Measuring and valuing biodiversity across **supply chains**

Implementation guidance for the Align project recommendations

Align | Aligning accounting approaches for nature

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Project consortium

1. BACKGROUND

The global decline in biodiversity is a risk to business and society. Businesses need to screen and measure their impacts and dependencies on biodiversity to provide the necessary building blocks for taking positive action and reporting on progress. In response to this need, at the end of 2022, the Align project published its recommendations for a standard on corporate biodiversity measurement and valuation. These recommendations comprise a set of principles and technical criteria that define 'what' elements of biodiversity should be measured and 'how' this should be done in different business contexts.

This guidance forms part of a series of briefs that have been produced to support the implementation of the Align recommendations and focuses on **supply chains,** providing further context on spatial scales and concrete examples of supply chain relevant approaches and tools.

In this document, fictional businesses are used to describe approaches that can be used to measure biodiversity impacts and dependencies across supply chains. They are structured around the criteria presented in the Align recommendations. As a preliminary step, it is important to prioritize by using a broad lens to examine company value chains and identify where significant impacts and dependencies occur. This can be high-level and location agnostic. Tools such as ENCORE, the Science Based Targets Network Materiality Screening Tool and High Impact Commodity List can be used to support this assessment. This guidance note focuses on the next step which involves assessing the impacts and dependencies within these prioritized supply chains.

Three different fictional cases are illustrated: an apparel company, a chocolate manufacturer, and a technology company. Together, with the sectors covered in the Align site-level guidance (mining, metal processing and energy), a relevant spread of industrial sectors is covered.

In each case study, the company has completed the initial prioritization assessment and identified the top raw materials and commodities that it sources where the potential for impacts and dependencies are highest. The examples below focus on specific commodities or groups of commodities for each company: cotton, cocoa and minerals.

Cottonlux Ltd is a multinational clothing company operating in the UK markets and Europe. Its production is outside the EU and it has a multi-tiered supply chain. Through its subcontractors, Cottonlux is sourcing cotton from three countries, India, China and the United States of America. Within each country, the company has located broadscale sourcing regions.

Cottonlux
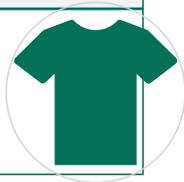
Chocolatery Ltd is a Central European business that manufactures chocolate products. It is sourcing cocoa from ten countries in South America, Africa and Southeast Asia. It has several contract producers that supply cocoa exclusively for Chocolatery.

Chocolatery
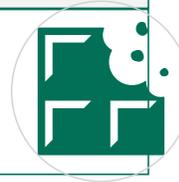
Tabletist Ltd is one of the world's leading technology companies with markets in all continents and production mainly in Asia. It is sourcing minerals, components and products from thousands of partners around the world. It has put effort into shortening its supply chains and getting more direct control over them.

Tabletist
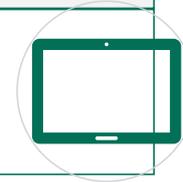
## 2. DECISION-MAKING CONTEXTS AT SUPPLY CHAIN LEVEL

It is now well understood that for many companies and sectors, the most significant biodiversity impacts and dependencies are found within the supply chain rather than through direct operations. This is particularly true for companies that have a heavy reliance on sourcing agricultural, forestry or mined commodities. Supply chains of companies may interface with regions of high biodiversity significance, such as Key Biodiversity Areas. They often also contribute to pressures like land use change and pollution. It is therefore important that companies fully consider their supply chain when screening risks, considering opportunities and measuring their impacts and dependencies on biodiversity. The importance of measuring embedded supply chain impacts, measuring dependencies and considering the resulting risks is reflected in emerging voluntary and mandatory reporting and disclosure initiatives. For example, the exposure draft of the revised Global Reporting Initiative (GRI) Biodiversity Standard, the Taskforce on Nature-related Financial Disclosure (TNFD) recommendations, and the EU Corporate Sustainability Reporting Directive (CSRD) and deforestation regulation extend to value chains. This increases the need for robust biodiversity measurement across supply chains.

In this guidance, the focus is on measuring impacts and dependencies embedded in the production of prioritized raw materials that serve as inputs to business activities. However, for many sectors the greatest pressures on biodiversity come further up the supply chain (e.g., the impacts of growing cotton vs. the impacts of the fabric dyeing process used in the apparel sector). According to the SBTN guidance, "*Companies should assume that sourcing (extraction/growing/harvesting) is the highest impact activity unless there is evidence to prove otherwise for a specific pressure category.*" [1] Equally, dependencies will occur throughout the value chain but are expected to be significant in the production of raw materials given the reliance of production sectors such as agriculture and forestry on biodiversity and ecosystem services.

The objectives related to screening and measuring impacts and dependencies for the fictional company case studies are provided below. In turn, the objectives are related to the level of engagement, control on production practices and availability of data (section 3).

Cottonlux is screening potential impacts and dependencies within its supply chain to inform its risk assessment processes. It is also measuring on-the-ground impacts to understand performance where possible. This information allows Cottonlux to develop its sourcing strategy to manage reputational risks and to inform investors about its biodiversity performance.

Cottonlux
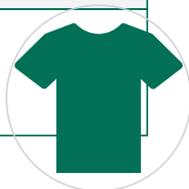
Chocolatery aims to monitor the effectiveness of different agricultural practices at production level. This could give it better control, security and predictability of supply while simultaneously granting higher biodiversity performance.

Chocolatery
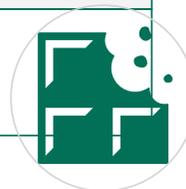
Tabletist's objective is to identify the sourcing locations of raw materials, screen biodiversity dependencies and estimate the realized impacts of sourcing from specific suppliers. It will use this information to identify and report biodiversity risks related to its business activities in accordance with the various assessment and disclosure frameworks to which it is committed. It will also use this information to further develop its responsible sourcing strategy.

Tabletist

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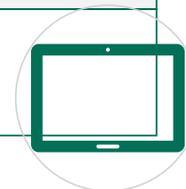
[1] Science Based Targets Network (2023). Technical Guidance: Step 1: Assess. Available at: https:// sciencebasedtargetsnetwork.org/wpcontent/uploads/2023/05/TechnicalGuidance-2023-Step1-Assess-v1.pdf

3. DATA AVAILABILITY FOR SUPPLY CHAINS

An acknowledged challenge with screening and measuring biodiversity impacts and dependencies within supply chains is that the availability of spatial location data for where supply chain activities occur is often lacking. This is because it is difficult to trace many key raw materials/commodities to their source.

Efforts to increase traceability are required to produce a more reliable assessment of impact, dependency, risk and opportunity and to more accurately and transparently measure and report on performance. For example, screening processes that can account for fine-scale spatial differences in biodiversity will be more robust for assessing risks than screening processes on the larger scale (like those that are conducted country-wide). Similarly, being able to factor in differences in management practices between sourcing locations will enable a more accurate estimate of impacts and dependencies than relying on sector-averaged inputs. Increased traceability will also allow for impacts on vulnerable groups, including Indigenous Peoples, local communities, women, girls and young people to be more robustly considered. A summary of different spatial scales of measurement is provided in Figure 1.

Country

Broad-scale sourcing region (within country)

Sourcing landscape

Location of production
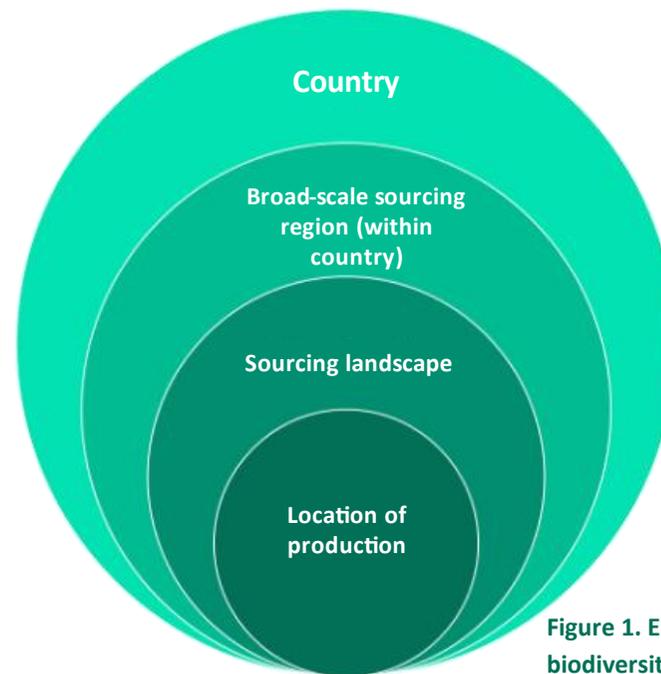
Figure 1. Example spatial scales for screening and measuring biodiversity impacts and dependencies in supply chains

Unfortunately, the resources required to trace products/raw materials to source and therefore measure impacts can be prohibitive and hamper attempts to apply measurement at scale across the business. Therefore, the spatial scale of measurement that can be achieved may depend upon multiple factors, including:

The traceability of the commodity: How resource-intensive and feasible is it to trace to the site level given the structure of the supply chain? For example, is the commodity sourced from a smallholder/artisanal based system? Is a cooperative involved? Is the raw material being sourced as a transformed commodity? Is there information available in commodity sourcing databases[2]?

The heterogeneity of likely impacts and dependencies: This refers to whether the impacts and dependencies of the commodity in question vary according to the location. This is partly determined by the biodiversity significance and level of ecosystem service provision at sourcing locations.

The type of actions that can be taken: Will the assessment inform sourcing decisions? Can the organization support efforts to implement changing practices at production level?

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[2] e.g TRASE supply chains https://www.trase.earth/

Differences in access and availability of information, and differences in objectives, means the fictional case studies will apply different methods for assessing impacts and dependencies.

- Cottonlux can trace the sources of raw materials up to the tier 1 suppliers. The company has not conducted a systematic supply chain biodiversity analysis before. In its materiality analysis, Cottonlux has found that most of the biodiversity impacts in the supply chain are related to cotton production, which is why they focus on it.

- Data available: Cottonlux knows the countries that it sources cotton from, with the possibility to obtain data and/or estimates on tonnages and purchasing of cotton within each country. Tonnage data are preferred as purchases data need to be converted to tonnes and so are less accurate.

Cottonlux

- Chocolatery has identified that of all the raw materials for chocolate, cocoa is the one with the highest potential biodiversity impacts and dependencies. It has therefore decided to focus its efforts on the cocoa supply chain.

- Data available: Chocolatery has the ability to track the exact locations of its sourcing sites, tonnages and purchases. The company has the possibility to take some on-site measurements of the state of biodiversity and obtain information on the cultivation methods that are being used.

Chocolatery

- Tabletist sources minerals for its tablets from 25+ countries. It has done some internal work to map the main raw materials within suppliers and countries. It has a lot of resources available for sustainability work but acknowledges the challenges of the complex supply chain and the high number of raw materials and suppliers in countries where data are not easily available.

- Data available: For the minerals identified in the materiality analysis as highest risk raw materials (tantalum, gold, cobalt and lithium), Tabletist has listed the known smelters and refiners by name and country (based on the location of head offices). It does not yet know the exact sourcing regions or sites for each company. Tabletist knows the revenue generated by the tablets and phones that it sells and has access to data on mineral purchases for a selection of suppliers, although data extraction is laborious. The company is planning to reach out to a few suppliers to collect refinery-level impact driver data.

Tabletist

4. SCREENING POTENTIAL IMPACTS AND MEASURING ACTUAL IMPACTS ON THE GROUND

The Align recommendations set out criteria for screening potential impacts to inform risk and opportunity assessments and measuring realized impacts on biodiversity on the ground. These criteria are split into good practice, which are suitably robust and represent a step change from business as usual, and best practice, which reflect a direction of travel for biodiversity measurement. Approaches available for measuring impacts and dependencies on biodiversity of supply chains are likely to rely more on estimates and models than those applied for direct operations, due to the lower availability of spatially specific and directly measured information. Direct on-ground measurement of biodiversity state for accurate and precise measurement of *actual* impacts is less likely to be used for assessing supply chain impacts and is often only possible for small subsections of the supply chain. It is more common and realistic to assess the *potential* impacts of supply chains, using lower accuracy and precision screening. For specific production sites that are known within supply chains, site-based approaches can be applied.[3] The good and best practices for supply chain biodiversity screening and measurement from the Align recommendations are shown in Table 1.

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[3] Arcadis, UNEP-WCMC, Capitals Coalition, ICF, WCMC Europe (2023). Measuring and valuing biodiversity at site level, Aligning accounting approaches for nature

Table 1: Good and best practice criteria for supply chains (Align Recommendations, 2022)[4]

SUPPLY CHAIN LEVEL

GOOD PRACTICE   BEST PRACTICE

	WHAT TO MEASURE	CHARACTERISTICS OF MEASUREMENT APPROACH	MOST APPLICABLE METHODS
SCREEN	○ 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	○ 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	○ 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	○ 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

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[4] UNEP-WCMC, Capitals Coalition, Arcadis, ICF, WCMC Europe (2022). Recommendations for a standard on corporate biodiversity measurement and valuation, Aligning accounting approaches for nature. Available at: https://capitalscoalition.org/wp-content/uploads/2021/03/330300786-Align-Report_v4-301122.pdf

In the fictional case studies below, good and best practices are applied for both screening and impact measurement. Examples of named tools and methodologies for the approaches (given in bold) are provided in Annex 1.

SCREEN: WHAT IS THE BIODIVERSITY STATUS AT SOURCING LOCATIONS?

Summary:

Characterizing the biodiversity status of sourcing areas is an important step for risk screening. At a minimum, this involves identifying the countries or regions sourced from, and obtaining country-scale information on ecosystems and species using data layers on ecosystem condition and species threats and ranges. Best practice involves increased spatial precision of risk screening through more precise sourcing location data. This may be achieved through identifying specific sourcing locations within countries (instead of broad sourcing regions for the good practice screening).

Approaches and tools for screening biodiversity status at procurement sites are typically easy to apply at scale as they do not necessarily require spatial data and can be quickly applied to different business activities.

Company 1: Cottonlux Ltd	Company 2: Chocolatery	Company 3: Tabletist
Objective: Cottonlux wants to understand the biodiversity status within the countries it sources cotton from as a starting point for framing sustainability strategy development.	**Objective**: Chocolatery wants to understand the biodiversity status of areas at precise sourcing locations so that it can better inform its supplier engagement strategy.	**Objective**: Tabletist wants to understand the biodiversity status of sourcing countries so that it can focus on improving its sourcing strategy in places where biodiversity risks are highest.
Cottonlux sources cotton from three countries, India, China and the United States of America. Within each country, Cottonlux identifies the likely cotton sourcing regions, using sub-national production data. The sub-national production data show the proportion of cotton produced in each region and Cottonlux infers the volume of cotton from each region based upon these proportions.	Through a supplier survey, Chocolatery manages to identify precise regions within countries where it sources most of its cocoa. Where possible, information shared by local NGOs is analyzed for specific ecosystem types and their threat status. A refined list of threatened species likely to be present within cocoa production	To understand the current state of biodiversity in the top ten sourcing countries, Tabletist overlays maps of the sourcing countries with **[1] data layers on ecosystem extent and condition and species threat and range**. Using the data layers, Tabletist extracts the mean, minimum and maximum values of ecosystem and species variables from the ecosystem and species data layers for each sourcing country. This information is used to

To obtain an overview of the current state of biodiversity, and potential risks, in the regions of each sourcing country, Cottonlux applies **[1] data layers on ecosystem extent and condition, and species threat and range.** Cottonlux extracts the mean, minimum and maximum values of ecosystem and species variables from the data layers for each broad-scale sourcing region. These values are used to characterize the ecosystem condition and the importance of the ecosystem for species and to make comparisons between regions. Cottonlux also applies **[2] designated area layers** to identify locations with high importance to biodiversity.

With this information, Cottonlux can start to understand the current state of biodiversity in its different sourcing countries and learn which have particularly high biodiversity importance. It helps them to frame further efforts within each country as they develop their sustainable sourcing strategy and action plan.

landscapes within these regions can also be produced.

The results help Chocolatery to assess which areas it should invest in to increase engagement with suppliers on improving production practices.

characterize the state of the ecosystem and its importance for species and to make comparisons between countries.

Screening the current state of biodiversity enables Tabletist to better understand biodiversity risks associated with its main sourcing countries. It helps the company to focus further efforts on the most relevant countries as they develop their sustainable sourcing strategy and action plan.

SCREEN: WHAT ARE THE POTENTIAL IMPACTS AT SOURCING LOCATIONS USING SECTOR AVERAGE INFORMATION?[5]

Summary:

In addition to screening biodiversity at sourcing locations, best practice screening involves estimating potential impacts of supply chains through model-based approaches. At a screening level, the tonnage, purchases, or revenue of commodities sourced at a location can be used to derive sector average pressure data, which is used to assess potential impacts on ecosystems.

Approaches and tools for screening biodiversity status at procurement sites are typically easy to apply at scale, as they do not necessarily require spatial data and can be quickly applied to different business activities.

Company 1: Cottonlux Ltd	*Company 2: Chocolatery*	*Company 3: Tabletist*
Objective: Cottonlux wants to understand the potential impacts associated with the cotton that it sources from priority countries.	**Objective:** Chocolatery has already conducted high-level screening on potential impacts and is focusing its efforts on measuring realized impacts on the ground (see the next table).	**Objective:** Tabletist wants to gain information on the main environmental pressures associated with its mineral extraction in identified priority locations.
First, it obtains data on estimated purchased tonnage by country before feeding into a **[3] model-based footprinting approach.** The footprinting tool estimates the land use associated with the purchased tonnage by country, based on FAO yield data. This provides an estimated area of land required to produce the sourced tonnage of cotton. This area of land is combined with a multiplier reflecting the	Chocolatery has already conducted a **[4] life cycle impact assessment** of its chocolate products, including the impact of cocoa sourced from known sourcing countries. This has provided an overview of the potential impacts associated with the cocoa within its products. However, it provides limited information on actual biodiversity impacts in priority landscapes. Chocolatery is now focused on measuring site level impacts to take account of the impact of land use and farming practices, which are described in the next table.	Tabletist partners with a consultant to use an **[5] Environmentally-Extended Multi-Regional Input-Output model (EE-MRIO)** and assess pressures on the environment from mineral extraction at the sites of its prioritized suppliers. First, data on purchases of mining sector products from each country are collated. Using these data, the EE-MRIO provide estimates of the environmental inputs (land use and water use) and outputs (emissions) associated with mineral extraction.

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[5] This Best practice for Screen is also a Good practice for Measure in the Align recommendations.

potential impact of intensive agricultural land use on ecosystem condition. Where tools allow, this can also be completed for pesticides, fertilizers and greenhouse gas emissions. Using tonnage data instead of monetary data to model the pressure state response is likely to increase the accuracy of the results.

As a result of the analysis, Cottonlux will have an estimated biodiversity footprint of the land use (and potentially other impact drivers) associated with the cotton it has purchased. As it did not collect data from its suppliers, the result reflects the industry average footprint (e.g. based on average yields and a generic multiplier for intensive croplands).

Cottonlux can use the outputs as an initial estimate of the footprint of the land use (and potentially other impact drivers) associated with its supply of cotton. This information can guide decisions on product development and procurement practices. It can also be used for reporting and disclosing potential biodiversity impacts.

Using the estimated pressures, a [3] model-based footprinting approach is applied. The approach draws on sectoral average data to identify how these pressures translate into impacts on ecosystem quality.

The results are not specific to Tabletist. They reflect sector averages and provide a high-level estimate of potential impact. The methodology applied also offers the possibility to increase the accuracy of results by using company-specific impact driver data in the future.

MEASURE: WHAT ARE THE REALIZED IMPACTS, BASED UPON COMPANY-SPECIFIC PRESSURES AND PRIMARY BIODIVERSITY DATA?

Summary:

To move from risk screening to more accurate estimates of realized impacts more specific information on pressures and suppliers can be fed into model-based footprinting approaches. These model-based footprinting approaches can be complemented with measured impacts on the state of biodiversity using primary data at priority locations. This, in turn, requires precise locations and known boundaries of sourcing sites. Direct measurements taken on the state of biodiversity allow the development of biodiversity accounts to begin at these locations.

The approaches and tools used to estimate realized impacts based on company-specific pressures and environmental baseline data are typically of medium responsiveness. This means that if production practices vary between sourcing locations, this will be reflected to some extent in the assessment results.

Company 1: Cottonlux Ltd	Company 2: Chocolatery	Company 3: Tabletist
Objective: Cottonlux wants a more accurate estimate of the realized impacts of its sourcing on biodiversity to better inform its sustainability reporting.	**Objective**: Chocolatery wants to understand the impact of the specific production practices implemented by its suppliers.	**Objective**: Tabletist is looking to improve its estimation of impacts by using supplier-specific data to estimate the realized impacts of specific suppliers.
Cottonlux does not have full supply chain traceability, so it cannot engage directly with producers to collect the site level data needed to inform best practice. To be able to implement best practice, Cottonlux identifies and contacts its suppliers so that it can engage with them in the future and obtain measured data.	Chocolatery assesses the impacts of different agricultural practices on biodiversity in its supply chain. It uses primary data rather than sectoral averages and assesses the state of biodiversity on the ground. Chocolatery engages with suppliers to collect data on cultivation practices implemented at different sourcing locations and on land occupancy by land use type. It also uses **[6] on-the-ground surveys** to	It first selects a few suppliers for piloting. From each supplier Tabletist requests primary impact driver data. This includes data on land use in hectares, land use type, energy and chemical use, water and soil pollution, and waste. Tabletist applies a **[3] model-based footprinting approach** or a **[4] life cycle impact assessment** method using these primary data, to provide the company specific results and avoid the use of sector averages.

Cottonlux is also sourcing certified cotton to reduce impacts on biodiversity, but wants further assurances that this objective is met. Thus, Cottonlux conducts an analysis on the certification to assess how it reduces impacts on land use change, affects climate change, alters pollution levels, influences natural resource use and impacts a range of species.	collect information on consumption of irrigation water, fuel, fertilizers, and pesticides. Chocolatery selects a pilot subset of sourcing sites for on the ground, site level biodiversity measurements. It works with an external service provider that collects [7] eDNA samples from a subset of fields to determine the presence and/or distribution of species. Chocolatery also partners with a local NGO to gather views on different production practices from local communities (including the views from women and Indigenous Peoples). For the rest of the pilot sourcing sites, Chocolatery partners with [8] remote sensing service providers to monitor possible changes in land use intensity and forest extent. **The assessment helps Chocolatery select evidence-based sustainable agricultural practices in cooperation with suppliers to improve the effectiveness of biodiversity conservation measures. A deeper understanding of the supply chain also improves the control and predictability of the supply.**	**Tabletist can assess its estimates of the realized impacts of its mineral sourcing from specific suppliers. It can also use the information to inform its sustainable sourcing strategy and procurement decisions.**

5. MEASURING BIODIVERSITY SUPPORTING ECOSYSTEM SERVICES THAT SUPPLY CHAINS DEPEND UPON

As well as impacting biodiversity, supply chain operations can have strong dependencies on biodiversity and ecosystem services. Reductions in ecosystem service flows at production level can have cascading effects up the supply chain. For this reason, securing the stocks of biodiversity-supporting service flows at production level can enhance the long-term resilience of supply chains. Measurement of the biodiversity underpinning these services is therefore important when assessing exposure to dependency-related risks and understanding opportunities.

Below is an example of how one of the fictional case studies, Chocolatery, assesses their material dependencies and incorporates measurement of the biodiversity supporting these dependencies.

Chocolatery has applied a [9] dependency screening tool, which reveals that the supply chain has a very high potential dependency on pollination ecosystem services. This dependency was confirmed by assessing the specific reliance of cocoa crops on wild pollinators. Published literature reports that cocoa is entirely dependent on insect pollination, and therefore changes to the flow of pollination services would likely disrupt the supply chain and affect the financial viability of Chocolatery's operations.[6]

Chocolatery assesses the extent and condition of pollinator habitat surrounding its cocoa farms, using [8] remote sensing. This assessment is a proxy measurement of the capacity of the ecosystem to provide pollination services. Previous studies have identified that potential pollinator habitat such as secondary forest surrounding a cocoa farm can be a predictor of the abundance of pollinators.[7] By measuring the habitat in the surrounding landscape, Chocolatery also takes into account other stakeholders which operate within the landscape which could also have an impact on pollination services. This allows Chocolatery to assess potential operational risks and prioritize engagements at the landscape level.

Chocolatery also wants to understand which management practices best support pollinator abundance while maintaining high yields. At select sites, it assesses the impact of different land management practices, including implementation of agroforestry and different levels of pesticide use, on pollinators using direct on-the-ground surveys. The study measures the abundance of pollinator groups and cocoa flower visitation rates within different land management practices, as well as relevant condition variables such as proximity to secondary forest and depth of leaf litter. This monitoring programme builds an evidence base of how the company can best support the resilience of pollination services within its supply chain.

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[6] Klein, A., Vaissière, B., Cane, J., Steffan-Dewenter, I., Cunningham S., Kremen, C., Tscharntke, T (2007). Importance of pollinators in changing landscapes for world crops. Available at: http://doi.org/10.1098/rspb.2006.3721

[7] Toledo-Hernández, M., Tscharntke,T., Tjoa,A., Anshary, A., Cyio,B., Wanger, T (2021). Landscape and farm-level management for conservation of potential pollinators in Indonesian cocoa agroforests. Available at: https://doi.org/10.1016/j.biocon.2021.109106

6. VALUATION OF IMPACTS AND DEPENDENCIES

Valuation is where impacts and dependencies are understood through the lens of importance to different stakeholders. Stakeholders may have different values of biodiversity. For example, Indigenous Peoples and local communities may value biodiversity that has bio-cultural importance to them, and women and men in local communities may value aspects of biodiversity and ecosystem services differently based on their roles and responsibilities. Broadly speaking, there are four types of value (Table 2). It may not be possible to consider all these types of value in every decision.

From a business perspective, direct value may be the most important of the four types of value (Table 2), especially where the business depends upon that resource for future viability. However, understanding the underpinning and indirect values to a range of stakeholders, including groups considered vulnerable, will help to ensure that the rights and needs of local people are considered, and that the outcomes are sustainable. Businesses should also acknowledge intrinsic values and understand the need to maintain ecosystems in good condition to maintain their intrinsic value.

There is often an assumption that values may change in a linear fashion related to supply and demand. However, ecosystems are complex systems and are subject to tipping points. Tipping points are hard to establish and when trying to value ecosystems with potential tipping points, a precautionary approach should be taken. For example, in the case of destroying habitat that pollinators depend upon, it may be that the entire cocoa crop will become unviable (due to a lack of pollination).

Table 2. An example of the outcomes of a values assessment for one of the fictional companies, Chocolatery, is provided below. The focus of the example is on assessing the different values of their dependencies and impacts on pollination services. It does not reflect an attempt to assess the full value of ecosystems that Chocolatery and its supply chains interact with.

Value type	Description	Example valuation technique	Company example- Chocolatery
Direct value	The final goods or services from nature that contribute directly to Chocolatery's production processes.	Market prices for goods and services.	Within the supply chain of Chocolatery, there are dependencies on provisioning services associated with basic ingredients for their core products (like cocoa and sugar). The market value of these products can be included.
Underpinning or indirect value	Benefits that support (or underpin) the direct values. This reflects that biodiversity has an important role in supporting the generation	The underpinning values may be assessed through connections to the market price of final goods and services as described above. However, values beyond these	Chocolatery relies indirectly on a range of ecosystem services that

	of ecosystem services that have a direct value. It is important to understand these values as it helps to reveal the contribution that well-functioning ecosystems play in maintaining the quantity and quality of the direct benefits. Indirect values in this context capture wider values beyond a company's direct supply chain, i.e. the wider benefits of well-functioning ecosystems for other stakeholders in the landscape.	contributions to final goods and services may need to be assessed through alternative methods. For example, by conducting contingent valuation studies that assess the 'willingness to pay' for environmental assets through questionnaires. Importantly, underpinning values which represent supporting ecosystem services should not be added to the value of final ecosystem goods and services as this would count their benefit twice.	support the production of their raw commodities, including pollination. Animal mediated pollination is essential to produce the fruit of the cocoa plant. Without midges providing a pollination service, cocoa fruit production would be dramatically reduced. The value of this ecosystem service can be expressed in qualitative, quantitative or monetary terms. In its assessment, Chocolatery considers the underpinning or indirect values of pollination to their own operations. It also considers the potential impacts of the presence of cocoa pollinators beyond Chocolatery's plantations for local communities, including groups of people that are considered most vulnerable (e.g., women and Indigenous Peoples).
Insurance and options value	The diversity of species that provide ecosystem functions and thus ecosystem services has insurance value. This means that when one species is under pressure, other species can potentially fill that functional niche. Option value represents undiscovered, underutilized or less understood benefits that might exist though greater understanding in the future.	Willingness to pay studies, market values.	Other pollinating species in the local area may have insurance value. If the primary pollinator species declines, other pollinating species may be able to fill the niche and pollinate cocoa trees. The surrounding habitat, which can contribute to cocoa pollination, also has some insurance value. Chocolatery notes that maintaining

			the surrounding habitat in good condition can be important for supporting these less studied processes.
Intrinsic value	The non-human value of an ecosystem.	These cannot be valued through human lenses (because in doing so they become instrumental) so they should be acknowledged, and the relationships understood.	Chocolatery acknowledges that the biodiversity it both impacts and depends upon has intrinsic value that cannot be accurately captured through a human-centred lens. It can be acknowledged that better functioning ecosystems will likely increase this form of value.

Approach from case study	Category	Examples	Source
[1] Data layers on ecosystem extent and condition and species threat and range	Secondary data layer[8]	Ecosystem Integrity Index (EII) global layer	UNEP-WCMC
		Global Forest Watch Open Data Portal	Global Forest Watch
		Red List of Ecosystems	IUCN RLE
		Mean Species Abundance (MSA) global layer	GLOBIO
		Ranges of IUCN Red List of Threatened Species	IBAT
		IUCN Species Threat Abatement and Restoration (STAR) Metric data layer	IBAT
		Rarity-weighted species richness layer	IBAT
[2] Designated area layers	Secondary data layer	World Database of Key Biodiversity Areas	IBAT
		World Database on Protected Areas	IBAT
[3] Model-based footprinting approaches	Measurement methodology	Global Biodiversity Score (GBS)	CDC BIODIVERSITÉ

[8] The following database can be further consulted to find more secondary data layers: ABMB. 2019. 'Dataset Mapping'. Appendix 2 of Position paper on corporate data inputs. Aligning Biodiversity Measures for Business. https://www.dropbox.com/sh/ym0agydww9haz40/AABhLuktuXNy3Ue8qfWv696Ca?dl=0&preview=20190912_ABMB_SG3A-datasets_database_v4_extract.xlsx.

		Biodiversity Impact Metric (BIM)	CISL
		Biodiversity Footprint Calculator (BFC)	Plansup
		Product Biodiversity Footprint (PBF)	The PBF project
		Bioscope	Bioscope
		LIFE Key	LIFE
		Corporate Biodiversity Footprint	Iceberg Data Lab
		Biodiversity Impact Assessment Tool (BIAT)	ISS ESG
[4] Life cycle impact assessment	Measurement methodology	ReCiPe	ReCiPe
		LC-IMPACT	LC-IMPACT
		IMPACT World+	IMPACT World+
[5] Environmentally-Extended Multi-Regional Input-Output models (EE-MRIO)	Database	EXIOBASE	EXIOBASE Consortium
		The Eora Global Supply Chain Database	Eora
		SEI's Input-Output Trade Analysis (IOTA) model	SEI
		Global Trade Analysis Project (GTAP)	GTAP

[6] On-the-ground surveys	Primary data collection method	Farm Sustainability Assessment (FSA)	SAI platform
		The Biodiversity Performance Tool (BPT)	EU LIFE
[7] eDNA	Primary data collection method	Some eDNA service providers listed in the next column	A list available at eDNA RESOURCES
[8] Remote sensing	Primary data collection method	Some remote sensing data platforms and service providers listed in the next column	Landsat by NASA Sentinel by ESA CBERS RSS – REMOTE SENSING SOLUTIONS GMBH AWS Marketplace
[9] Dependency screening tool	Dependency tool	ENCORE database	ENCORE
		WWF Risk Filters	WWF Water Risk Filter, WWF Biodiversity Risk Filter
		Aqueduct	Aqueduct