICABLE METHODS
Good practice – SCREEN	○ Potential presence & proximity to material species & ecosystems ○ Potential impacts based on **sector-average impact drivers**	○ **Feasibility (screening) - High** (able to apply screening at multiple sites) ○ **Spatial precision - Medium** ○ **Accuracy - Medium** (measures reflect potential presence & impacts on species & ecosystems, but are not ground-truthed)	✓ Spatial overlays with static biodiversity data layers (ecosystem extent / condition) ✓ Species threat & range layers ✓ Screening using modelled state based on pressures
Good practice – MEASURE	○ Ecosystem extent & condition indicators; or ○ Measurement of material impact drivers (at least land use change) ○ Periodic measurements that start from a baseline, & measurements that reflect changes in state resulting from company-specific impact drivers	○ **Responsivness - Medium** (able to reflect how changes in pressures affects biodiverisity state) ○ **Spatial precision - Medium** ○ **Accuracy - Medium** (measures reflect potential presence & impacts on species & ecosystems, but are not grounded-truthed)	✓ Primary data based on surveys ✓ Measuring using responsive biodiversity data layers ✓ Measuring using modelled state based on pressures
Best practice – SCREEN	○ Potential presence & condition of material species & ecosystems, results **ground-truthed** ○ Species extinction risk indicators ○ Potential impacts based on **company specific impact drivers**	○ **Feasibility (screening) - High** (for screening, able to apply for screening at multiple sites) ○ **Spatial precision - High** (captures species & ecosystems at site level) ○ **Accuracy - High** (measures reflect actual, ground-truthed presence of/impacts on species & ecosystems)	✓ Modelled state based on pressures **(using company specific impact driver data)** for screening only ✓ Species threat & range layers
Best practice – MEASURE	○ Ecosystem extent & condition for **individual ecosystem assets** ○ Species extinction risk indicators ○ Periodic measurements that start from a baseline, & measurements that reflect changes in state resulting from **site-level mitigation measures** Based on primary data on **material impact drivers**	○ **Responsiveness (measuring impacts) -** reflects effects of site-level mitigation measures ○ **Spatial precision - High** (captures species & ecosystems at site level) ○ **Accuracy - High** (measures reflect actual, ground-truthed presence of/impacts on species & ecosystems)	✓ Primary data based on surveys

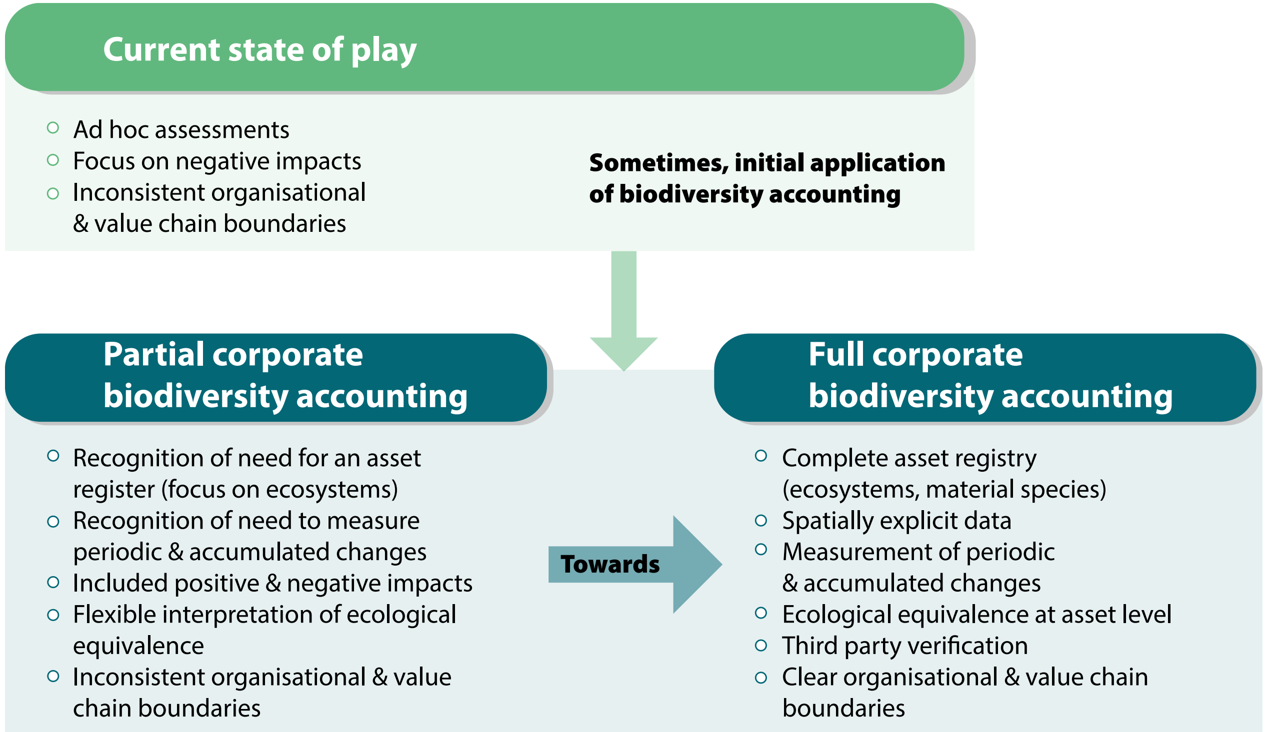
SUPPLY CHAIN LEVEL

GOOD PRACTICE | BEST PRACTICE

	WHAT TO MEASURE	CHARACTERISTICS OF MEASUREMENT APPROACH	MOST APPLICABLE METHODS
SCREEN (Good practice)	○ Ecosystem extent & condition & species extinction risk at broad-scale sourcing regions	○ **Feasibility (applicable for screening) - High** ○ **Spatial precision - Low** ○ **Accuracy - Low** (e.g., can measure potential impact based on sector-average impact diver-data)	✓ Spatial overlays with biodiversity data layers (ecosystem extent / condition) ✓ Species threat & range layers
MEASURE (Good practice)	○ Potential impacts on ecosystems based on volumes of materials sourced (or revenue) within each **country** sourced from	○ **Responsivness - Medium** (responsive to changes in impact drivers along supply chain) ○ **Spatial precision - Low** (screening/measuring can use models based on global data) ○ **Accuracy - Low** (e.g., can measure potential impact based on sector-average impact driver-data)	✓ Modelled state based on pressures (sector averages)
SCREEN (Best practice)	○ Ecosystem extent & condition & species extinction risk at specific sourcing locations ○ Potential impacts on ecosystems based on volumes of material sourced (or revenue) within each **country** sourced from	○ **Feasibility (applicable to screening) - High** ○ **Spatial precision - Medium** (reflects differences in potential impact based on sourcing region) ○ **Accuracy - Medium** (screens potential impact based on company-specific impact driver data)	✓ Modelled state based on pressures **(using company specific impact driver data)** for screening only ✓ Species threat & range layers
MEASURE (Best practice)	○ Measurement of potential impacts reflects differences in biodiversity between sourcing locations and production processes at sourcing locations ○ Measurement of impact driven & state at sampled sites using primary data is used to complement full-supply chain measures	○ **Responsiveness - Medium -** (reflects changes in production practices at source location) ○ **Spatial precision - Medium** (reflects differences in potential impact based on sourcing regionl) ○ **Accuracy - Medium** (screens/measures potential impact based on company-specific impact driver data)	✓ Modelled state based on pressures **(including land use intensity)** ✓ **Primary data** based on species/habitat surveys (for measuring impact) **at sampled sites**

- **Business should measure their dependencies on biodiversity, as well as their impacts for a more complete picture of risks and opportunities.** Some business activities depend directly on biodiversity, and most will depend in some way on the ecosystem services that biodiversity underpins. Measuring biodiversity dependencies involves assessing which ecosystem services are material to the business, and which ecosystem types are most likely to be providing those services across business value chains. This assessment then allows an understanding of how current and future trends in the extent and condition of ecosystems may affect business dependencies on ecosystem services and the risks associated with biodiversity loss.
- **When conducting valuation, the types of biodiversity values assessed, and the values omitted should be made clear to decision makers.** The valuation of some benefits and costs to people and business from changes in biodiversity may be difficult to be accurately captured. Decision makers should be conscious of the types of values assessed and omitted, and the values of biodiversity assessed should be always considered as minimum estimates of the overall value of biodiversity. In addition, valuation should be undertaken based on a good understanding of changes in the state of biodiversity, the context where those changes are taking place, and who may be impacted by biodiversity loss (e.g., impacts on Indigenous Peoples and Local Communities (IPLCs).
- **The application of formalised accounting approaches to biodiversity is immature, but developing, and is beneficial to enhance the rigour and value of measurement methods for business decision-making.** Organising measurements into structured biodiversity accounts (often as part of a broader natural capital account) facilitates accurate tracking of gains and losses in biodiversity over time and is recommended for tracking against no net loss or net gain targets where site level data are available. Accounting involves compiling a comprehensive asset register and developing statements of position and performance, analogous with financial accounting. It requires methodologies that use spatially explicit data (Figure 3).

Figure E3. The current state of play of accounting within biodiversity measurement and direction of development towards full biodiversity accounting



These recommendations provide scientifically robust criteria for screening risks and opportunities, and measuring biodiversity performance. They set out a direction of travel towards comprehensive accounting of biodiversity stocks, and valuation of impacts and dependencies. Collective effort between standard setters and tool developers is needed to ensure there is consistency in 'what' should be measured and reported by businesses with regards to biodiversity, and 'how' biodiversity should be measured in terms of the tools and methods needed to implement these requirements. This 'alignment' can support the transformative corporate action so urgently required to halt and reverse the loss of nature.

01

INTRODUCTION

1.1 Background

1.1.1 The relationship between business and biodiversity

Biodiversity provides a wide range of values to people and society. Biodiversity is both an integral component of natural capital (the stock of natural resources that combine to yield ecosystem service flows), as well as an indicator of the resilience of natural capital stocks such as soil and water. More than half of global economic output is either moderately or highly dependent on nature, but the biodiversity underpinning these ecosystem service dependencies is being lost at an unprecedented rate, with an estimated one million species at risk of extinction, many in the near future[1]. In turn this loss of biodiversity impacts wider society, including specific groups that are considered vulnerable including women and girls, and indigenous peoples and local communities (IPLCs).

Businesses impact and depend on biodiversity and the ecosystem services it provides. Business impacts can be negative or positive, resulting in both costs and benefits for society, and risks and opportunities for business and financial institutions. As awareness grows of the business risks and opportunities that biodiversity loss presents, there are increasing drivers for businesses to measure and report on their impacts and dependencies on biodiversity alongside their wider natural capital, climate and social responsibilities. These include regulations, market forces (consumer pressure), reputation, securing operational efficiencies and ability to access finance.

International agreements, resolutions, policies and targets, particularly the development of the post-2020 global biodiversity framework, the UN resolution on the human right to a healthy environment[2], as well as national or regional policy and regulatory developments, are expected to further drive business measurement and disclosure of biodiversity impacts and dependencies. In France, for example corporate biodiversity footprinting is expected to become mandatory under the national Biodiversity Plan [3]. The EU Sustainable Finance Framework requires enhanced environmental disclosures while the EU New Green Deal [4] encourages development of business natural capital accounting approaches. From a disclosure perspective, the Corporate Sustainability Reporting Directive (CSRD) is likely to lead to greater biodiversity disclosures in the European Union. At the global level, the Taskforce on Nature-Related financial Disclosures (TNFD) will set a disclosure framework for nature-related risk and the Science Based Targets Network (SBTN) will guide companies to set science-based targets for nature. The International Sustainability Standards Board (ISSB) will also develop comprehensive sustainability disclosure standards. A common challenge across all these will be determining how to measure and value impacts and dependence on biodiversity, and this is the key challenge that the Align project aims to address.

1.1.2 Developments in biodiversity measurement and valuation

Currently, business measurement and reporting on natural capital in general, and biodiversity in particular, is extremely limited[5]. For many businesses, the quality of disclosed biodiversity information is poor and gives little insight into business risk, opportunities, or performance, focusing on management narratives with little quantitative, non-monetary information[6]. Nevertheless, businesses are increasingly understanding the need for robust and consistent measures of biodiversity impacts and dependencies, including measuring positive impacts. There is also a growing demand for quantitative measures from investors and auditors as part of evolving reporting and disclosure frameworks.

Within the context of natural capital assessment and accounting approaches, biodiversity measurement methodologies have developed to meet this demand; however, their uptake remains limited to a few front-runner companies. Measures of corporate biodiversity impact and performance are still not broadly agreed upon, and there is a need for a more consistent approach. When faced with a range of different measurement methodologies, it is easy for businesses and financial institutions to become overwhelmed.

There is a need for improved understanding and a set of agreed principles and criteria for biodiversity measurement that can be used in different contexts, are scientifically robust, and are fit for purpose. Similarly, clarity is needed on the valuation of biodiversity and ecosystem services to make clear to business and financial institutions the consequences of biodiversity loss, including the impacts to vulnerable local communities. This relies on robust information on the change of state of biodiversity.

1 IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. 56 pages. https://doi.org/10.5281/zenodo.3553579

2 See Human Rights Council (2021), *The Human Right to A Clean, Healthy, and Sustainable Environment*, Resolution 48/13, adopted 8 October 2021, UN Doc A/HRC/RES/48/13.

3 Comité interministériel biodiversité (2018) Plan biodiversité. Available at: https://www.ecologique-solidaire.gouv.fr/sites/default/files/2018.07.04_PlanBiodiversite.pdf

4 European Commission (2019) The European Green Deal. Communication from the Commission to the European Parliament, The European Council, The Council, The European Economic and Social Committee and the Committee of the Regions.

5 Leaders Arena (2021) Biodiversity Reporting Study. Available at: https://54672270-a3a8-4c2f-8ed8-f933153cc32e.usrfiles.com/ugd/546722_c27aa824437d4587af9b6e42783099da.pdf

6 Ecogain (2022) Ecogain Biodiversity Index. Ranking Biodiversity in Business. Available at: https://www.ecogain.se/biodiversity-index?fbclid=IwAR1U7eQ2QtugAV7jF7p8PGcuCkv-a9nS1qkWxNxqHddxq4eYwgvfUjBAQ2I

1.1.3 The Aligning accounting approaches for nature (Align) project

To address this need for agreed principles and criteria for biodiversity measurement, the European Commission funded Align project – aligning accounting approaches for nature was formed. Led by UNEP-WCMC, the Capitals Coalition, Arcadis, ICF and WCMC Europe, Align is designed to support businesses, financial institutions and other stakeholders in developing standardised natural capital accounting practices, including recommendations for biodiversity measurement and valuation. It has three objectives (Figure 1).

Figure 1: The Align project objectives

Objective 1

- Establish and operate a dedicated natural capital management accounting platform for **facilitiating best practice exchange** among practitioners

Objective 2

- Establish and operate a **business-driven discussion and alignment process** to streamline and strengthen methods and metrics for measuring impacts and dependencies on biodiveristy

Objective 3

- Define **needs** and **opportunities** relating to **education & training**, and **research & innovation** to mainstream natural capital management accouting within the business community

The Align recommendations were developed through consultation with 47 technical experts on corporate biodiversity assessment within a Technical Hub and a Community of Practice of over 170 companies and other stakeholders.

1.2 Objectives

- This document sets out recommendations for undertaking biodiversity measurement across different business contexts and how they can support valuation.
- The recommendations are intended to be additional and complementary to any regulatory measurement requirements (e.g. Environmental Impact Assessments), and support performance measurement.
- The recommendations do not explicitly favour one named measurement approach over another, but instead specify which type of approach is applicable for specific business contexts based on standardised and agreed technical criteria. The recommendations within the document are developed with the intention that they will be adopted within broader sustainability disclosure standards such as the Corporate Sustainability Reporting Directive (CSRD), International Financial Reporting Standards (IFRS), the Global Reporting Initiative (GRI) revision of its biodiversity indicators, the Taskforce for Nature-Related Financial Disclosures (TNFD) framework and the Science Based Targets Network (SBTN) guidance, as well as connect with other natural capital measurement initiatives including the Transparent project and the Partnership for Biodiversity Accounting Financials (PBAF).

1.3 Audience

The recommendations are intended for measurement and disclosure standard setters, developers of biodiversity measurement approaches and users of these approaches. Users could include:

- environmental/sustainability and finance managers within a business.
- consultants who will be supporting businesses to measure, value and report on the biodiversity performance of an organisation, fund, product or parts of an organisation, as well as those who oversee the validation of outcomes.
- third parties, including government regulators and civil society, who wish to understand how companies are managing their impacts and dependence on biodiversity.

The recommendations are applicable to organisations of all types (public, third sector and listed and unlisted private), across all sectors, and of any size (such as small and medium sized enterprises and multinational businesses). Although the project is supported by the EU, the recommendations are also intended to be broadly applicable to all organisations, independent of the country or countries in which they operate.

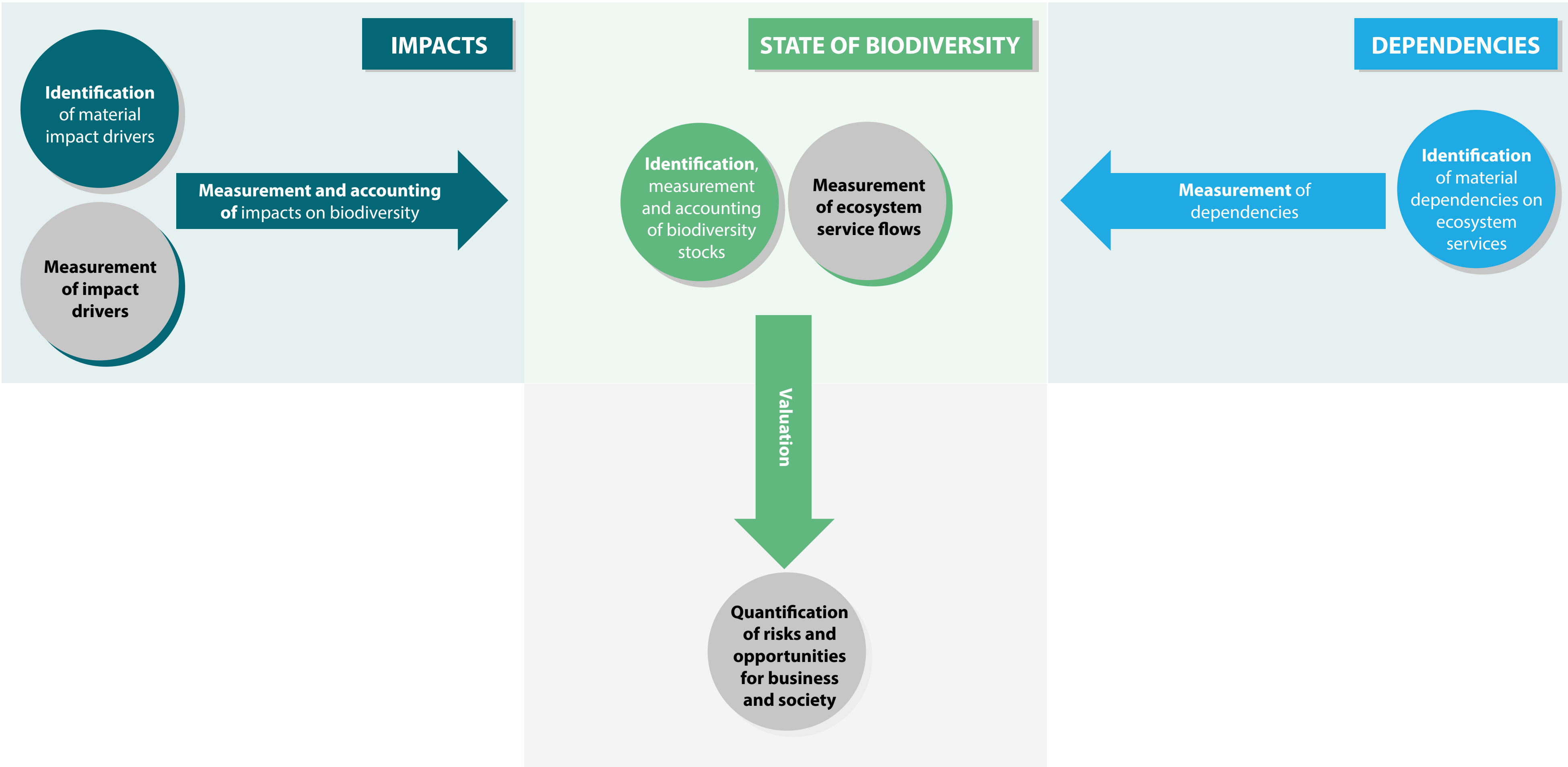
1.4 Scope of the recommendations

In the context of the Align project, 'Measurement' refers to the process of quantifying the amount, extent, and condition of biodiversity and associated ecosystem services in physical terms as a way of assessing performance or risk, while valuation is the process of estimating the relative importance, worth, or usefulness of biodiversity to people (or to a business) in a particular context. Valuation may involve qualitative, quantitative or monetary approaches, or a combination of these[7].

The recommendations focus on the measurement and valuation of the state of biodiversity that underpins ecosystem service provision, drivers of biodiversity loss (impact drivers) and dependencies on biodiversity and ecosystem services. The scope of the recommendations is presented in Figure 2 below:

7 Capitals Coalition (2016). Natural Capital Protocol. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/

Figure 2: Setting out the scope of the recommendations. Blue boxes and arrows reflect content covered by the Align recommendation, whilst white boxes reflect content out of scope of the recommendations.



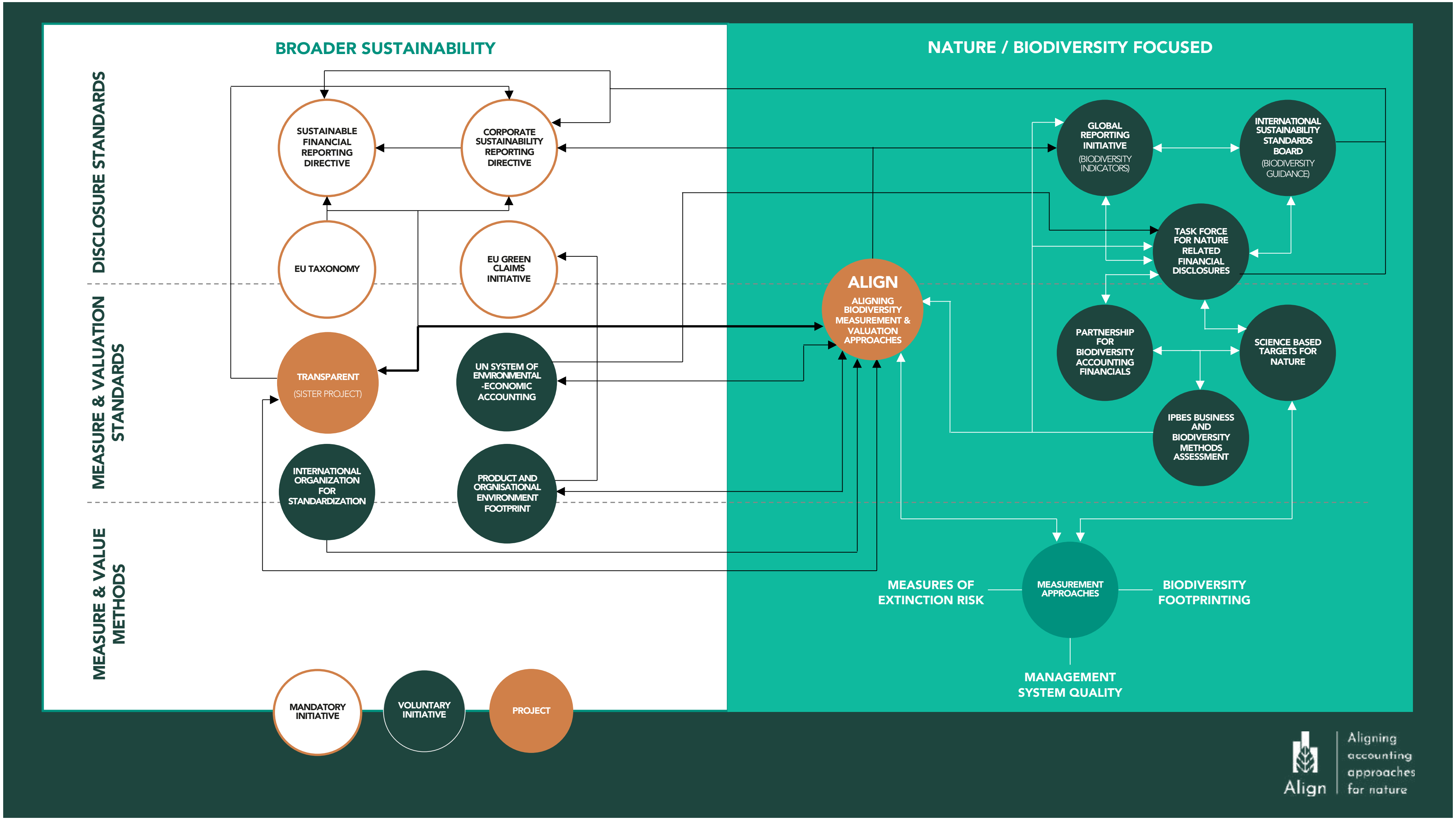
The recommendations are not intended to provide a step-by-step approach; however, the sections broadly follow the steps of the Natural Capital Protocol[7] and accompanying Biodiversity Guidance [8] which outlines the full steps of undertaking a biodiversity inclusive natural capital assessment. These recommendations focus on the 'measure and value' steps of the Natural Capital Protocol and biodiversity guidance, providing more detailed requirements for credible, decision-useful biodiversity measurement and valuation approaches.

8 Capitals Coalition and Cambridge Conservation Initiative (2020) Integrating biodiversity into natural capital assessments. https://capitalscoalition.org/guide_supplement/biodiversity-4/

The relationship of the Align project to other approaches and initiatives is outlined in Figure 3. The recommendations do not include the following as they are the subject of existing detailed guidance:

- How to measure drivers of biodiversity loss such as climate change and land-use (guidance is being developed in Transparent, and the Science-Based Target Network).
- How to measure and value flow of ecosystem services (guidance already in place within the System of Environmental Economic Accounting – Ecosystem Accounts and the corporate natural capital accounting guidance), The Natural Capital Protocol, and the BSI Standard on Natural Capital Accounting.
- The translation from impacts and dependencies to articulation of business risk and opportunity (being developed by the Taskforce for Nature related Financial Disclosure).
- Biodiversity management measures put in place by a company (World Benchmarking Alliance and CDP are developing this).
- Gender differences in the social valuations of biodiversity and ecosystems services

Figure 3: Relationship of Align to other approaches and initiatives.



1.5 Principles

The following guiding principles should underpin any measurement and valuation process: relevance, rigor, replicability and consistency. They are designed to ensure appropriate methods, metrics and data are used to fit the intended business application (Table 1).

Table 1: Guiding principles for biodiversity measurement [9]

Principles	
Relevance: the most relevant biodiversity impacts, risks and opportunities are considered including those impacts that are material for society and the business or the financial institution and their stakeholders.	**Replicability:** means that all assumptions, estimates, data, caveats, and methods used are transparent, traceable, fully documented, and repeatable. This allows for eventual verification or audit, as required.
Rigour: refers to the use of technically robust (from a scientific and economic perspective) information, data and methods that are up to date, accurate, complete and reduce uncertainty as far as possible.	**Consistency:** all data and methods used for an assessment are compatible with each other and within the scope of the analysis, which depend on the overall objective and expected business application

These principles should be applied to all business contexts and all levels of maturity of biodiversity assessment.

1.6 Materiality

To prioritise effort and attention, companies and investors need to focus on those activities and associated biodiversity impacts and dependencies that are most relevant or 'material' to the business. Using a materiality assessment, activities and their associated impact drivers and dependencies on biodiversity can be identified that have the potential to influence a decision made by stakeholders and businesses and therefore that require management attention.

For the purposes of these recommendations, materiality is a concept that can be dynamic (change over time) and is dual in nature (also referred to as 'double materiality'). It encompasses both 'societal materiality' (i.e. the level of significance of the entity's impacts on the environment and people, including Indigenous Peoples and Local Communities, women, and youth, deriving from its own operations or those linked to its upstream or downstream supply chain) and 'financial materiality' (i.e. the likelihood of a biodiversity-related matter to influence an entity's value). For the purposes of assessing biodiversity from a corporate or financial institution perspective, a biodiversity-related issue will meet the criteria of double materiality if it is material from the societal or financial perspective, or both [10].

9 Adapted from: Capitals Coalition (2016). Natural Capital Protocol. https://capitalscoalition.org/capitals-approach/natural-capital-protocol/;

European Business @ Biodiversity Platform (2019) Assessment of biodiversity measurement approaches for businesses and financial institutions. Update report 2;

Endangered Wildlife Trust (2020). The Biological Diversity Protocol (BD Protocol). National Biodiversity and Business Network - South Africa, 123p. Available at: https://nbbnbdp.org/biodiversity-protocol/;

CDSB (2021) CDSB Framework. Application guidance for biodiversity related disclosures. https://www.cdsb.net/biodiversity ;

SBTN (2020) Science Based Targets for Nature. Initial guidance for business.

10 EFRAG (2022) [Draft] European sustainability Reporting Standard 1 General provisions.

Considering societal value alongside business value will provide a more comprehensive view of materiality and the consequences to a company of its relationship with nature. Business impacts on biodiversity stocks may affect the flows of ecosystem services and alter business activities that depend on them. The role of biodiversity in providing ecosystem services may be hidden and its value under-estimated, so may not be initially identified as material to a business [7]. Considering materiality from the perspective of society is likely to result in the consideration of a broader range of issues within measurement and valuation given growing societal concern about biodiversity loss.

The value of biodiversity to society and business may shift over time, including the different values from a gender perspective, hence there is a need to periodically re-evaluate materiality of an assessment.

Decisions around materiality arise at several stages of biodiversity measurement and valuation:

- Decisions around what aspect of the value chain to focus upon (Section 2: Business Context).
- Decisions on which impact drivers and dependencies to focus on (Section 4: How to measure business impacts and Section 5: How to measure business dependencies).
- Decisions on what aspects of biodiversity state should be measured (Section 3: Indicators and metrics for biodiversity state).

1.7 Format

1.7.1 Format of the recommendations

1. Universal recommendations are provided to help users and developers of measurement approaches move towards more robust and credible biodiversity measurement and valuation.

2. Technical criteria are provided for how to measure biodiversity in different business contexts. These are provided at two-levels:

- **'Good' practice technical criteria:**
  - should be followed by every company, independent of sector, size and level of materiality of impacts (*technical criteria don't apply to non-material impacts*).
  - are scientifically robust and, if adopted across more businesses, will ensure a significant change in how biodiversity is measured (i.e., compared to 'business as usual').
- **'Best' practice technical criteria:**
  - can be followed by any company for all material impacts but should be followed for highly material impacts.
  - represent a 'direction of travel' for biodiversity measurement, i.e., where biodiversity measurement should be building towards, even if not currently deemed feasible by businesses just starting out in the process of measuring their impacts and dependencies.
  - encompass a more comprehensive and robust assessment than the good practice criteria.

Note these good and best practice criteria are separate from legally prescribed minimum standards (e.g., in permit conditions). However, as these legally imposed measurements are context specific, they are out of scope of the recommendations.

02

BUSINESS CONTEXTS

Biodiversity measurement and valuation takes place in different contexts – different business needs (applications) and scales of operation (organisational focus areas) will require different levels of accuracy, frequency of measurement, boundaries of assessment and will introduce a variety of challenges in terms of data availability and quality.

In addition to a clear understanding of the business need for measurement, a business should set transparent organisational and value chain boundaries for which it will measure and/or value its impacts and dependencies on biodiversity. This requires consideration of which part of the business and which element of the value chain to address within measurement and, in the case of investors, how to determine the investor's proportion of the overall impact of an investment.

Within the Align recommendations, two key factors define the business context: (i) the reason for undertaking biodiversity measurement/valuation, and (ii) the level within the organisation that will be subject to this measurement/valuation.

Three clusters of business applications are considered from a measurement perspective:

- **Screening of risks related to potential impacts and dependencies, and opportunities for mitigation**; it requires less detailed measurement approaches and might even have qualitative outcomes; outputs are indicative in nature but sufficient for prioritisation purposes.
- **Measuring biodiversity impacts and performance**; this requires more precise, quantified figures to understand the change in biodiversity state that is observed or predicted based on a company's activities.
- **Measuring changes in the state of biodiversity underpinning business dependencies,** this requires quantitative measures of the state of biodiversity and the provision of ecosystem services on which the business activity depends.

Any measurements taken for external reporting purposes benefit from a validation process. Valuing societal and business impacts is the next step following measurement.

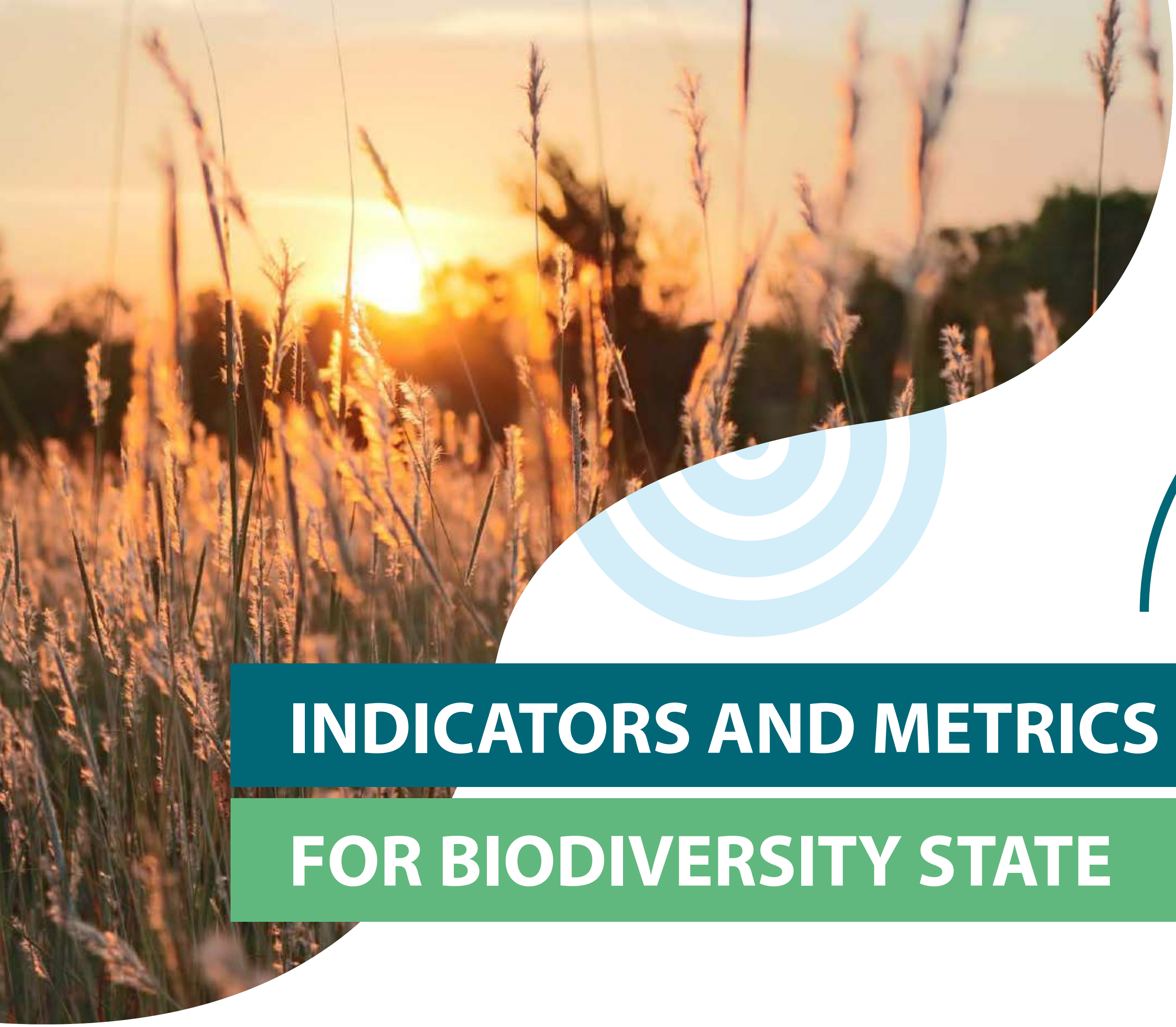
Within these clusters of business applications, the recommendations define four main organisational focus areas[7], with technical criteria focusing on the first two:

- **Site or project level:** site level usually refers to existing sites while project level usually refers to planned undertakings or initiatives at a specific location; site and project level impacts are directly related to the site or project activities, processes, and incidents and exclude supply chains delivering to the site or project. These are also sometimes known as Direct Operations.
- **Supply chain:** focus is on the upstream parts of the value chain where primary sectors are active (e.g. extraction of raw materials, agriculture, fisheries, forestry).
- **Product level:** goods and/or services, including the materials and services used to produce the product and the downstream activities.
- **Corporate level:** assessment of a corporation or group, including all subsidiaries, business units, divisions, different geographies or markets etc. This requires aggregation of information across the full value chain.

Table 2 provides an explanation of these business contexts with example applications, providing the basis for the good and best practice criteria that are provided in Section 4. Information on measuring changes in state of biodiversity underpinning dependencies is given in Section 5, but good/best practice criteria are not provided within the recommendations for this business context as it is more nascent.

Table 2: Business contexts for which recommendations are made in terms of technical criteria

SCREENING OF BIODIVERSITY RISKS AND MITIGATION OPPORTUNITIES	
	Screening for biodiversity risks and opportunities from direct operations at site or project level for:
Site/Project	■ Identifying and assessing potential material biodiversity issues at site level. ■ Comparing alternative sites based on biodiversity risk (e.g., criterion for site selection). ■ Ranking of existing sites based on biodiversity risk (e.g., for prioritising more in-depth measurement). ■ Identification of potential mitigation measures (including biodiversity positive measures) that can be implemented at an existing site/project or can be integrated in the design or construction of the new site/project.
	Screening for biodiversity risks and opportunities within specific supply chains for:
Supply Chain	■ Identifying and assessing potential material biodiversity within supply chains. ■ Comparing biodiversity risks among commodities or different sourcing regions. ■ Developing engagement strategies with suppliers (as an opportunity for increasing biodiversity performance in supply chains). ■ Assessing whether a certification scheme or other requirement will address the likely biodiversity risks in supply chains.
MEASURING BIODIVERSITY IMPACTS	
	Measurement to quantify localised impacts on biodiversity of site operations for:
Site/Project	■ Understanding the current biodiversity impact of existing sites/projects which allows: ■ Identification of mitigation measures. ■ Prioritisation of mitigation measures (e.g. at specific sites/projects or among sites/projects). ■ Monitoring effectiveness of mitigation measures. ■ Demonstrating continuous improvement over time or progress to target (e.g. no net loss or net positive). ■ Assessing progress over time. ■ Estimating the predicted biodiversity gains in offset areas. ■ Monitoring losses and gains of biodiversity and calculating the balance, as part of a no net loss or net positive ambition.
	Measuring impacts on biodiversity within specific supply chains for:
Supply chain	■ Comparing biodiversity impacts among commodities or different sourcing regions and sites. ■ Measuring impacts of sourced commodities identified as material and effectiveness of mitigation measures. ■ Developing engagement strategies with suppliers (as an opportunity for increasing biodiversity performance in supply chains).



03

INDICATORS AND METRICS FOR BIODIVERSITY STATE

3.1 Background

This section identifies the key aspects of biodiversity that must be considered to understand biodiversity state and changes in biodiversity state (that is linked to impact drivers and affects dependencies) and describes criteria for metrics for each aspect.

Biodiversity is composed of ecosystems, species, and genes. As such, these are considered the components of biodiversity to be measured. This can be achieved by measuring key variables that act as indicators of the overall state of biodiversity or reflect business impacts on state. Indicators can be simple metrics (a system of standard measurement), or more complex indices (e.g. numerical scales) [11]. Describing the state of biodiversity with a single metric (like the carbon indicator for climate targets and assessments) is unlikely to be possible or credible. Instead, several metrics reflecting the multiple components of biodiversity are needed to understand changes in the state of biodiversity (which may be combined to develop a composite index). The use of multiple metrics will then reflect the multi-dimensional nature of biodiversity and their interconnectedness [12]. For example, understanding what species are present and their abundance, gives insight into the condition or 'health' of the ecosystem. The health of the ecosystem, in turn, may drive changes in an individual species' threat status [13].

Each component of biodiversity will have different **aspects** that can be measured:

- **Ecosystems:** There are two aspects to consider for the biotic component of ecosystems – **extent and condition.** Ecosystem condition (also referred to as integrity) can be assessed through measuring elements including composition of ecological communities, ecosystem structure, here including spatial structure of patches at the landscape level, and ecosystem functioning.
- **Species:** There are two aspects to consider for individual species - **population size** and **extinction risk**. These provide insight on the health of a single species' population and its relative resilience to human induced and naturally occurring change.
- **Genes:** Currently there is one aspect to consider - **genetic diversity,** which can be a component of both genes and species. Genetic diversity describes the variability in genetic characteristics within a given species, or within an ecosystem, and provides an indication of its resilience to change (e.g. the ability of a single species to withstand disease) [14]. This is particularly relevant when considering agrobiodiversity, as higher genetic diversity in crops can support more resilient agro-ecosystems.

Different biodiversity indicators/metrics consider various aspects of biodiversity at distinct geographic scales (e.g., local, regional and/or global biodiversity) [15]. For example, indicators that reflect global extinction risk consider biodiversity at the global level and can reflect how business activities potentially impact total numbers of species globally. At the local level, actual contributions to extinction risk can be measured by looking at the change in a species population size at a particular site.

Figure 4 provides examples of indicators for various aspects of biodiversity, recognising that other indicators will exist for each aspect. It is anticipated that the number of metrics/indicators available is likely to increase as the science and available approaches further develop.

Table 3 describes how a given indicator is relevant to each component and aspect of biodiversity. Examples are provided to describe how the indicator changes over time in response to business activities. Information on the underlying methods for measuring these indicators, and their strengths and limitations are described in Section 4.

11 Biodiversity Indicators Partnership. (2011) Guidance for national biodiversity indicator development and use. UNEP World Conservation Monitoring Centre, Cambridge, UK. 40pp.

12 Nicholson et al. (2021). Scientific foundations for an ecosystem goal, milestones and indicators for the post-2020 global biodiversity framework. Nature Ecology & Evolution; Soto-Navarro et al. (2021) Towards a multidimensional biodiversity index for national application. Nature Sustainability.

13 Czúcz, et al. (2019) Discussion paper 2.3: Proposed typology of condition variables for ecosystem accounting and criteria for selection of condition variables. UN SEEA EEA Technical Committee.

14 It should be noted that the use of eDNA, although measuring genetic diversity, provides a snapshot on species composition and can be used as an indicator for species composition at this point in time. Studies on use of eDNA for understanding changes to population genetics is ongoing, however, common use of eDNA as an indicator of genetic diversity in a business use context is under development (Adams, et al. 2022. eDNA reflects common haplotypic variation. https://doi.org/10.1101/2022.02.26.481856 (pre-print publication)).

15 Purvis, A. (2020). A single apex target for biodiversity would be bad news for both nature and people. Nature Ecology & Evolution, 4(6), 768-769

Figure 4. Components of biodiversity and example measurement indicators

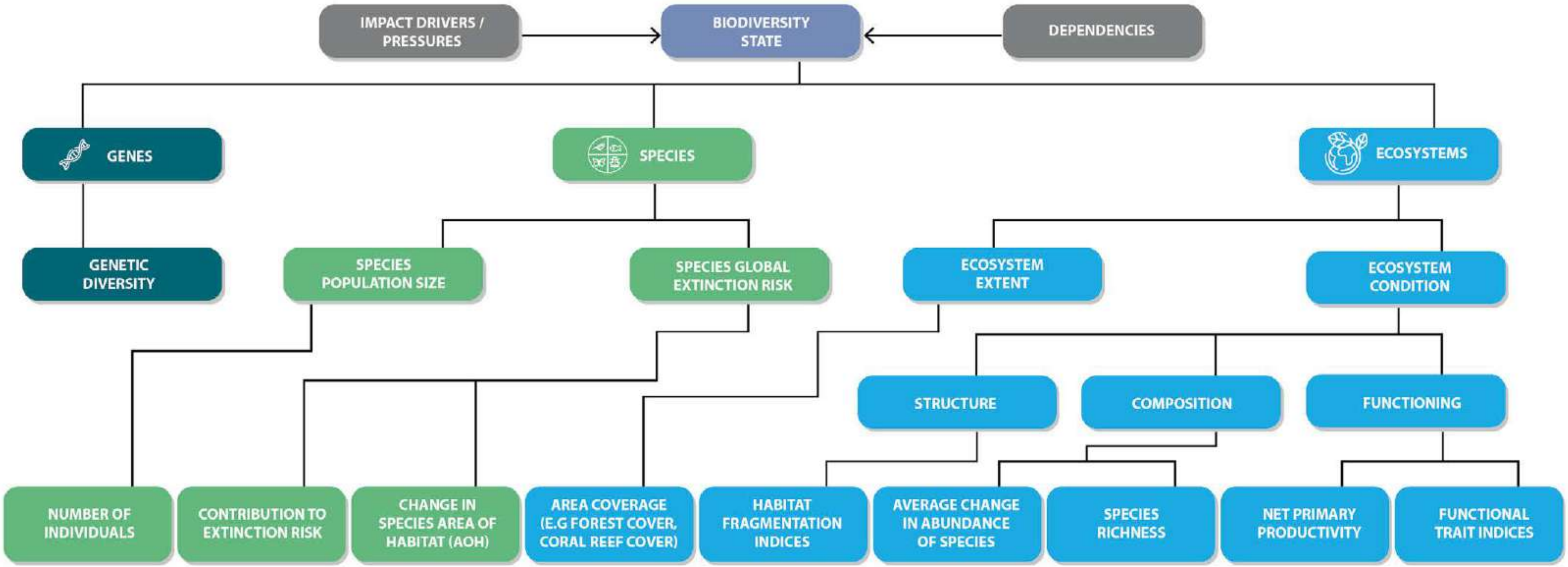


Table 3. Criteria describing an indicator's relevance to the different aspect of biodiversity.

Component of Biodiversity	Aspect	Criteria for indicators	Hypothetical example of how an indicator fits criteria(s)
Ecosystem (biotic component)	**Ecosystem extent**	Indicator measures area coverage of a particular ecosystem without necessarily considering the quality of the area being assessed.	**Forest cover** - a measure of the extent of a particular ecosystem type, without factoring in the condition of the ecosystem (e.g. provides the area without describing the species diversity within the forest).
	Ecosystem condition	Indicator measures the quality of ecosystems relative to a pre-determined reference state, considering elements such as composition, structure and function. Composition - Indicator measures multiple species (rather than the number of a individuals within a single species) within an ecosystem.	**Mean Species Abundance** - measures the average change in population size of native species in an area from a reference intact state. By measuring at the **ecological community** level, and including common species, it provides a proxy of ecosystem condition. Combined with information on ecosystem extent, it can be used to 'adjust' the total extent to produce **condition adjusted hectares** (also referred to as condition weighted areas). **Potentially Disappeared Fraction (PDF) –** measures the average change in local native species richness in an area from a reference intact state.
		Structure - Indicator reflects aggregate properties of ecosystems, irrespective of specific species composition, such as vegetation height and balance of different levels of food webs. Here, structure also includes levels of fragmentation and connectivity at the landscape level (i.e. how linked one piece of habitat is to another).	**Fragmentation indices** assess change in the size and spatial configuration of ecosystem patches. These changes may affect composition or overall functioning, but do not measure these factors directly.
		Functioning - Indicator measures a process (or function) that the ecosystem completes or reflects the ability to undertake these processes (e.g. through using functional traits as a proxy)	**Net Primary Productivity (NPP)** - measures the rate that energy is stored by plants and made available to other species in the ecosystem. It is a core process that occurs for ecosystems to function. It is related to many factors, such as species diversity, but does not measure these factors directly.
Species	**Species population size**	Indicator measures changes in the number of individuals of a species within a specific area.	**Number of breeding pairs** of a bird species of interest - measures the local population size and may provide information on changes in suitability of an area as a breeding ground.
	Species global extinction risk	Indicator measures the threat status of species and how activities/ pressures may affect the threat status.	**Contribution to extinction risk** metrics - use threat assessments and range sizes of the species present at a given location to estimate how different activities at that location may drive species extinctions globally.
		Indicator measures change in the available habitat for a species as a proxy for impact on local or global extinction risk.	**Change in species Area of Habitat (AoH)** metrics measure the change in habitat size as a proxy of a change to a species population size. Indicators such as these can be used when direct population counts are not possible to obtain, however, direct in situ population measures are preferred.
Genes	**Genetic diversity**	Indicator measures the variability in genetic characteristics within a given species, or within an ecosystem.	

3.2 Universal recommendations

To develop a more holistic understanding of the state, and change in state, of biodiversity, businesses can combine indicators that reflect different aspects. For example, combining measurements of changes to the population size of a species with those of ecosystem condition for a given assessment area contributes to understanding changes to the species and ecosystem component of biodiversity respectively.

To ensure a multi-dimensional and comprehensive approach for measuring corporate impacts and dependencies on biodiversity is achieved, the recommendations for 'what to measure 'include:

Indicators for ecosystem extent and condition should form the core of measurements of state and changes in state, supplemented with species level indicators for a more complete assessment.

Ecosystem extent and condition should form the foundation of measurement when assessing state. This information should then be supplemented with species-based indicators. Understanding ecosystem extent and condition is also integral to developing a biodiversity account (see Section 7). If a business were to only look at the effects of their operations on the population size of an indicator species, they may miss important changes in ecosystem condition of the area, which may result in reduced ecosystem service provision. By measuring both it is also more likely that correlations between population changes and reductions in overall ecosystem condition can be found and appropriate mitigation methods (e.g. to improve habitat connectivity) can be implemented.

Genetic diversity should be considered when it is material to do so, however there is currently a lack of practical tools for measuring performance in relation to genetic diversity.

When screening and measuring ecosystems, more robust assessments will be spatially explicit and based on defined ecosystem types, and there is often a need to consider their relative significance based on threat, strategic and cultural importance.

In contrast to business impacts on climate, biodiversity impacts and dependencies are spatially explicit. Therefore, considering spatially resolved, individual ecosystem assets based on a defined ecosystem classification system, such as the IUCN ecosystem typology, leads to the most robust assessment. Some measurement approaches may measure impacts on ecosystem condition at a broader resolution or geographic scale than specific ecosystem assets and are not disaggregated to individual ecosystem types.

In addition, screening of risks and opportunities may involve assessing the significance of the ecosystem types potentially impacted by business activities. Criteria for assessing significance include:

- Relative distinctness - ecosystems that are threatened, rare or declining may be more material that ecosystems that are more common and widespread. Understanding threat status may also include consideration of the level of cumulative pressures on ecosystems.
- Strategic and cultural significance - ecosystem may have high cultural significance or be in an area designated as strategically important for nature, or an area managed for conservation (such as a legally designated Protected Area), as well an important contribution to connectivity at the landscape scale.

Screening and measurement of ecosystem condition should include changes in the composition of species, irrespective of the rarity, threat status or value of individual species, compared to an intact reference state.

Often assessments of biodiversity focus only on globally threatened or charismatic species. Consideration of common species, in addition to high-risk species is more reflective of the quality/condition of ecosystems and it is important to capture the insurance value of biodiversity underpinning ecosystem services [16]. For this reason, consideration of common as well as threatened species is needed for a complete picture of ecosystem condition.

Screening and measurements of individual species (population size/extinction risk) should focus on material indicator species.

Measurements of species should consider abundance and extinction risk for material species. It is not feasible to measure the state of all individual species impacted by business operations, or that contribute to business dependencies. Selecting a subset of species to monitor as indicator species should be based on clear materiality criteria.

Criteria to consider in determining materiality of species include:

- The species is sensitive to company-induced impact drivers, with impacts likely to result in a significant change in its local and/or overall population, and so changes in state can be attributed to company activity over external factors
- The species is legally protected, according to local, national and/or international laws, conventions and action plans
- The taxon is recognised as a priority/threatened species at a local, national and/or international level (e.g. species listed on the IUCN Red List);
- The effective management (or lack thereof) of the species generates significant financial revenues and/or expenses;
- The species plays a critical role in the ecosystem;
- The species plays a significant cultural or economic role (e.g. hunting, harvesting, pollinating services, educational and recreational services) for stakeholders.

Each of these criteria will differ in the data required to assess materiality [17].

16 Winfree, R., W. Fox, J., Williams, N. M., Reilly, J. R., & Cariveau, D. P. (2015). Abundance of common species, not species richness, drives delivery of a real-world ecosystem service. Ecology letters, 18(7), 626-635

17 United Nations et al. (2021). System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA); Endangered Wildlife Trust (2020). The Biological Diversity Protocol (BD Protocol). National Biodiversity and Business Network - South Africa, 123p. Available at: https://nbbnbdp.org/biodiversity-protocol/

04

HOW TO MEASURE BUSINESS IMPACTS ON BIODIVERSITY

4.1 Biodiversity impact drivers

4.1.1 Background

This section outlines the concept of impact drivers and how to identify them to enable a better understanding of the link between business activities and changes in biodiversity state. Impact drivers are exerted by business activities (e.g., pollution from emissions or land conversion by agriculture) and result in a change (positive or negative) in the state of biodiversity. These impacts in turn have consequences (positive or negative) for business and society.

Impact drivers are also called 'pressures' in the Drivers, Pressures, State, Impact, Responses (DPSIR) framework [18] advocated by SBTN and 'direct drivers of change' under the Convention for Biological Diversity (CBD) [19] and IPBES [20]. Indirect drivers of change, such as the broader underlying causes of the direct drivers like population change and technological innovation (also called 'Drivers' in the DPSIR framework), are excluded from these recommendations as they cannot be directly attributed to, or managed by, a company.

An impact driver generally has three main characteristics: magnitude (e.g., amount of contaminant, noise intensity), spatial extent of the impact driver (e.g., area of land changed) and temporal extent (e.g. duration of persistence of contaminant). Impact drivers are neutral; they may result in both positive and negative changes in the state of biodiversity and associated impacts on business or society (e.g., impacts on human wellbeing). Several impact drivers, either from one company or combined with those of other organizations, can result in cumulative impacts.

To assess how an impact driver from a specific business activity gives rise to changes in biodiversity, 'impact pathways' must be understood. Business impacts on biodiversity may be via direct or more complex ecological pathways (e.g. water emissions and consequent changes in water quality may directly influence algal populations which may then indirectly affect shellfish and human health). Irrespective of the pathway there is a need for a business to show a causal link for which their contribution to a change in biodiversity state can be measured, managed and accounted for.

Measurement of impact drivers may act as inputs to models that estimate associated changes in biodiversity state, such as ecosystem condition, or can be used to interpret or anticipate trends in biodiversity state indicators. Identification of material impacts is also needed to identify relevant parts of the value chain on which to focus for measurement of impact drivers. Guidance and standards already exist or are in development for measuring impact drivers, e.g., Transparent, the GHG Protocol and ISO standards for water [21], hence criteria for measuring impact drivers are not addressed within these recommendations. The recommendations focus on identification and prioritisation of impact drivers based on a materiality assessment.

4.1.2 Universal recommendations

Impact drivers and pathways should reflect those identified through the IPBES assessment and required by relevant policy.

Materiality criteria should guide the scoping or prioritisation process (see Section 4.3). As a minimum the impact drivers considered should reflect the identified overarching impact drivers through the IPBES global assessment (land and sea use change, climate change, resource exploitation, pollution and invasive alien species) and those required by law. It is important that the impact drivers that are considered in the measurement approach are justified. Table 4 sets out some examples of the indicators that could be used to track the IPBES impact drivers. The scope should include impact drivers in all realms (land, freshwater, air and marine). Fragmentation and isolation are further impact drivers highlighted by the Convention for Biological Diversity, but these can be seen as the effects of extraction or land use change. Restoration is interpreted in these recommendations as a land/sea use change. The potential for a company's impact drivers to become material due to cumulative effects should be considered when scoping priorities.

Where data exist, direct physical measurement will be possible. However, where data are unavailable (e.g., a company with a complex supply chain wishes to understand the impact drivers generated by its supply chain activities), turnover value, purchases and volumes of commodities purchased could be used to calculate potential impact drivers using established environmentally extended input-output databases.

18 EEA. (1999). Technical report No 25/1999. Environmental indicators: Typology and overview.

19 Secretariat of the Convention on Biological Diversity, Netherlands Commission for Environmental Assessment (2006). Biodiversity in Impact Assessment, Background Document to CBD Decision VIII/28: Voluntary Guidelines on Biodiversity-Inclusive Impact Assessment, Montreal, Canada.

20 IPBES (2019): Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. 1148 pages. https://doi.org/10.5281/zenodo.3831673

21 ISO (2017) ISO Water. https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100293.pdf

Table 4: Impact drivers for consideration

Impact drivers (IPBES drivers of change)	Example indicator
Land and sea use change	Annual land use change (ha, km^2, m^2)
Green House Gas Emissions (Climate change)	Greenhouse gas emissions (Tons of CO_{2e})
Pollution	Ecotoxic emissions (µg/l or parts per million)
	Nitrogen and phosphorous released to water (mg/l)
	Organophosphate pesticide discharged to soil (kg/ha)
Natural resource use and exploitation	Quantity of individuals of a species harvested annually (e.g. Tons of fish harvested/year),
Introduction of invasive alien species	Extent of surface covered by introduced invasive alien species. (Ha)

Use a priority filter to identify the most significant impact drivers based on characteristics of the impact driver (spatial extent, frequency and duration, and magnitude) and characteristics of biodiversity (exposure and sensitivity to impact drivers).

To assess the importance of a potential impact driver in influencing the state of biodiversity, five factors can be considered, three of them addressing the impact driver and two of them the biodiversity affected, (Table 5.). These criteria for low, medium and high priority are qualitative and act as guidance (e.g., occur over a small area, of low magnitude). The specific characteristics of the biodiversity element (e.g., the spatial extent of an ecosystem type and its sensitivity to an impact driver) should then be considered to develop into a more refined assessment. In Environmental Impact Assessment these are typically considered in an impact matrix[22] or more sophisticated modelling approaches that integrate multiple factors.

22 e.g. Leopold, LB., Clarke, F.E., Hanshaw, B.B., Balsley, J.R. (1971). A Procedure for Evaluating Environmental Impact. Washington, D.C.: 19 – via U.S. Geological Survey; Pastakia, C.M.R. and Jensen, A. (1998). The Rapid Impact Assessment Matrix for EIA. Environmental Impact Assessment Review Volume 18: 461 – 482.

Table 5: Factors influencing the priority of impact drivers

Factor	Low	Medium	High
■ **1. The spatial extent over which the impact driver occurs.**	The impact driver and its resulting effects on biodiversity state are expected to occur over a small total area with respect to the area of specific biodiversity.	The impact driver and its resulting effects on biodiversity state are expected to occur over a medium total area with respect to the area of specific biodiversity.	The impact driver and its resulting effects on biodiversity state are expected to occur over a large total area with respect to the area of specific biodiversity.
■ **2. The frequency and duration of the impact driver.**	The impact driver and its resulting effects on biodiversity state are expected to last a short time (e.g. only during construction/set-up) or occur only a small number of times in the project life cycle.	The impact driver and its resulting effects on biodiversity state are expected to occur regularly throughout the project life cycle (e.g. from several times per year to several times per month).	The impact driver and its resulting effects on biodiversity state are expected to be permanent or occur continuously throughout the project life cycle.
■ **3. The magnitude of the impact driver, e.g., concentration of contaminant.**	The magnitude of the impact driver is low relative to the sensitivity of the biodiversity element.	The magnitude of the impact driver is moderate relative to the sensitivity of the biodiversity element.	The magnitude of the impact driver is high relative to the sensitivity of the biodiversity element.
■ **4. Exposure of biodiversity to impact driver[23]**	Within the impact driver's area of influence material ecosystems and species do not or almost not occur.	Within the impact driver's area of influence material ecosystems and/or species do occur but only to a limited degree.	The impact driver's area of influence affects an area with important surface of material ecosystems and/or important numbers or high diversity of material species (e.g., biodiversity hotspot).
■ **5. Sensitivity of biodiversity to impact driver.**	The present material ecosystems and/or species are not sensitive to the impact driver.	The present material ecosystems and/or species are to a limited extent sensitive to the impact driver.	The present material ecosystems and/or species are highly sensitive to the impact driver.

23 Exposure and sensitivity are factors determining the vulnerability of a species or ecosystem.

4.2 Methodologies to measure business impacts on biodiversity

4.2.1 Background

This section addresses how impacts of business activities on biodiversity can be measured. Measurement of business dependencies on biodiversity are covered in Section 5. Corporate measurement of impacts on biodiversity can measure the state of biodiversity and/or flows of ecosystem services. Here, the focus is on measuring the state of biodiversity that underpin the stocks of natural capital, through measuring change in the indicators of state discussed in section 3. This measurement of impacts on stocks is fundamental to assessing and valuing changes in ecosystem service flows.

To achieve this, a typology of methodologies and their associated characteristics is provided below. Accompanying the typology is a set of technical criteria and underlying data requirements for implementation. Adhering to the technical criteria is critical for ensuring the chosen methodology accurately reflects changes to biodiversity state.

Note that individual corporate biodiversity measurement approaches or tools are not described within the recommendations. This is to ensure the recommendations do not become outdated as available measurement approaches improve. Instead, the methodologies underpinning the available approaches and the technical criteria to ensure robust assessment are described.

Methodologies available to collect data and measure indicators of biodiversity state can be separated into three categories. These categories are not mutually exclusive and can be combined within a measurement approach as follows:

- Primary biodiversity state data: collected in-situ for the purpose of the assessment using 'on the ground' surveys or remote sensing, including eDNA and bioacoustics surveys.
- Secondary biodiversity state data: used by the assessment but collected for broader purposes, including geospatial data layers that can be overlaid with geographic location data of business activities. These geospatial data layers may be produced through different methods, including the outputs of models (e.g. species distribution models) or through remote sensing:
  - At the *species* level, data layers on the ranges of different species (range layers) can be used to predict the species that may be present at different sites or sourcing locations. Each will have differing levels of accuracy depending on factors (e.g., whether species ranges have been refined based on availability of habitat, how wide ranging the species is). Information on the threat status of the species, and the activities that threaten them, can provide an indication of the likely contribution that business activities may be having on driving population trends and threat status.
  - At the *ecosystem* level, data layers reflecting change in the extent and condition of ecosystems can be applied, including levels of habitat fragmentation and connectivity.
- Modelled pressure-state data: model-based 'footprinting' approaches are commonly used for measuring changes in ecosystem condition, or changes in species' area of habitat.
  - Models quantify how the magnitude of different pressures affects the state of biodiversity. These are referred to as 'pressure-state' relationships and within corporate footprinting approaches are often based on global data.
  - Modelling results are applied locally to estimate how company-level pressures will cause changes in ecosystem condition ('footprint').
  - Modelled biodiversity footprints will be more accurate when using directly measured primary pressure data, than when using estimated pressures or sector averages.
  - There are currently fewer pressure-state models for the marine environment applied in corporate measurement approaches.

Interpretation of the results acquired after using the chosen methodology will depend on the type of data that is collected and used. Primary and secondary biodiversity state data are most likely to provide an estimate of *actual* impact to biodiversity state. It is important to note that directly collected primary data based on sampling will still be measured with a degree of error and variability and depends on the sampling approach used.

In the absence of any ground-truthing or use of primary state data, model-based approaches provide only an estimate of *potential* impact, rather than measuring actual impact.

4.2.2 Universal recommendations

Methodologies should be selected based on four characteristics of: spatial precision, accuracy of measurement, responsiveness to mitigation and feasibility to apply at scale.

Determining which methodology (Figure 5) is most appropriate for assessments should be based on four characteristics described in Table 6 below. This is because the requirements for measurement approaches around these characteristics will differ depending on the business context.

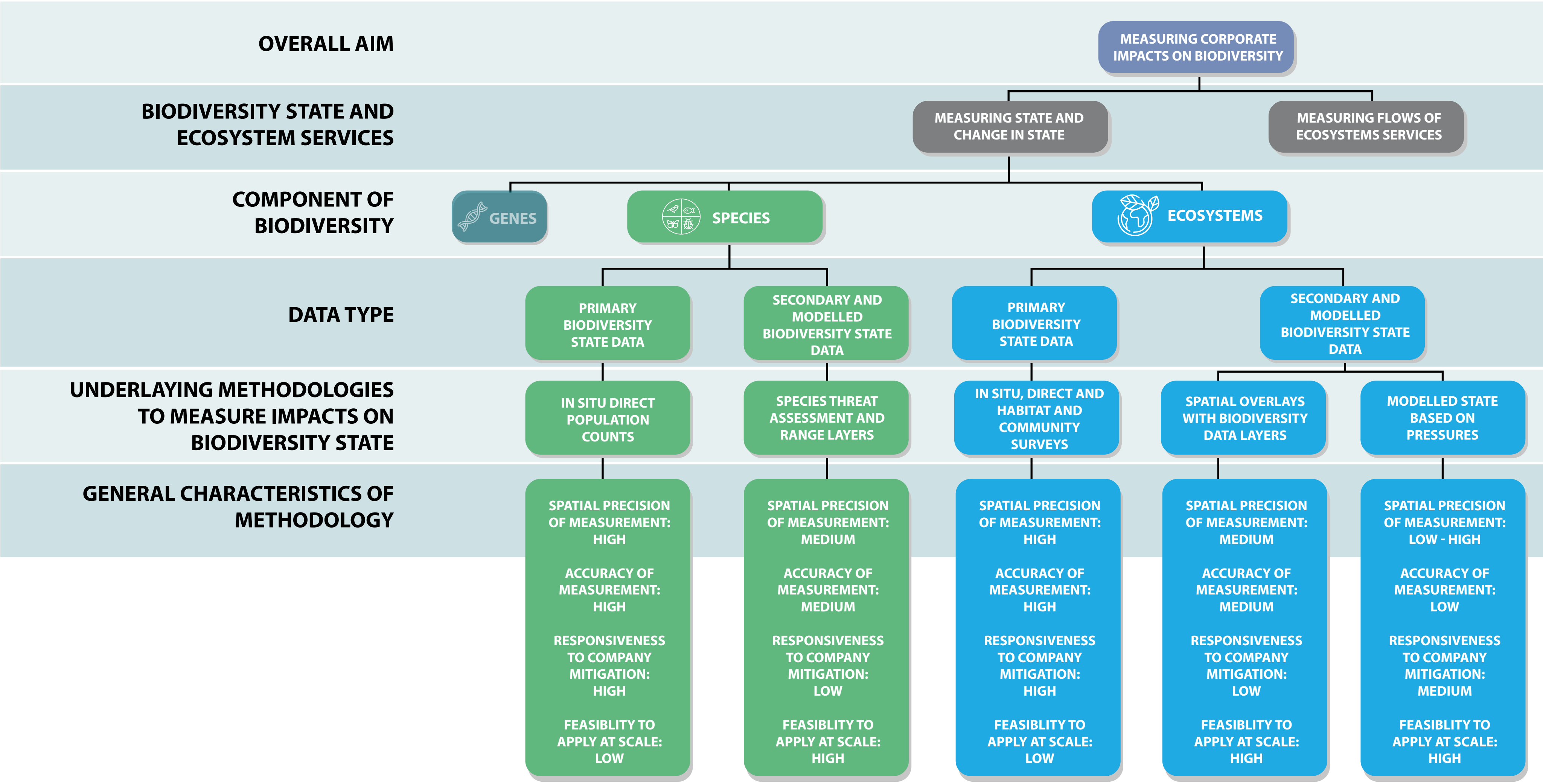
Table 6. Four characteristics to consider when determining methodology suitability.

Methodology characteristics	Definition	'High' level of characteristic	'Medium' level of characteristic	'Low' level of characteristic
Spatial precision of state measurement	Refers to whether the resulting measure considers the geographic location of the activity and the biodiversity within the area.	State at specific location measured.	Biodiversity state across wider area than specific location represented (e.g. ecoregion).	State measure has no spatial specificity (e.g. results are globally applicable).
Accuracy of measurement	Refers to how well the measurement reflects changes that are actually occurring 'on the ground'.	Measure estimates actual state change 'on the ground'.	Reflects on the ground-changes but changes are not ground-truthed.	Estimates state-change based on pressures.
Responsiveness of measurement to mitigation	Refers to whether the approach produces a metric that can change over time in response to changes in company management interventions.	Metric responds to site-level mitigation interventions at the appropriate temporal scale.	Metric responds to broad-level reductions in pressure (e.g. reduced land intensity).	'Snap-shot' metric that does not reflect company management interventions but may change based on avoidance of areas.
Feasibility to apply at scale	Refers to the relative feasibility of applying the approach over A) multiple sites within an organisation or B) across value chains or C) across portfolios of companies.	Able to be replicated across business activities rapidly and does not necessarily require location data.	Able to be applied rapidly at scale but requires location data.	Involves in-situ data collection so often unfeasible to apply at scale.

As an example, a company completing a site-level assessment would ideally use in-situ, primary biodiversity state data (Figure 5). This is because the spatial precision, accuracy of measurement and responsiveness to mitigation would all be 'high' and it is feasible for the company to collect data on site, and this would enable the company to monitor the effectiveness of their impact mitigation measures. Use of the same methodology, however, might mean that the feasibility to apply the methodology at scale, would be 'low' if applying the methodology across a wider range of sites, especially if data are not normalised across sites.

Contrasting this, a company wishing to assess impacts across the value chain is likely to choose a methodology with a 'high' feasibility to apply at scale to be able to compare and aggregate impacts (across value chains). This could be achieved through model-based methodologies relying on sector-average pressure data. In turn, the same model-based methodology may only provide a 'medium' responsiveness of measurement to mitigation, and 'low' spatial precision, and accuracy. The spatial precision and accuracy in this example could be improved through using primary directly measured pressure data to model state, rather than sector averages.

Figure 5. Typology of approaches for the three aspects of biodiversity. Typology is based on the 'data type' required (primary or secondary) and the underlying approaches used to measure impact [24]



24 General characteristics of methodology are true if best available data is used and technical criteria described in Table 7 are met. Note that measuring ecosystem service flows are outside the scope of the recommendations.

Good or best practice data collection techniques should be followed to ensure methodology strengths are met.

To ensure the general characteristics of each methodology are met, the data collected must be robust. To achieve robust data collection, technical criteria for 'good' and 'best' practice are described for species and ecosystems in Table 7 below.

Best practice data collection can help address some of the limitations associated with different methodologies. For example, the accuracy of measurement for the methodology 'modelled state based on pressures' could be improved using pressure data with high accuracy (i.e., direct measurement of company level pressure data). Even if this is the case, however, the results provide estimates of changes to biodiversity state that are not specific to the location where impacts are occurring. Although the accuracy will be higher, the spatial precision of the state measure is still low. Spatial precision can be improved in these approaches through refining pressure-state relationships to more specific locations or contexts.

Table 7. Examples of Good and best practice for collecting species and ecosystem data (based on expert opinion).

Species		Ecosystems		
In-situ direct population count	**Species threat assessment and range layers**	**In-situ habitat and community surveys**	**Spatial overlays with biodiversity data layers**	**Modelled state based on pressures**
good practice				
■ Site-based data are collected according to legally and/or generally accepted survey protocols for the species or taxonomic group ■ Data are collected at the appropriate time of year for the species or taxonomic group ■ Biodiversity data collected undergoes rigorous quality assurance review.	■ Data are used at an appropriate scale based on the resolution of underlying range data ■ Threat assessments are based on agreed standards such as the international IUCN red list and national or local red lists.	■ Site-based data are collected according to legally accepted or standardised survey protocols, notably for condition or integrity assessment ■ Data are collected at the appropriate time of year ■ Biodiversity data collected undergoes rigorous quality assurance review.	■ Data layer needs to have a temporal component (change over time) to estimate impact ■ The resolution of data must be at an appropriate level to attribute change to company operations.	■ Pressure-response model used to assess biodiversity state or impact, based on peer-reviewed studies. ■ 'Total footprint' disaggregated into direct and indirect impacts ■ Full transparency is maintained on the pressures included in any estimate of impacts on state, and any uncertainties should be properly disclosed.
best practice (in addition to good practice criteria)				
■ Multiple surveys are completed to accurately reflect species trends and/or presence or absence. ■ Traditional ecological knowledge is embedded within data collection programme.		■ Multiple surveys are completed to accurately reflect ecological trends ■ Use of eDNA and bioacoustics surveys for data collection ■ Traditional ecological knowledge is embedded within data collection programme.		■ Use of primary pressure data leads to a more accurate measurement of impact on state ■ Use of a spatially refined model that models regionally specific biodiversity response to pressures ■ Modelled impacts on biodiversity complemented with primary or secondary in-situ biodiversity state data, to interpret potential significance ■ All material pressures should be considered by the pressure-response model and known uncertainties should be properly reported.

Assessment of biodiversity impacts should be conducted against a clear and transparent baseline supported by evidence

A key consideration when measuring biodiversity impacts is the need to specify a "starting point" or "benchmark" from which to compare business activities' impacts for monitoring change, especially in the context of reporting and disclosure. Baselines represent the known biodiversity at a fixed point in history and are often limited by data availability. The choice of baseline will directly influence the assessment of the impact. A related concept is reference state. This is a previous state of biodiversity for comparison e.g., pre-industrial, or a desired state that a company or investor hopes to achieve. Some measurement indices of ecosystem condition use a fully 'intact' state (e.g., primary vegetation that is largely absent of human pressures) as a reference state to calibrate relative declines in condition.

The choice of baseline will depend on the business context. For example, for screening risks the baseline will often be the situation at the time of the first risk screening. As risk screening can be periodically repeated, the baseline will offer a good basis for assessing how risks have evolved (e.g., due to changes in presence of protected species and/or designated or planned protected areas). For measuring impacts, baselines can consider the time business activities begin, but there is often a need to account for historic impacts, particularly for land use change that may occur prior to – but driven by - business activities. The selection of baseline needs to be justified (be transparent and supported with sufficient evidence). Often multiple baselines may be required to capture changes in relation to different time scales.

The implications of time lags between impact and changes in biodiversity state, and the need to consider historic impacts should be considered by the assessment methodology

Long time lags may exist between the impact drivers of a business activity and the subsequent changes to biodiversity state. This long-time horizon may have profound implications for actions to mitigate risks of ecosystem collapse[25]. Efforts to improve the environment and ability to measure positive impacts from mitigation actions may suffer from recovery time lags.

Similarly, many historical impacts may be persistent and long lasting, affecting the assessment of current business impacts. It is important that both time lags, and historical influence, are acknowledged when using changes in biodiversity state to evaluate biodiversity performance. Some measurement approaches explicitly address these issues, for example:

- Time integration: Land use-related impacts on biodiversity may take place during a certain period and converted land may at some point in time recover to its previous biodiversity state. In life cycle assessment, future impacts on biodiversity are integrated over a predefined time horizon (usually 100 years).
- Dynamic vs static impacts: To address historical influence, some approaches differentiate the 'dynamic' impacts during the period assessed, (i.e., footprint caused by changes, consumptions or restorations) from 'static impacts' (i.e., 'all the 'persistent' or 'long-lasting' effects which remain over time and reduce biodiversity from an intact reference state). Static impacts can be considered as an 'ecological opportunity cost'. In life cycle assessment, conversion impacts are separated from occupation impacts.

4.3 Technical criteria for measuring biodiversity impacts in different business contexts

To ensure measurement is completed in a scientifically robust way, good practice and best practice criteria are provided for two core business needs: 1) screening risks and opportunities and 2) measuring impacts to biodiversity state (see Section 2 on business context). These differ according to whether the assessment is for site and project level, or for supply chains as shown in Figure 6.

Good practice recommendations should always be implemented, as the criteria provide a foundation for scientifically credible measurement. It is however recommended that best practice be followed for more accurate and robust assessments, and this is strongly recommended for highly material impacts.

25 Dasgupta, P. (2021), The Economics of Biodiversity: The Dasgupta Review. London: HM Treasury

Figure 6. Good and best practice criteria for site and supply chains

SITE & PROJECT LEVEL

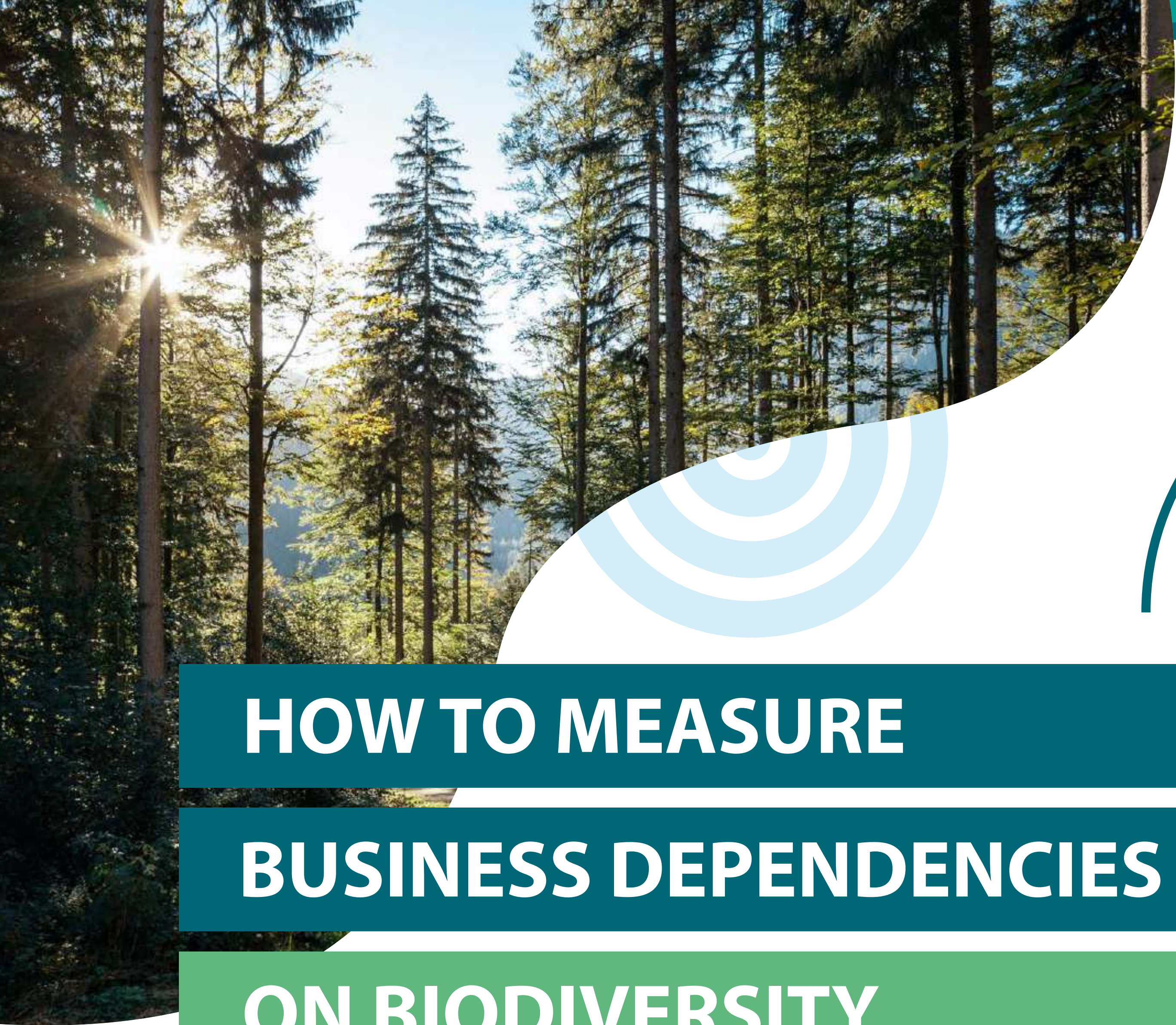
GOOD PRACTICE | BEST PRACTICE

	WHAT TO MEASURE	CHARACTERISTICS OF MEASUREMENT APPROACH	MOST APPLICABLE METHODS
SCREEN (good practice)	○ Potential presence & proximity to material species & ecosystems ○ Potential impacts based on **sector-average impact drivers**	○ **Feasibility (screening) - High** (able to apply screening at multiple sites) ○ **Spatial precision - Medium** ○ **Accuracy - Medium** (measures reflect potential presence & impacts on species & ecosystems, but are not ground-truthed)	✓ Spatial overlays with static biodiversity data layers (ecosystem extent / condition) ✓ Species threat & range layers ✓ Screening using modelled state based on pressures
MEASURE (good practice)	○ Ecosystem extent & condition indicators; or ○ Measurement of material impact drivers (at least land use change) ○ Periodic measurements that start from a baseline, & measurements that reflect changes in state resulting from company-specific impact drivers	○ **Responsivness - Medium** (able to reflect how changes in pressures affects biodiverisity state) ○ **Spatial precision - Medium** ○ **Accuracy - Medium** (measures reflect potential presence & impacts on species & ecosystems, but are not grounded-truthed)	✓ Primary data based on surveys ✓ Measuring using responsive biodiversity data layers ✓ Measuring using modelled state based on pressures
SCREEN (best practice)	○ Potential presence & condition of material species & ecosystems, results **ground-truthed** ○ Species extinction risk indicators ○ Potential impacts based on **company specific impact drivers**	○ **Feasibility (screening) - High** (for screening, able to apply for screening at multiple sites) ○ **Spatial precision - High** (captures species & ecosystems at site level) ○ **Accuracy - High** (measures reflect actual, ground-truthed presence of/impacts on species & ecosystems)	✓ Modelled state based on pressures **(using company specific impact driver data)** for screening only ✓ Species threat & range layers
MEASURE (best practice)	○ Ecosystem extent & condition for **individual ecosystem assets** ○ Species extinction risk indicators ○ Periodic measurements that start from a baseline, & measurements that reflect changes in state resulting from **site-level mitigation measures** Based on primary data on **material impact drivers**	○ **Responsiveness (measuring impacts) -** reflects effects of site-level mitigation measures ○ **Spatial precision - High** (captures species & ecosystems at site level) ○ **Accuracy - High** (measures reflect actual, ground-truthed presence of/impacts on species & ecosystems)	✓ Primary data based on surveys

SUPPLY CHAIN LEVEL

GOOD PRACTICE | BEST PRACTICE

	WHAT TO MEASURE	CHARACTERISTICS OF MEASUREMENT APPROACH	MOST APPLICABLE METHODS
SCREEN (good practice)	○ Ecosystem extent & condition & species extinction risk at broad-scale sourcing regions	○ **Feasibility (applicable for screening) - High** ○ **Spatial precision - Low** ○ **Accuracy - Low** (e.g., can measure potential impact based on sector-average impact diver-data)	✓ Spatial overlays with biodiversity data layers (ecosystem extent / condition) ✓ Species threat & range layers
MEASURE (good practice)	○ Potential impacts on ecosystems based on volumes of materials sourced (or revenue) within each **country** sourced from	○ **Responsivness - Medium** (responsive to changes in impact drivers along supply chain) ○ **Spatial precision - Low** (screening/measuring can use models based on global data) ○ **Accuracy - Low** (e.g., can measure potential impact based on sector-average impact driver-data)	✓ Modelled state based on pressures (sector averages)
SCREEN (best practice)	○ Ecosystem extent & condition & species extinction risk at specific sourcing locations ○ Potential impacts on ecosystems based on volumes of material sourced (or revenue) within each **country** sourced from	○ **Feasibility (applicable to screening) - High** ○ **Spatial precision - Medium** (reflects differences in potential impact based on sourcing region) ○ **Accuracy - Medium** (screens potential impact based on company-specific impact driver data)	✓ Modelled state based on pressures **(using company specific impact driver data)** for screening only ✓ Species threat & range layers
MEASURE (best practice)	○ Measurement of potential impacts reflects differences in biodiversity between sourcing locations and production processes at sourcing locations ○ Measurement of impact driven & state at sampled sites using primary data is used to complement full-supply chain measures	○ **Responsiveness - Medium -** (reflects changes in production practices at source location) ○ **Spatial precision - Medium** (reflects differences in potential impact based on sourcing regionl) ○ **Accuracy - Medium** (screens/measures potential impact based on company-specific impact driver data)	✓ Modelled state based on pressures **(including land use intensity)** ✓ **Primary data** based on species/habitat surveys (for measuring impact) **at sampled sites**



05

HOW TO MEASURE BUSINESS DEPENDENCIES ON BIODIVERSITY

5.1 Background

Businesses are vulnerable to the operational and systemic risks associated with declines in the state of biodiversity. Measuring business dependencies on biodiversity is needed to assess and manage these risks and guide positive action, although this is less evolved than measuring impacts, with fewer established measurement approaches, metrics and tools. It is anticipated that these will evolve over time in response to increasing number of initiatives calling for businesses to measure dependencies as well as impacts. Whilst this section focuses on materiality from a business value perspective, an understanding of the dependencies of society on biodiversity is needed for a full double-materiality perspective.

Businesses may depend on biodiversity, through ecosystem services, directly, for example through wild sourcing of ingredients, or may depend on the final ecosystem services that biodiversity underpins, for example clean water supported by filtering ecosystem services. Broadly speaking, the condition of ecosystems relates to their capacity to provide ecosystem services[13]. This is because the biophysical variables describing condition relate to the underlying functions of the ecosystem that provide services. While ecosystems in poor condition may still provide ecosystem goods and services, they may be less resilient to future change[26], and the long-term provision of services may be at risk.

Measuring biodiversity dependencies involves understanding which ecosystem services are material to the business, and which ecosystem types are most likely to be providing those services across business value chains. This allows an understanding of how current and future trends in the extent and condition of ecosystems may affect business dependencies on ecosystem services. Although measuring ecosystem service flows may most directly assess the current state of business dependencies, a sole focus on ecosystem service flows when measuring dependencies could lead to poor business decision-making, as risks associated with declining capacity of the ecosystem to provide services into the future will be missed.

It is important to note that many impact drivers result from business dependencies on resources from ecosystems (e.g., water abstraction leading to a change in condition of wetlands). In some cases, business impacts on biodiversity may feedback directly on their own dependencies, but in many cases business dependencies will be affected by declines in ecosystem condition that occur independently of business activities. Therefore, changes in extent and condition that occur independently of impact drivers resulting from business activities should also be considered when measuring dependencies. Further information on valuing changes in ecosystem services is provided in Section 6.

5.2 Universal recommendations

Identification of ecosystem service dependencies should use a structured framework and consider spatial context.

Established frameworks such as the UN SEEA[17] link specific 'economic actors' to specific ecosystem services they depend on. These can inform a list of ecosystem services that businesses within a given sector are likely to depend on for their operations, for example through enabling the production processes integral to a sector's economic activities or reducing potential disruptions to these processes. Ecosystem service dependencies may also vary by location, for example operating in coastal regions exposed to storm surges will likely have higher dependency on coastal hazard protection services more than inland operations.

Use a prioritisation filter to screen the materiality of identified ecosystem service dependencies, for example based on potential loss in production processes and associated financial losses should ecosystem service flow decline.

To assess materiality of business dependencies on ecosystem services, two factors can be considered in relation to the role of ecosystem services in the production processes of a business' operations,[27] as shown in Table 8 below:

26 Chambers, J. C., Allen, C. R., & Cushman, S. A. (2019). Operationalizing ecological resilience concepts for managing species and ecosystems at risk. Frontiers in Ecology and Evolution, 7, 241.

27 Natural Capital Finance Alliance (Global Canopy, UNEP FI, and UNEP-WCMC) (year2022). ENCORE: Exploring Natural Capital Opportunities, Risks and Exposure. [On-line], [insert month/year of the version downloaded], Cambridge, UK: the Natural Capital Finance Alliance. Available at: https://encore.naturalcapital.finance. DOI: https://doi.org/10.34892/dz3x-y059.

Table 8. Materiality criteria matrix for ecosystem service dependencies

		Consequence of the potential loss of functionality in the production proce ss (financial losses)?		
		Limited – disruption to the production process doesn't materially affect the company's profits.	**Moderate –** disruption to the production process materially affects the company's profits.	**Severe –** there is a reasonable possibility that the disruption in the production process will affect the financial viability of the company.
Likelihood of loss of functionality in the production process if the ecosystem service is disrupted?	**Severe –** disruption in the service provision prevents the production process.			
	Moderate – the production process can continue only with important modifications (e.g. slower production or use of substitutes.			
	Limited – the production process can continue as is or with minor modifications.			

The definitions of 'limited', 'moderate' and 'severe' for both loss in production processes and associated financial losses will vary depending on the size of the business and specific context. Therefore, these categories should be complemented by transparent quantitative thresholds.

Ecosystem types supporting dependencies should be identified, and current and future trends in their extent and condition should be assessed.

Different ecosystem types support different ecosystem services to varying extents, because of variations in their compositional, structural and functional characteristics. Structured ecosystem services frameworks list common ecosystem types that support different ecosystem services. These can be used to identify the ecosystems that are most likely to support business dependencies. For example, mangrove ecosystems are linked to the service of coastal flood protection.[28]

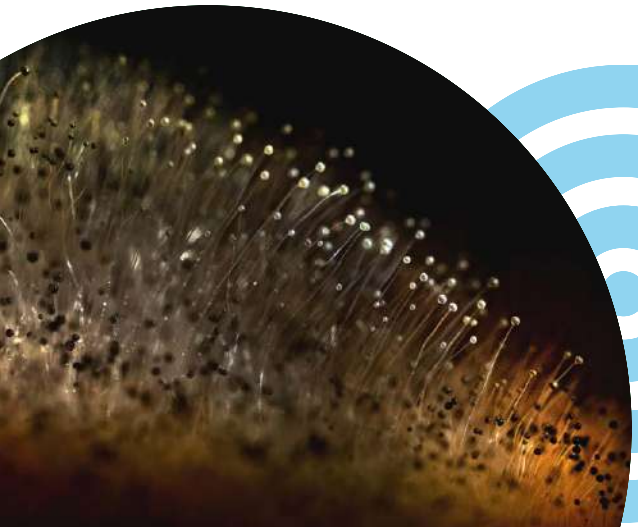
An assessment should be made of how declines in condition of these ecosystems may affect the capacity to supply the specific services that are depended upon. This can guide a more targeted and harmonized selection of ecosystem condition indicators (Section 3) that best reflect the functions that supply that service, as well as an understanding of the relative levels of risk associated with declines in condition. For example, increased fragmentation in mangrove ecosystems affects their structural integrity and may reduce their capacity to provide coastal hazard defence services. This may mean that business operations are at an increased risk of disruption from flooding.

An important element of understanding links between biodiversity state changes and business dependencies in understanding future trends in state, as this indicates the resilience of ecosystem service flows into the future. Practical, packaged business facing tools for assessing trends in biodiversity state that are independent of business impacts are however limited. Secondary geospatial data layers, such as global layers showing change in ecosystem extent (e.g., showing forest cover change through time) or ecosystem condition (e.g., showing change in intactness of ecological communities through time) as well as the results of future scenario models may be used to understand current and future trends.

28 Lee, S. Y., Primavera, J. H., Dahdouh-Guebas, F., McKee, K., Bosire, J. O., Cannicci, S., ... & Record, S. (2014). Ecological role and services of tropical mangrove ecosystems: a reassessment. Global ecology and biogeography, 23(7), 726-743.

06

VALUATION OF IMPACTS AND DEPENDENCIES



While the previous sections focused on how to measure changes in the state of biodiversity, this section focuses on valuation. This involves understanding how changes in the state of biodiversity can affect the delivery of ecosystem services and what should be considered when valuing the costs and benefits resulting from these changes in biodiversity. It is important that all valuations of biodiversity impacts and dependencies are underpinned by robust measurement of the underlying changes in the state of biodiversity, as described in Section 3.

Understanding value of biodiversity requires a broad understanding of trade-offs of business decision-making, especially when deciding among different management options. For example, in the short term the most financially profitable approaches may favour extractive monocultures such as timber plantations or monoculture crops with little or no biodiversity. However, valuation of the benefits supported by biodiversity can help take account of a wider range of values. Accounting for the long-term resilience and value of business activities may demonstrate that biodiverse approaches such as nature friendly farming or alternative land uses represent the highest value option for businesses and society.

6.1 Types of value provided by biodiversity

6.1.1 Background

The causes of the global biodiversity crisis and the opportunities to address them are tightly linked to the ways nature is valued in political and economic decisions at all levels. Integrating biodiversity in decision-making processes by undertaking valuation can contribute to a sustainable and just future for businesses undertaking the assessment and the wider society the business sits within. The valuation recommendations outlined here are focussed on business decision-making processes and compliments the IPBES Values Assessment summary[29], which demonstrates that a huge range of values exist.

One way people derive value from nature is through ecosystem service flows that come from natural capital stocks. In general, higher ecosystem condition equates to a greater range and higher overall quantity, quality, and resilience of the services provided by the ecosystem, which underpin the benefits to business and society[7].

The value provided by biodiversity can be broadly broken down as follows:

- **Direct value**: In some instances, biodiversity itself will add value directly to people or business through direct use of the natural resource, for example, through providing food, or in tourism based on wildlife watching. The value captured through direct value is under representative of the full value of biodiversity and is supplemented (but not necessarily additive) by the other values described here.
- **Underpinning (or indirect) value:** More commonly, biodiversity has value through its role in the supporting of the delivery of final ecosystem services. Systems such as water cycles, carbon cycles, and crop production, which are essential to support final ecosystem services, rely on the interactions of living things and the functioning of ecosystems. This underpinning value contributes to the resilience of an ecosystem in the long term and the provision of final ecosystem services in the short term. The emergent properties of complex interactions of species and ecosystems can be hard to value and are often absent from current decision-making processes, despite their importance.
- **Insurance and options value**: Some goods and services can be delivered with relatively low biodiversity but are vulnerable to change from factors such as pests, diseases, or climatic instability. Biodiversity provides options for delivery of ecosystem services from alternative sources in the future (for example new crop species that might be domesticated for agriculture or new medicines). Biodiversity also provides benefits that are not yet recognized or services that will only become beneficial in the context of future technological or societal innovations due to future changes to the natural environment or changes to the way people live or what they value.
- **Non-use value**: These include several values, such as bequest value (knowing that future generations will continue to benefit from biodiversity), altruist value (knowing that other people of the same generation can benefit from biodiversity), and existence value (connected to our desire to protect biodiversity irrespective of whether we derive any value from it other than associated with our knowledge of its existence).
- **Intrinsic value**: Biodiversity has value independent of human use of the goods and services it provides. This value is associated with the moral right of living things to exist. This type of value is non-human centred, and consequently can be assessed and acknowledged but not using economic methods. [30]

29 IPBES (2022) Methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. P. Balvanera, U. Pascual, M. Christie, B. Baptiste, D. González-Jiménez (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6522522

30 Ahn, S., Amankwah, E., Asah, S.T., Balvanera, P., Breslow, S.J., Bullock, C. and Figueroa, E., (2015) Preliminary guide regarding diverse conceptualization of multiple values of nature and its benefits, including biodiversity and ecosystem functions and services (deliverable 3 (d)). Ecol Soc, 19(4), p.26.

The terms 'instrumental value' and 'relational value' are also used to describe and categorize biodiversity values (i.e., IPBES). Instrumental value encompasses the direct value, underpinning value, insurance and option value and non-use value outlined above.[31] Relational value refers to the meaningfulness of interactions between people and nature, and interactions among people (including across generations) through nature (e.g., sense of place, spirituality, care, reciprocity)[29].

6.1.2 Universal recommendations

It should be clear which types of biodiversity values are assessed and which are omitted from any indicators presented but still all values require consideration in decision-making processes.

Many biodiversity valuation approaches focus primarily on assessing flows of ecosystem services from changes in state of biodiversity. The valuation of ecosystem service approach mainly captures the direct value of nature to business and society, and it may be difficult to accurately capture other values from biodiversity. Where this is the case, it is still beneficial to highlight that other additional types of values exist. This should be considered during decision-making processes, as well as considering who may be affected by changes on biodiversity in the local environment.

Consequently, when estimating biodiversity values, it should be clear which types of values have been assessed and the approach used to capture them (specifying whether these are: direct, underpinning, insurance and option, non-use and/or intrinsic). When any value has not been captured, it should be made explicit that the value from changes in biodiversity are likely to be larger than may be indicated.

It should not be assumed that all values of biodiversity can be derived simultaneously. The values captured are not always additive because trade-offs may have to occur between different uses. For example, a forest cannot provide timber whilst also providing existence or bequest values. This should be considered when using different values in decision-making processes.

6.2 Approaches to valuation

6.2.1 Background

Assessing impacts on the business.

Business itself may be affected by the changes in biodiversity that result from their own activities. These include any financial costs or benefits that directly affect the business bottom line as a result of their dependencies (see Section 5). They could also include less tangible impacts that may affect the bottom line indirectly, such as reputational impacts, delays in permitting, or the relative ease or difficulty of recruiting or retaining employees. Impacts on the business may, but not exclusively, relate to:

- The cost from fines or legal claims for environmental damages ('legal and regulatory risk'[32]). This may be linked to measured changes in biodiversity (e.g. restoration of environmental accidents).
- The cost from taking actions to mitigate adverse impacts on biodiversity (e.g. mitigation hierarchy or no net loss targets) or to comply with environmental regulatory standards (e.g. use of native species in forest plantations) ('legal, regulatory and reputational risk').
- The cost and/or revenue from regulatory environmental market mechanisms, whereby companies increasingly need to pay for the use of or impacts to natural capital or get paid for environmental enhancements they provide (e.g. purchasing or selling biodiversity offsets in response to environmental damages, 'legal and regulatory risk').
- The cost of production inputs (e.g. the purchase costs of timber) and any costs relating to the reduction of operations ('operational risks').
- The cost and/or benefit of outputs (e.g. increased cost of eco-tourism permits, increased revenue from nature-based solutions or perceived value of goods and services from customers) ('operational risk').
- The changes in revenue due to changes in customers values or preferences associated with the brands' reputation ('reputational risk/opportunity').

Market based approaches can be used to quantitatively or monetarily value the consequences of impacts on the business. For example, in the case of setting a biodiversity target, the cost of implementing all measures required to reach the target, including measures to avoid, minimize, restore, and compensate impacts, as well as to monitor them. Businesses may also wish to qualitatively assess material biodiversity risks that may arise in the future, for example through changing social attitudes and market trends.

Assessing impacts on society and dependencies

The approach to estimate the values of impacts to society and business dependencies consists of three steps:[33]

31 Christie, M. Martín-López, B. Church, A., Siwicka, E., Szymonczyk, P., Sauterel, J.M. (2019) Understanding the diversity of values of "Nature's contributions to people": insights from the IPBES Assessment of Europe and Central Asia. Sustainability Science, 14, 1267–1282 (2019). https://doi.org/10.1007/s11625-019-00716-6

32 For further discussion of natural capital risk and opportunities, see the Taskforce for Nature-related Financial Disclosures Beta Framework, Available at https://tnfd.global/wp-content/uploads/2022/03/220315-TNFD-beta-v0.1-full-report-FINAL.pdf

33 Defra (2007). An introductory guide to valuing ecosystem services. London. https://www.gov.uk/government/publications/an-introductory-guide-to-valuing-ecosystem-services

- **1) Identification of relevant changes on ecosystem services and identification of stakeholders affected**

An initial screening should be developed to provide a preliminary qualitative assessment of which ecosystem services are likely to be affected from changes in quality and quantity of biodiversity (as per sections 4 and 5) and the likely importance of these changes. This screening could be done by using an established checklist to identify and provide a qualitative assessment of the potential ecosystem services affected and the magnitude of the changes in ecosystem services following indications from materiality in Section 1.6 and understanding of dependencies, as indicated in Section 5. All ecosystem services should be considered when conducting the screening as a means to identify those impacted, as well as where uncertainties and evidence gaps exist, with transparency of the section process maintained throughout. Stakeholder consultations and gender assessments strengthen the robustness of this screening process.

- **2) Quantification of relevant changes on ecosystem services**

The quantitative assessment focuses on those ecosystem services likely to experience significant changes identified in the preliminary screening. The aim is to measure the relative change in the provision of different ecosystem services resulting from the changes in state of biodiversity, as measured in Section 6, based on the extent and condition of ecosystem assets. This connection is embodied in the concept of ecosystem capacity[17] . When assessing the changes in ecosystem service provision, the trade-offs or complimentary nature of different services should be considered. When assessing insurance and option values, having a long-term perspective is needed to capture changes that happen in the long run. Alternatively, the cost of maintaining biodiversity to ensure the provision of benefits in the future can be used.

- **3) Valuation of relevant changes on ecosystem services.**

The valuation consists of assessing the value resulting from the changes in the provision of ecosystem services. They can be valued in qualitative, quantitative, or monetary terms, each requiring a different valuation technique. A hybrid approach that combines two or all three approaches may also be appropriate.

- **Qualitative valuation techniques** are used to inform the potential scale of costs and/or benefits expressed through qualitative, non-numerical terms (e.g., high/medium/low decrease in recreational benefits). Qualitative methods may be required to ensure that a full range of benefits are considered, especially intrinsic values and when the full range of benefits cannot be fully accounted for in quantitative or monetary valuations. Qualitative valuation should be done ensuring highly collaborative and participatory process to capture a wider range of value subsets[34]. Where possible it is good practice to report material unmeasured benefits.
- **Quantitative valuation techniques**, in turn, focus on numerical data which are used as indicators for the costs and/or benefits (e.g. number of people that experience a decrease in recreational benefits). Quantitative valuation can take the form of an assessment of the physical flow of ecosystem services from a habitat. Quantitative valuation is convenient to assess those benefits that are inherently or intrinsically valuable and quantifiable but that cannot be well captured in monetary terms.
- **Monetary valuation techniques** translate quantitative estimates of costs and/or benefits into a single readily understood unit (e.g. recreational value lost in USD), allowing for simple assessments of trade-offs between biodiversity values, as well as other environmental, social and economic considerations. Economic valuation techniques should be applied to estimate the possible monetary values attributed to ecosystem services. Economic valuation should be an extension of quantitative valuation, where reliable monetary valuation metrics exist. Table 7.1 in the Natural Capital Protocol Biodiversity Supplement gives an overview to the types of monetary valuation techniques, their benefits and limitations[8].

6.2.2 Universal recommendations

Changes to biodiversity state that affect value should be identified and underpin the valuation.

The multitude of biodiversity components (e.g. species, ecosystems, genes) upon which business might have impacts and/or dependencies, can lead to it being undervalued.

An assessment should identify all relevant changes in biodiversity state, focusing on ecosystem extent and condition and supplemented with species-level indicators (as indicated in Section 6) as a basis to conduct valuation relating to material topics. For example, monoculture forests may be more susceptible to diseases, whilst more diverse forests tend to be healthier and provide longer term ecosystem services. Assessing the changes on biodiversity state should underpin the valuation.

Information about location and context (including the groups of people affected) where changes in biodiversity take place is required.

The location and context of biodiversity changes will have an impact on the level of benefits provided by ecosystems. The location of biodiversity loss may affect the ecosystem functions and therefore delivery of specific ecosystem services. Furthermore, the proximity of the impacted ecosystem to people and businesses, as beneficiaries of the services, will impact the scale of benefits that are provided. Equally the significance of losses of individuals of species at a certain location depends on national, regional or global extinction risk. Understanding this will help to understand the scarcity of species

34 Díaz et al. (2015) The IPBES Conceptual Framework - connecting nature and people. Current Opinion in Environmental Sustainability, 14: 1–16.

in context and will also highlight opportunities for collaboration with other actors at a larger scale.

Local context may also highlight when certain sites hold a higher level of non-use value, for example sites, species or individuals with a high spiritual value.

The valuation should assess final ecosystem services, not intermediate ecosystem services.

When accounting for the benefits provided by nature, to avoid double counting, the final ecosystem services which provide benefits to people directly should be included. Despite this need, care should be taken to ensure that the supporting services are not ignored completely. Losses in intermediate or supporting services can indicate a time-lagged risk of final services loss and should still be carefully monitored. An assessment of these underpinning services can help to reveal where supporting services are important contributors to the final ecosystem services. For example, pollination can be a vital supporting service for the final ecosystem service of food production.

It may be useful to use a final ecosystem services classification scheme to assist with capturing all forms of ecosystem services that nature provides. Leading examples include The Common International Classification of Ecosystem Services (CICES), the Final Ecosystem Goods and Services Classification System (FEGS-CS) and the National Ecosystem Services Classification System (NESCS). These classifications will all vary in scope and focus and an assessment for an appropriate framework should be taken by the assessor.

To address the limitations of only valuing final ecosystem services, it is important to identify where the condition of biodiversity stocks has been overlooked in estimated values, and to consider the importance of biodiversity for continuing to provide benefits to the business in the future. This can help identify where businesses can invest in biodiversity improvements to secure future benefits.

Where possible clarity and transparency should be provided on how the ecosystem services have been valued, as well the source of value transfers, and any adjustments that have been made.

Monetary valuation should be used more cautiously, and in conjunction with other decision-making information, when irreversible change is expected, when values may be significantly inaccurate, when morally inappropriate and where large-scale change in biodiversity is taking place.

Monetary valuation should be used cautiously, and in conjunction with other information, when:

- An irreversible change is expected. The timeframe of the assessment should be appropriate to identify the presence of thresholds or tipping points. In the presence of tipping and/or irreversible points, monetary valuation can only provide a minimum estimate of the future loss of benefits but will not be able to capture the full spectrum of values, such as intrinsic or optional values. When tipping points and thresholds exist, a precautionary approach should be adopted and a registry of the gap in physical units to the threshold or tipping points should be used (alongside any estimate of monetary valuation).
- Values cannot be estimated to a reasonable level of accuracy.
- It can be considered morally inappropriate (e.g. placing a monetary value on intrinsic or culturally valuable areas to the surrounding communities).[35]
- A large-scale change in biodiversity is taking place for example when a large proportion of a remaining population or ecosystem is affected.

Where a monetary approach is not suitable, but the decision maker wishes to contain structure to their decisions a weighted multi-criteria decision analysis may be suitable where values are compatible. By weighting considerations that are not suited for monetary valuation, such as intrinsic values or large-scale ecosystem change or loss, they can be incorporated into decisions more easily. However, some values are incommensurable, even with weighting applied[29].

Biodiversity values should be considered a minimum estimate and a precautionary approach adopted.

Many use and non-use values will continue to be underappreciated due to limitations in scientific understanding of the relationships between biodiversity and delivery of goods and services. Consequently, a precautionary approach should be adopted, and the values of biodiversity identified should be always considered minimum estimates, taking into account other information and in consultation with stakeholders. When a monetary approach is adopted to infer the value of a stock of natural capital from the expected

35 Synder, R., Williams, D., & Peterson, G. (2003). Culture loss and sense of place in resource valuation: Economics, anthropology and indigenous cultures. In: In: Jentoft, S.; Minde, H.; Nilsen, R., eds. Indigenous peoples: resource management and global rights. Delft, The Netherlands: Eburon Academic Publishers: 107-123. https://www.fs. usda.gov/treesearch/pubs/23838

future flow of benefits (using, for example, the net present value (NPV) method) results will be very sensitive to the selection of the discount rate, which is the parameter that reflects the balance of preferences between present versus future flows. The selection of the discount rate should be considered carefully to account for the regenerative nature of biodiversity and therefore its ability to outlast traditionally-produced capital assets while often requiring smaller maintenance costs. Longer asset life cycles and the long-term nature of many natural capital benefits means that there is often an intergenerational element to the values involved that should be carefully considered[25].

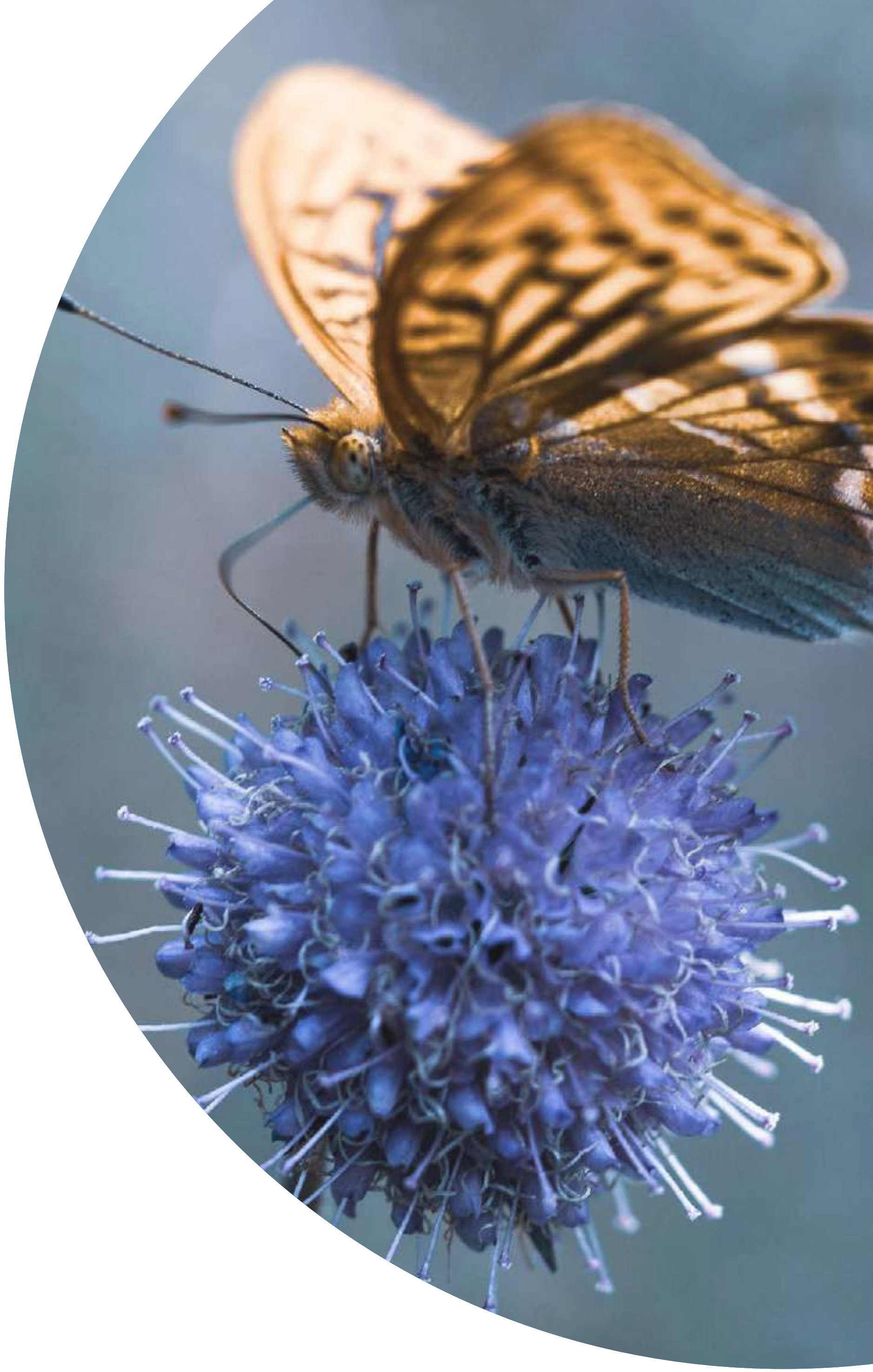
Where tipping points are expected, a precautionary approach to valuation is required and any biodiversity loss avoided.

Tipping points are a set of conditions in which an ecosystem can no longer cope with environmental change and, so, suddenly shifts from one state to another, preventing it to return to its former state. At the species level, tipping points may lead to species extinctions. When tipping points are identified and are likely to happen, a precautionary approach should be used and any biodiversity loss should be avoided, as consequences could be irreversible and have significant implications for a range of activities and livelihoods. Restoration is not only costly but once tipping points are reached cannot return ecosystems back to their original state[31] . In particular this is important for valuation if these potential tipping points are not factored into decision-making processes this a large-scale risk to business operations that depend on nature and can present a risk to long-term finance. Valuation will need to factor in the wide range of potential losses that could occur if tipping points are exceeded.

Qualitative and quantitative factors should be used to support the acknowledgement of intrinsic and relational values.

Intrinsic and relational values cannot be captured within the total economic value approach due to their non-economic and relational nature. Qualitative and quantitative approaches that measure changes in the state of biodiversity can be used to understand the functioning of an ecosystem and acknowledge the existence of these intrinsic and relational values[36]. Using indicators or a classification that reflects the integrity or threat level, such as IUCN Red List species status, can be used. Local and global context should also be considered when acknowledging these intrinsic and relational values.

36 Schulz, C. and Martin-Ortega, J., 2018. Quantifying relational values—why not?. Current opinion in environmental sustainability, 35, pp.15-21.



07

MOVING TOWARDS ACCOUNTING

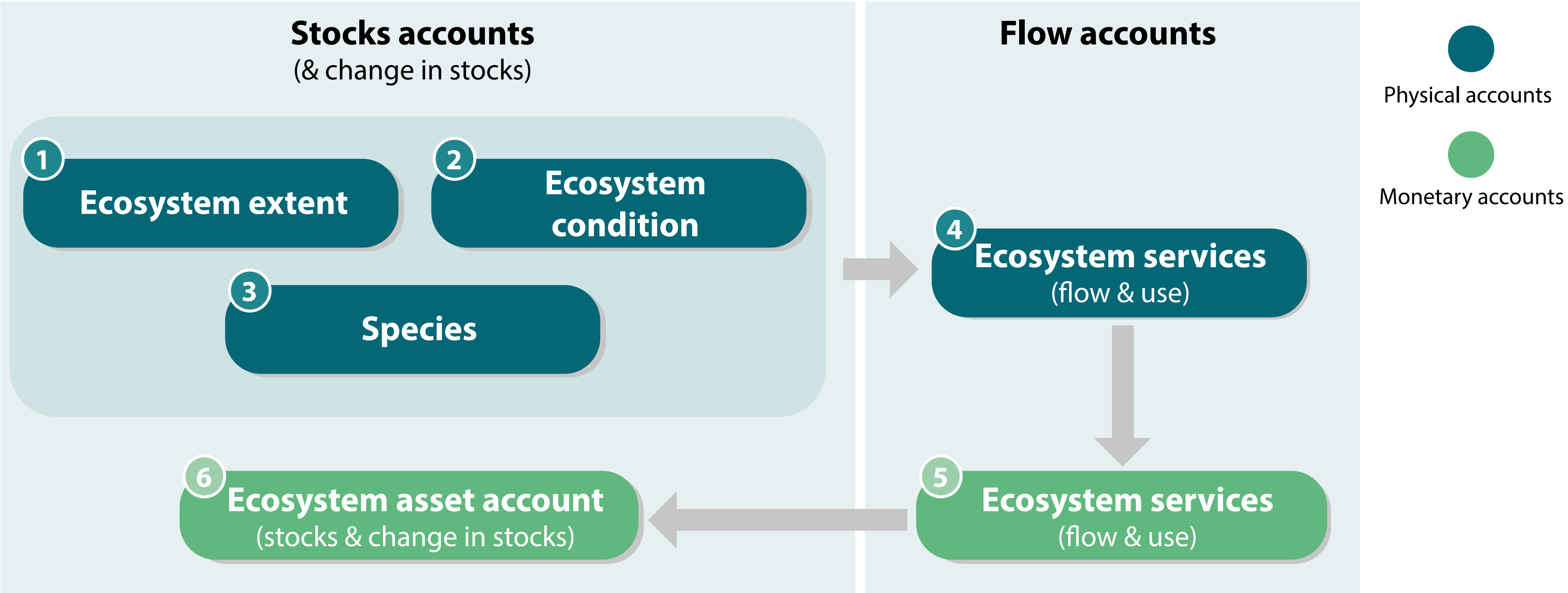
This section sets out how biodiversity impacts and dependencies can start to be organised into an accounting format to track performance against targets and over time. It outlines technical recommendations and a direction of travel from individual measurements of performance to compiling robust corporate biodiversity accounts, either as a separate exercise or as part of a broader effort to develop corporate natural capital accounts. It recognises that the term 'accounting' is currently interpreted in very different ways and the use of accounts is currently limited in the context of biodiversity measurements.

7.1 Background

Accounting – the measurement, processing, and communication of financial and non-financial information about economic entities such as businesses and corporations[37] – can be used to organise measurements of biodiversity or natural capital stocks and ecosystem service flows. They can be monetary or non-monetary or combine elements of both (see Figure 7), although, it is important to recognise that not all values of biodiversity can – or should – be expressed in monetary value (see Section 6).

Biodiversity measurement organised via an accounting framework enables the provision of standardised, comparable and high-quality information both for screening of biodiversity risks and for understanding biodiversity impact and dependencies. Accounting can be used for both internal management of biodiversity and disclosure of corporate biodiversity performance to stakeholders[38].

Figure 7. Accounting approaches to organise measurements of biodiversity or natural capital stocks and ecosystem flows.[17]



37 Needles, Belverd E.; Powers, Marian (2013). Principles of Financial Accounting. Financial Accounting Series (12 ed.). Cengage Learning. ISBN-10: 1133940560.
38 Feger, Clément and Mermet, Laurent (2021) Advances in accounting for biodiversity and ecosystems: A typology focusing upon the environmental results imperative. Accounting Auditing Control Volume 27, Issue 1, January 2021, pages 13 to 50.

Several different forms of accounting for nature have evolved:

- **Ecosystem accounting:** Ecosystem accounting as described by the UN System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA)[17] is designed to record physical stocks and flows in environmental assets and changes in those stocks and flows over time. It is a spatially-based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity. It is usually undertaken at country, regional or landscape level. Five different accounts are used to measure different aspects of ecosystems and their relationship to the economy in physical (1, 2 and 4 in Figure 7) and monetary terms (5 and 6 in Figure 7). The approach can also focus on specific issues or geographic areas that are of particular interest to decision makers e.g. water, biodiversity or protected areas. Although designed initially for the public sector, concepts, methods and data used for national ecosystem accounting can be both relevant and useful for corporate ecosystem accounting. Accounting for species is still being developed within ecosystem accounting.
- **Corporate natural capital accounting[39]:** Such approaches extend beyond consideration of biodiversity to measure broader changes in the stocks of natural capital (1, 2 and 4 in Figure 7) and the value of associated ecosystem services (5 and 6 in Figure 7). It results in the development of a natural capital balance sheet showing the organisation's dependency on natural capital assets and an income statement showing the positive and negative impacts of the organisation on natural capital[40]. Corporate natural capital accounts can also be future looking. As yet, the physical and monetary value of biodiversity is not addressed in detail within such approaches but qualitative data on biodiversity can be included[41].
- **Corporate biodiversity accounting[42]:** Can be a sub-set of corporate natural capital accounting, included as part of a natural capital account (through extent and condition) or separately depending on the purpose of the account[43]. It focuses on the systematic process of identifying, measuring, recording, summarising and reporting the biophysical state of ecosystem and material species assets and the periodic and accumulated net changes to those assets (1, 2 and 3 in Figure 7) .This approach uses recording rules adapted from double-entry bookkeeping (DEBK)[44] from financial accounting and focuses on biodiversity state measures (species abundance in addition to ecosystem extent and condition).[42].

The approaches differ in the scope of assets considered (biotic component of ecosystems only versus inclusion of abiotic natural capital stocks) and their treatment of monetary valuation metrics (exchange values are favoured in SEEA-EA, a range of value types are useful in natural capital accounting/for business). Although designed for different purposes e.g., national accounting to inform policy making, these accounting frameworks share similarities, and there are strong synergies between corporate natural capital accounting and corporate biodiversity accounting, so they should not be considered as siloed processes. All approaches measure and connect data on assets and can be used to understand benefit flows to people. They:

- Account for the state of ecosystem assets (extent and condition)
- Require an ecosystem asset register or impact inventory
- Employ measurement techniques that use spatially explicit data
- Measure net change applying the principle of ecological equivalency (like-for-like)
- Compile statements of periodic and accumulated changes

Few organisations however, are currently creating biodiversity accounts, and understanding of corporate biodiversity accounting is relatively limited, hence, there is a need to build understanding and capacity to undertake accounting over time. In the first instance, starting to apply accounting elements in the context of biodiversity measurement could lead to greater transparency and uptake of such approaches. This 'accounting' journey is outlined in Figure 8.

39 Approaches such as the British Standards institute BS 8632 and Natural Capital Protocol.

40 BSI (2021) BS 8632 - Natural capital accounting for organizations. Standard not publicly available but webinar viewable at https://www.bsigroup.com/en-GB/our-services/events/webinars/2020/bs-8632/.

41 Dickie, I., Koshy, A., ten Kate, K., and von Hase, A. (2018). Biodiversity Net Gain in Corporate Natural Capital Accounting: a Resource Paper. Business and Biodiversity Offsets Programme (BBOP). Forest Trends, 2018, Washington, D.C.

42 Endangered Wildlife Trust (2020). The Biological Diversity Protocol (BD Protocol). National Biodiversity and Business Network - South Africa, 123p. Available at: https://nbbnbdp.org/biodiversity-protocol/

43 Accumulated changes are the residual state of biodiversity assets at a point in time, based on Capitals Coalition (2022) Time to take stock. https://capitalscoalition.org/publication/time-to-take-stock/

44 A process adapted from financial accounting. In financial accounting this means that every financial transaction entered into an account has an equal and opposite effect in at least one other account. These transactions are summarized in the preparation of financial statements, including the Statement of Financial Position (or Balance Sheet) and Statement of Financial Performance (or income Statement). DEBK thus enables businesses to record both periodic and accumulated changes in transactions of a financial nature and to aggregate individual financial events at the company level. Source: Trotman M. Gibbins Financial accounting: An integrated approach 2nd edition 2003 Thomson Nelson Australia.

Figure 8. The current state of play of accounting within biodiversity measurement and direction of development towards full biodiversity accounting

Current state of play

- Ad hoc assessments
- Focus on negative impacts
- Inconsistent organisational & value chain boundaries

Sometimes, initial application of biodiversity accounting

Partial corporate biodiversity accounting

- Recognition of need for an asset register (focus on ecosystems)
- Recognition of need to measure periodic & accumulated changes
- Included positive & negative impacts
- Flexible interpretation of ecological equivalence
- Inconsistent organisational & value chain boundaries

Towards

Full corporate biodiversity accounting

- Complete asset registry (ecosystems, material species)
- Spatially explicit data
- Measurement of periodic & accumulated changes
- Ecological equivalence at asset level
- Third party verification
- Clear organisational & value chain boundaries

Accounting will become increasingly important in the context of more stringent policy and disclosure requirements anticipated through implementation of the Post-2020 Global Biodiversity Framework and developments such as the Corporate Sustainability Reporting Directive and the Taskforce on Nature-related Financial Disclosures.

To get to a point where biodiversity measurement approaches can be organised within an accounting framework, additional considerations are needed on the measurement methodologies used. These are set out in the recommendations below which focus on physical measurement rather than valuation. Developing biodiversity accounts, can however, provide the building blocks on which values, including monetary values, can be based.

7.2 Universal recommendations

The following recommendations are relevant for both corporate biodiversity accounting as a stand-alone exercise and the integration of biodiversity into corporate natural capital accounting. These are *suggestions* for how measurement approaches could be structured to enable biodiversity accounting rather than *requirements*.

If companies wish to track and disclose progress to quantified targets such as no net loss or net gain of biodiversity at a site level, a full corporate biodiversity accounting approach is recommended.

It is possible to account for impacts at the corporate level and in the supply chain using the consolidated results of biodiversity accounting or biodiversity inclusive natural capital accounting applied at the site level. However, this practice is currently very rare in the market-place. Accounting at the supply chain level in particular is challenging and currently only partial accounting is practical. As a starting point, companies with complex supply chains or investors can apply elements of an accounting approach to measurement methods to support efforts to track and disclose progress to targets.

A biodiversity asset register should be developed and maintained as a basis for measurement[42].

For full accounting, an asset register should be developed that compiles details of the assets being measured within the selected organisational and value chain boundaries and organised in line with relevant classification systems (e.g. IUCN Global Ecosystem Typology[45] - IUCN GET). This also aligns with BS 8632 Natural Capital Accounting for Organisations[40]. An asset register should include:

- **For ecosystems:** location (GIS/GPS), size/extent (hectares), a score assessing the type and condition of the ecosystem (e.g. the intactness or degree of functioning of the ecosystem; see Section 3), information sources and basis for ecosystem condition scoring, and any other relevant information (e.g. threat level derived from the IUCN Red List of Ecosystems[46]).
- **For species**: scientific and common names, basis for materiality assessment (see Section 5.2), threat level as defined by the IUCN Red List or National listings, current and target habitat or population sizes and information sources. Where species population data are unavailable, habitat extent and condition can be used as a proxy.

For partial accounting, where this granularity may not currently be possible (e.g. in certain supply chains), a broader level ecosystem typology can be applied for larger areas but these are not considered as assets in an accounting context. Within this there should be provision for estimation of the state of spatially explicit assets.

If undertaken in support of corporate natural capital accounting the asset register should be consistent with any similar natural capital inventory/register e.g. national level registers and make the relationship of the biodiversity data to the natural capital accounts clear.

Measurement techniques should use spatially explicit data where possible and modelled data should be ground truthed.

Spatially explicit data are required for full accounting. Modelled state based on pressure can be used within biodiversity accounting only where they can directly be linked to assets. The use of location specific data is supported by the Natural Capital Protocol[7], BS 8632 Natural Capital Accounting for Organizations[40] and the Taskforce for Nature-related Financial Disclosures.

Accessing data may be challenging for companies with complex supply chains, hence, estimations of the state of assets at the level of the asset register using modelled state based on pressures may be helpful. However, in such approaches, responses are often not asset-specific (low spatial specificity) and state information may be missed when using pressures as input (low accuracy). To enable full accounting, they will need to be ground truthed; that is, verified based on direct site level sampling. Where such estimations are used, they must be transparent, based on credible statistical/scientific methods and their limitations must be acknowledged.

Accounts should aim to address the state of all ecosystems as a foundation and, where possible, address all material (in business and societal terms) species.

Measurements should address ecosystems (extent and condition) as a foundation for biodiversity accounting. Where possible, measurement should also address the populations of material taxa[42] using metrics set out in Section 3, identified through a materiality assessment.

45 Keith, D.A., Ferrer-Paris, J.R., Nicholson, E. and Kingsford, R.T. (eds.) (2020). The IUCN Global Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups. Gland, Switzerland: IUCN

46 A tool to assess the conservation status of ecosystems. It is based on scientific criteria for performing evidence-based analyses of the risk of ecosystem collapse. These include changes in geographical distribution, and the degradation of the key processes and components of ecosystems

Statements of position and performance should be compiled [42].

A statement of position is backward looking and represents the accumulated [47] or overall, residual state of the asset. It is the equivalent of the balance sheet in financial and natural capital accounting. It is the balance between accumulated negative impacts (total losses in condition compared to reference state) and accumulated positive impacts (residual or remaining condition of the ecosystem compared to the maximum potential). It should be noted that a business may not be responsible for all accumulated impacts, hence it is important to set a baseline, e.g., year of property acquisition, from which subsequent changes in the state of biodiversity should, where possible[48], be directly attributed to the company's activities.

A statement of performance shows the net changes to the state of biodiversity, over a defined time period e.g., a year and is equivalent to an income statement in financial accounting and in natural capital accounting. The period over which performance is assessed may be annual or may be a longer period depending on the nature of the decisions to be informed and the biodiversity assets under review.

Individual species or ecosystem accounts should be compiled to underpin the statements of position and performance based on the asset register or impact inventory above. For each impact (negative or positive), a change recorded in one account will always have an equal and opposite effect in at least one other account, so that accounts are complete, accurate and credible. This is termed double-entry bookkeeping (DEBK).

Table 9 shows how loss and gains are defined in the context of biodiversity accounting.

Table 9: Defining positive and negative impacts in the context of biodiversity accounting [42]

	Statement of Position	
	Ecosystems	Species
Accumulated positive impacts (P)	Areas (A) of ecosystem assets x (condition score (I)/Maximum potential condition score (J) (ha) P = A x (I/J)	Population (e.g. number of breeding or mature individuals) or habitat size (e.g. ha /Km^2) of a species.
Accumulated negative impacts (N)	Areas (A) of ecosystem assets – Area adjusted for condition/(P) (ha equivalents) N = A – P	Gap to target population (e.g. number of breeding or mature individuals) or habitat size (e.g. ha/Km^2) of a species (i.e. N = A – P)
Total impact (A)	Sum of accumulated positive and negative impacts	Target population (e.g. number of breeding or mature individuals) or habitat size (e.g. ha/Km^2) of a species

	Statement of Performance	
	Ecosystems	Species
Periodic gains (G)	Increase in condition of the ecosystem assets, in area equivalents (e.g. ha equivalents).	An increase in the population (e.g. number of breeding or mature individuals) or habitat size (e.g. ha/Km^2) of a species.
Periodic losses (L)	Decrease in the condition of the ecosystem assets, in area equivalents (e.g. ha equivalents).	A decrease in the population (e.g. number of breeding or mature individuals) or habitat size (e.g. ha/Km^2) of a species.
Periodic net impact	Gains minus losses (can be consolidated across asset categories)	Gains minus losses (per species)

47 The accumulated net change in a biodiversity asset, such as an ecosystem type, is equal to its current area adjusted for its condition. It shows the residual state of biodiversity assets at a point in time. This residual state is measured by multiplying the extent of an ecosystem asset by its current condition/integrity score over the maximum condition/integrity score (as per the relevant metric used). All biodiversity state measurement approaches (e.g. MSA.km2) measure condition or integrity as per a reference or pristine state.

48 In some cases, changes in the state of biodiversity may not be directly attributable to the company, such as external pollution, beyond the control of the company, negatively affecting biodiversity within the company's location.

Statements of position and performance can be aggregated for ecosystems to give a total biodiversity footprint and overall gain/loss in surface area equivalents respectively for the boundary of the accounts (i.e. project, supply chain, or company). The total biodiversity footprint can be broken down into a negative and positive footprint.

Biodiversity accounting, using recording rules for accounting events adapted from DEBK in financial accounting[49], connects the statement of position and performance and enables the consolidation of both the positive and negative changes in the state of biodiversity stocks (e.g. using conversion tables to translate various metrics into surface area equivalents such as ha eq.), using different sets of metrics. In DEBK each transaction has an equal and opposite impact recorded within two distinct 'accounts'. By doing this, it overcomes the challenges of aggregation posed by the lack of a single or universal biodiversity performance metric.

Accounting should be based on the concept of ecological equivalence[42].

No two components of biodiversity are identical. This is recognized by the concept of ecological equivalence or the 'like-for-like" principle. It is important to ensure that the principle of ecological equivalency underpins calculations of losses (negative impacts), gains (positive impacts) and net impact accounting. Corporate biodiversity accounting requires measurement of net changes for ecologically equivalent biodiversity assets (i.e. each species or ecosystem type must be considered in turn, and a loss of extent and condition of a wetland for example, cannot be balanced by a gain in extent and condition of a forest).

To allow consolidation, the same condition rating method should be used for ecologically equivalent ecosystem types[42].

There are many different ways of measuring ecosystem condition (see technical criteria set out in Section 3). For ecosystem assets, a biodiversity footprint may be calculated using different condition assessment or rating methods to score the integrity of different ecosystem types. The resulting metric will be the same (e.g. surface area equivalents regardless of the assessment/rating method used). However, selecting different condition/ integrity-rating methods will lead to different ecosystem impact results, hence, companies should:

- Use the most generally accepted or recognized method applicable within the jurisdiction (e.g., a country) where the impact occurs are; and
- Use the same method for ecologically equivalent, or like-for-like, ecosystem types.

Consolidation should be undertaken separately for individual species.

If species assets are part of the accounts, consolidation should be undertaken separately for individual species using either population (e.g., number of breeding pairs) or habitat size (surface area) metrics. Individual statements of position based on species cannot be summed.

Asset linked impacts and impacts that cannot be linked to assets should be accounted for separately and transparently to avoid double counting[42].

Company impacts on biodiversity can be (a) directly linked to a specific ecosystem asset and (b) involve impact drivers to which change in a specific ecosystem asset cannot be attributed. Both should be accounted for, but separately disclosed.

Complete transparency is required regarding the modelling and apportionment methods used to estimate impact drivers to which change in a specific ecosystem asset cannot be attributed e.g. greenhouse gas emissions.

Accounting results and underlying methods should be transparently presented, integrate datasets and reflect appropriate accounting periods[40].

Biodiversity impacts must be accounted for consistently across business reporting periods and be designed to prevent companies from selecting the time periods of their assessments and choosing periods when impacts are lower than usual.

The following information should be disclosed to enable the user of the information to understand its limitations and value[42]:

- Position and performance statements
- The value chain boundary (i.e. direct operations, downstream and/or upstream)
- The accounting period and date of preparation of the accounts
- The baseline and any baseline restatements based on enhanced understanding of the situation or new data (rationale and impact)
- The aspects addressed within the accounts (e.g. ecosystem extent and condition, species, ecosystem services)
- An asset register
- Explanations of major changes in the accounts (e.g. significant losses or gains)
- Data gaps or quality and implications for decision-making
- Methods used (e.g. condition scoring, rationale for apportionment of responsibility for indirect impacts).

49 Capitals Coalition (2022) Time to take stock. https://capitalscoalition.org/publication/time-to-take-stock/

7.3 Technical criteria for accounting for biodiversity

This section builds on the Universal recommendations for accounting above. Recognising that biodiversity accounting is in its infancy, instead of providing good and best practice criteria, criteria for partial implementation of biodiversity accounting and full implementation are set out in Table 10, in line with the 'journey towards accounting' presented above. This recognises the need to balance accuracy and cost-effective measurement to generate biodiversity information for decision-making.

Although some measurement approaches may not yet enable full corporate biodiversity accounting, they are nonetheless helpful to provide a practical step forward in understanding a company's relationship with biodiversity. It is recommended that companies with access to site-based data work towards full biodiversity accounting particularly where they are setting quantitative targets linked to, for example, no net loss, net gain or nature-positive commitments. For those with more challenging access to data (e.g. through supply chains), taking steps towards partial accounting is recommended.

Table 10: Criteria for full and partial biodiversity accounting

Criteria	Partial accounting	Full accounting
Asset register	Understand need for an asset register or impact inventory, maintain registers for ecosystems/high-risk operations or material pressures respectively.	All ecosystems are included, as per relevant transparent classification systems (e.g. national lists, IUCN GET) and – for more complete assessment – material species, based on transparent external stakeholder engagement.
Measurement of condition	Spatially explicit, science-based estimates of the state and condition of ecosystems where direct measurement is not possible. Basis of estimates and limitations transparent.	Spatially explicit, science-based measurement of the state and condition of assets impacted using primary or secondary in-situ data, at the level of the asset register. See best practice measurement in Section 3.
		Same ecosystem condition method used for the same ecosystem types and same measurement approach for same material species.
Ecological equivalency	Gains and losses are recorded for like for like assets within asset register (asset register based on criteria for partial accounting).	Gains and losses are recorded for like-for-like assets within asset register (asset register based on criteria for full accounting).
Accounting records	Records are maintained and checked through internal verification.	Records are based on double entry book-keeping checked through internal and external verification.
	Narratives – explanations for losses and gains .	
Statement of performance	Recognition of need to measure periodic changes and produce statements of performance.	Details of gains and losses per ecosystem asset and material species.
Statement of position	Consolidated total, positive and negative impacts within statements of position.	Consolidated total, positive and negative impacts, which are also broken down per site and asset.
Targets	Defined for the consolidated total impacts.	Defined per biodiversity asset and site, which are also framed for the forthcoming Statements of Performance and Position.
Segregated reporting and disclosure	For all impacts that cannot be traced directly to a spatially explicit asset (e.g. indirect impact drivers such as GHG emissions).	
	For impacts caused directly by other economic agents (suppliers, clients). For future impacts (i.e. impacts that are likely to occur but are yet to).	

Ultimately, it is hoped that companies with complex value chains will be able to consolidate accounting results from each supplier and site and that investors will be able to measure their impact based on their proportion of consolidated corporate results prepared in accordance with best practice above. However, the market is not yet in a position where this is likely to occur in the short or even medium term, hence other approaches are required for to address impacts throughout the value chain in the short to medium term. Accounting frameworks are nonetheless useful for all measurement approaches to bring greater rigour to the measurement approach.

06

GLOSSARY

Term	Definition
Accounting (in relation to biodiversity)	Biodiversity accounting for organisations can be defined as the systematic process of identifying, measuring, recording, summarising and reporting the biophysical state of biodiversity assets and the periodic and accumulated net changes to those assets.
Accounts	A record in an accounting system that tracks the losses and gains of a specific asset. Biodiversity accounting includes asset accounts, positive and negative impact accounts, gain and loss accounts and net impact accounts.[42]
Avoided negative impact	The avoidance of negative impact on biodiversity refers to the reduction or impact prevention of negative impacts resulting from an intervention/ economic activity by means of, for example, better management practices or the replacement of raw materials with a high impact on biodiversity with raw materials with a lower impact on biodiversity. The avoided negative impacts can refer to existing impacts, but can also relate to future, expected impacts.
Baseline	A minimum or starting point with which to compare other information (e.g. for comparisons between past and present or before and after an intervention).
Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.[50]
Biodiversity asset inventory/register	A list of all the species and ecosystems or impact drivers that are relevant to the accounts, including information about their location, extent, condition/quality and other relevant factors.[51]
Biodiversity asset/stock	Individual species and ecosystems that occur in the area where measurement is occurring.[42]
Biodiversity indicator	A measure, based on verifiable data, that conveys information about more than just itself. Indicators can be simple metrics (a system of standard of measurement), or more complex indices (numerical scales).[11]
Business application	The intended use of the results of a natural capital assessment, to help inform decision-making.
Business context	Combination of 1) core business needs for measurement (screening for biodiversity risks and opportunities and measuring impacts on biodiversity) and valuation and 2) organisational focus area (site level, supply chain, product and corporate focus areas).
Condition adjusted hectares	A standard measurement framework for ecosystems is 'Extent × Condition', combining physical area or volume with a measure of its condition compared to the intact state. Units may, for example, be expressed as quality-hectares or weighted hectares. 'Extent × Condition' is the framework adopted by the UN for ecosystem accounting and is widely used in corporate biodiversity assessments.[42]

50 Convention on Biological Diversity (1992) Convention on Biological Diversity. Secretariat of the Convention on Biological Diversity, Montreal, Canada
51 EFTEC, RSPB, PWC (2015) Developing Corporate Natural Capital Accounts. Final Report for the Natural Capital Committee.

Term	Definition
Corporate biodiversity accounting	The systematic process of identifying, measuring, recording, summarising and reporting the biophysical state of biodiversity assets, and the periodic and accumulated net changes to those assets.[42]
Cumulative impact	Impacts that arise from the combined impacts of a company's operations, those of other organizations – including other businesses, governments, and local communities – and other background pressures and trends.[52]
Dependency (in relation to biodiversity)	A business reliance on or use of biodiversity and associated ecosystem services. Note: In this document, interactions between different elements of natural capital are not referred to as dependencies.[7]
Direct impact	A change in the state of biodiversity caused by an impact driver or business activity with a direct causal link.[7]
Disclosure	Disclosure refers to the voluntary or required/statutory release of any information relevant to a company, security, fund or any third party. In financial accounting, disclosure refers to a statutory or good faith revelation of a material fact (or an item of information that is not generally known) on a financial statement or in the accompanying notes (footnotes). Biodiversity disclosures refer to the voluntary or required/statutory release of any biodiversity-related information to external stakeholders.[42]
Double entry book-keeping	A fundamental concept underlying present-day financial book-keeping and accounting which states that every financial transaction has equal and opposite effects in at least two different accounts. This enables the production of statements of financial position (balance sheet) and performance (profit and loss statement). This concept has been adapted for application to biodiversity accounting using biophysical measures.[53]
Double materiality	Double materiality requires that both impact materiality and financial materiality perspectives be applied without ignoring their interactions. Impact materiality refers to sustainability matters that are material in terms of the impacts of the reporting entity's own operations and its value chain, based on the severity and likelihood of the impacts and urgency derived from social or environmental public policy goals and planetary boundaries.[10]
Ecological community	Groups of species commonly found living within a specific geographic location.
Ecological equivalency	It reflects the concept of 'like-for-like' when measuring the different components or aspects of biodiversity. When considering gains and losses and/or developing a biodiversity account, one cannot sum changes in one species with another. That is, only the same types of ecosystems or taxa can be compared within an assessment.[42]
Ecosystem	A dynamic complex of plants, animals, and microorganisms, and their non-living environment, interacting as a functional unit (e.g. deserts, coral reefs, wetlands, and rainforests).[51]
Ecosystem capacity	The ability of an ecosystem to generate an ecosystem service under current ecosystem condition, management and uses, at the highest yield or use level that does not negatively affect the future supply of the same or other ecosystem services from that ecosystem[17]

52 BBOP (2012) Glossary. Business and Biodiversity Offsets Programme, Washington DC, USA
53 Trotman M. Gibbins (2003) Financial accounting: An integrated approach 2nd edition Thomson Nelson Australia.

Term	Definition
Ecosystem condition/ integrity	The quality of an ecosystem measured in terms of its abiotic and biotic characteristics. Condition is assessed with respect to an ecosystem's composition, structure and function which, in turn, underpin the ecological integrity of the ecosystem, and support its capacity to supply ecosystem services on an ongoing basis. Measures of ecosystem condition may reflect multiple values and may be undertaken across a range of temporal and spatial scales.[17]
Ecosystem extent	The size of an ecosystem asset in terms of spatial area.[17]
Ecosystem services	The contributions of ecosystems to the benefits that are used in economic and other human activity or the contributions that ecosystems make to human well-being.[20]
Ecosystem type	A distinct set of abiotic and biotic components and their interactions (UN SEEA. 2021. System of Environmental-Economic Accounting - Ecosystem Accounting: Final Draft). Note that countries may have different classifications of ecosystem types, which may have implications for adherence to the equivalency principle, notably in the context of no-net-loss requirements. The IUCN has developed a Global Ecosystem Typology (GET) to support the development of its Red List of Ecosystems, however a standardised, universal classification system for ecosystems does not currently exist.[42]
Final Ecosystem Services	Ecosystems services that occur at the "point of handoff" from natural systems to human systems.[54]
Genetic diversity	The variation in the amount of genetic information within and among individuals of a population, a species, an assemblage, or a community
Impact driver	A measurable quantity of natural resource that is used as an input to production, e.g. volume of sand and gravel used in construction, or a measurable non-product output of a business activity, e.g. a kilogram of NOx emissions released into the atmosphere by a manufacturing facility.[7]
Impact pathway	This describes how, as a result of a specific business activity, a particular impact driver results in changes in natural capital (e.g. biodiversity) and how these changes in natural capital biodiversity affect different stakeholders.[7]
Impacts	The negative or positive effect of business activity on biodiversity.[7]
Indirect impact	A change in the state of biodiversity caused by an impact driver or business activity with an indirect causal link (for instance GHG emissions have indirect impacts on biodiversity).
Insurance and option values	Biodiversity's role in providing a stable and resilient flow of ecosystem services under changing environmental conditions (insurance value), and/or delivering other benefits in the future that may not yet be known, such as new medicines, materials, or crops (options value).
Materiality	An impact or dependency on biodiversity is material if consideration of its value, as part of the set of information used for decision-making, has the potential to alter that decision.

54 Newcomer-Johnson, T., F. Andrews, J. Corona, Ted DeWitt, M. Harwell, C. Rhodes, P. Ringold, M. Russell, P. Sinha, and G. Van Houtven. National Ecosystem Services Classification System (NESCS Plus). U.S. Environmental Protection Agency, Washington, DC, EP-A/600/R-20/267, (2020).

Term	Definition
Materiality assessment	The process that involves identifying what is (or is potentially) material in relation to the biodiversity measurement methodologies' objective and application.[7]
Measurement	The process of determining the amounts, extent, and condition of biodiversity and associated ecosystem services, in physical terms.[7]
Monetary values	They translate costs and benefits into a common currency.[7]
Natural capital	The stock of renewable and non-renewable natural resources (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.[7]
Negative biodiversity footprint	Calculated based on the difference between the total and positive biodiversity footprint of the business, overall or for individual biodiversity assets.[42]
Net impact accounting	It is the process of summing losses and gains for ecologically equivalent biodiversity assets over a period of time.[42]
Organisational focus areas	The part or parts of the business for which biodiversity measurement will be undertaken, e.g. the company as a whole, a business unit, product, project or portfolio.[7]
Positive biodiversity footprint	The sum of surface areas of all ecosystems identified within the asset register or inventory, adjusted according to their respective condition or integrity.[42]
Pressure-response model	A characterisation of the statistical relationship between a given level of pressure and the state of biodiversity, often through synthesising data across multiple studies.
Primary (biodiversity state) data	Data on biodiversity state that is collected first hand by the user through direct approaches such as field surveys.[55]
Qualitative values	They inform the scale of costs and benefits in non-numerical terms (e.g. high/medium/low decrease in recreational benefits).[7]
Quantitative values	They use numerical data as indicators of costs and benefits.[7]
Reference state	Previous state or desired state (of nature) which a target aims to recover or achieve.
Secondary (biodiversity state) data	Data on biodiversity state that has already been collected and made available for reuse by the user.[55]

55 EU B@B Platform (2022) Biodiversity data. Update Report 4.

Term	Definition
Societal impacts	Impacts on society from direct operations or indirectly from somewhere else in a company's value chain, including suppliers and consumers and investments, e.g. loss of pollinating species as a result of habitat fragmentation leading to loss of community food sources.[7]
Total biodiversity footprint	The sum of areas of all ecosystems within an asset inventory derived from individual statements of position for ecosystems.[42]
Total economic value	A framework that provides an all-encompassing measure of the economic value of natural capital assets. It decomposes into use and non-use (or passive use) values, and further sub-classifications can be provided if needed.[56]
Valuation (in relation to biodiversity)	The process of estimating the relative importance, worth, or usefulness of natural capital to people (or to a business), in a particular context. Valuation may involve qualitative, quantitative, or monetary approaches, or a combination of these.[7]
Value	The importance, worth, or usefulness of something.[7]
Value chain	A value chain encompasses the activities, beyond and in relation to direct operations, that convert input into output by adding value.

56 OECD (2006), "Total Economic Value", in Cost-Benefit Analysis and the Environment: Recent Developments, OECD Publishing, Paris, https://doi.org/10.1787/9789264010055-7-en.