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BIODIVERSITY MEASUREMENT APPROACHES FOR BUSINESSES AND FINANCIAL INSTITUTIONS

EU Business @ Biodiversity Platform

THEMATIC REPORT: BIODIVERSITY DATA

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Cover photo (Brown Hare – Lepus europaeus) by Johan Lammerant

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READER'S GUIDE

Between 2018 and 2021, the EU Business @ Biodiversity Platform has published annual 'update reports' with regard to the assessment of biodiversity assessment approaches for businesses and financial institutions. New update reports will follow in the future but this year, we publish the first 'thematic report'.

Contrary to the previous reports, this Thematic Report does not focus on biodiversity measurement approaches as such. It is completely dedicated to the rapidly evolving area of biodiversity data. Collecting and interpreting biodiversity data for application in a business context is often challenging. Despite the huge demand from businesses and finance institutions for more clarity on biodiversity data that are suitable for use in a business context, relatively limited guidance is available. The EU Business @ Biodiversity Platform aims to cover this gap by fully dedicating this Thematic Report to this topic. The report is partly based on the outcomes of a webinar series on biodiversity data for businesses, organized by the Platform in October 2021[1].

This thematic report has the following structure:

- Section 1: the landscape of biodiversity data.
- Section 2: needs, challenges and potential solutions.
- Section 3: primary data - innovative biodiversity data collection techniques.
- Section 4: secondary data - IBAT, ENCORE and Microsoft's Planetary Computer.
- Section 5: remote sensing and radar technology.

The series "Assessment of Biodiversity Measurement Approaches for Businesses and Financial Institutions" provides periodic update reports as well as thematic reports. Update Reports focus on measurement approaches (e.g. additional approaches, adaptations of the assessment methodology to reflect new developments, descriptions of case studies) while Thematic Reports focus on specific themes which are important in the context of corporate biodiversity measurement. We welcome new measurement approaches, new case studies and any constructive contribution on specific themes by members of the EU B@B Platform and beyond, with a view to progress the development, alignment and uptake of biodiversity measurement approaches by businesses and financial institutions.

References to private companies in these reports should not be interpreted as advertising or favouring one company over another. These are only included to inform the reader of the latest techniques in biodiversity measurement approaches.

[1] Webinar series available at https://ec.europa.eu/environment/biodiversity/business/news/news-312_en.htm.

1 THE LANDSCAPE OF BIODIVERSITY DATA

1.1 Context

The range of data sources used by companies and investors to assess biodiversity performance vary in their nature and origin. Often multiple data sets are used to determine impact and performance. Identifying and accessing appropriate data sources can be costly and time consuming. This section sets out the landscape of biodiversity data – sources, types and quality and considers when different types of data should be used.

1.2 The biodiversity data landscape

Figure 1 sets out the biodiversity data landscape. Data sources for biodiversity measurement come from a large number of sources ranging from ecological field surveys to government data bases and corporate disclosures.

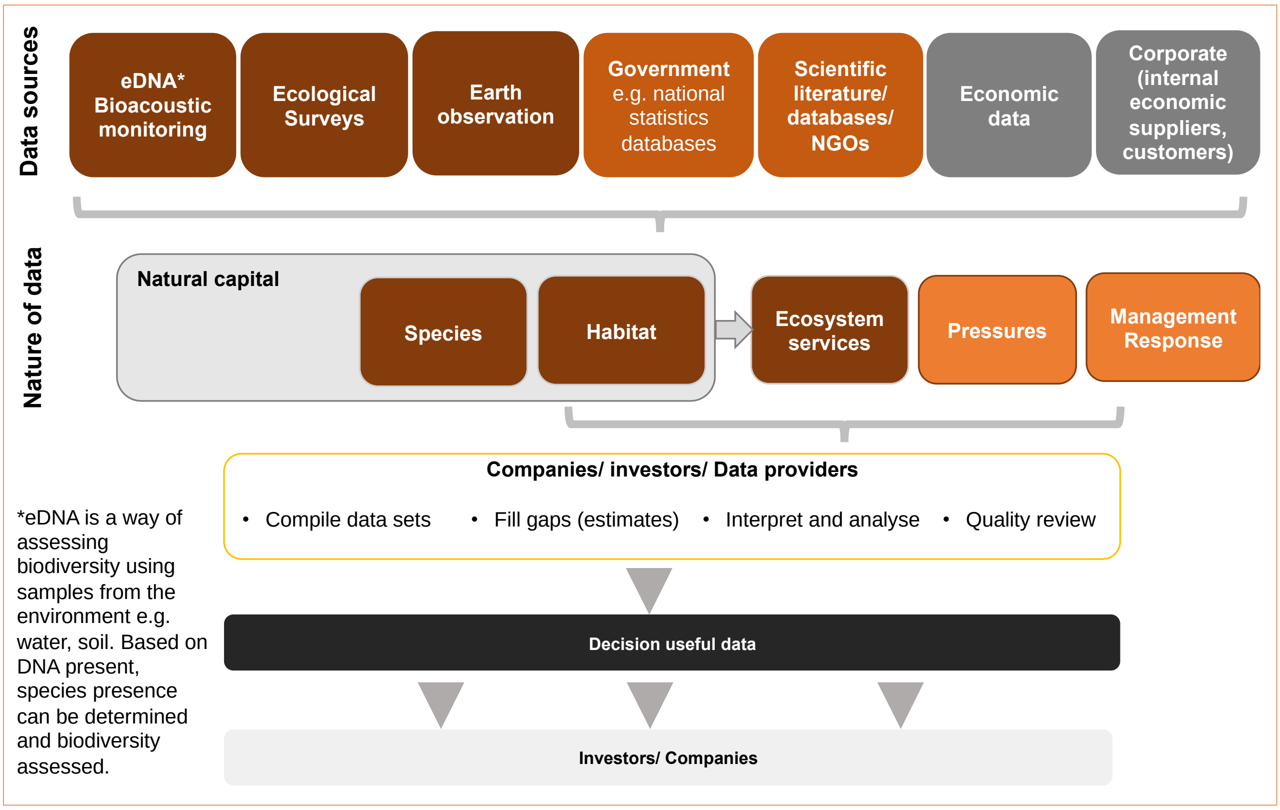


Figure 1: The biodiversity data landscape. Figure adapted from PRI, Chronos Sustainability, and Globalbalance 2021.

Some data sources give direct insight to the status of biodiversity, others – such as company turnover – can be used in combination with economic models such as EXIOBASE[2] or EORA[3] to calculate pressures on biodiversity which can then, through further data models (such as GLOBIO[4] or ReCiPe[5]) be used to calculate the status of biodiversity.

Data used by biodiversity measurement approaches can include data on (TNFD 2021):

- **Pressures on biodiversity** i.e. the impacts a company has on biodiversity (this may also include broader impacts on biodiversity), for example, climate change, resource exploitation, alien invasive species, pollution and land use change (IPBES 2019).
- **The state of biodiversity** (often spatially explicit) which covers the current, past and projected status of species, ecosystems (extent and condition), biodiversity at a genetic level and conservation priority.
- **The status of ecosystem services** (distribution, trends).
- **Economic** measures of human activity which can be used by some measurement approaches to determine a modelled corporate biodiversity impact e.g. turnover or raw materials use.
- Measures of the quality of **management response** i.e. data that assesses existence or quality of mitigation measures and biodiversity performance in response to the pressures and status of biodiversity and ecosystem services above.

The biodiversity data landscape is continually evolving. Within the finance sector, for example, data used has historically been qualitative in nature, derived from company disclosures, NGO or expert reports or analysis of media coverage of corporate actions. More recently science or policy-based databases or corporate databases are being employed. With increasingly affordable access to remote sensing/ satellite data, new data sets are becoming available that can track impact and performance in real time (Figure 2) (EU B@B Platform Webinar 4 2021).

Utilising these data sets for decision making within companies may require combining several of them – all of which may have different levels of quality and periodicity of update. The complexity of the landscape and the diversity of data sources makes it challenging for newcomers to navigate and problematic to deliver accurate and complete assessments of biodiversity performance using existing biodiversity measurement approaches.

From a corporate perspective, a similar trend is seen, with increasing use of technology to monitor, for example, supply chain risk and the evolution of technology-based approaches like bioacoustics monitoring and eDNA (section 3) to streamline and reduce the costs of onsite data collection for biodiversity monitoring. Digital technologies are enabling (i) new data connections through, for example, machine learning, (ii) new top-down data from Earth Observation Data and (iii) new bottom-

[2] EXIOBASE is a global, detailed Multi-Regional Environmentally Extended Supply-Use Table (MR-SUT) and Input-Output Table (MR-IOT). It was developed by harmonizing and detailing supply-use tables for a large number of countries, estimating emissions and resource extractions by industry. https://www.exiobase.eu/

[3] The EORA global supply chain database consists of a multi-region input-output table (MRIO) model that provides a time series of high-resolution IO tables with matching environmental and social satellite accounts for 190 countries. https://worldmrio.com/

[4] GLOBIO is a model that quantifies global human impacts on biodiversity and ecosystems. https://www.globio.info/

[5] ReCiPe is a method for the life cycle impact assessment. https://www.rivm.nl/en/life-cycle-assessment-lca/recipe

up data e.g. validation of earth observation data by local community records (Green Digital Finance Alliance 2020).

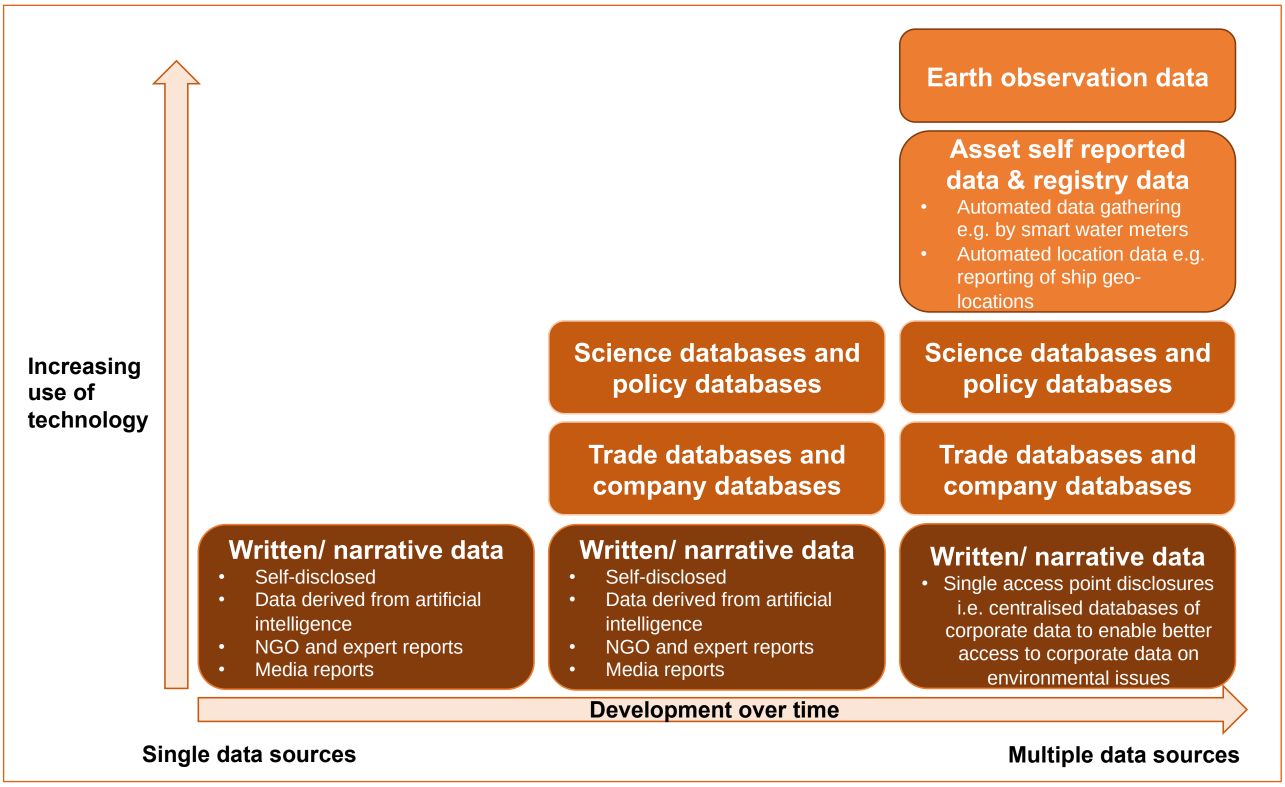


Figure 2: The evolution of data. Adapted from Haahr 2021 (EU B@B Platform Webinar 4 2021).

1.3 Types of data

Biodiversity data comes from a variety of sources, it can be quantitative, qualitative or spatial. It can also range from primary measured data derived from surveys to modelled data calculated based on turnover, as shown in Table 1 (Natural Capital Coalition 2016).

Table 1: Types of biodiversity data.

Data type	Example	Application
Primary data Data collected for the assessment being undertaken	• Internal business data e.g. raw material consumption, revenue. • Site level data collected through e.g. surveys or sampling. • Data collected from suppliers or customers.	Use of company revenue to calculate a biodiversity footprint
Secondary data Data collected for other purposes	Published, peer-reviewed, and grey literature (for example, life-cycle impact assessment (LCIA) databases; industry, government, or internal reports)	Use of global biodiversity data sets to identify where a company might be operating in or near a protected area
Modelled data (a form of secondary data)	Estimates derived using modelling techniques – these can be based on primary and secondary data	Data resulting from the translation of revenue data to biodiversity impact using a model such as GLOBIO[6]

All are required, modelled data calculated based on turnover is particularly useful where gaps in quantitative data exist. Assessing biodiversity performance at site level tends to use data on state and response and to focus on primary rather than secondary data. Biodiversity footprinting approaches developed for the finance sector and for application at corporate level emphasize the use of secondary pressure data to assess biodiversity state. The data that are appropriate for a company to use depends on the decision context and business application which it is to be used for.

1.4 When to use which data?

Companies and finance institutions wishing to determine which data they wish to use will need to consider the business application for which they want to apply data, the nature of the data available and its implication for decision making. The Taskforce for Nature Related financial disclosures (TNFD) sets out the characteristics of decision useful data which have been adapted in Figure 3 (TNFD 2021).

[6] Described in detail in Lammerant, J. 2019. “Assessment of biodiversity measurement approaches for businesses and financial institutions.” https://ec.europa.eu/environment/biodiversity/business/assets/pdf/European_B@B_platform_report_biodiversity_assessment_2019_FINAL_5Dec2019.pdf.

- Appropriate to the decision context
- Formal recognition for application in the decision context

- Suitable accuracy to enable companies to make decisions with reasonable assurance as to the integrity of the assessment results

- Spatial and non-spatial i.e. fit for use at the right scale for the decision

- Must represent the appropriate timescales for decision making

- Regularly updated or updated over an appropriate timescale for the decision context

- Easily accessible in different formats (including languages) and consideration of costs

- Facilitates comparison through inter-operable formats and be consistent and comparable within and between sectors

- Permit aggregation and disaggregation to allow for attribution across portfolios, footprints

- Should include pressures on nature, state of nature and response

- From authoritative (peer reviewed, published) or verifiable source (subject to third party audit)

Figure 3: Characteristics of decision useful data. Figure adapted from TNFD 2021.

The type of biodiversity data used by companies and investors is dictated by: 1) the decision context, 2) regulatory and compliance requirements, 3) the need to enable delivery against global biodiversity goals such as those set out under the Convention on Biological Diversity and proposed within the post 2020 Global Biodiversity Framework and 4) the materiality of the biodiversity issues concerned (the higher the materiality, the greater the requirements in terms of data accuracy and quality). This will, in turn, be influenced by availability, accessibility and quality of data.[7]

[7] Finance for biodiversity WG on impact assessment.

2 DATA NEEDS, CHALLENGES AND POTENTIAL SOLUTIONS

2.1 Context

Data challenges have been identified by investors and companies alike as the biggest impediment to including biodiversity within decision making (Natural Capital Coalition 2019; Credit Suisse and Responsible Investor Research 2021). Biodiversity measurement is an almost forensic exercise which requires the piecing together of multiple, often incomplete, sets of data to give an overall picture of company performance.

Previous reports from the EU B@B Platform have identified challenges with regards to the data required to apply biodiversity measurement approaches linked to a lack of adequate corporate biodiversity disclosures to drive data sets, the variety of data available and significant variation in its quality. Determining how to reflect these inaccuracies and assessing the sensitivity of the outcomes of the application of biodiversity measurement approaches to variations in data used, data quality and completeness will be important to enable informed decision making. (Lammerant et al. 2019) This section explores these challenges in more detail and outlines some of the solutions that are emerging.

2.2 Data challenges

Lack of standards, gaps in available data, ability to access data, lack of guidance, data quality and cost were identified by surveyed businesses as the primary data challenges.[8] The Capitals Coalition and United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) identified four key barriers to accessing data for natural capital assessments (Figure 4).

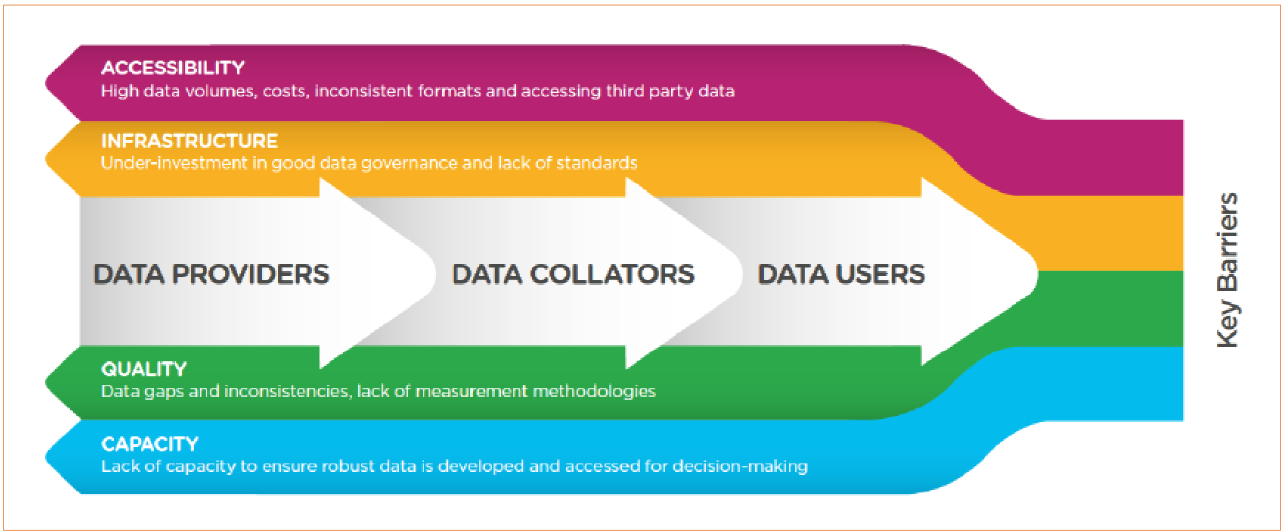


Figure 4: Natural capital data challenges. Figure from Natural Capital Coalition 2019.

Although the scope of this work was data challenges linked to natural capital assessments, biodiversity data was repeatedly highlighted as a particular challenge and many of the issues that

[8] EU B@B Platform Webinar 4 2021 - participant survey.

were highlighted for natural capital data are valid for biodiversity data (Natural Capital Coalition 2019).

2.2.1 Accessibility

The TNFD attributes disparate, piecemeal and inconsistent use of data in nature-related decision making to a lack of integration of nature data into standardized, aggregated metrics and measures in an accessible format (TNFD 2021).

Ability to access data that is required to undertake biodiversity measurement can be compromised by:

- Costs, licensing agreements, data security, and confidentiality which can throw up barriers to access – value chain data transfer, for example, may be costly and labour intensive as can building the capacity of value chain partners.
- Format of the data: different data may be in incompatible formats or exist in formats that are not readily accessible - much data (dark data) is locked up within PDFs of environmental impact assessments and is not readily available.
- High data volume may obscure important data or lead to processing challenges.

More recently, it has become clear that also lack of awareness on the existence of natural capital and biodiversity data might be an obstacle. National statistics offices are increasingly collecting such data, as part of their work on environmental economic accounts, but so far there is a disconnect between the business community and the statistical community (Lammerant 2019).

2.2.2 Quality

Figure 5 below reflects the data gaps perceived by a range of data users, providers and processors (EU B@B Platform Webinar 4 2021). Lack of asset level data, lack of agreement on how to assess best practice biodiversity management and data on biodiversity state were identified as key challenges.

From an investor perspective, lack of standardised disclosure requirements, lack of ability to access performance insights from on the ground data (most data available to the finance sector on biodiversity is modelled or focused on management system quality) and lack of consensus on metrics meant that corporate data for assessments was often unavailable. (PRI, Chronos Sustainability, and Globalbalance 2021; Liudmila Strakodonskaya 2021)[9] Although data focused on impacts is relatively widely available (albeit imperfect), data on dependencies, future scenarios, opportunities and data sets that address interdependencies between different environmental and social issues are few in number (PRI, Chronos Sustainability, and Globalbalance 2021). With increasing effort on delivering business transformation to enable transition to a nature positive economy, this is a key and potentially very impactful data gap. To enable delivery of the global goal for nature (no net loss by 2030, nature recovery by 2050), the ability to identify, manage and act on both risks and opportunities for biodiversity will be required. This means data on both risks and opportunities.

[9] L. Strakodonskaya is ESG Analyst at Axa Investment Managers.

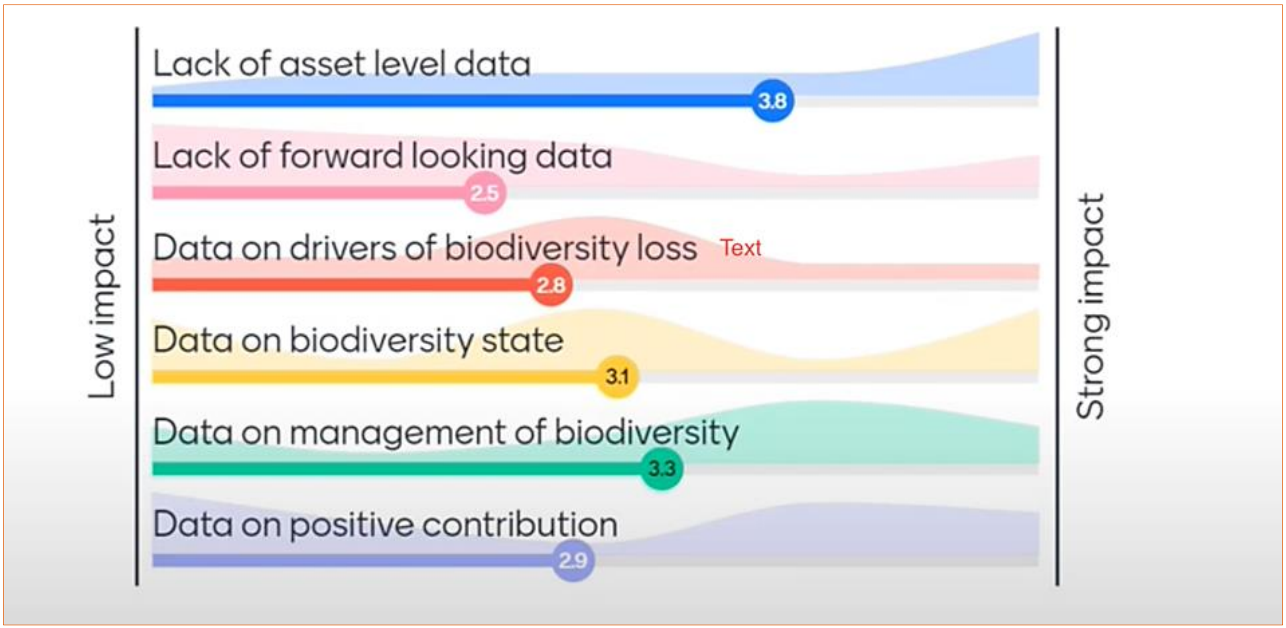


Figure 5: Most impactful data gaps.

Data gaps are more challenging for some sectors than others. For supply chain companies in particular, the complexity of supply chains and lack of direct ownership over the data producing entity makes accessing data challenging. Although data is available for some issues e.g. TraseEarth provides traceability of deforestation risk within supply chains, much broader coverage of issues and sectors is required. The proposed Open-source Biodiversity Data Platform initiative[10] by the Green Digital Finance Alliance is one of a number of initiatives that is trying to address this gap in data availability (section 2.3). Divergent standards or a lack of data standards can also reduce the comparability and use of data. (WWF-UK 2022)

2.2.3 Capacity

The ability to manipulate data and understand its limitations is becoming increasingly important in the context of biodiversity measurement with some companies and finance institutions building capacity to understand and assess spatial data, for example. Although a number, particularly site-based companies such as utilities, oil and gas and mining companies have strong geospatial analytical capabilities, not all companies wishing to use biodiversity measurement will have ready access to such capacity. Hence, there is a need for tools and approaches that can be used by those with limited capacity to analyse and manipulate data.

2.2.4 Infrastructure

The Capitals Coalition (Natural Capital Coalition 2019) identified the lack of a robust data infrastructure for natural capital data as a significant barrier to data access. The Open Data Institute defines data infrastructure as the datasets, technology, training and processes that makes them useable, policies and regulation such as those for data sharing and protection, and the organizations that collect, maintain and use data (Open Data Institute 2022). It identified significant data quality

[10] For more information, see Gardin, Francois, et al. 2022. “Open-source Biodiversity Data Platform Initiative – Technical Scoping Paper.” https://www.f4b-initiative.net/_files/ugd/643e85_57b52c5b97dc4e2ca3d493a116f75836.pdf

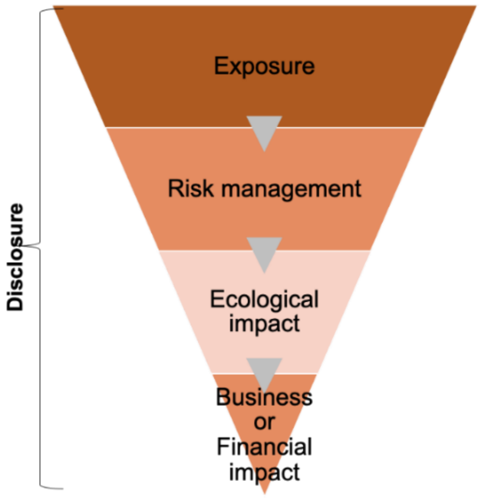
issues arising from a lack of investment in key data sets, a lack of standards and guidance on data and how to deal with data quality issues and weak governance (management, systems, policies and standards for data). Lack of capacity, quality and accessibility are directly related to challenges in data infrastructure.

The following are illustrations of some of the challenges around data infrastructure:

- **Conceptual:** confusion exists relating to the elements of biodiversity to consider within measurement. In particular, data to measure biodiversity dependencies are not well developed and understanding on how to approach measurement and which metrics to use is limited. This can pose challenges to determining which data is most appropriate for the business decision at hand. (PRI, Chronos Sustainability, and Globalbalance 2021)
- **Drivers for standardisation are inconsistent:** the drivers for standardisation of biodiversity data are inconsistent and weak. Reporting standards address different aspects of biodiversity, have different definitions of materiality (those with financial-focused definitions exclude biodiversity, those that use the concept of double materiality include it but do so in different ways).

The results of these challenges are that the data information flow required to gain insight of potential risk, actual risk, impact and business and financial impact is broken. These are key data to support biodiversity measurement. Most data sources provide one element of the overall picture required to gain insight into biodiversity performance.

Figure 6 shows examples of the data required at different aspects of the information flow. Few measurement approaches and associated data sets offer all elements of this information flow. Links between different data sets are not often (although are beginning to be) made with the result that laborious data manipulation using multiple data sets is required which is both time consuming and gives rise to potential risk of error.



Which means	Requires understanding of
Exposure of company (ies) to biodiversity related risk e.g. presence of protected areas or decline in pollinators/ pollination services	• Company location • Biodiversity present/ impacts • Nature of activities • Regulatory environment (law and enforcement)
Evaluation of effectiveness of corporate risk mitigation processes	• Quality of company policy, strategy and action plan • Assessment of effectiveness of implementation/ operational/location specific
Impact resulting following avoidance & mitigation through risk management	• Change in state of biodiversity/ change in pressure
Translation of ecological impact to business or financial implications	• Business performance impacts (e.g. financial, reputational, compliance with regulation, performance against objectives)

Figure 6: The biodiversity data information flow. Figure adapted from PRI, Chronos Sustainability, and Globalbalance 2021.

2.3 Solutions

To address all these needs and challenges in terms of biodiversity data, solutions are emerging in the field of:

- Data infrastructure and accessibility.
- Disclosure and measurement standards.
- Convergence between data requirements of measurement approaches.
- Tailoring of public level biodiversity data to the needs of the business community.
- Transparency and verification.
- Accessing new technologies.

These are discussed below.

2.3.1 Building data infrastructure

Ensuring that data meets certain quality criteria and that it is maintained and delivered in an accessible format has costs associated with it. There is a perception often that data is a public good, however, investment in data that can support corporate biodiversity measurement approaches is relatively low.

Some data sets are so crucial to our understanding of corporate impacts and dependence on biodiversity that they require funding as assets. Such data sets must be identified and supported financially by governments and businesses. Examples include the data sets underpinning the Integrated Biodiversity Assessment Tool, namely the World Database on Protected Areas, World Database on Key Biodiversity Areas and IUCN Red List (section 4.1) and GLOBIO (see Annex 1 in Lammerant et al. 2019) – an ecological model that underpins many of the biodiversity footprinting tools.

Part of an effective data infrastructure is the development of data sharing mechanisms which aim to unlock 'dark' data – data that is hidden in inaccessible formats or behind paywalls. Setting up mechanisms to enable the confidential exchange of company biodiversity data, particularly between suppliers and value chains are needed. WWF recently highlighted a need for new ways of aggregating and sharing data to overcome the challenges posed by the diversity of data sources (WWF-UK 2022). Secure interconnected data marketplaces with open data standards could help overcome these complexity and interoperability challenges. The Open-Source Biodiversity Data Platform initiative is a good example (Box 1 below).

Box 1: Open-Source Biodiversity Data Platform Initiative

Asset spatial locations (geolocation) data is rarely disclosed by organizations, costly or impossible to find. It may be commercially sensitive and there is no clear financial incentive to share the data. Disclosure is not required by regulation in many jurisdictions: some even prohibit storing such information on overseas servers.

What?

The recently launched **Open-Source Biodiversity Data Platform Initiative** by the Green Digital Finance Alliance is exploring how such barriers can be overcome by creating a decentralised data exchange mixing open-source features and privacy enhancing technology. The Initiative aims to make geolocation data available for capital and financial markets and to facilitate disclosure of biodiversity risks and impacts.

Why?

Overlaying geolocation and biodiversity data can indicate which assets are prone to biodiversity material risks, biodiversity impacts and alignment, and transition valuation risks. This would allow capital reallocation strategies concerning biodiversity targets to be guided by biodiversity metrics based on accurate, actual information, instead of on proxies, sentiment data, sector averages and modelled numbers.

How?

Development of a new type of data infrastructure to share geolocation data in a way that suits the needs and wishes of organizations providing them, setting clear rights and responsibilities to incentivise data sharing can realize these goals and has the potential to develop alongside geolocation disclosure regulation. Figure 7 provides a conceptual presentation of how this will work. The decentralized data exchange platform allows data providers to keep full control over their geolocation data, as data is not hosted on a central server but is stored across the network of data suppliers. It functions as a two-sided marketplace where users such as asset managers, asset owners, financial institutions and analytics providers can access specific corporate data from corporates, NGOs, and asset geolocation data companies via automatic interface.

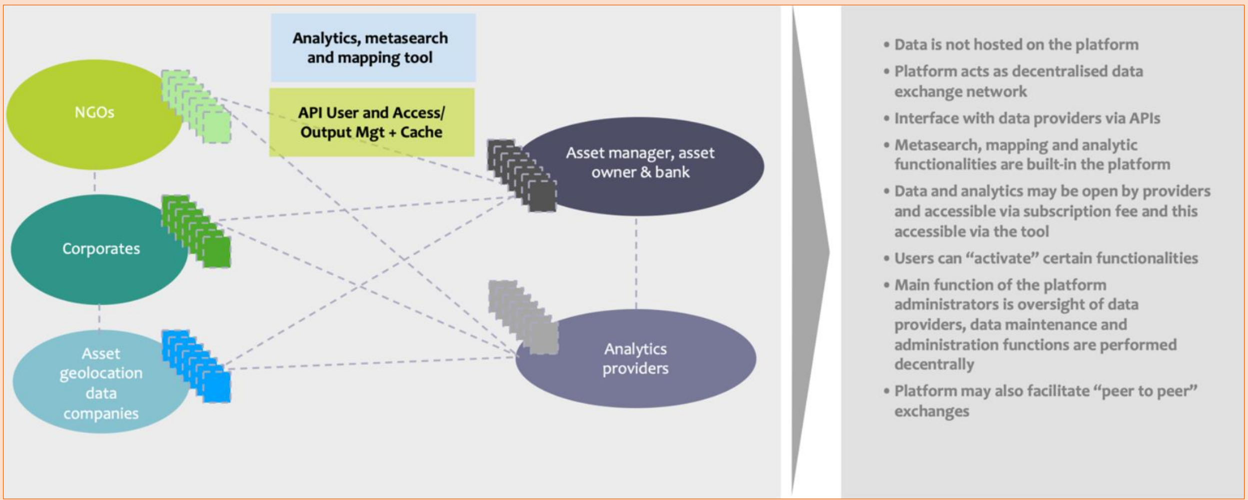


Figure 7: Concept of the Open-Source Biodiversity Data Platform

Who would benefit?

- **Specialists and small or mid-sized asset managers:** for internal risk models in asset valuation, to enable accurate risk pricing, engagement and to compare biodiversity risk between investment options.
- **Large financial institutions:** require geolocation data for developing biodiversity related targets and for assessing progress regarding target achievement.
- **Asset owners:** performing biodiversity footprint analyses.

- **ESG analytics and research providers:** helping them to support financial institutions to comply with new regulations, such as the Sustainable Finance Disclosure Regulation and can lower transaction costs related to data gathering and improving its value.

Biodiversity data infrastructure also includes dedicated knowledge centres. The European Commission provides a range of Knowledge Centres to experts, researchers, and policymakers to provide scientific evidence for addressing policy questions. The centres are focused on 10 domains, for example bioeconomy, global food and nutrition security, earth observation, and biodiversity. The centres arise from the Knowledge4Policy (K4P) platform, a database created by different scientific teams (Knowledge Services) to provide scientific information from across Europe to European policymakers. The Biodiversity Information System for Europe (BISE), a collaboration between the European Commission and the European Environment Agency, serves as a key information source for the initiative.

The Knowledge Centre for Biodiversity[11] was created to support mainstreamed, evidence-based policymaking and facilitate the implementation of the EU Biodiversity Strategy for 2030, by processing up-to-date, high-quality scientific information tailored to EU policy needs and by making it freely accessible in a central database. Through transparent, tailored, and concise communication, the centres bridge the gap between researchers and policymakers, NGOs, industry, and citizens. Although the database of the Knowledge Centre for Biodiversity can already be consulted, it is still under development.

2.3.2 Enhancing disclosure and measurement standards

Better standards could drive improvements to the data landscape: enabling more consistent disclosure of data on company performance, enhancing transparency of data limitations for decision making and enabling progress in biodiversity measurement to be attained.

Transparency improvements are already occurring with the Sustainable Finance Reporting Directive Regulatory Technical Standards Article 40 requiring that investors disclose information of the data sources used, the measures taken to ensure data quality, how data is processed and proportion of data estimated. This transparency regarding data constraints will be helpful to enable the user to determine its strengths and limitations for decision making. Similar requirements for the wider business community will be embedded in the Corporate Sustainability Reporting Directive.

Initiatives such as the TNFD and the Global Reporting Initiative review of their biodiversity indicators should lead to more relevant and comprehensive corporate disclosures which could assist in delivering higher quality data for use within biodiversity measurement approaches. The TNFD will also produce specific guidance on how different data can be used for disclosure purposes. It is important that such initiatives consider the data needs of biodiversity measurement models in order to drive consistency, quality and completeness of their outcomes as these, will in turn, enable quantitative rather than qualitative corporate disclosures on biodiversity performance.

[11] Information in this section was retrieved from European Commission 2020; 2021b; 2021a.

2.3.3 Convergence between data requirements of measurement approaches

Existing measurement approaches use different data sets and require different data inputs to conduct assessments. Some data sets are public, others have restricted access. Convergence is required between biodiversity measurement approaches in terms of content and format of data required to provide clarity to companies on the data needed for credible biodiversity measurement.

Agreeing on, and requiring the use of, common data sets to feed into the measurement models is required to promote consistency in the results between different approaches and reduce the disclosure burden on companies. Key data required are outlined in Table 2. Agreement on the pressure-based data and company data set out below, for example, could promote consistency between the range of biodiversity footprinting approaches that have emerged, enhance the disclosure of impact drivers/ pressures on biodiversity derived from corporate activities and build consistency in disclosing corporate biodiversity management response.
Various initiatives are working to address these gaps and misalignments:

- Finance for Biodiversity Initiative[12] (F4B) and the Green Digital Finance Alliance recently produced a feasibility study for the development of an open data platform that addresses the current lack of company geolocation data (Box 1 in section 2.3.1) (Finance for Biodiversity Initiative 2020).
- Funded by the European Commission, the Align (aligning accounting approaches for nature) initiative[13] is working to align biodiversity measurement and valuation methodologies and provide recommendations on metrics and associated data for use within biodiversity measurement and valuation approaches.
- The Finance for Biodiversity Foundation[14], set up to support the investors' call to action under the Finance for Biodiversity Pledge, is working with financial institutions through its impact assessment working group to better understand needs and challenges around data for impact assessment and identify pathways to overcome them.

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12 https://www.f4b-initiative.net
13 https://ec.europa.eu/environment/biodiversity/business/align/index_en.htm
14 https://www.financeforbiodiversity.org

Table 2: Encouraging consistency in company disclosures to enhance available data for biodiversity measurement. Table adapted from CDC Biodiversité and unpublished thinking from the Align project.

	Indicator	Detail required
Pressure based data	**Annual land use change (km^2)**	• Distinguish between land use categories e,g, forest, grassland, crop-land, natural bare and ice, urban area. • Distinguish between different land use intensities. • Geographical location.
	Ecotoxic emissions (kg)	• Emissions of ecotoxic substances split by discharge compartment (air, water, soil etc). • Geographical location.
	Greenhouse gas emissions (kg)	• Split by greenhouse gas and address scopes 1,2,3.
	Nitrogen and phosphorous concentration (g/m3) or emissions (kg)[15]	• With details on type and area where discharge occurs. • Geographical location.
	Annual water use (m^3)	• To include withdrawals[16] and consumption[17] and specify the category of water (seawater, surface water, groundwater). • Geographical location.
State	**Status of species**	• Population and trends of species.
	Status of ecosystems (ha, condition adjusted ha)	• Measured through consideration of extent, condition and function. • Disclose rating methodology.
Response	**Management actions to avoid, reduce, restore and transform impacts on biodiversity**	• Process for identifying impacts and dependence on biodiversity. • Proportion of biodiversity action plans at high-risk sites. • Proportion of commodities achieving certification.
Company data	**Commodities purchased or produced (tonnes)**	• Quantities per commodity type and region.
	Turnover and purchases (EURm)	• Per industry type and region.
	Company locations	• Location of company assets (spatial).

[15] The pressure indicator is the concentration of Nitrogen and Phosphorous. However as this data is rarely available (mostly because it is difficult to evaluate the area to which it applies), emission levels can also be used.
[16] "[water pumped out] of e.g. a groundwater body or diverted from a river." Also called "water abstraction" or "water use". (CREEA_D8.1_Water Case Study Report, p. 10).
[17] Water consumption: "share of the water originally abstracted [incorporated] into the product or lost to the ecosystem it was taken from (e.g. water evapotranspirated throughout a production process)". In other words, the "water consumption" is the abstraction minus the return flows. It is also called "consumptive use". (CREEA_D8.1_Water Case Study Report, p. 10).

2.3.4 Tailoring of public level biodiversity data to the needs of the business community

We Value Nature, together with the Capitals Coalition and its Combining Forces programme, is exploring the potential for improved natural capital data flow between governments and businesses in the EU and will publish a Position Paper soon (expected in April 2022). This Position Paper highlights the increasing needs of the business community in terms of natural capital data (given the growing awareness of risks related to ecosystem degradation, the rapidly changing regulatory framework on external disclosure of corporate natural capital performance and the increased harmonization and standardization of natural capital assessment approaches) as well as the value (to governments and businesses) of greater alignment of public level (for example, the Ecosystem Accounting section of the System for Environmental Economic Accounting, SEEA EA[18]) and corporate natural capital accounting approaches. The paper identifies the following business needs in terms of natural capital information – which is all relevant for biodiversity data too:

- Information that provides an insight in or a better understanding of the natural capital context in which companies operate, i.e. at a landscape level; contextual information is particularly useful with regard to natural capital state and changes in state, pressures threatening state of natural capital and thresholds which should not be exceeded.
- Information that is easily understandable for non-experts; 'integrated narratives' that have transformed data into information that can easily be digested by businesses is most welcome.
- Includes scenarios e.g. expected evolution of ecosystem state under different climate change scenarios and/or ecosystem degradation scenarios; this will become increasingly important as is already reflected by emerging initiatives such as the TNFD.
- Is sufficiently detailed, in particular for project or site level assessments.
- Is comprehensive; a total picture is required, providing information on all four pillars (air, water, land, biodiversity) of natural capital.
- Is spatially referenced; SEEA EA is spatially explicit.
- Is regularly updated.
- Is credible.

Contextual information at a landscape level is essential for the identification and assessment of business risks related to ecosystem degradation e.g. operational risks due to decreasing availability of water. In the specific case of water availability, companies indicate that the following types of contextual information would be of most interest to them (Lammerant 2019):

- Data on water levels, both actual water levels as trends and predictions of future water levels (under several scenarios).
- Data on pressures from other stakeholders (e.g. who else is extracting ground water in the watershed area?).
- Data on policy priorities (e.g. protection status) and policy targets (e.g. Science Based Targets).

[18] The Position Paper builds further on groundbreaking work performed under the NCAVES project workstream on business accounting (https://seea.un.org/content/business-accounting).

- Data on the minimum acceptable water level (threshold values) in order not to disturb other human activities (such as transport on rivers) or not to harm biodiversity (e.g. wetlands).

The paper identifies opportunities for public authorities and/or National Statistics Offices (NSOs) to provide more tailored information to the business and financial community, such as:

- **Information on ecosystem restoration opportunities;** impact investors as well as individual businesses are increasingly looking for concrete projects in which they can invest, either for offsets or as bankable projects; today, they are seeking bankable projects which can create positive environmental returns that lead to improved biodiversity and climate mitigation and/or adaptation, while also being attractive for financial institutions to invest in; governments/NSOs are best placed to define priority areas for restoration, based on objective and comparable data.
- **Science-based targets at a landscape level;** the science-based targets for nature idea (based on planetary boundaries concept) is increasingly being adopted by the business community; this will require specific natural capital data/information; companies which have adopted a 'zero impact' or a 'planetary boundaries' approach will be very interested in data related to safe operating space, threshold values, environmental flows, etc.; there is an opportunity for governments/NSOs to translate science-based targets which have been established at a supranational level (e.g. extent and condition of specific ecosystem types such as threatened habitats) to define concrete targets at national and subnational level and connect these to the spatially explicit contextual information on natural capital at a landscape level (e.g. river basin).
- **Spatially referenced extent and condition metrics with a high level of granularity to the business community**; an increasing number of companies are committing to achieve 'nature-positive' (e.g. by 2030); application of the mitigation hierarchy is key when the 'nature-positive' concept is applied to biodiversity; this will require biodiversity data for defining a baseline, as well as for selecting potential offset areas and investing in offset restoration measures; alignment on applied metrics is recommended (currently businesses use metrics such as Mean Species Abundance (MSA) and presence of threatened species, as these are most frequently applied in available corporate biodiversity measurement tools).

2.3.5 Transparency and verification

Putting in place strong documentation trails, clear methodologies and internal quality reviews within companies and commissioning third party verification of data can help to ensure the quality, completeness and rigour of the data used within biodiversity measurement approaches.

Some measurement approaches have introduced the use of data quality tiers to enable the user of the data to understand the nature of the data and its limitations. CDC Biodiversité's Global Biodiversity Score (CDC Biodiversité 2021; 2020), for example, have developed quality tiers ranging from 1 to 5 where Tier 1 is generally the least accurate (e.g. financial data) and Tier 5 is the most accurate (e.g. data derived from the direct measurement of biodiversity state).

2.3.6 Accessing new technologies

The application of Earth Observation or DNA-based technologies may help address some of the data gaps outlined in this report (sections 3, 4 and 5). Machine learning can be used to update multiple observational data layers from one high resolution land cover layer, improvements in on the ground species monitoring and habitat disturbance technology will also help increase the quality of data available for decision making. Combining earth observation technologies with more local technologies such as smartphone technology to gather community observations and cross verify remote sensing data results could also lead to much more accurate, real time data sets for decision making. (Green Digital Finance Alliance 2020) The use of eDNA, bioacoustics monitoring combined with complex machine learning models will enable combination of data insights from these different technologies to create a step change in understanding of corporate impacts and dependence on the natural world. (WWF-UK 2022)

3 INNOVATIVE APPROACHES FOR COLLECTION OF PRIMARY DATA ON BIODIVERSITY

Species and ecosystems monitoring is essential in the current context of global biodiversity decline. Primary data on biodiversity state and changes in state provide a good insight in the real situation and should be the preferred source of biodiversity data if it is feasible to collect them. Indeed, primary data collection by means of field surveys, in some cases preferably executed over different seasons, is often costly and therefore mainly applied for site or project level measurements. Field survey-based monitoring methods also have their limits as the process of visually identifying and counting individuals requires solid taxonomic expertise and in almost all cases observations cover only a part of the species that occur in the area. Conventional monitoring is sometimes based on invasive techniques that harm species and damage their habitats. Moreover, 86 percent of terrestrial species and 91 percent of marine species are still undiscovered (WWF-UK 2022). Recently, innovative primary data collection approaches have become available such as eDNA, bioacoustics, satellite tagging, camera traps, bee cams[19] and biomonitoring[20]. They all offer considerable added value in the field of primary data collection on biodiversity. In this section, we focus on eDNA and bioacoustics. More information on both techniques can be found in EU B@B Platform Webinar 2 2021. This webinar includes a practical example of a company (Total) experimenting with all these innovative techniques.

3.1 Environmental DNA (eDNA)

3.1.1 What is eDNA and how does it work?

The eDNA process (Figure 8) is used to identify which species are or were present in the sampled environment. eDNA monitoring requires DNA retrieved from environmental samples such as water, biofilms, air, sediment, soil, honey and faeces and is suited for all types of environments ranging from permafrost to aquatic ecosystems. Animals, plants, and bacteria constantly leave cellular and extracellular DNA traces in the form of cells, hairs, dead individuals, etc. These traces can be conserved for days or weeks (in the case of freshwater habitats), or up to hundreds of thousands of years (in ice cores). eDNA can thus be obtained from both ancient and modern samples to study past and present biodiversity. (Abbott et al. 2021)

eDNA analysis is carried out by first extracting DNA from a sample according to the method that best suits the sample type (Abbott et al. 2021). Next, the DNA is amplified, sequenced, and compared to a DNA sequence library to link the genetic material to a specific species. Amplification can be performed by the single-species approach or the more recent multiple-species approach. (Abbott et al. 2021; Pedersen et al. 2015). Multiple taxa can be identified (community analysis) in a single sample due to the development of next-generation DNA sequencing techniques (Abbott et al. 2021). This greatly increases the scale at which biodiversity data can be generated. Results can be incorporated into biodiversity databases. Figure 8 outlines the eDNA process in more detail.

[19] Used to monitor pollinator activity, their interaction with plants and to evaluate ecosystem health.
[20] Companies such as BeeOdiversity analyze pollen collected by bees to study plant species diversity and pollution.

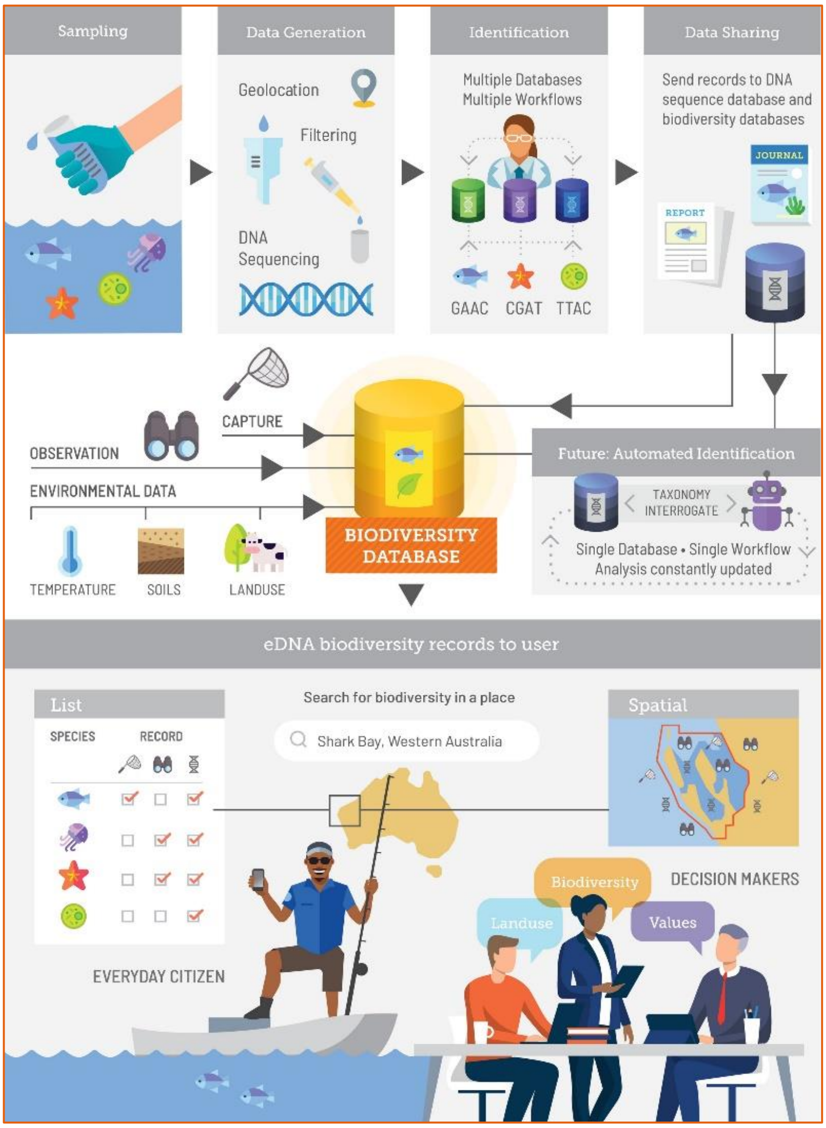

Figure 8: The eDNA process. Figure from Berry et al. 2021.

3.1.2 Applications of eDNA

3.1.2.1 Freshwater

To make the technique more accessible, ready-to-use kits are being marketed to easily collect eDNA while minimizing the risk of sample contamination. Some companies, such as NatureMetrics[21], a specialist eDNA company that provides biodiversity monitoring services, offer end-to-end services. Companies offering end to end services can provide aquatic eDNA sampling kits, logistical support for transporting the samples to the laboratory, and a laboratory analysis and data processing service. The sampling technique is relatively cost-efficient, which allows to regular monitoring, and can be performed by anyone (Figure 9). Each sample contains sufficient DNA to carry out different analyses targeting different taxonomic groups. The DNA sample can be stored, so it can be analyzed at a later moment in time. Using such techniques can result in increased species detection, NatureMetric's

[21] https://www.naturemetrics.co.uk/

detected five times more fish species using this sampling technique, compared to using a traditional netting technique. (EU B@B Platform Webinar 3 2021)

Figure 9: DNA filter unit for aquatic samples allows anyone to collect samples, democratizing biodiversity data collection. Figure from NatureMetrics 2021.

3.1.2.2 Marine environment

Collection of eDNA can be performed in several ways. Depending on the sampling technique, different research goals can be achieved. For example, Applied Genomics[22] developed the inDepth eDNA sampler for the marine environment. The sampler can be deployed by field teams with limited training and provides samples that are representative for the entire studied environment by automatically collecting a large volume of water. The system is especially suitable for maritime ports, where two samplers are set up on either side of the port. One device samples the incoming tide, while the other captures the outgoing tide (Figure 10). (EU B@B Platform Webinar 3 2021)

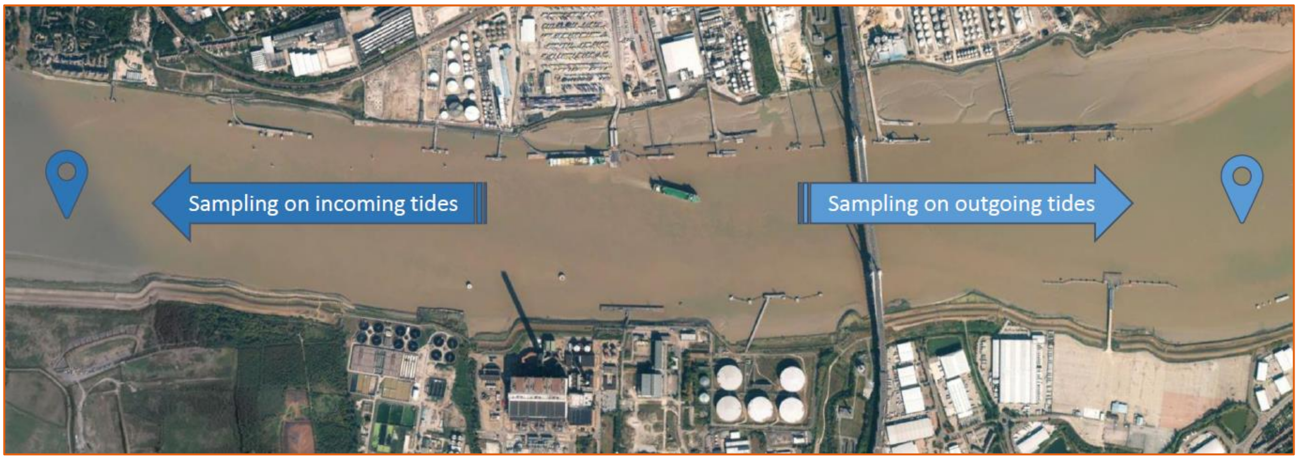

Figure 10: Sampling of eDNA in marine environments. Figure from EU B@B Platform Webinar 3 2021.

Two datasets are generated, which can be used to study up- and downstream biodiversity. The intersect of both datasets provides information on endemic and seasonal biodiversity patterns in the port, such as exotic species threats. Moreover, the samples help to grasp what spatial separation is needed to obtain independent samples, for example along a coastline. Studies demonstrated that

[22] https://appliedgenomics.co.uk/

this way of sampling detected double the number of species compared to information obtained from catch data collected over five years. (EU B@B Platform Webinar 3 2021)

3.1.2.3 Soils

Soil samples generate data on diverse groups and species that are difficult or impossible to monitor with conventional techniques. Although, it is generally not possible to distinguish specific soil species using eDNA, it can help to develop a signature of what healthy soil looks like in different habitats, which can support restoration projects. This signature is developed by sampling widely along gradients of habitat conditions and generating community data using metabarcoding (identification of many taxa in one eDNA sample) and applying machine learning techniques to build models that assign any sample to a condition category based on its biological community. (EU B@B Platform Webinar 3 2021)

3.1.2.4 Holistic approach

An ecosystem is often made up of several habitats: pond, river, hedge, meadow, trees, etc. By combining different types of eDNA samples and interpreting the results based on ecological expertise, it is possible to get a comprehensive overview of the biodiversity in each environment.

This holistic approach is applied, for example, by E-BIOM[23], a company specialized in biodiversity conservation based on eDNA monitoring. By combining different kinds of sampling methods (e.g. a syringe and filter for small water samples, portable peristaltic pumps for sampling larger amounts of water, soil samples at different depths, honey samples as plant diversity indicator, malaise traps to collect bulk samples of insects for metabarcoding analysis, feces samples to study diets, etc.), E-BIOM detected 27 fish species (compared to 4 species caught by electrofishing), 78 plants (compared to 11 plant species by pollen observation under a microscope) and 132 insect species in a given ecosystem. These eDNA inventories can then be compiled with other relevant information such as species status (e.g. IUCN Red List, endemic versus invasive species), ground cover indexes, mean species abundance, ecosystem services, etc. This allows recommendation of specific actions to preserve and regenerate biodiversity, for example by strengthening blue and green corridors, installing fauna habitats, etc. (E-BIOM 2022)

3.1.3 Added value of eDNA

Evolutions in DNA-based monitoring, such as eDNA, make it possible to collect a larger amount of data on a larger number of species. This enables better informed biodiversity related decisions to be taken and will support a wide range of applications including systematic conservation planning, evaluation of conservation outcomes, due diligence and environmental impact assessment. (WWF-UK 2022) As shown in Figure 11, eDNA is currently being used for purposes such as detection of invasive species, measurement of biodiversity, characterizing ancient environments, mapping pollinator networks and food-web analysis amongst other things (Berry et al. 2021).

[23] https://www.e-biom.com/

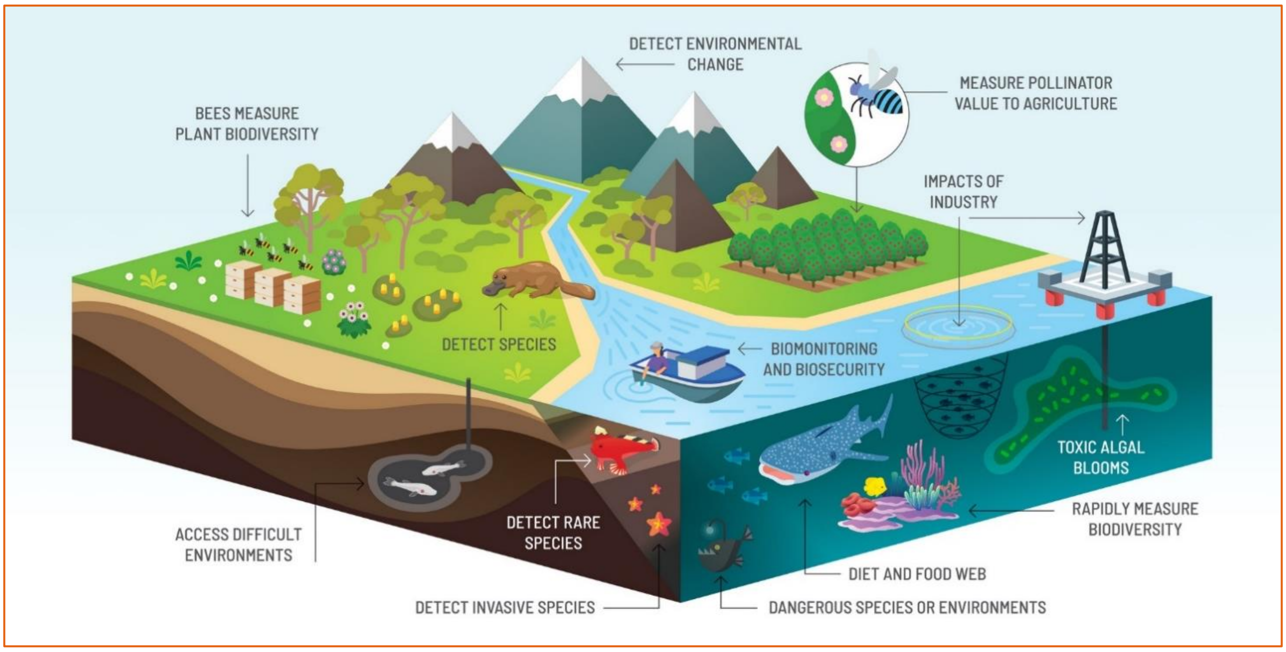

Figure 11: Applications of eDNA for environmental management. Figure from Berry et al. 2021.

eDNA is an efficient tool for species conservation monitoring. Besides for species that can be studied through traditional methods, eDNA is particularly interesting for studying and monitoring endangered, cryptic (morphologically indistinguishable species), invasive, and presumably extinct species. (Abbott et al. 2021)

Studies show that eDNA is a cost and time efficient technique, although this depends on the studied species. Collecting and processing eDNA can be performed in a standardized way, which is a challenge for classic monitoring techniques. (Thomsen and Willerslev 2015) Currently, the technique is mainly applied to identify animal species. Plant species are harder to differentiate at the species level and require a longer barcode to reliably differentiate between species (EU B@B Platform Webinar 3 2021). However, this depends on the sample type: promising results exist for honey, pollen and bulk samples (E-BIOM 2022).

Applying big data approaches to DNA-based datasets offers significant potential for improving our understanding of ecosystem functioning. Initiatives such as eBioAtlas[24] and Vigilife[25] allow to identify the signatures of healthy ecosystems. DNA-based approaches can assist in ground-truthing the predictions of models by validating the link between pressures and outcomes; measuring progress towards restoration and net positive targets; and link field data to earth observation data to achieve insights on a large scale and to track changes in near-real-time. (WWF-UK 2022)

[24] The eBioAtlas program is a recent partnership between NatureMetrics and IUCN. The goal is to collect DNA samples worldwide to provide a global source of up-to-date and standardized biodiversity data. This database will be freely available for research and conservation purposes. (EU B@B Platform Webinar 3 2021) https://ebioatlas.org/

[25] Vigilife is an international alliance of public and private partners that develops a Global Life Observatory using eDNA technologies. The Vigilife Maps cartography platform allows data and biodiversity indicators to be quickly collated, managed, analyzed and shared with researchers, environmental managers, decision-makers, and the general public. https://www.vigilife.org/en/

While eDNA is very promising, some drawbacks should be considered. Sample contamination during field work, sample transport, or in the laboratory can cause false positives. Furthermore, errors in DNA sequences, often caused during DNA sequencing, can lead to erroneous outcomes. Species identification relies on gene databases, which are currently often still incomplete, especially in the case of lower taxonomic levels. Finally, DNA does not break down at equal rates in all environments. For example, DNA in soils can remain intact for hundreds of years, implying that eDNA analysis of a deep soil sample can falsely flag a species that is no longer present. In the context of species studies, studies have shown that the best estimate of biodiversity can be made by combining eDNA and traditional proxies such as pollen, macrofossils and living species. (Pedersen et al. 2015)

3.2 Bioacoustics

3.2.1 What is bioacoustics and how does it work?

Bioacoustics study and analyze the production, transmission, and reception of animal sounds. Recorders can collect data in a continuous way, depending on the availability of (solar) power, data storage, and cellular network signal for data transmission. (Mcloughlin, Stewart, and McElligott 2019) There exist two basic systems for sound recording: unidirectional, handheld microphones and omnidirectional, automated systems. The first system comes in the form of a shotgun or parabolic microphone and consists of a separate microphone and recording unit (Figure 12). (EU B@B Platform Webinar 3 2021, information from Baker Consultants[26])

Figure 12: Left: shotgun microphone (Marino 2016). Right: parabolic microphone (NHBS 2020).

The omnidirectional recorder is an automated recording device with built-in microphones, which typically records sound at a greater range of frequencies, including ultrasound (frequency range of e.g. bats) and infrasound (frequency range of e.g. elephants). The omnidirectional system is attached to a structure such as a post or a tree and is equipped with batteries, SD cards, and a GPS system and can be programmed to record according to predefined time schedules for days, weeks, or months (Figure 13). (EU B@B Platform Webinar 3 2021)

[26] https://bakerconsultants.co.uk/

Figure 13: Omnidirectional sound recorder. Figure from Hausheer 2015.

Acoustic data is captured by autonomous recorders, and the recordings are often automatically analyzed using techniques similar to speech recognition technology. In addition to speech recognition, researchers have focused on the classification of sound scenes (also referred to as *soundscapes*: the environment a sound recording was collected in) and sound events (the event that triggers the recorded sound). (Mcloughlin, Stewart, and McElligott 2019; Burivalova, Game, and Butler 2019). Since processing sound recordings requires knowledge on digital signal processing, mathematics, machine learning and ecology, interdisciplinary expertise on these topics is required (Mcloughlin, Stewart, and McElligott 2019). Collaboration with bioacoustics experts could therefore be a solution. Depending on the research goals, several methods based on sound physics are available for extracting audio features (meaningful audio information) from a recording. Audio feature extraction is executed using mathematical calculations, supervised and unsupervised machine learning, species recognition algorithms, indices, or simply by the human ear (Burivalova, Game, and Butler 2019; Mcloughlin, Stewart, and McElligott 2019). In supervised machine learning, audio features are combined with species names and recording locations. This is a time-intensive process which requires expert knowledge and is prone to human error. (Mcloughlin, Stewart, and McElligott 2019)

3.2.2 Applications of bioaccoustics

Figure 14 shows the soundscape for a Sumatran region. The low frequency calls of orangutans are at the bottom of the graph. Slightly higher frequencies correspond to a range of different bird species. Broad bands in the middle of the graph indicate insect sounds. Bats produce very high frequency sounds, which are at the top of the graph. This graph indicates that different acoustic niches exist, so that different species produce sounds that do not overlap in frequency. (EU B@B Platform Webinar 3 2021)

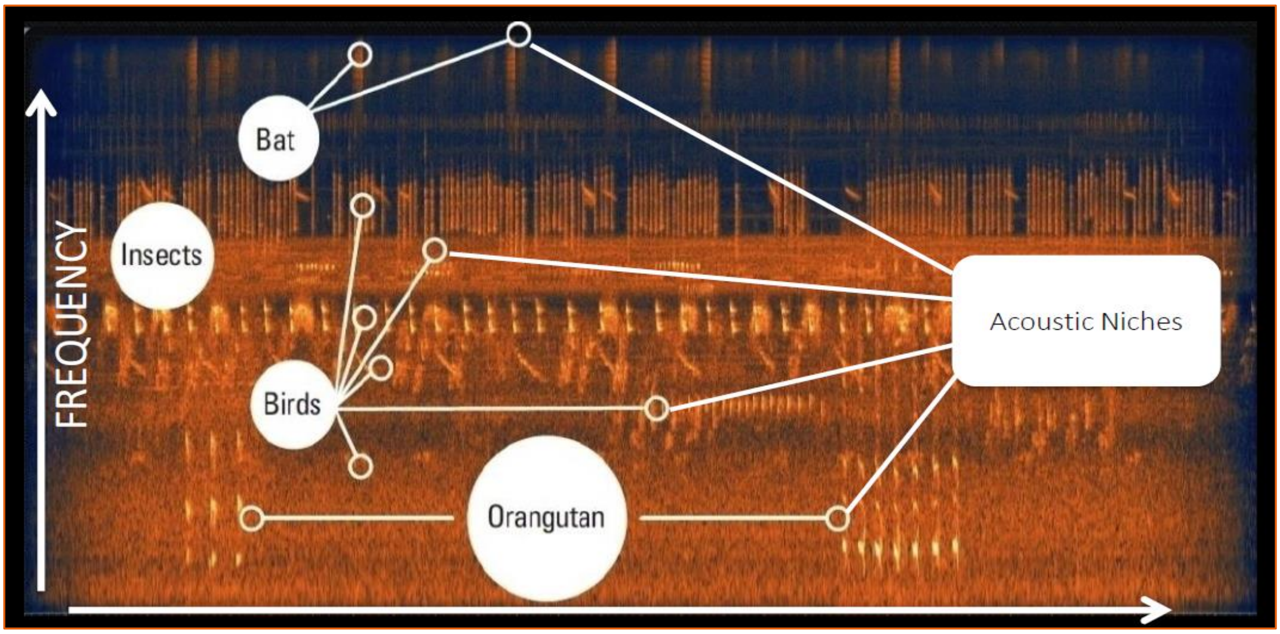

Figure 14: Soundscape showing acoustic niches for different animals. The X-axis represents time, the Y-axis represents sound frequency. Figure from EU B@B Platform Webinar 3 2021.

By comparing soundscape recordings over time and by overlaying them with baseline nearby soundscapes, the biological integrity of a landscape can be assessed as well (Figure 15). (Burivalova, Game, and Butler 2019)

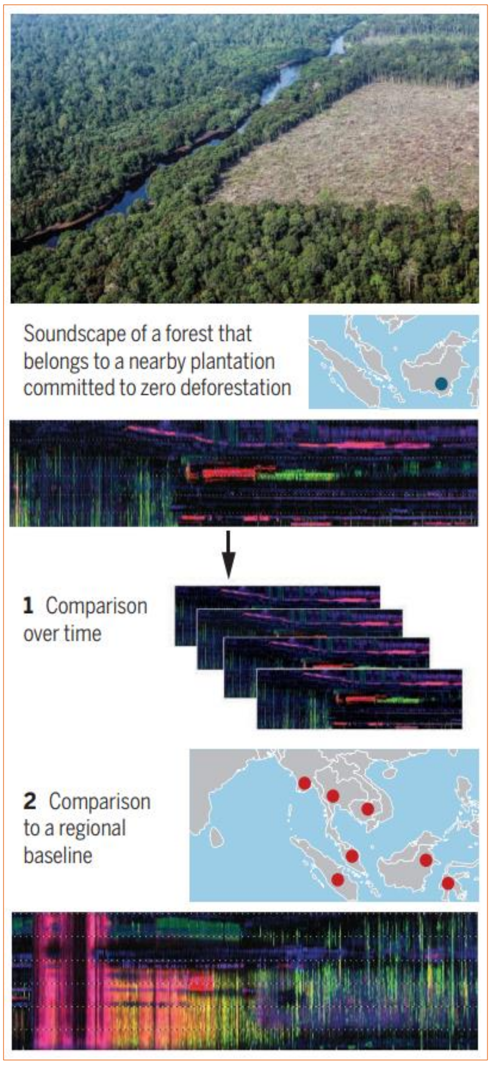

Figure 15: Assessing conservation and sustainability efforts through analysis of soundscape time series and regional baseline recordings from similar intact landscapes nearby. Figure from Burivalova, Game, and Butler 2019.

Indices, which are mathematical representations of sounds, have proven useful for detecting the number of biological sounds in terrestrial ecosystems, although index performance is negatively affected by noise related to insects, weather, and human activities. (Mcloughlin, Stewart, and McElligott 2019) In particular, indices are particularly useful for monitoring the general state of forests, as no site-specific species lists are required to identify recorded acoustics (Burivalova, Game, and Butler 2019). Bioacoustics can be used for studying individuality, behaviour, and morphology of species. For example, the frequency of fallow deer (*Dama dama*) noises is related to their size and social status. In marine science, locations of animals are determined by passive acoustic sonars, which are arrays of microphones. By computing the difference in sound arrival between these microphones, the animal's location is calculated using the triangulation principle. (Mcloughlin, Stewart, and McElligott 2019)

Combining the acoustic recordings of target species at different locations with GIS and satellite data of the habitats present at each location, environmental variables that determine species presence and detectability can be assessed (Abrahams and Geary 2020).

3.2.3 Added value of bioacoustics

In conservation and ecology, bioacoustics studies are adopted for monitoring animal species occurrence, location, individuality, behaviour, and morphology (Mcloughlin, Stewart, and McElligott 2019). Acoustic monitoring is an indispensable technique to document and protect biodiversity, which can increase the chances of a species being protected (Sugai and Llusia 2019). Although the technique also has potential for studying animal health and welfare, it is still in its infancy regarding these applications and is therefore adopted to a limited extent in this context (Mcloughlin, Stewart, and McElligott 2019). Bioacoustics can also identify how anthropogenic noise affects habitat quality and can help to track illegal activities by monitoring gunshots related to poachers or chainsaws in the case of illegal logging (Burivalova, Game, and Butler 2019). Finally, bioacoustics time capsules can serve as documentation on Earth's acoustic communities and can act as acoustic fossils for future generations (Sugai and Llusia 2019). Nevertheless, bioacoustics monitoring is a developing field, as the relation between ecosystems and ecosystem audio recordings is not yet well understood (Mcloughlin, Stewart, and McElligott 2019).

Bioacoustics are particularly useful for monitoring species in marine, tropical, low light, and hostile (e.g. disease risk for humans) environments. (Mcloughlin, Stewart, and McElligott 2019) Burivalova *et al.* argue that remote sensing techniques for monitoring forest ecosystems are rather proxies than exact values for animal biodiversity, as they often solely rely on forest cover metrics. Although field surveys can provide a solution, they are expensive, sensitive to human bias and limited in spatial extent. Bioacoustics monitoring is a more cost-efficient technique and allows to compose time series of data. Moreover, one recording covers multiple taxonomic groups at once, including vocalizing birds, mammals, insects, and amphibians. Legal requirements and voluntary commitments regarding industry sustainability, zero-deforestation and sustainability certifications can be evaluated using sound analysis. (Burivalova, Game, and Butler 2019) Also in a business context, the bioacoustics technique has already proven its value. For example, Total Energies uses it as part of its biodiversity monitoring toolbox to study targeted species and for global ecosystem assessments. Practically, for each inventory, microphones recorded 6 hours before and after sunrise and sunset. Bioacoustics indexes were developed to assess biodiversity richness and to identify seasonal and daily variation in species richness. (EU B@B Platform Webinar 3 2021)

Research states that only 21 out of 100 studies share bioacoustics recordings, implying data is rather hard to find (Baker and Vincent 2019). Considering the required computational power for processing large acoustic datasets, there is a need for a worldwide hosting and analysis platform. A collection of regional soundscape baselines would contribute to the understanding of interannual variation of soundscapes and could help to assess conservation measures. (Burivalova, Game, and Butler 2019)

4 SECONDARY BIODIVERSITY DATA SOURCES

As primary data collection is not always feasible, businesses also rely on secondary biodiversity data sources. Secondary data can be found in published, peer-reviewed, and grey literature (for example, life-cycle impact assessment (LCIA) databases; industry, government, or internal reports) but can also be offered by some biodiversity assessment tools which rely on extensive databases such as the Integrated Biodiversity Assessment Tool (IBAT) and the Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) tool. Both tools are increasingly being used by businesses and financial institutions, mainly for screening risks, opportunities, impacts, dependencies, etc. related to biodiversity. Two other databases used extensively within biodiversity footprinting – GLOBIO and ReCiPe – were featured in the Update 2[27] report of the EU B@B Platform (Lammerant et al. 2019).

4.1 IBAT (Integrated Biodiversity Assessment Tool)[28]

4.1.1 What is the purpose of the tool?

IBAT is an authoritative biodiversity data tool for desktop biodiversity screening at terrestrial and marine site level. The tool helps companies to understand their exposure to biodiversity regarding risks and opportunities linked to the spatial location of important areas of biodiversity and species. It is used to understand biodiversity risks, understand impacts to inform disclosure according to the Global Reporting Initiative (GRI), evaluate certification schemes and provide insight into potential risks for project finance. Users are businesses (often companies with multiple sites globally) and financial institutions (project finance wishing to comply with performance standards such as IFC Performance standard 6[29], insurance companies for risk screening, impact investors[30]). 120 of the world's largest companies use IBAT for biodiversity risk screening.

4.1.2 How does it work?

IBAT is a web-based platform, developed through a collaboration between BirdLife International, Conservation International, IUCN and UNEP-WCMC. It is based on three of the most important global biodiversity datasets: the IUCN Red List of Threatened Species[31] (138,000+ species); the World Database on Protected Areas[32] (including nationally and internationally recognized sites (265,000+), IUCN protected area management categories I-VI, World Heritage sites, Ramsar

[27] Available at https://ec.europa.eu/environment/biodiversity/business/assets/pdf/EU_B@B_Platform_Report_Biodiversity_Assessment_2019_Annexes_Final_5Dec2019.pdf.

[28] Information in this section was retrieved from the IBAT website [https://www.ibat-alliance.org/] (BirdLife International et al. 2021) and Webinar 1 of the EU Business @ Biodiversity Platform Webinar Series on Biodiversity Data for Corporate Biodiversity Measurement (EU B@B Platform Webinar 1 2021).

[29] Biodiversity Conservation and Sustainable Management of Living Natural Resources. More information available at https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps6.

[30] On condition they have company specific spatial data

[31] A compendium of information on the taxonomy, conservation status and distribution of plants, fungi and animal species that have been globally evaluated using the IUCN Red List Categories and Criteria. This system is designed to determine the relative risk of extinction, and the main purpose of the IUCN Red List is to catalogue and highlight those plants and animals that are facing a higher risk of global extinction. (UNEP-WCMC 2014)

[32] Protected area: a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives (UNEP-WCMC 2014)

Wetlands of International Importance); and the World Database of Key Biodiversity Areas[33] (+16,000 areas, Figure 16). The protected areas database is updated on a monthly basis, while the Red List data and Key Biodiversity Area data are updated at least three times a year.

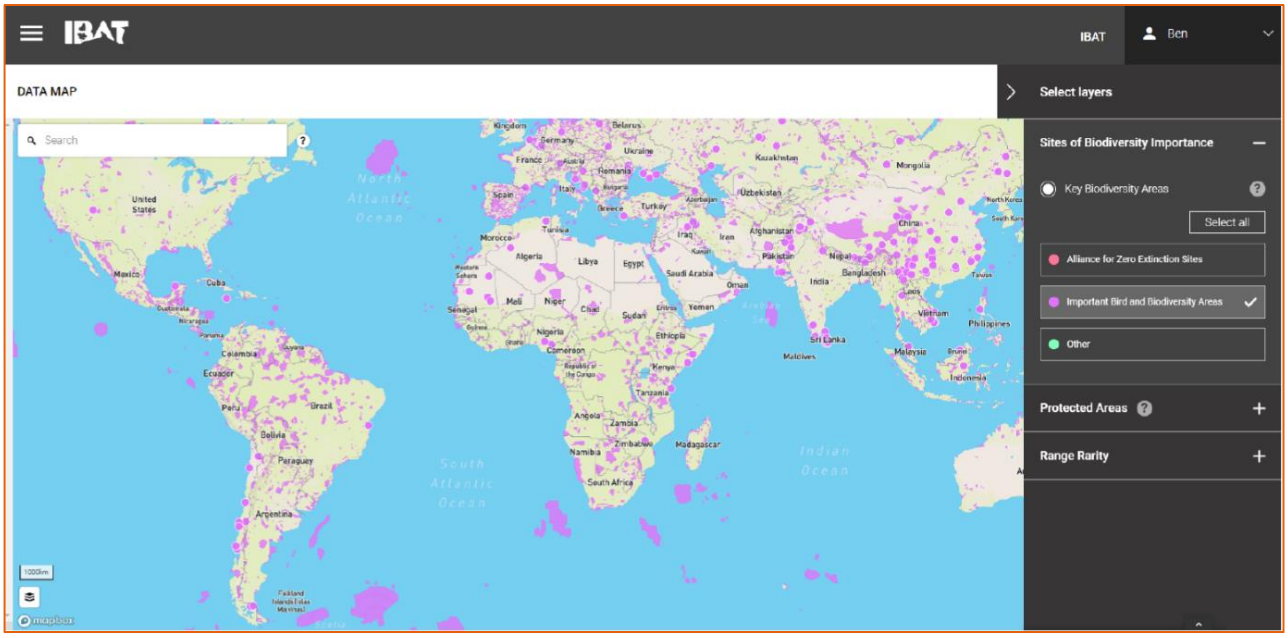

Figure 16: IBAT allows to view global biodiversity layers on an interactive data map.

IBAT also contains the Species Threat Abatement and Restoration (STAR) metric. This metric focuses on positive site level biodiversity opportunities and was initially developed with the aim to demonstrate a conservation return on investment from an impact investment perspective. STAR quantifies the contribution of operating at specific locations to reduce the threat of species extinction risk. The metric is created by overlaying species range maps from IUCN Red List (bird, mammals, amphibians) and threats that these species are facing. The tool uses global species distribution maps and assumes that species populations and the threat that these species face are equally distributed across their distribution ranges. These assumptions need to be calibrated with local insights and information on what losses have occurred due to the user's operations.

4.1.3 Data input/output

The IBAT website allows users to create and save projects, download reports, and view maps of Key Biodiversity Areas, protected areas (according to designation type, governance type, or IUCN management category), range rarity, and STAR data layers. New projects can be created by entering a project name and indicating a location by means of a point, line, or polygon on a map, after which information on Key Biodiversity Areas, protected areas, range-size rarity scores, and STAR metrics can be visualized directly on a world map (Figure 17).

[33] Sites contributing significantly to the global persistence of biodiversity. They represent the most important sites for biodiversity conservation worldwide, and are identified nationally using globally standardized criteria and thresholds. (UNEP-WCMC 2014)

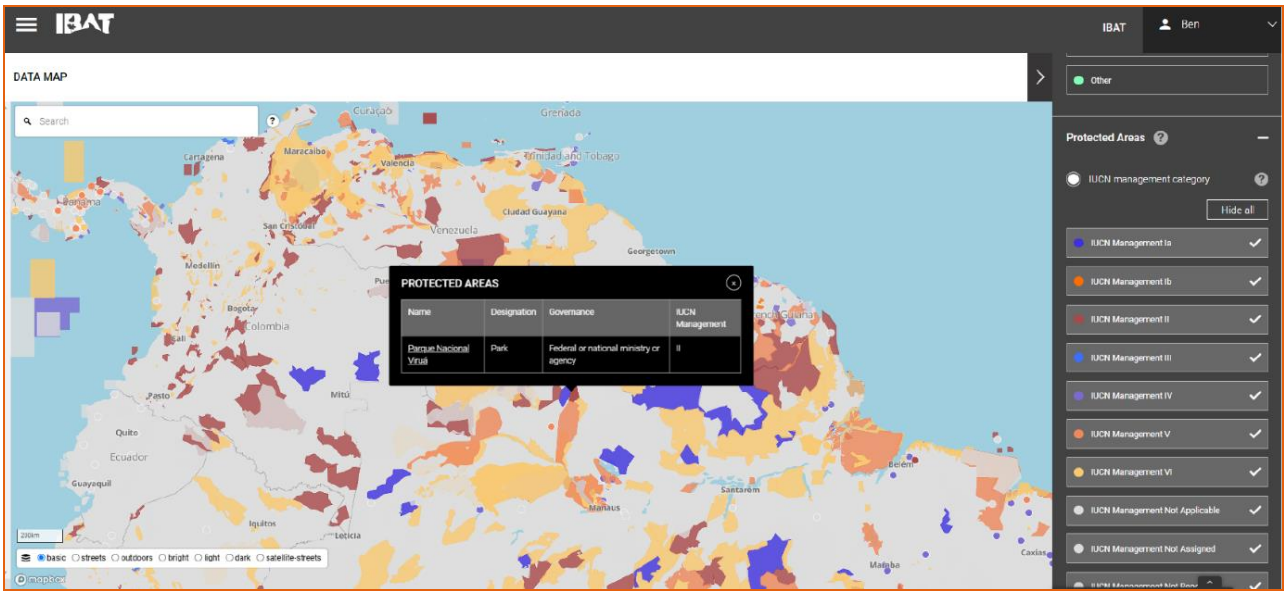

Figure 17: Details on Key Biodiversity Areas and protected areas can be accessed directly from the map.

Various site-level risk screening reports are available and include:

- Proximity Report: single location, contains information on protected areas, Key Biodiversity Areas and Red List Species and is suitable for high-level early-stage biodiversity risk screening.
- Performance Standard 6 (PS6) & Environmental and Social Standard 6 (ESS6) Report[34]: similar to the Proximity Report but includes likelihood of critical habitat and is suitable for biodiversity risk screening against IFC and World Bank performance standards.
- Multi-Site Report: similar to the Proximity Report, extended with the possibility to include multiple locations.
- Freshwater Report: risk screening in the context of freshwater species upstream and downstream of a specified location.
- STAR report: identification of opportunities for positive biodiversity actions and target setting.

Sample reports can be downloaded from IBAT's website. The free IBAT version only provides data for 50-kilometer buffer around the user's study area. In the IBAT reports, information on protected areas and Key Biodiversity Areas can be requested for buffer sizes between 1 and 50 kilometers, since the boundaries of these areas are rather static over time. In contrast, Red List Species distribution is dynamic over time due to range contractions and expansions, poleward shifts, population changes, etc. To avoid excluding species in the analysis, only a 50-kilometer buffer is available for information on Red List Species distributions.

Downloads of raw data from global datasets for protected areas, Key Biodiversity Areas, IUCN Red

[34] Biodiversity Conservation and Sustainable Management of Living Natural Resources. More information available at https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps6 and https://www.worldbank.org/en/projects-operations/environmental-and-social-framework/brief/environmental-and-social-standards.

List species are paid features and are available for a particular project area or as complete global data sets.

Summaries on protected and Key Biodiversity Areas can be consulted by clicking on these areas in the map viewer. Country/territory profiles are also available in IBAT and provide general information on species extinction risk, protected areas, and Key Biodiversity Areas.
STAR's threat abatement and restoration variables can be visualized in IBAT on a 5-kilometer spatial resolution map. STAR allows companies to set targets, to determine contributions to reduce biodiversity threats and to have positive impacts. STAR can assist companies in planning projects that offer benefits for threatened species and in assessing biodiversity risks if a company's activities are similar to threats identified through STAR (Figure 18, Figure 19). If these threats decrease, then species extinction risk in that area decreases. The STAR report provides a similar breakdown figure as Figure 19 for STAR restoration scores.

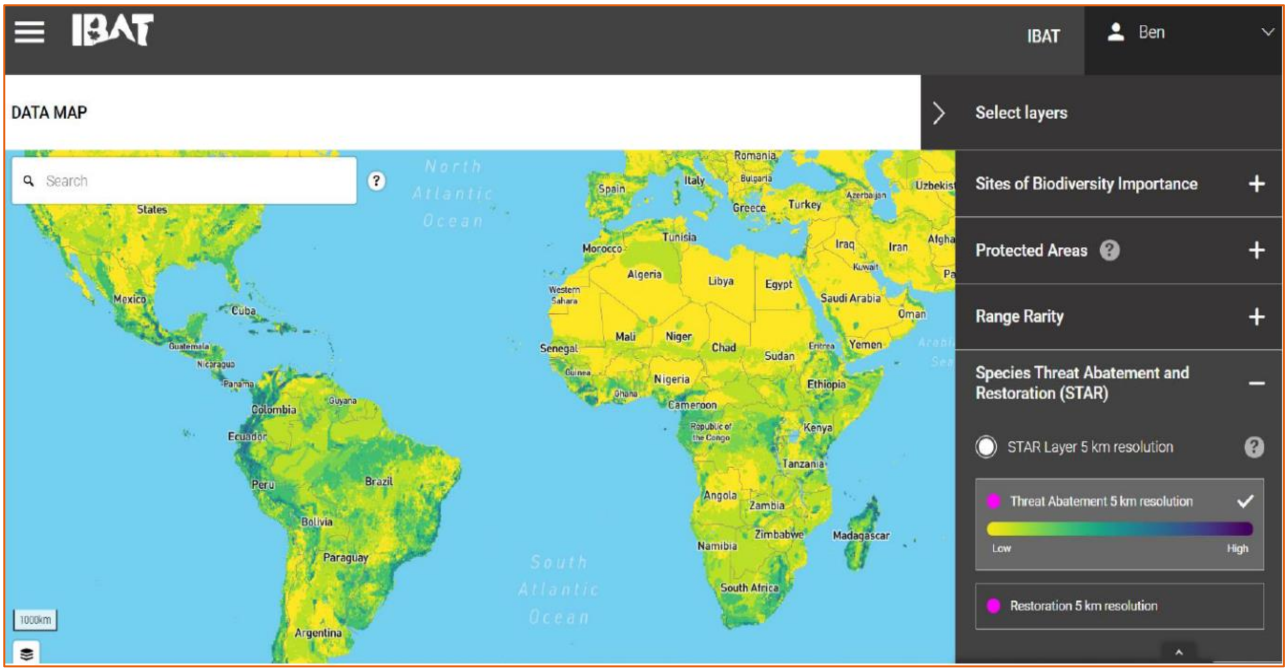

Figure 18: STAR threat abatement map.

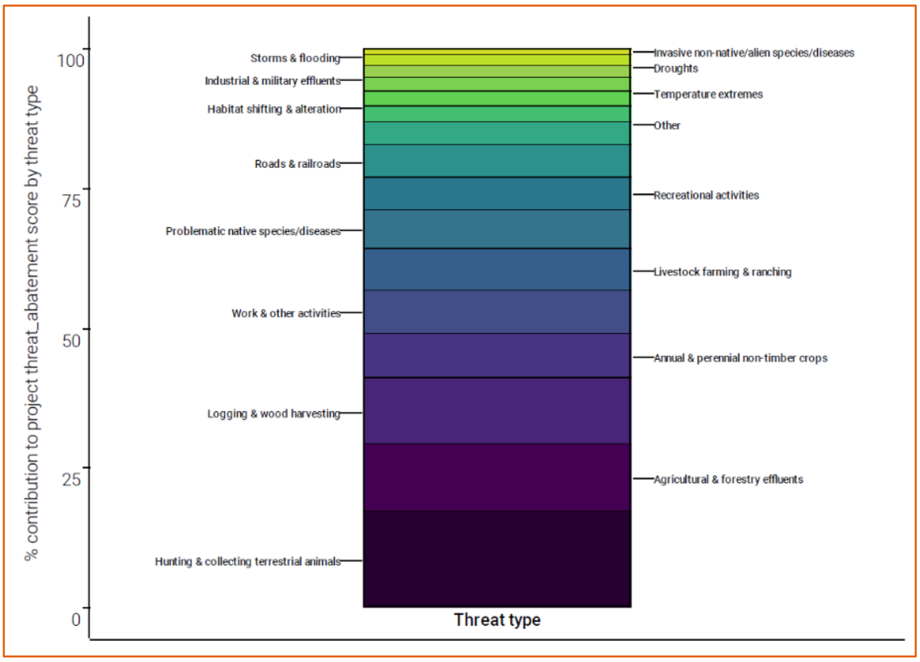

Figure 19: Breakdown of STAR threat abatement scores by threat type within an area of interest.

Although highly valuable in screening for biodiversity risk, users of IBAT must be aware that the tool has some limitations. Some aspects of the data held within IBAT may be incomplete or out of date. For the protected areas in particular, no data is provided on the effectiveness of the protection status and therefore the protected area may by significantly degraded. Since there is no near-real time information on the status of ecological intactness (WWF-UK 2022), IBAT data represents an initial screening only that must be supplemented with additional investigation. For example, a protected area can be converted to a less sustainable land use type and this may not necessarily be reflected rapidly within IBAT data, although the World Database on Protected Areas is updated monthly. Species occurrence information in IBAT reports is only available for a buffer area with a radius of at least 50 kilometers around the study area. This is often too coarse for site- or project-level assessments. The same applies to the resolution of STAR data (5x5-km pixels). Another drawback of STAR is that it does not allow assignment of STAR scores to specific species. Furthermore, it can be argued that the categories into which the STAR threat types are subdivided are too general to be interpreted unambiguously.

4.1.4 Accessibility

IBAT is a subscription-based tool: the license cost is determined by the subscription type. The paid services are also available as a *Pay as you go* regime. A selection of functionalities, such as viewing datasets on the world map, is freely available, after free subscription. STAR reports (up to 30 reports) are temporarily freely available. Revenues go back to the data providers to ensure that IBAT is up to data and maintained. An IBAT account offers access for all colleagues in the same organization. The data sets that underpin IBAT cost in the region of USD 6.5 million annually to maintain (Juffe-Bignoli et al. 2016). There is no ongoing source of funding to maintain. Without maintenance their value for decision makers will degrade over time. It is for this reason that the data is restricted for commercial use purposes.

4.2 ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure)[35]

4.2.1 What is the purpose of the tool?

ENCORE is a web-based tool launched in 2018. It is the first of its kind in synthesizing a large amount of literature on potential natural capital dependencies and impacts regarding economic activities.

Although originally developed for the finance sector, the tool assists businesses across all sectors in assessing the risks associated to natural capital dependency. ENCORE provides insights into how businesses are dependent on nature and how they impact it, how climate change and biodiversity loss affect the ecosystem services that businesses depend on, and how environmental change affects these dependencies. This allows for risk management improvement regarding investments, loans, and insurance.

4.2.2 How does it work?

ENCORE is an online tool developed by a collaboration between Natural Capital Finance Alliance and UNEP-WCMC and was financed by the Swiss State Secretariat for Economic Affairs (SECO), MAVA Foundation and the Swiss Federal Office for the Environment.

Background data for the tool was obtained through literature study on ecosystem services classes, provision of ecosystem services by natural capital assets and mechanisms linking ecosystem services to environmental change drivers. Expert interviews filled remaining information gaps and provided information on how ecosystem services are linked to economic sectors.

Information in ENCORE is structured in three levels: type of economic activity (classified in sectors), sub-industry, and production process (related to the sector or sub-industry). Natural capital assets are natural capital components that provide ecosystem services. There are eight assets in ENCORE (atmosphere, habitats, species, land geomorphology, ocean geomorphology, minerals, soils and sediments, water) and 27 drivers of environmental change which are linked to the natural capital assets and impact drivers. The latter are direct production process inputs or outputs. ENCORE knowledge base (Figure 20) is divided into two parts: dependencies and impacts. The dependencies component links natural capital assets to ecosystem services and scores how strong this link is. Dependencies between production processes and ecosystem services are evaluated too. The impact part assesses to what extent the production process impacts natural capital assets and provides a materiality rating towards different impact drivers. Impact drivers are linked to environmental change drivers, which are assigned a rating regarding how much they influence specific natural capital assets.

[35] Information in this section was retrieved from the ENCORE website [https://encore.naturalcapital.finance/en] (Natural Capital Finance Alliance and UNEP-WCMC 2021) and Webinar 1 of the EU Business @ Biodiversity Platform Webinar Series on Biodiversity Data for Corporate Biodiversity Measurement (EU B@B Platform Webinar 1 2021).

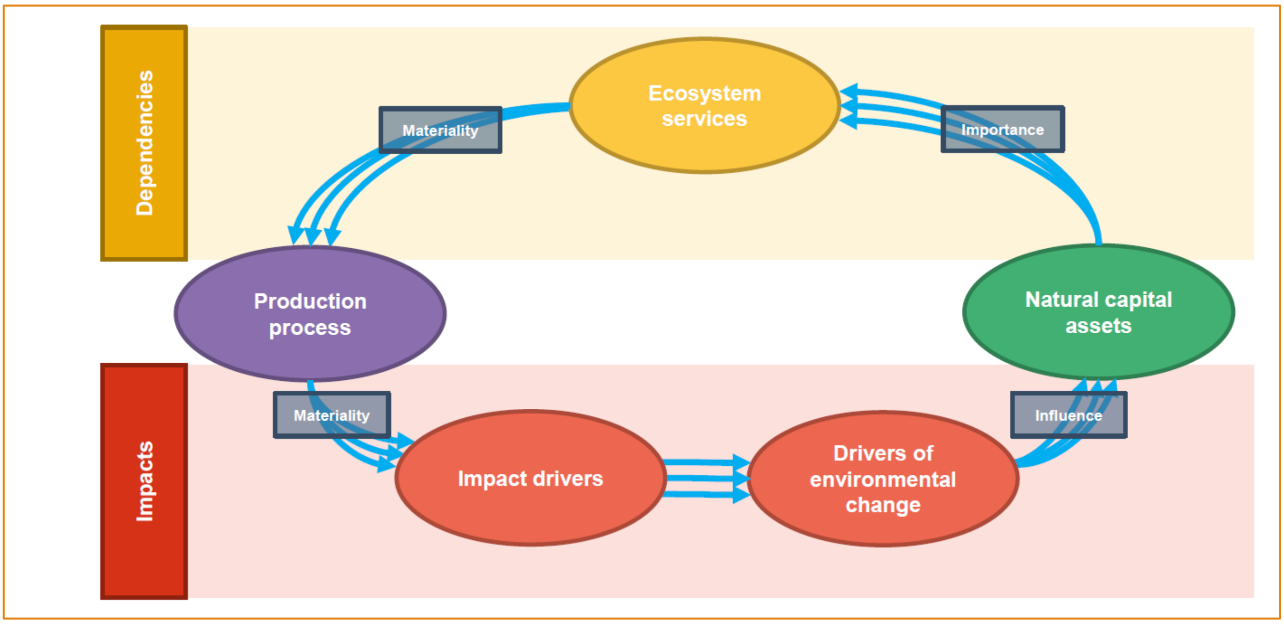

Figure 20: Impacts and dependencies in ENCORE's knowledge base.

In the future, ENCORE's methodology will be updated by adding quantitative indicators to assess materiality and building value chain links as currently impacts and dependencies are linked to direct sector operations, not to up- or downstream operations. Generally, the dependency and impact database will be continuously reviewed.

4.2.3 Data input/output

In ENCORE's dashboard (Figure 21), the *Visualize Links Between the Economy and Nature* functionality shows the relation between the user's sub-industry and production process. It provides information on ecosystem service dependencies, which impact drivers the production process contributes to (and vice-versa), and the materiality rating of the ecosystem services and impact drivers. Also references to ENCORE information pages on the ecosystem services, impact drivers and their relationships are provided. All information is presented in a dashboard view and on a world map. The Explore Potential Portfolio Alignment with Biodiversity Goals functionality investigates a portfolio's biodiversity performance and alignment with global biodiversity goals.

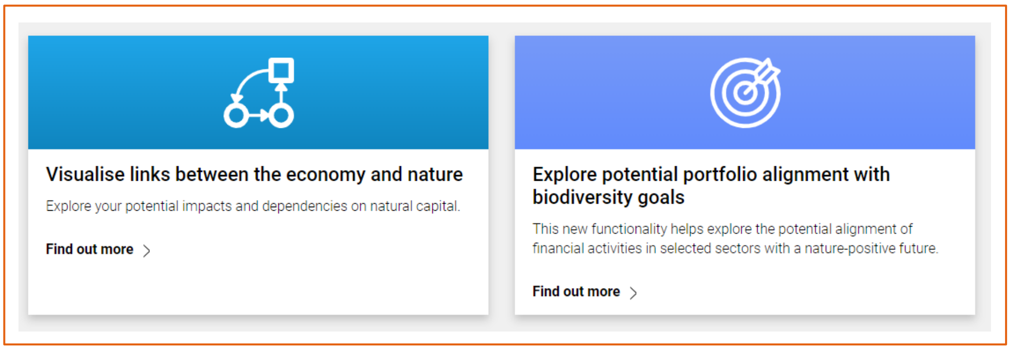

Figure 21: Snapshot of the ENCORE dashboard.

Natural capital dependencies and impacts are presented as flow charts (*flows* tab in ENCORE). Sub-industry and production processes are linked to ecosystems services, which are linked to natural capital assets. The diagram in Figure 22 shows that hydropower production is highly dependent on water flow maintenance. The water flow maintenance ecosystem service is maintained by habitats, the natural hydrological cycle (influenced by the atmosphere) and water.

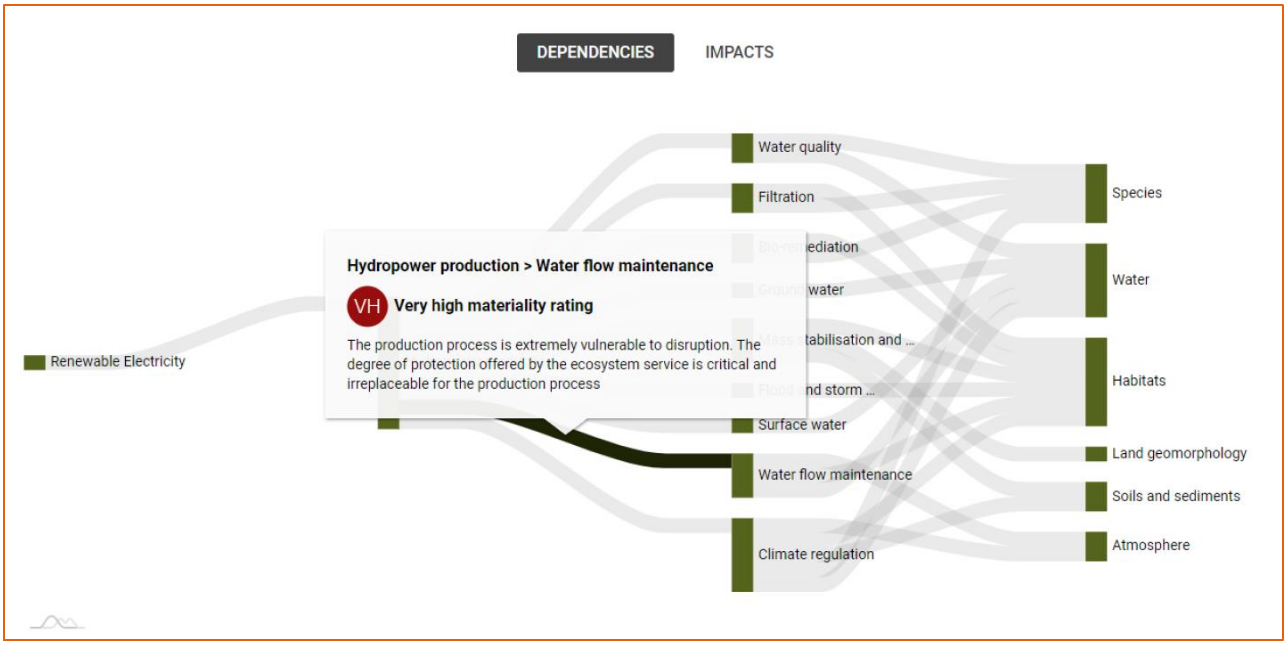

Figure 22: Example of an ENCORE dependencies flow chart for hydropower production.

Additional information on dependencies is presented under the *data* tab. Here, links with more information to each of the ecosystem services related to the production process are presented. Also details on natural capital assets that might be impacted by the production process are provided in this section. Information on impacts is presented in a similar way to the information on dependencies: sub-industries and production processes can lead to certain impact drivers, which in turn can have impacts on natural capital assets. Information on impact drivers is summarized in the *my most material potential impact* page.

Furthermore, the *Explore Potential Portfolio Alignment with Biodiversity Goals* functionality, also referred to as *Biodiversity Module*, is part of the dashboard. This module consists of an A*griculture* and *Mining Method*. The module's target group is financial institutions, who are interested in information on investments aimed at reducing negative impacts and/or increasing positive impacts. It checks the biodiversity performance of a portfolio and alignment with global biodiversity goals by assessing ecological integrity and potential to mitigate species' extinction risk. The module provides answers to questions as: "What is my current portfolio's potential to reduce species' extinction risk and ecological integrity risk?", "What are potential pathways for positive impacts within my agriculture or mining portfolio?" and "What types of actions can I take to increase the alignment of my portfolio with global biodiversity goals?". The module's output covers total portfolio exposure to agriculture or mining impacts, a regional breakdown of exposure, average mine exposure for the *Mining Method*, future exposure, and engagement guidance. Licensing requirements mean that individual mine results cannot be obtained.

ENCORE's Biodiversity Module is based on an iterative consultation process consisting of consultations with financial institution and external experts, testing by two pilot banks, and user testing. The agriculture method in the Biodiversity Module works in several steps. First, cropland and pastureland areas are derived from 2015 GLOBIO land cover data. Next, extinction risk is calculated through IUCN's Species Threat Abatement and Restoration (STAR) metric. Finally, the ecological integrity risk metric is calculated by an approach related to the Biodiversity Impact Metric. A similar methodology applies for the mining method in the Biodiversity Module. First, mine areas of influence are determined. Next, extinction risk is calculated based on the STAR metric, disaggregated to the threat of mining. Finally, the ecological integrity risk metric is calculated. Detailed information on the *Biodiversity Module*'s output can be found in the corresponding manual[36].

Currently, the module is not linked to Post-2020 Global Biodiversity Framework, as the Framework is not finalized yet. The Biodiversity Module is expected to be updated in 2022. The goal is to expand sectoral coverage beyond agricultural and mining sectors, expand spatial granularity of data (different commodities, higher precision), and explore types of output data that can be provided to users (company/asset level).

ENCORE comes with some limitations. Sector relationships with ecosystem services and drivers of change are location specific, and therefore only give insight into generic results. The tool does not include supply chain or product impacts. Biodiversity figures are only rough estimates.

4.2.4 Accessibility

The dashboard is only accessible after logging in, while the Explore function is always accessible. The Biodiversity Module and all of ENCORE is accessible for free. Underlying excel spreadsheets outlining the materiality relationships are available on request.

[36] https://s3.eu-west-2.amazonaws.com/ncfa.documents/resources/ENCORE+Guide+to+Biodiversity+Module.pdf

5 GEOSPATIAL DATA

This section offers insight in the rapidly evolving field of geospatial data, with a particular focus on biodiversity data and related applications. It is based on a review of the 2022 WWF-UK report on geospatial data (WWF-UK 2022), a literature review as well as on the presentations in the 2021 webinar series on biodiversity data of the EU Business @ Biodiversity Platform (EU B@B Platform Webinar 2 2021).

5.1 What are geospatial data?

Geospatial data provides information on the characteristics of an object, event or phenomenon and is linked to a specific location. Often it also includes temporal information describing the life span at which the location and attributes exist is included in geospatial data. (Stock and Guesgen 2016). Both the IBAT and ENCORE tool described previously hold geospatial data.

In-situ collection of environmental data is effective but comes with several drawbacks. Besides being labour intensive, expensive and unsuitable for collecting data at scale (WWF-UK 2022), field measurements are potentially destructive, result in point data instead of continuous data, are challenging to collect in hard-to-reach areas, and are often less suitable for compiling time series (Lechner, Foody, and Boyd 2020). Remote sensing allows users to quickly collect large amounts of information over a large spatial extent in a consistent, unbiased, repetitive way and therefore excludes hurdles associated with traditional field measurements. (Lechner, Foody, and Boyd 2020). Moreover, collecting data through remote sensing is often more cost effective than classic data collection techniques (e.g. Mumby et al. 2000; Rhodes et al. 2015).

The 2022 WWF-UK paper identifies the importance of geospatial data in generating an understanding of Environmental (E), Social (S), and Corporate Governance (G) (ESG) related to a specific commercial asset, company, portfolio or geographic area. The precise location and definition of ownership of a commercial asset (e.g. factory, field) is a key component of geospatial ESG and is referred to as *asset data*. Remote sensing data is often combined with *observational data*, or vice versa, depending on the context of the study and the investigated variable, to provide insights into the ESG variables. For example, the Intergovernmental Panel on Climate Change (IPCC) recommends combining remote sensing data with field inventories to estimate forest area and carbon stocks (Mitchell, Rosenqvist, and Mora 2017a). Also, environmental variables such as biodiversity require in-situ ground observations in parallel to remote sensing data. Such in-situ information is often obtained from NGOs and intergovernmental organizations. (WWF-UK 2022).

Geospatial ESG data functions as an additional data source that provides independent, global and high frequency data on the environmental impact and risks of single assets, companies (by grouping the assets of a company), and supply chains, or on environmental impacts and risks within a given area such as a state or country. Instead of assessing environmental variables separately, they can also be assessed in connection with another by applying more complex geospatially driven methods that consider dependencies, such as water risks, and wider risk modelling. (WWF-UK 2022)

The remote sensing landscape has evolved rapidly. The number, range and performance of sensors, platforms and applications has increased significantly over the past years (Lechner, Foody, and Boyd 2020). It has become an indispensable source of information for many domains, such as disaster management related to natural disasters and humanitarian crises (Boccardo and Tonolo 2015). Remote sensing data informs decision making by scientists, policy makers and authorities, as well as businesses and landowners and is particularly well used in the natural sciences. Examples include modelling three-dimensional forest structure (e.g. Lim et al. 2003), determining soil humidity (e.g. Ennouri and Kallel 2019), monitoring plant diseases (e.g. Jingcheng Zhang et al. 2019), studying phytoplankton (e.g. Basedow et al. 2019), monitoring water quality (e.g. Ross et al. 2019), monitoring alien plant invasions (e.g. Garzón López et al. 2018), assessing biodiversity (e.g. Luque et al. 2018), monitoring land use change (e.g. Butt et al. 2015), etc.

In the case of deforestation, remote sensing has proven its value driving continuous developments of specific forestry-related techniques (see for example Mitchell, Rosenqvist, and Mora 2017b). Increasing computing power and the availability of free satellite data allows for time series analysis and enables researchers to estimate vegetation parameters such as biomass and canopy closure, which are indispensable for monitoring deforestation. Moreover, it is possible to create large-scale, high-resolution change maps. (Schultz et al. 2016) A time-lapse consisting of satellite images allows to rapidly sketch the spatial and temporal context of a studied variable in a certain area (Figure 23) and the data in the time series can be quantified to obtain detailed information on changes in the studied variables (WWF-UK 2022).

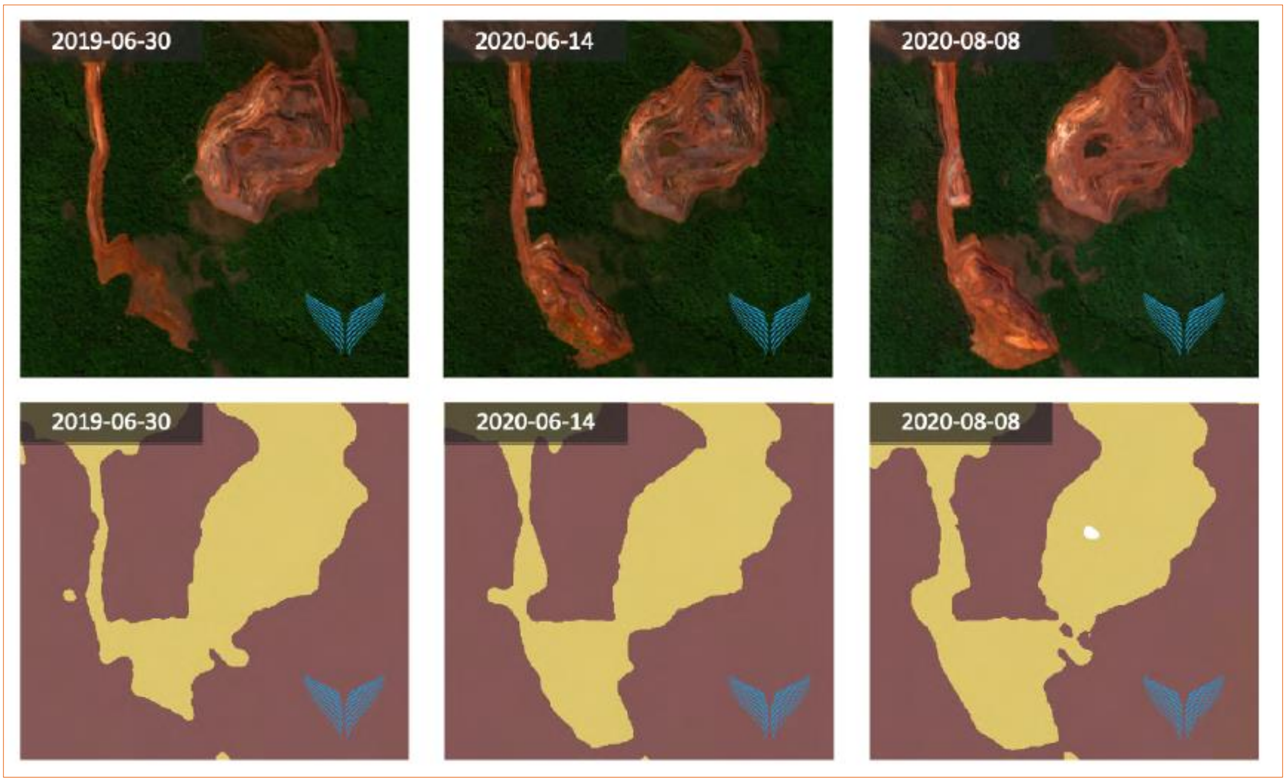

Figure 23: Top row: time series consisting of optical satellite images for three moments in time. Bottom row: land cover classification for each of the images. Figure from WWF-UK 2022.

Developments in the field of artificial intelligence and machine learning have led to a variety of open-source algorithms and automation software for efficient, large-scale image analysis, which broadens the possibilities and applications of remote sensing data. Examples of existing geospatial technology companies adding machine learning capabilities include Google Earth Engine and Microsoft

Planetary Computer (section 5.3). This knowledge was previously only available to government agencies and technology companies, but thanks to open-source code repositories and coding communities, it is becoming more readily available. These developments imply that assets, corporates and nations will no longer be the key factor in disclosing their environmental impacts. (WWF-UK 2022)

For research on animal migration and behaviour, biodiversity impact of herds, etc. remote sensing data is often combined with animal tracking data, which is obtained through satellite linked telemetry devices worn by animals. Location data can be gathered via a global navigation satellite system (such as the commonly used Global Positioning System (GPS)), the Argos satellite constellation (a global location and environmental data collection system, Figure 24) or a combination of both, as GPS collects more precise positional fixes compared to Argos (Farve n.d.; Perras and Nebel 2012).

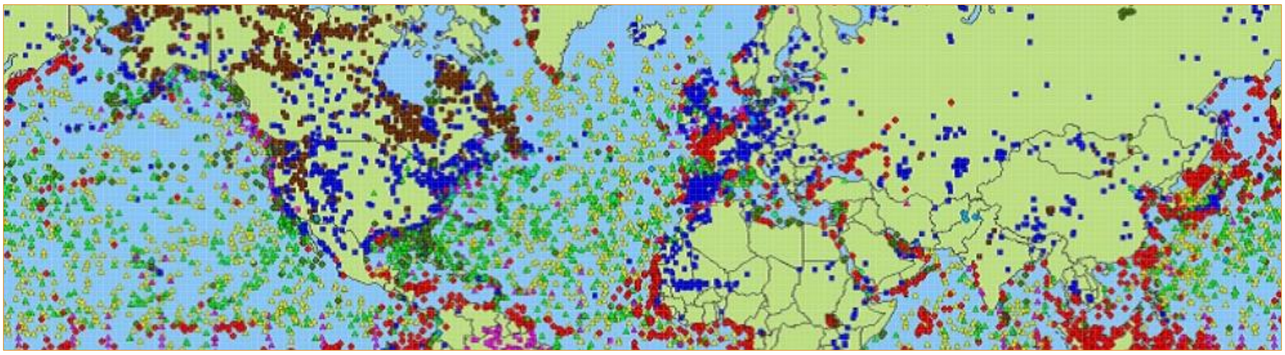

Figure 24: Argos. The dots give an impression of 22 000 transmitters and 8 000 trackers worn by animals worldwide (ARGOS 2021e). Figure from ARGOS 2021b.

5.2 How does it work?

Earth and its natural resources are widely studied, mapped, and monitored by remote sensing and more specifically by electromagnetic radiation sensors on spaceborne (e.g., satellite), airborne (e.g., drones and other unmanned aerial vehicles), and ground-based platforms (e.g., field spectroscopy). Remote sensing is the gathering and analysis of information on a target consisting of an object, area, or phenomenon by a sensor which is not in direct physical contact with that target (Gandhi and Sarkar 2016). The remote sensing principle is based on reflection and emission of radiation (Figure 25). The studied object reflects or emits radiation, which is captured by the sensor on a platform such as a satellite. The original source of the reflected radiation can be the sun or the object (passive remote sensing), or electromagnetic waves emitted by the sensor (active remote sensing, e.g. light detection and ranging (lidar) and radio detection and ranging (radar) systems). Sensors operate in the visible, infrared and microwave portions of the electromagnetic spectrum (EMS) and capture the intensity of radiation reflected or emitted by the target in different wavelengths. The captured radiation is electronically registered and sent to ground stations on Earth, after which the data is processed, analyzed, and interpreted. Materials with different physical and chemical properties reflect and emit radiation at different wavelengths and intensities, which allows to identify them.

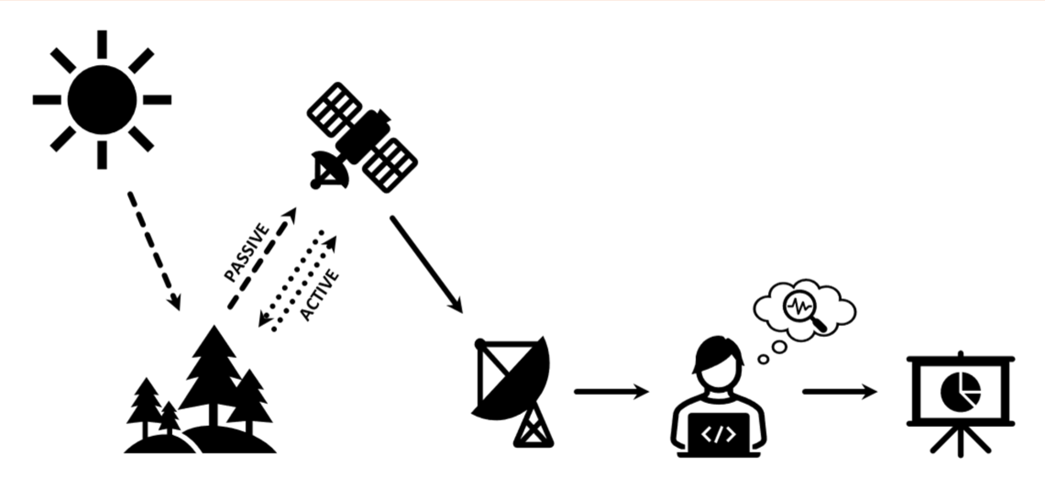

Figure 25: The remote sensing process.

Choice of sensor and platform determines spatial and temporal resolution of the gathered data and should therefore be tailored to the goals of the research. For example, drones collect data at high spatial (centimeter range (Gray et al. 2018)) and temporal (revisits a study area as often as the user wants) resolution, while for example the spatial resolution of Landsat 8 starts at 15 m for its panchromatic band and has a 16 day repeat cycle (USGS 2021). However, satellites can collect data at relatively high spatial and temporal scale too, such as the Quickbird mission with a maximum spatial resolution of 0.6 m for its panchromatic band and a revisiting time of 1 to 3.5 days, depending on latitude (Yang, Everitt, and Bradford 2006). Figure 26 shows aggregation of detail depending on spatial resolution, i.e. pixel size.

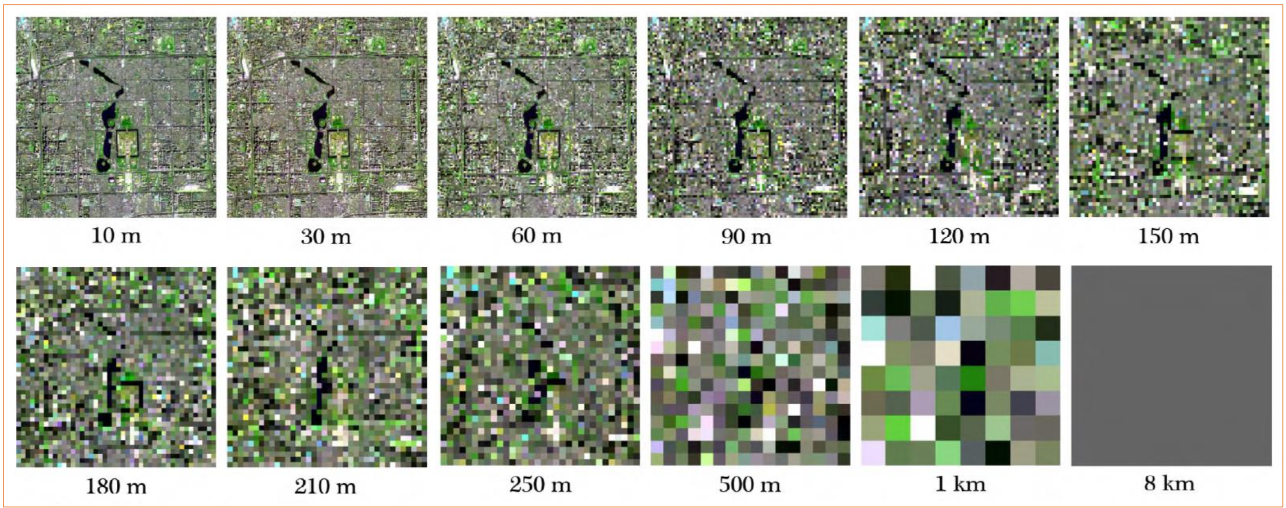

Figure 26: Spatial resolution. Figure from WWF-UK 2022.

Depending on the target's studied variables, panchromatic (single, broad band of the EMS imaged) multispectral (about a dozen of narrower bands imaged) or hyperspectral (hundreds of very narrow bands imaged) sensors are used. Hyperspectral sensors have the highest spectral resolution, which means that they distinguish more spectral wavelengths, collect information over a larger part of the electromagnetic spectrum and are able to detect subtle changes in reflected energy intensity. For example, data collected by multispectral sensors is used to distinguish forest from other types of ground cover, while hyperspectral data allows to identify tree species and determine tree condition.

The availability of a wide variety of sensors and platforms offers the possibility of combining data of different spatial and spectral resolutions into what is referred to as fused data. In this way, one data source is created that is more detailed than any of the data sources from which it is built. (Jixian Zhang 2010)

Many remote sensing databases allow easy downloading of analysis ready data. Depending on the application, advanced data processing and image analysis techniques will be necessary. This requires knowledge about data processing techniques and relevant software. However, ready-to-use applications (e.g., Copernicus' Global Land Cover Viewer[37], NOAA View[38]) allow users to interpret satellite data without knowledge on remote sensing analysis techniques. In this case, interpretation of the data is limited to the analysis that the application provides.
In the context of telemetry, transmitters connected to Argos satellites emit radio signals, which are captured by satellites and next sent to Earth (Perras and Nebel 2012). GPS trackers receive signals from at least four satellites and apply the trilateration principle, so the exact location of the GPS tracker on Earth can be determined (U.S. National Ocean Service 2021). GPS tracking data can be transmitted to a ground station using the Argos system (Perras and Nebel 2012).

Transmitters connected to Argos satellites can collect more than just geographic locations: they gather information on water depth, water temperature, animal heart rate and so on (ARGOS 2021a). Trackers also serve other purposes, when attached to non-living platforms. For example, on vessels to help implement fishery management policies, or in buoys for monitoring sea currents and oil spills (ARGOS 2021d; 2021c). Telemetry devices do not function if the signal path is significantly obstructed, for example by dense canopy (Perras and Nebel 2012).

In the case of animal tracking, these monitoring devices require animals to be captured to attach the equipment. The device, with a certain weight and volume, needs to be carried by the tracked animal, which can raise ethical concerns (Figure 27).

[37] https://lcviewer.vito.be/2015
[38] https://www.nnvl.noaa.gov/view/globaldata.html

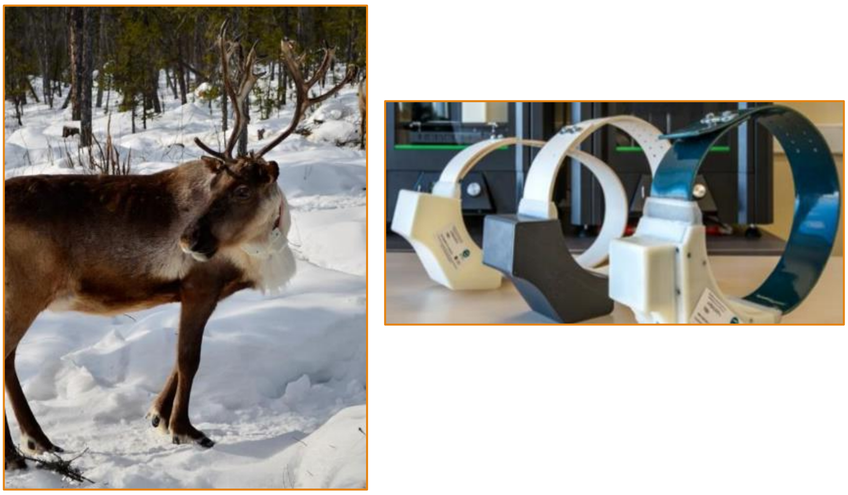

Figure 27: Left: smart herding system. Right: detail of animal collar with transmitter. Figure from EU B@B Platform Webinar 2 2021.

The weight of a transmitter should not exceed 5 percent of the animal's body weight. Although generally the effects of fitting tracking devices on animals are minimal, neck collars can potentially cause behavioural and habitat use changes, and adverse health effects such as stress, irritation, tissue damage, reduced fitness, and death (as a direct result of the device or by increased predation pressure). (Stabach et al. 2020)

Since the 1980s, the ARGOS system has evolved significantly: the weight of a transmitter evolved from several kilograms to 2 grams and is expected to decrease to a few milligrams by 2030. The number of satellites has increased from 1 to 9, the number of transmitters from 500 to 20,000. By 2030, 37 satellites will support 2 million ARGOS transmitters. (EU B@B Platform Webinar 2 2021)

5.3 Applications of geospatial data

No direct conclusions can be drawn from raw remote sensing information. Data processing is an essential step in the remote sensing process and includes data validation and calibration, and correcting for atmospheric, topographic, and other effects (Palombo and Santini 2020). Processing ensures reliable, qualitative data, which serves as input for data analysis and can be combined with other data layers in statistical software (data in formats as arrays, matrices), GIS software (data in map format) and so on.

To calculate specific variables, such as plant biomass, remotely sensed data is used in regression analyses, radiative transfer models, artificial intelligence models, etc. to calculate vegetation indices such as the Normalized Difference Vegetation Index (NDVI).

Besides calculating environmental variables, remote sensing data offers additional opportunities. For example, in the oil and gas industry, satellites are used to monitor flaring levels, methane leakage rates and development practices. Another application is 3D rendering using stereo images (images of a location from different angles), which can be converted to a 3D model by an algorithm. This allows to spatially model the topography of areas (Figure 28) and can for example be used to track the volume of material that has been removed from a mining site. (WWF-UK 2022)

Environmental risks and impacts are frequently non-linear and can take place over long time horizons. They materialize abruptly when they do occur, due to threshold effects or tipping points. The development of more advanced technology, sensors and models will make it possible to analyse near-real-time trends of ecosystem condition. (WWF-UK 2022)

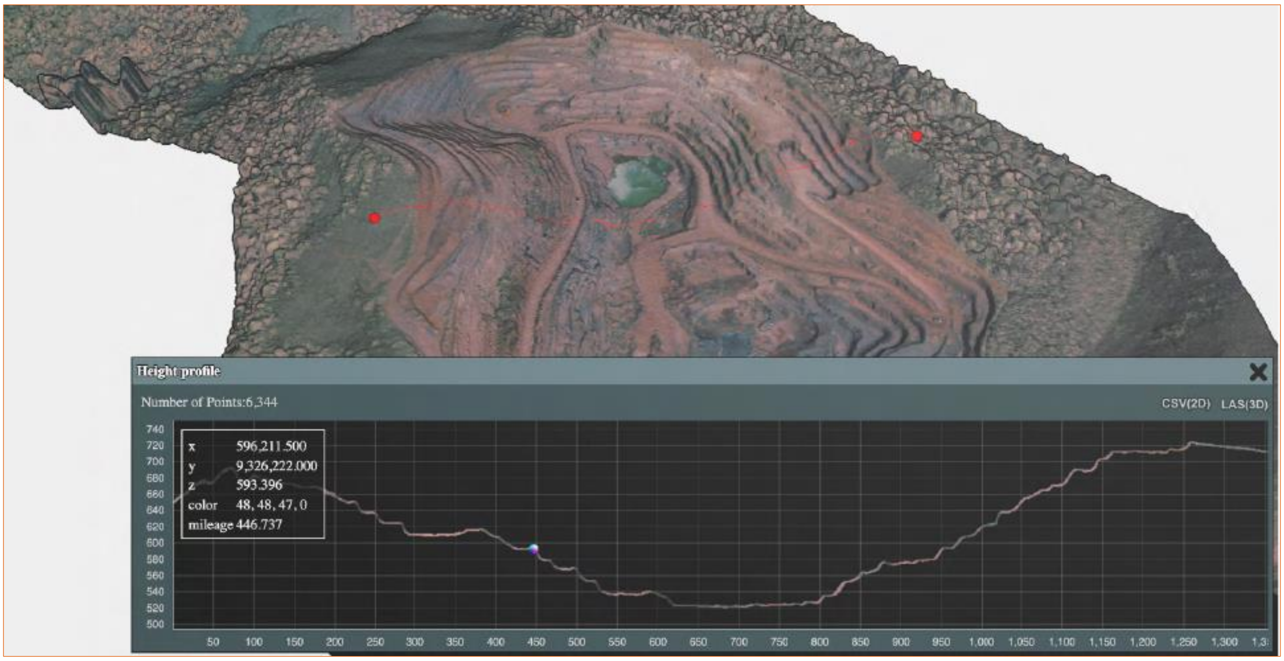

Figure 28: Digital reconstruction of a mine area based on images from the SkySat constellation. Figure from WWF-UK 2022.

A specific user group are financial institutions. Geospatial ESG data is currently constrained to the sectors that provide robust asset data, mainly primary industries such as mining, oil and gas, shipping, etc., whose impacts are directly linked to operations. The impacts of many other industries are rather in their supply chains, on which data are usually scarce. To provide some level of insight into the supply chain, regional values labelled as *impact* or *risk* averages are developed by companies, as they often only know the larger region the product was sourced from instead of an exact location. Thanks to the growing availability of geospatial data, ESG investors can make better informed decisions. (WWF-UK 2022).

Microsoft's Planetary Computer[39] helps to monitor, model, and manage natural resources by providing data, computing power and machine learning capability. The Planetary Computer is based on open-source tools. For example, Pangeo (a big data geoscience community platform) contributed to the development of the *Hub*, while the application programming interfaces (APIs) were created based on inputs from the STAC (SpatioTemporal Asset Catalog, a common language to describe geospatial information) community. The Planetary Computer's *Applications* are developed by partners (Figure 29).

[39] Information on Microsoft's Planetary Computer was retrieved from the Planetary Computer website [https://planetarycomputer.microsoft.com/] (Microsoft 2021) and the explanatory video by Microsoft's Chief Scientist Lucas Joppa [https://www.youtube.com/watch?v=eOgIuw-JTUU] (Microsoft 2020).

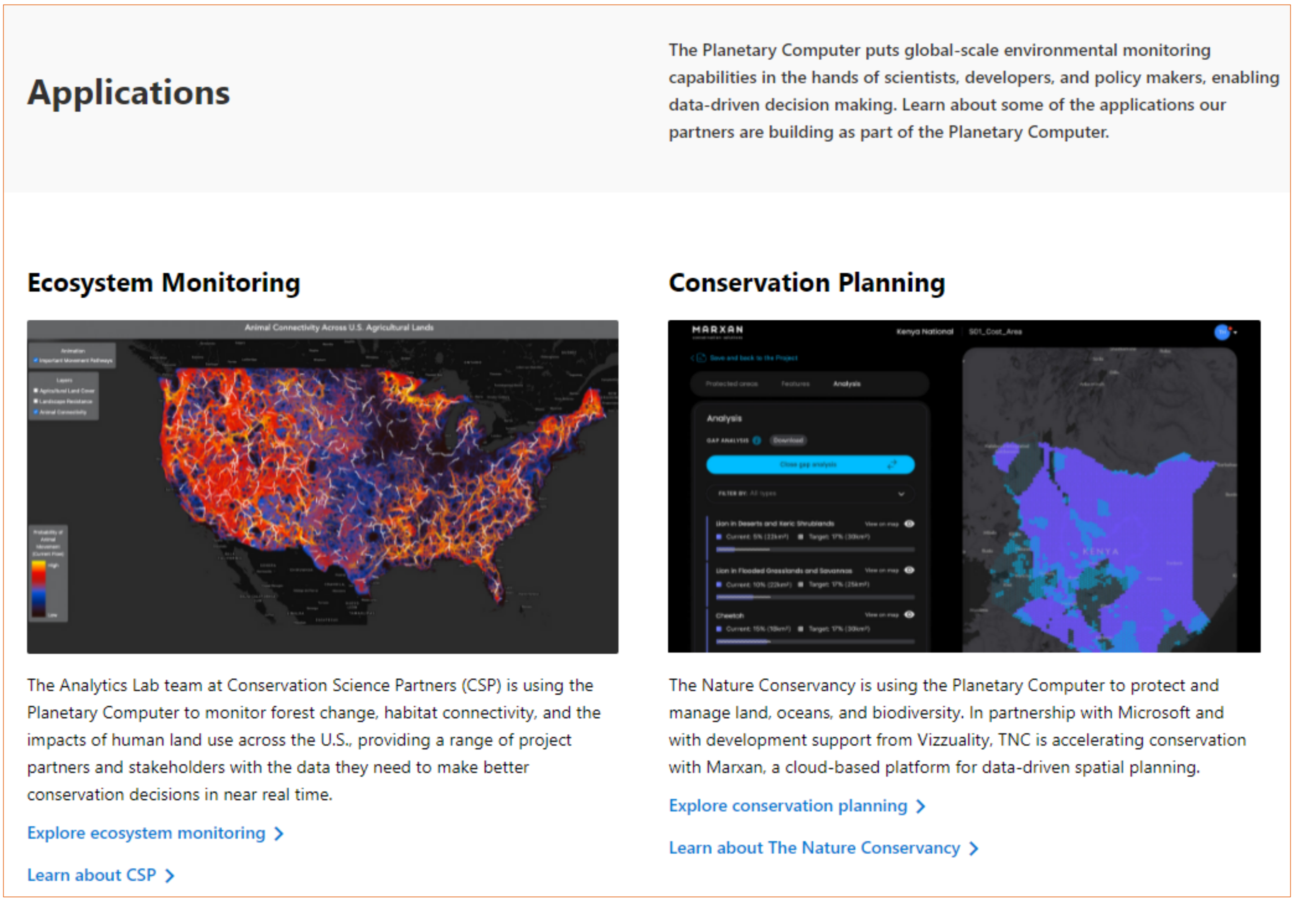

Figure 29: Examples of applications available on Microsoft's Planetary Computer.

The planetary computer bundles large quantities of data so that scientists and decision-makers have access to a large amount of accurate, updated, and consistent information in formats that can be used in analytics right away (Figure 30). This data is available to everyone anywhere in the world at any time and ranges from penguin colony health to forest cover. All datasets are provided with metadata and example code that shows how to access and use the data.

Data is accessible through the *Data Catalog*, hosted on Microsoft's cloud computing platform Azure and can be queried through the Planetary Computer's APIs. The *Hub* allows to analyse data using popular packages for sustainability and geospatial analyses. Data can also be processed outside the *Hub*. Finally, the Planetary Computer provides its users with *Applications* based on the datasets.

Since the Planetary Computer is an open-source initiative, all data and APIs are freely accessible. Because the platform is still under development, functionalities such as the *Hub* are only available in *Private Preview*. This means that an account must be requested to become an *early user*. In time, all functionalities will become fully available.

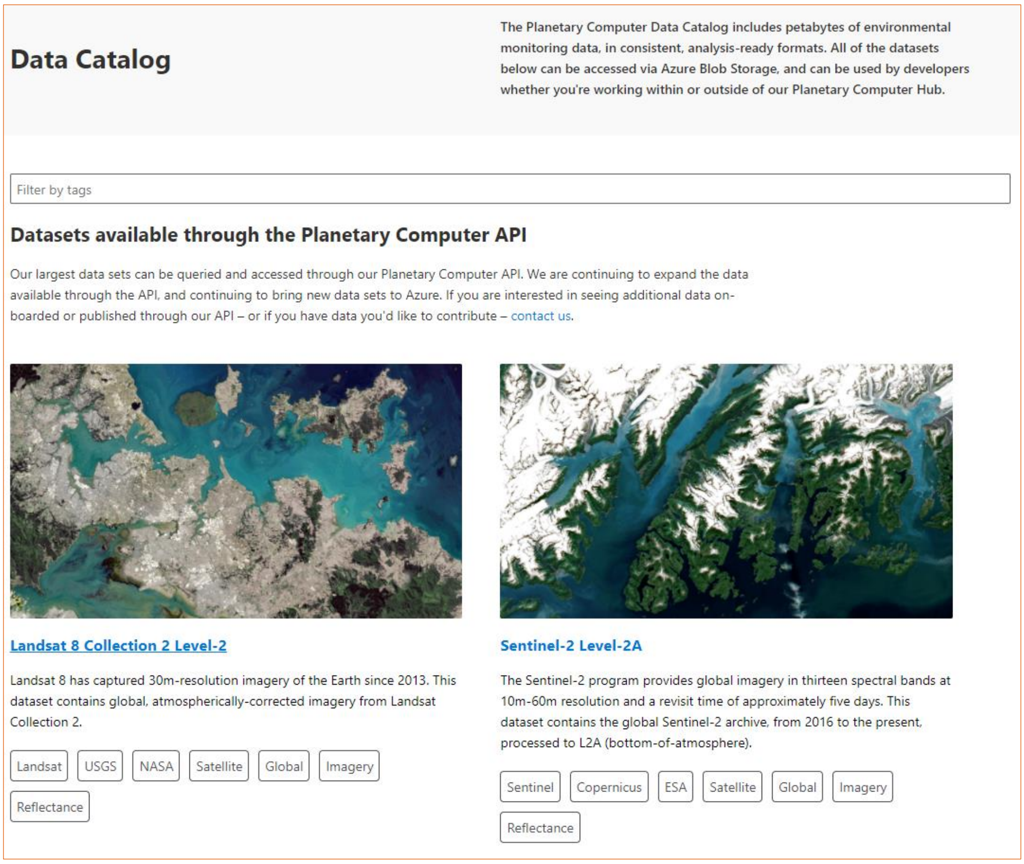

Figure 30: Examples of data provided by Microsoft's Planetary Computer.

Google Earth Engine[40] (GEE), not to be confused with Google Earth, is a powerful cloud computing platform for accessing, visualizing, and analysing daily updated satellite imagery (Landsat, MODIS, Sentinel-1, etc.) and other geospatial data (sea surface temperature, precipitation, climate, etc.). Users can also upload their own datasets for analysis. GEE provides APIs and other tools for analysing extensive datasets and is free to use for researchers, educational institutions, and non-profit users. (Google 2021)

Platforms like Resource Watch[41] and UN Biodiversity Lab[42] provide a (non-exhaustive) overview of major publicly available geospatial datasets and can be used, alone or in parallel with other datasets, to provide ESG insights on environmental variables and biodiversity impacts and risks. Commercial geospatial ESG applications often rely on public datasets provided by NGO, IGOs, academia and multilaterals. (WWF-UK 2022)

Satelligence[43] offers remote sensing services that provide insights in land degradation, forest fires, carbon stock loss, and deforestation. Satellite forest data assists in planning and decision making processes for forest protection and restoration. Safeguarding large carbon stocks such as natural forests is linked to safeguarding biodiversity, and satellite data can help to identify where such carbon

[40] https://earthengine.google.com/
[41] https://resourcewatch.org/data/explore
[42] https://unbiodiversitylab.org/
[43] https://satelligence.com/

losses occur. Satelligence provides real-time and forecasted deforestation data, which helps to proactively inform farmers and suppliers so that deforestation, protected area encroachment, loss of carbon stocks, and biodiversity decline can be prevented. Users receive automatic deforestation alerts for areas in and around their supply chain. These alerts are complemented with context information such as whether risks are located inside concessions or within a certain buffer of the concession, and whether the deforestation overlaps with peatlands, mangroves, primary forests, or other habitats (Figure 31). (EU B@B Platform Webinar 2 2021)

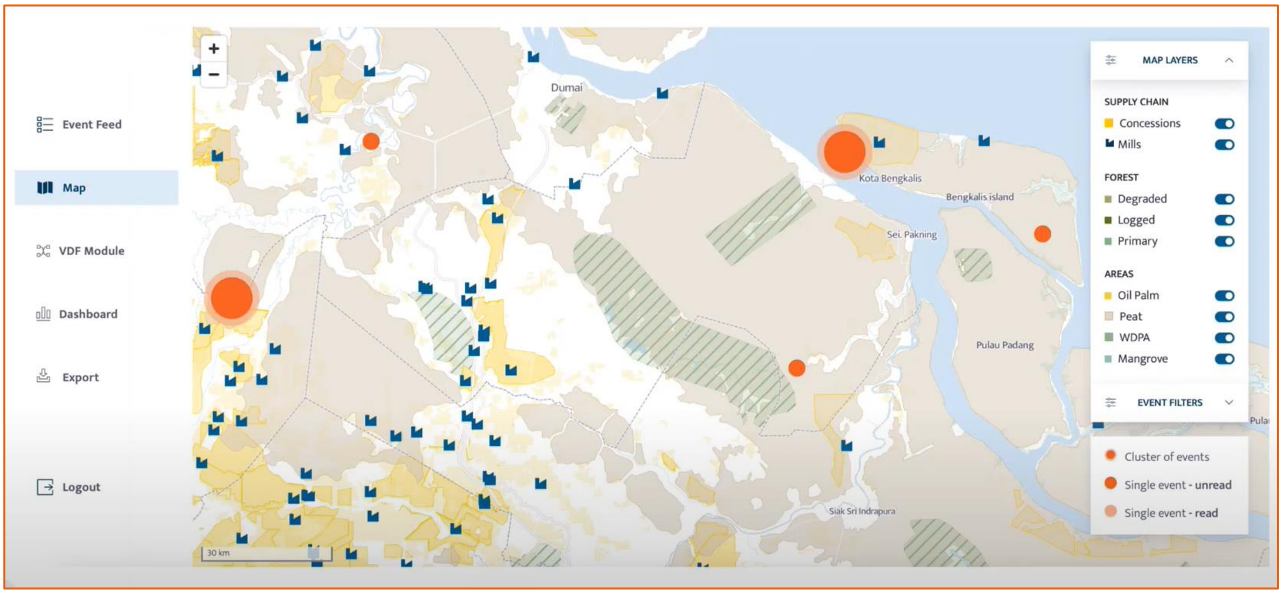

Figure 31: Example of deforestation alerts and complementary context information in the Satelligence system. Figure from EU B@B Platform Webinar 2 2021.

In cooperation with InCubed, Satelligence recently developed Deepview[44]. This tool allows companies to track deforestation risks in their supply chain by mapping the relationships between producers, traders, and goods manufacturers. Deepview currently focuses on the palm oil supply network of large traders and consumer goods consumers but can be scaled to other commodities as well. (ESA 2021)

SarVision[45] is specialized in monitoring forest degradation and deforestation by means of radar-based remote sensing. SarSentry is a fully automated, near-real-time deforestation and forest degradation monitoring system that detects low-intensity forest disturbance. It is especially suitable as an early warning system, and for impact, REDD[46], and biodiversity assessments. In addition, SarSentry monitors forest regrowth and carbon losses, and serves as a biomass and carbon mapping tool. The system is unique in that it can detect small-scale selective logging, which cannot be monitored using high-resolution optical systems or other existing radar systems. SarSentry supports certification schemes and allows to compare forest degradation in certified concession areas with degradation in non-sustainably managed areas. In Figure 32, the SarSentry system is illustrated. The left-hand map indicates how the construction of roads (deforestation) is accompanied

[44] https://incubed.phi.esa.int/portfolio/deepview/
[45] https://www.sarvision.nl/
[46] Reducing Emissions from Deforestation and Forest Degradation.

by forest degradation (light green colors correspond to heavy degradation). On the right-hand map, red colored polygons correspond to forest concessions. Forest degradation outside these concessions corresponds to illegal deforestation. Accurate monitoring of forest degradation is essential, as it contributes significantly to global forest and biodiversity loss. In the area shown on the right-hand map (Pará, Brazil), forest degradation is responsible for 82 percent of total forest loss. This number can be larger in for areas with more selective or illegal logging. (EU B@B Platform Webinar 2 2021)

Figure 32: SarVision’s SarSentry system. Left: forest degradation by deforestation for road construction. Right: deforestation in forest concessions (red polygons) and illegal deforestation outside the concessions. Figure from EU B@B Platform Webinar 2 2021.

Impact Observatory[47] created deep-learning algorithms to develop a global land use and land cover time series product which is about 100 times more detailed than some previous global open science products, as it is based on 10 meter Sentinel-2 data. The product is updated within the year and allows for near-real-time monitoring, unlike traditional products that are often only updated after a delay of one to several years. Also the ESA WorldCover programme[48], and teams leveraging Google Earth Engine and Microsoft’s Planetary Computer (section 5.3) plan to develop similar 10 meter land use and land cover products. Impact Observatory partners with academic and environmental NGO science teams to automate and scale models related to human footprint and ecosystem services such as carbon storage and biodiversity intactness, to develop automated and open-licensed datasets with global coverage. Based on land use and land cover time series and in cooperation with the UNEP World Conservation Monitoring Centre, Impact Observatory has operationalised the calculation of the biodiversity intactness index and above-ground biomass carbon change. In this context, the organisation creates publicly available global 100 meter products every year that can be generated on demand. (WWF-UK 2022)

CLS Group[49], a subsidiary of the Centre National d'Etudes Spatiales (CNES)[50] monitors biodiversity by optical imaging, artificial intelligence and a nanosatellite constellation, and is responsible for

[47] https://www.impactobservatory.com/
[48] https://esa-worldcover.org/en
[49] https://www.cls.fr/en/cls-group/
[50] National Centre for Space Studies.

environmental applications of the worldwide ARGOS program. The Space Innovative System to Monitor Animals (SISMA) project is a smart herding solution focused on livestock management (Figure 33). The project is a cooperation between space agencies, private companies, NGOs, authorities, farmers, and manufacturers. SISMA monitors wild reindeer in Russia, which are decreasing in number due to global warming, famine, epidemics, etc. To monitor the reindeer's population numbers, migration routes and behaviour, collars with trackers that have GPS and ARGOS connectivity are used. Gathered information is supplemented with environmental data based on habitat mapping, metadata, terrestrial models and so on. (EU B@B Platform Webinar 2 2021)

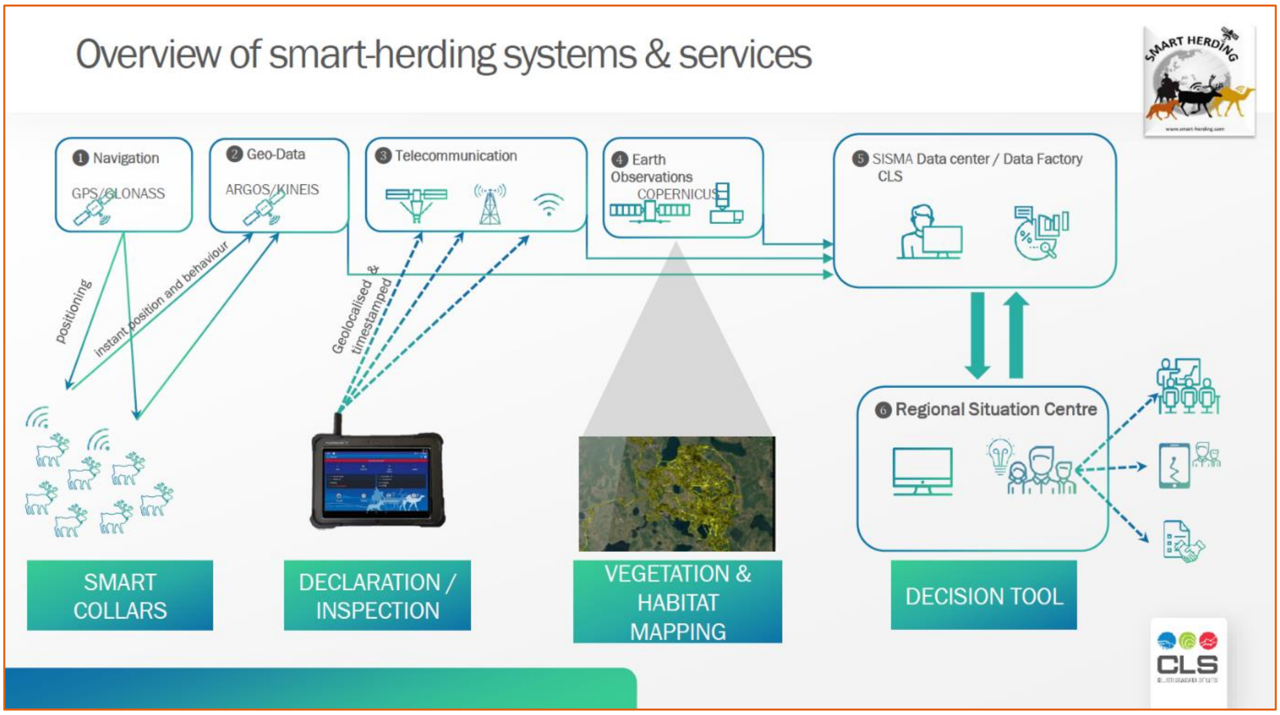

Figure 33: CLS Group's smart-herding system. Figure from EU B@B Platform Webinar 2 2021.

5.4 Considerations

Although remote sensing infrastructure is costly to build, launch and operate, a lot of satellite data archives are publicly available. Especially key datasets for environmental science are made increasingly available in recent years (Lechner, Foody, and Boyd 2020). Data collected by private initiatives is usually available for a fee. Examples of free of charge remote sensing databases include those of space agencies such as ESA (e.g., Earth Online[51]), NASA (e.g., Earth Data Search[52]) and NOAA (NOAA View[53]). In the context of telemetry, GPS is free to use, while the Argos system requires a paid subscription (Perras and Nebel 2012).

Using publicly available geospatial datasets requires a critical attitude and additional analysis as they are typically found to be limited by six issues: temporal consistency, spatial resolution, accuracy,

[51] https://earth.esa.int/eogateway
[52] https://search.earthdata.nasa.gov/search
[53] https://www.nnvl.noaa.gov/view/globaldata.html

data interdependencies, relevancy, and challenges of biodiversity. As an example, Figure 34 provides an overview of the spatial and temporal resolutions of 70 UN Biodiversity Lab raster layers. (WWF-UK 2022)

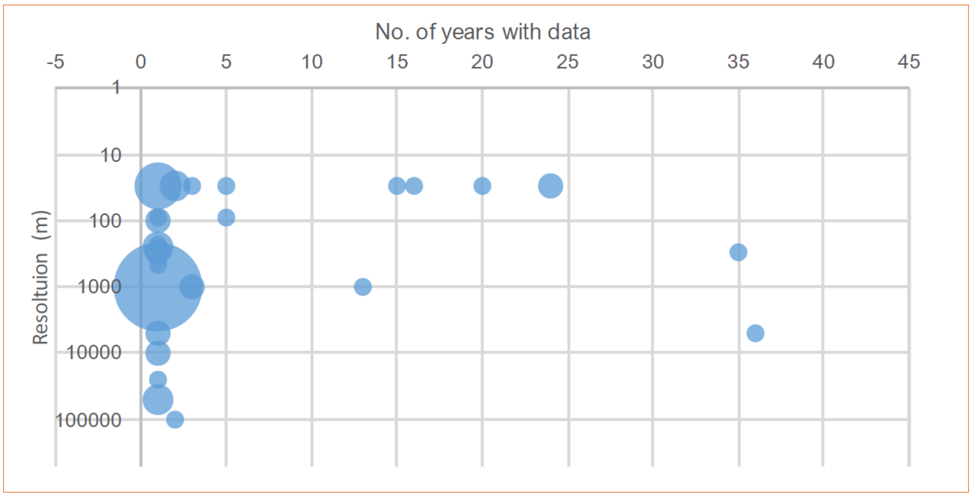

Figure 34: Spatial and temporal resolution of 70 UN Biodiversity Lab raster layers. Larger circles correspond to a larger number of datasets. Figure from WWF-UK, 2022.

Geospatial techniques are providing data, but it is often unclear when an environmental score can be considered a good score. As an example, vegetation data ideally should be converted into generally accepted condition scores but so far, these are not available. In addition to the lack of a conceptual standard for what can be seen as a good score, this is also due to missing data (so that instead estimated values are used), out-of-date statistics, and heterogenous reporting standards. Geospatial data is useful for assessing the environmental materiality of indicators such as deforestation but does not directly convert into economic materiality such as economic output, which influences financial materiality such as investment incentives. The data should be processed and converted into economically relevant numbers: in terms of units, aggregation level of the data, and interpretation. (WWF-UK 2022)

To enable the development of such metrics, improvements in asset and observational data, machine learning techniques, sector-site-specific and user-case-specific products for financial institutions will be necessary. According to WWF's Geospatial ESG Report (WWF-UK 2022), environmental indicators ideally meet the following conditions[54]: low cost and easy to produce; accurate, reliable and scientifically robust; sensitive to change and allow the separation of impact to a specific asset; comparable across sites and scales; applicable across a wide variety of sectors, environments, and sectors. The report elaborates on the six key conditions in more detail and provides an overview of the temporal coverage of 105 open and commonly used geospatial environmental datasets (38 and 19 percent of datasets had values for more than one and five years, respectively). Specifically on biodiversity challenges, the report states that no product has yet been able to define the biodiversity impact of commercial activities at a global scale and a high temporal frequency. Nevertheless, data providers often claim that their product offers a holistic insight into such matter, which could lead to

[54] WWF-UK's Geospatial ESG Report (WWF-UK 2022) includes proposals for widely applicable, high-level key performance indicators relevant for geospatial ESG environmental insights.

the data being used for greenwashing and reduced trust in and effectiveness of the ESG process that seeks to realign capital to support nature recovery.

Initiatives such as the Global Biodiversity Information Facility (GBIF[55]), a global network and data infrastructure for biodiversity data funded by governments worldwide, need more regular and higher frequency field data to be able to provide geospatial ESG insights that can show subtle changes and trends in habitat condition over short periods of time. In this context, Data4Nature[56] encourages sharing biodiversity data generated by development projects with GBIF. (WWF-UK 2022)

55 https://www.gbif.org/
56 https://www.gbif.org/data4nature

6 CONCLUSION

The demand from the business community for useful and credible biodiversity data has never been higher. Significant developments have occurred in technology in recent years, ranging from the use of eDNA sampling methods to satellite technology. These innovations give us a greater insight into biodiversity than ever before. It is likely that a range of these approaches will be needed to understand and manage biodiversity performance. Overall, however, much more is needed to grasp the full potential of these developments in biodiversity data collection. Investment will be required in the creation of data infrastructure, enhancing disclosure and measurement standards, convergence between data requirements of measurement approaches, tailoring of public level biodiversity data to the needs of the business community, transparency and verification, and building capacity for accessing new technologies.

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COLOPHON

ASSESSMENT OF BIODIVERSITY MEASUREMENT APPROACHES FOR BUSINESSES AND FINANCIAL INSTITUTIONS

THEMATIC REPORT ON BIODIVERSITY DATA

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ABOUT THE EU B@B PLATFORM
The EU B@B Platform is a forum for dialogue and policy interface to discuss the links between business and biodiversity at EU level. It was set up by the European Commission with the aim to work with and help businesses integrate natural capital and biodiversity considerations into business practices. The EU B@B Platform focuses its work on three thematic workstreams: Methods, Pioneers and Mainstreaming. ICF is supporting the European Commission in running the EU B@B Platform since 2013. Arcadis is leading the Methods Workstream.