biodiversa+
European Biodiversity Partnership

GUIDE ON HARMONISING BIODIVERSITY MONITORING PROTOCOLS ACROSS SCALES

Support to effectively integrate monitoring results

Co-funded by the European Union

To cite this report

Michelle Silva del Pozo, Guillaume Body, Gaby Rerig, Mathieu Basille. (2023). Guide on harmonising biodiversity monitoring protocols across scales. Biodiversa+ report. 60 pp.

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Layout

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Pixabay: cover picture, p.2-3; 4-5; 7; 11; 12; 13; 20-21; 26; 32; 37; 38; 44-45; 47; 59
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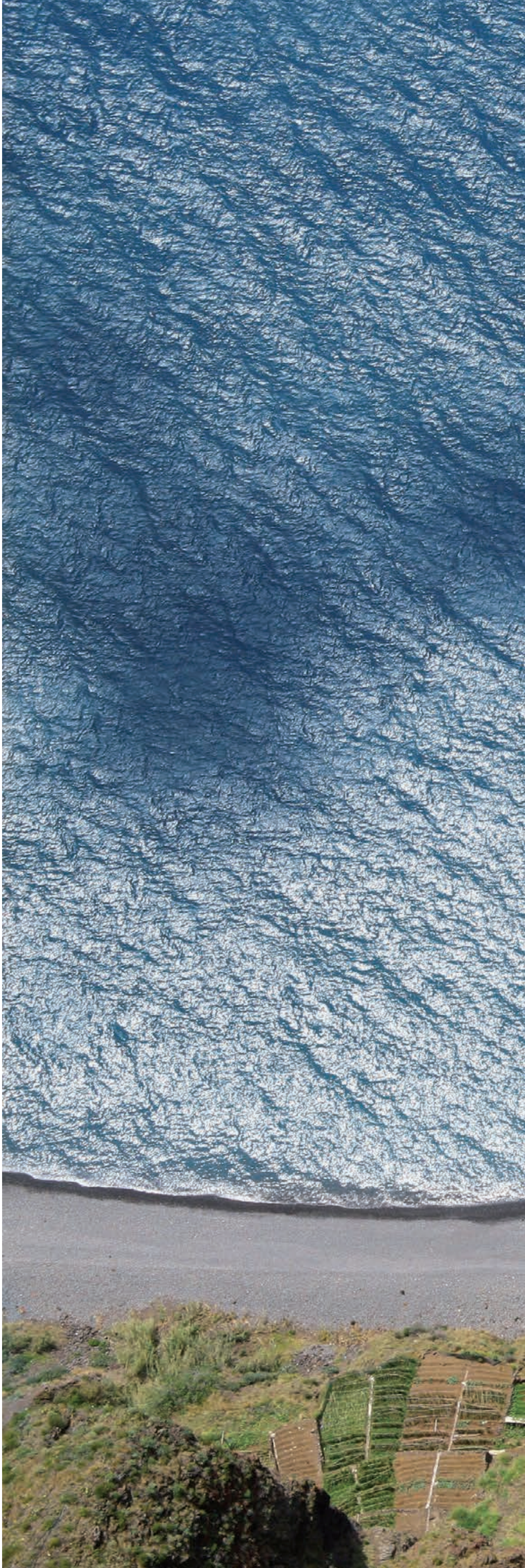
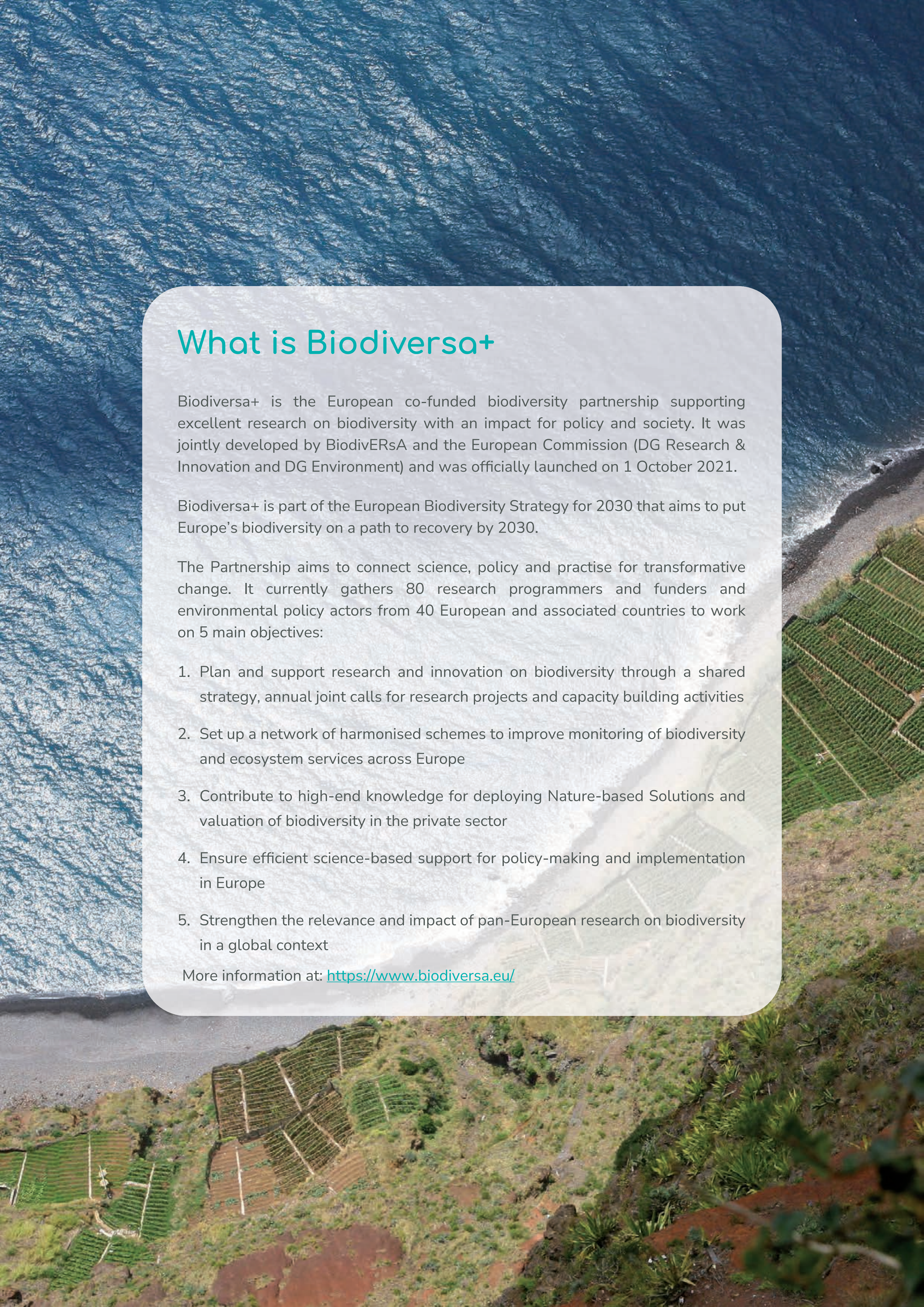
Acknowledgements

This Guidance for best practice draws on a variety of helpful sources of information on transnational biodiversity monitoring programmes. The authors acknowledge the valuable help and feedback of our Biodiversa+ and EuropaBON partners. We are also particularly grateful to the different programme coordinators and experts who took part in interviews and in the workshop, organised on the 2nd of March 2023 at the Natural History Museum of Paris: “Biodiversity monitoring protocols harmonisation across countries: experts’ analysis on the different possible strategies”. We would like to thank them for their time and valuable contributions in the development of the case studies and analysis of the strategies presented in this document.





What is Biodiversa+

Biodiversa+ is the European co-funded biodiversity partnership supporting excellent research on biodiversity with an impact for policy and society. It was jointly developed by BiodivERsA and the European Commission (DG Research & Innovation and DG Environment) and was officially launched on 1 October 2021.

Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030.

The Partnership aims to connect science, policy and practise for transformative change. It currently gathers 80 research programmers and funders and environmental policy actors from 40 European and associated countries to work on 5 main objectives:

1. Plan and support research and innovation on biodiversity through a shared strategy, annual joint calls for research projects and capacity building activities
2. Set up a network of harmonised schemes to improve monitoring of biodiversity and ecosystem services across Europe
3. Contribute to high-end knowledge for deploying Nature-based Solutions and valuation of biodiversity in the private sector
4. Ensure efficient science-based support for policy-making and implementation in Europe
5. Strengthen the relevance and impact of pan-European research on biodiversity in a global context

More information at: https://www.biodiversa.eu/

LIST OF ABBREVIATIONS

ABLE: Assessing Butterflies in Europe

BON: Biodiversity Observation Network

CBD : Convention on Biological Diversity

DG ENV: Directorate-General for Environment

eBMS: European Butterfly Monitoring Scheme

EBV: Essential Biodiversity Variables

EC: European Commission

EEA: European Environment Agency

EU: European Union

EUROBATS: Agreement on the Conservation of Populations of European Bats

EuropaBON: Europa Biodiversity Observation Network

FW BON: Freshwater Biodiversity Observation Network

GBIF: Global Biodiversity Information Facility

GEO BON: The Group on Earth Observations Biodiversity Observation Network

HELCOM: Baltic Marine Environment Protection Commission

JRC: Joint Research Centre

LUCAS: Land Use/Cover Area frame Survey

MARCO-BOLO: Marine Coastal Biodiversity Long-term Observations

MBON: Marine Biodiversity Observation Network

NGO: Non-Governmental Organisation

PECBMS: Pan-European Common Bird Monitoring Scheme

SPRING: Strengthening Pollinator Recovery through Indicators and Monitoring

TDWG: Biodiversity Information Standards

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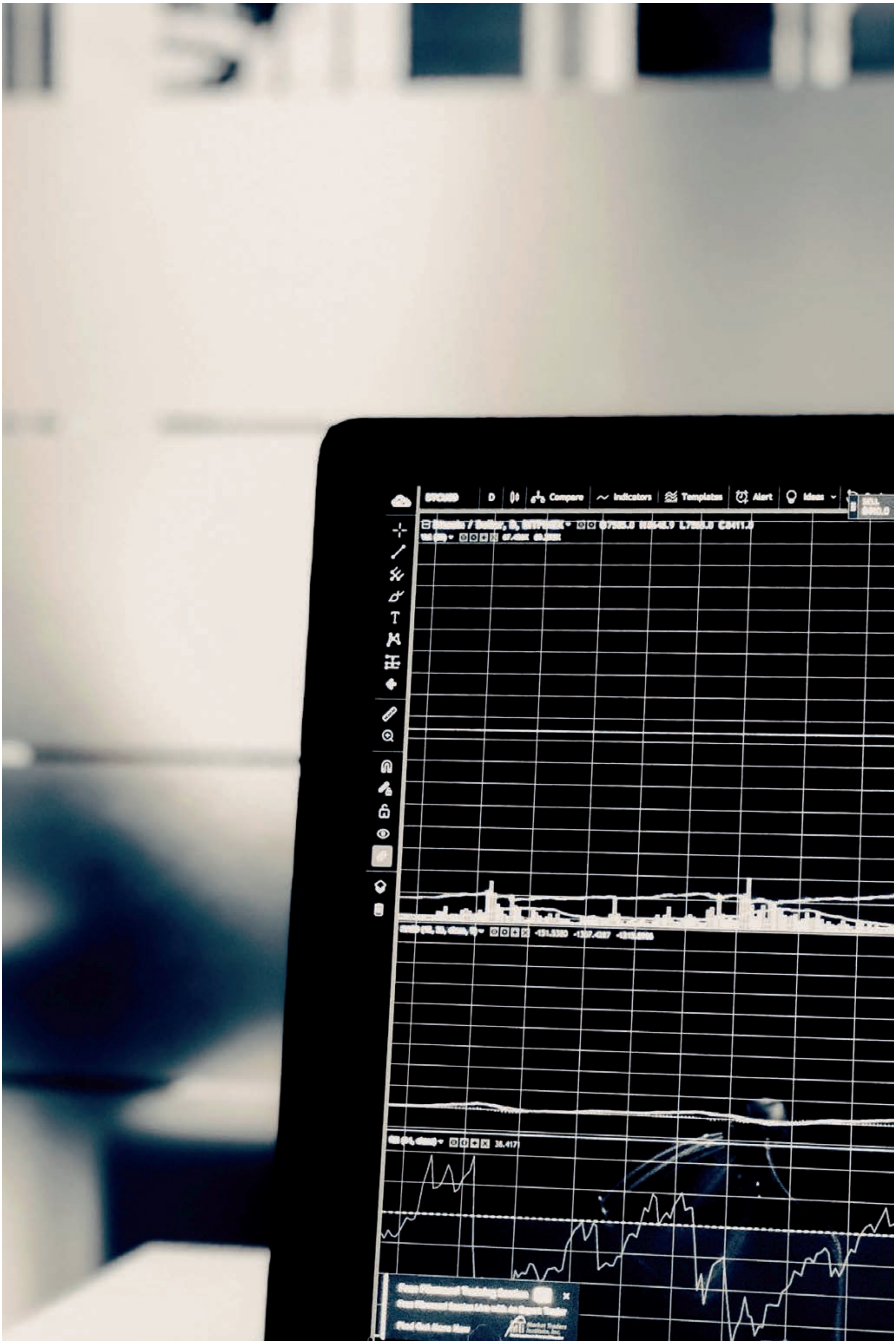
EXECUTIVE SUMMARY

The European Biodiversity Partnership, Biodiversa+, in collaboration with EuropaBON and other large-scale initiatives, seeks to harmonise existing biodiversity monitoring protocols and integrate biodiversity information across scales from various conservation initiatives. This recommendations document offers a **starting point for discussions on strategies for harmonising biodiversity monitoring**, emphasising collaboration across multiple stakeholders. The document does not delve into all technical aspects of protocol harmonisation but serves as an **introduction to key concepts and approaches**. It is designed to aid stakeholders tasked with -or exploring the idea of- harmonising biodiversity monitoring across diverse territories and scales. The guide covers the flexibility of protocols, biodiversity information workflows, and the establishment of common frameworks. Strategies for harmonising protocols are examined, focusing on three main approaches: common strict protocol with joint data analysis, independent protocols with locally-produced EBVs, and general flexible protocols with a parallel data chain.

Recommendations advocate (1) protocol flexibility, (2) a parallel data workflow (producing and sharing both EBV and raw data), and (3) building common frameworks to integrate results in the various biodiversity monitoring communities.

Firstly, the choice of a monitoring protocol should be context-specific, considering existing schemes, gaps in coverage, and available resources. Adaptation of existing protocols or harmonisation of minimum standards can streamline efforts and promote compatibility. Secondly, a parallel approach to data sharing, involving both raw datasets and EBV estimates, can offer flexibility and broader insights while addressing data compatibility concerns. Thirdly, building common frameworks among monitoring communities is crucial, requiring collaboration and the establishment of technical expert groups to work on the specificities of the minimum requirements for the monitoring efforts. This collaborative approach ensures data quality, interoperability, and a sense of ownership among stakeholders.

The proposed harmonisation framework strives to align diverse stakeholders' interests and establish a network to facilitate collaboration, data sharing, and effective biodiversity monitoring across scales.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INTRODUCTION

1.1. THE IMPORTANCE OF HARMONISATION OF BIODIVERSITY MONITORING PROTOCOLS

In the realm of biodiversity conservation, the imperative to harmonise monitoring protocols is paramount, driven by the need to enhance the comparability of data and thereby facilitate more effective conservation measures. However, the task of harmonisation is not without its challenges, as the landscape of biodiversity monitoring is characterised by a rich tapestry of national traditions, many countries have developed their own distinct national monitoring programmes, each rooted in unique methodologies and based on their own guidance. While these traditions underscore the unique conservation priorities of individual countries, this diversity also poses a challenge in achieving a comprehensive global assessment. This challenge is increased by several gaps inherent in current monitoring efforts. These gaps span the spectrum from the lack of taxa to deficiencies in spatial and temporal coverage (Morán-Ordóñez *et al.*, 2023). These disparities collectively impede the attainment of a cohesive and standardised global view, inhibiting the synergistic efforts required for effective conservation practices.

This urgency for harmonisation finds further resonance in policy realms[1]. The absence of harmonisation in monitoring habitat quality at the EU-wide level can lead to incoherent reporting within the European Union, and makes it more difficult to define ecosystems restoration targets[2]. The call for harmonising methods becomes imperative for informed decision-making and efficient policy implementation.

Strengthening international collaboration and adopting a multiscale approach that spans nations, regions, and continents are foundational elements (Leadley *et al.*, 2022). Some projects, such as EUMON (2004-2008), the European biodiversity observation network (EBONE[3]) (2008-2012), the pan-European Marine Biodiversity Observatory System (EMBOS[4]) (2010-2015, and EMBOS+ from 2015-on), or the European Biodiversity Observatory Network (EUBON[5]) (2012-2017), have aimed to design and test a biodiversity observation system over large scales of time and space. The positive outcomes of these projects stand as testament to the potential realisation of a cohesive and integrated European biodiversity monitoring framework. Nevertheless, they have highlighted that the journey toward harmonisation is multifaceted and demands considerable efforts to address the diverse array of methodologies, protocols, and practices that span across national boundaries.

The European Biodiversity Partnership, Biodiversa+[6], in collaboration with EuropaBON and other large-scale initiatives, is studying the possible strategies for an optimal way to harmonise existing monitoring protocols across scales to allow the integration of biodiversity information produced by different initiatives.

1. EU biodiversity Strategy for 2030: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
2. EU Nature restauration law https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_enhttps://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en
3. EBONE: https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Projects/EBONE.htm
4. EMBOS: https://embos.info/
5. EUBON: http://www.eubon.eu/
6. Biodiversa+: https://www.biodiversa.eu/biodiversity-monitoring/

1.2. THE PRESENT GUIDE

WHAT & FOR WHOM?

This report aims to provide a starting point for discussions on the strategies to consider for moving towards a harmonised approach of biodiversity monitoring; and to promote the collaborative use of these strategies at different scales, acknowledging that harmonisation involves the cooperation of multiple stakeholders. This guidance note does not intend to develop all aspects related to harmonising the monitoring protocols in detail. Rather, it provides an entry point to the main concepts and highlights the approaches used from existing initiatives that have set in place transnational biodiversity monitoring protocols.

This Biodiversa+ guidance on best practices is designed to **support** stakeholders who are tasked with, or exploring the idea of, **harmonising the existing biodiversity monitoring efforts across their specific territories and scales**. This includes a diverse spectrum of stakeholders, ranging from individuals overseeing harmonisation efforts at local to regional spatial scales, such as national parks, to environment agencies and ministries, research institutes, non-governmental organisations, and larger transnational initiatives and projects (i.e. Biodiversa+). EuropaBON[7], SPRING[8], MARCO-BOLO[9] and EUROBATS[10] can also be cited as a few examples of EU-coordinated projects with a harmonisation component in their aims. The spectrum of stakeholders encompasses those responsible for harmonising biodiversity monitoring at both regional and national levels, reflecting a comprehensive approach to collaborative harmonisation efforts.

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7. EuropaBON: https://europabon.org/

8. Strengthening Pollinator Recovery through Indicators and Monitoring: https://www.ufz.de/spring-pollination/

9. Marine Coastal Biodiversity Long-term Observations: https://marcobolo-project.eu/

10. Agreement on the Conservation of Populations of European Bats: https://www.eurobats.org/

HOW WAS IT BUILT?

In order to generate a broader understanding of the biodiversity monitoring process from data collection to information output at a large scale (e.g. European scale), a review[11] of existing trans-national monitoring programmes was conducted, to examine which strategies were used in terms of type of protocol used and data workflow. Consultation with stakeholders involved in a few of the monitoring programmes taken as examples for this report provided us with additional insight into the functioning and reasoning behind the different approaches used. A workshop was organised on the 2nd of March 2023 at the Natural History Museum of Paris: "Biodiversity monitoring protocols harmonisation across countries: experts' analysis on the different possible strategies". Discussions on the European capacities for harmonised biodiversity monitoring in terms of data workflows and governance were carried out between different experts and stakeholders, such as the coordinators of the key monitoring programmes studied (LUCAS soil, PECBMS, SPRING), representatives of DG ENV and EuropaBON, and Biodiversa+ partners linked to national implementation of biodiversity monitoring actions. More specifically, this exercise provided an analysis of the different possible strategies and drew out some directions on which stakeholders could work to develop such systems.

The compilation of the results is presented in this report in the form of general guidance for future applications, with the possibilities and challenges on the ways to harmonise biodiversity monitoring protocols.

Before delving into the main principles and proposed recommendations, some concepts are presented, laying the groundwork for a better understanding of the subject matter. Three main recommendations are then proposed, and some possible limitations and areas for further exploration and improvement are mentioned. Finally, an Annex featuring a glossary is provided to assist readers in navigating the diverse terminology used throughout the document.

11. Biodiversa+ literature survey on biodiversity monitoring protocols: https://www.biodiversa.eu/wp-content/uploads/2022/12/MS55-Literature-survey-biodiversity-monitoring-protocols.pdf

2 SOME USEFUL CONCEPTS BEFORE STARTING

2.1. WHAT IS A BIODIVERSITY MONITORING PROTOCOL?

Biodiversity monitoring is the systematic observation and recording of a biological object in order to determine possible changes in the various forms of biodiversity (genes, taxa, ecosystems, etc.) (Juergens, 2009).

For this guidance note, **a monitoring protocol is understood to be a structured set of procedures, methodologies, and guidelines designed for collecting biodiversity information**. A protocol comprises several components, including a sampling plan that specifies the rules for selecting sampling units or sites, one or more techniques and methods to be applied for data collection, and additional application rules, such as the frequency of monitoring and considerations for weather conditions (Schmeller *et al.*, 2015).

Additionally, a protocol is usually accompanied by a data analysis plan, outlining how the collected data will be processed and analysed to produce the required information and results for evaluating biodiversity monitoring objectives (e.g production of population abundance trends).

2.2. WHAT IS UNDERSTOOD BY HARMONISATION?

In the context of biodiversity monitoring efforts, harmonisation[12] refers to the process of aligning various aspects of the existing monitoring programmes to ensure compatibility and consistency in the results obtained. It involves bringing together different components and levels of the monitoring programme to facilitate comparability of data and information across regions, countries, or monitoring sites.

Harmonisation can occur at different levels of the monitoring programme (Schmeller *et al.*, 2015), including:

- **Harmonising targets**: This involves setting common priorities, indicators, and adequate spatial and temporal coverage for monitoring efforts. By establishing shared goals and objectives, it becomes possible to compare and assess biodiversity trends and changes consistently.
- **Harmonising technical protocols**: Harmonisation at this level addresses the scientific and technical aspects of data collection. It encompasses aligning sampling strategies, field protocols, techniques, and site selection procedures. It may also involve integrating new technologies and modelling approaches to improve data quality and efficiency (Moersberger *et al.*, 2022; Schmidt & Van der Sluis, 2021; Hoye *et al.*, 2022[13])
- **Harmonising data management**: This aspect involves ensuring common data formats, interoperability, and coordinated management of data storage systems. Adopting common standards for metadata and using shared platforms and coordination centres are essential for effectively handling and sharing biodiversity monitoring data (De Blust *et al.*, 2013; Basset *et al.*, 2023[14])
- **Harmonising data analysis and reporting**: Harmonisation at this level involves using consistent analytical approaches and methodologies to produce final results for policy reporting and for private and public decision-making (Heck, 2023[15]).

Discussions and agreements about harmonisation should occur at each stage of the monitoring programme, starting with the harmonisation of targets. This is of major importance, as it would be nearly impossible to harmonise protocols and analyses if the monitoring objectives are too far apart. Achieving harmonisation requires collaboration and coordination among various stakeholders, including scientific experts, organisations handling monitoring data collection, and governance bodies. It also involves addressing infrastructure issues, communication challenges, and the development of shared workflows to ensure the smooth functioning of the monitoring programme.

12. IPBES glossary definitions: https://www.ipbes.net/glossary-definitions

13. Biodiversa+ report on biodiversity monitoring knowledge gaps, R&I priorities: https://www.biodiversa.eu/wp-content/uploads/2022/12/D2.1-Report-on-biodiversity-knowledge-gaps-VF.pdf

14. Biodiversa+ report on data interoperability: https://www.biodiversa.eu/wp-content/uploads/2023/05/D2.2-Report-data-interoperability.pdf

15. Biodiversa+ report on the use of biodiversity monitoring data in private decision-making: https://www.biodiversa.eu/wp-content/uploads/2023/04/D2.4-Use-biodiversity-monitoring-data-private-decision-making.pdf

2.3. THE ESSENTIAL BIODIVERSITY VARIABLES: WHAT ARE THEY AND WHY ARE THEY RELEVANT FOR HARMONISATION?

The Essential Biodiversity Variables (EBV)[16] are a minimal set of biological state variables that are key for supporting multi-purpose biodiversity information systems at various levels, from local to global. EBVs serve as an intermediate layer of abstraction between raw data and the derived high-level indicators used to communicate the state and trends of biodiversity (Pereira *et al.*, 2013). They are grouped in six classes (table 1), three about species: 1) Genetic composition; 2) Species traits; 3) Species populations; and three about ecosystems: 4) Community composition; 5) Ecosystem functioning; and 6) Ecosystem structure.

Table 1. EBV classes and attributes measured, as defined by GEOBON.

Entity measured	EBV class	Attributes measured
Species [Species-focused EBVs]	Genetic composition	Genetic diversity
		Genetic differentiation
		Effective population size
		Inbreeding
	Species traits	Morphology
		Phenology
		Movement
		Reproduction
	Species populations	Species distributions
		Species abundances
Ecosystem [Ecosystem-focused EBVs]	Community composition	Community abundance
		Taxonomic/phylogenetic diversity
		Trait diversity
		Interaction diversity
	Ecosystem functioning	Primary productivity
		Ecosystem phenology
		Ecosystem disturbances
	Ecosystem structure	Live cover fraction
		Ecosystem distribution
		Ecosystem vertical profile

Through EBVs, data coming from different sources and methods can be integrated into biodiversity indicators relevant for assessments and policy reporting while leaving current practices on the ground (i.e. field protocols) as they are. EBVs offer a promising approach to harmonise biodiversity monitoring methods used by different stakeholders with little effort and at low cost (Navarro *et al.*, 2017; Hardisty *et al.*, 2019; Schmidt & Van der Sluis, 2021), by facilitating the comparability and interoperability of monitoring products, and allowing for a common language across different conservation efforts and scales. Establishing a group of essential variables that are universally assessed across conservation goals and areas enables monitoring systems to contribute directly to broader monitoring efforts, thereby maximising the effectiveness of conservation management and monitoring across borders, ecosystems, and realms (Guerra *et al.*, 2019; Vihervaara *et al.*, 2017, Junker *et al.*, 2023).

16. GEO BON.What are EBVs? https://geobon.org/ebvs/what-are-ebvs/

2.4. WHAT IS THIS GUIDE FOCUSING ON?

Guidance is proposed for harmonising the processes from existing monitoring protocols. A particular interest will be taken on biodiversity monitoring data workflows and governance by the different types of organisations handling monitoring data collection and aggregation in transnational monitoring programmes. Here, Biodiversa+ aims to assess the possible strategies related to harmonising the identified processes.

In this guidance document, the different forms that biodiversity information can take in these workflows are categorised as raw data (i.e unprocessed observations and measurements), Essential Biodiversity Variables (EBVs), and indicators (i.e quantitative or qualitative measures that provides a simple and reliable way to communicate the state and trends of biodiversity).

3

MAIN PRINCIPLES FOR BIODIVERSITY MONITORING PROTOCOLS HARMONISATION

3.1 THE PROTOCOL FLEXIBILITY GRADIENT: ROBUSTNESS AND LOCAL ADAPTABILITY

Biodiversity monitoring can be done following different scenarios considering the choices taken around the protocols that will be used to carry out the surveys. When reviewing existing transnational monitoring programmes (Silva del Pozo & Body, 2022), there appears to be a gradient regarding the type of protocols that are applied, referring to the range of approaches and choices made regarding the protocols used to conduct surveys and data collection within transnational monitoring programmes. The gradient encompasses three main strategies (Fig 1):

- **Strict Standardised Protocol**: At one end of the gradient, transnational monitoring programmes adopt a single, rigid, and standardised protocol that is uniformly applied across the entire territory covered by the monitoring initiative. In this scenario, there is little to no variation in the methods, sampling design, and data collection procedures used in different regions or countries. The aim is to ensure high comparability and consistency of data, facilitating cross-regional or cross-country assessments.
- **Independent Protocols**: At the other extreme of the gradient, transnational monitoring programmes allow each region or country to independently choose and implement their own distinct protocols for biodiversity monitoring as long as they meet the common target(s). In this scenario, there is a higher level of flexibility, and different regions may opt for different methods, sampling designs, and data collection approaches based on their specific needs, capacities, and priorities. This approach acknowledges the diversity of ecosystems and species biological traits across regions and allows for tailored monitoring strategies.
- **General Protocol with Flexibility**: In between the two extremes, transnational monitoring programmes adopt a general protocol that provides a common framework for data collection but also allows for certain degrees of flexibility within set boundaries in its implementation. This flexible approach permits regions or countries to make certain adjustments to the protocol, such as defining collection sites, adjusting sampling frequencies, or using alternative methods when necessary. This approach seeks a balance between standardisation and adaptation to local contexts.

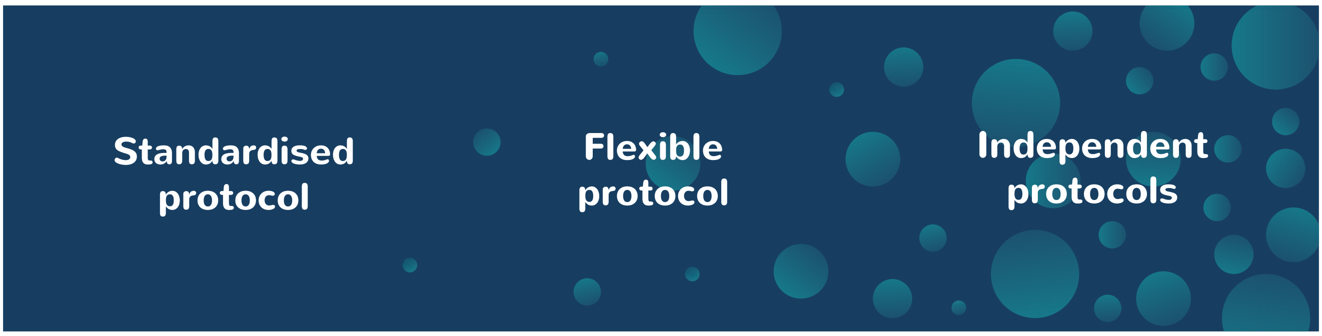

Fig 1: Three main strategies for biodiversity monitoring protocols

While strict standardisation ensures high comparability, it may overlook cultural, historical and socio-economic differences between involved parties, as well as biological differences among territories, that can influence the applicability of a given protocol (Kühl *et al.*, 2020). It should be noted, nevertheless, that flexibility and scientific robustness are not mutually exclusive. On the other hand, full independence in protocols may lead to challenges in data comparability and hinder regional or transnational assessments. The adoption of a general protocol with some flexibility aims to strike a balance, allowing for harmonisation while accommodating contextual differences. The choice of where a monitoring programme lies on this gradient depends on factors such as the objectives, resources, and the level of regional or transnational collaboration desired for biodiversity monitoring.

A monitoring programme can be structured as either top-down, wherein decisions are made at an upper scale (e.g., EU), irrespective of the strategy, or bottom-up, where decisions are made independently at a lower scale (e.g., national), with the potential need for harmonisation at a higher scale. The strict component of such programmes is often established via a top-down approach by an authoritative body. This approach has its advantages, such as providing clear specifications that can be applied universally, without the need of specialised expertise (as seen in cases like LIFEPLAN[17], LUCAS[18], and EMBAL[19]). Alternatively, the implementation can be approached from a bottom-up perspective, offering the benefit of easier initiation. Furthermore, consensus achieved at a finer scale is frequently closely connected with the operators, enabling direct application and potentially yielding richer insights. It should be noted that a bottom-up approach doesn't always necessitate a higher-scale project (as exemplified by RMQS[20] in France, or even further all historical naturalist monitoring initiatives).

The intermediary approach between top-down and bottom-up demands considerable consultation and ongoing enhancement efforts. While it may require more time, it ensures cross-scale compatibility and facilitates the creation of a strong community (as evidenced by PECBMS[21], SPRING[22], and EUROBATS[23]). The choice between top-down and bottom-up approaches significantly impacts the development of monitoring programmes, each with its own set of advantages and challenges. It should be kept in mind that there are complexities linked to differences in scale as well, as the same programme can be seen as top-down on a national scale (for example the STOC[24] in France) and bottom-up on a European scale (STOC becoming a contributor to PECBMS, which was implemented later).

17. A Planetary Inventory of Life: https://www.helsinki.fi/en/projects/lifeplan
18. Land use and land cover survey: https://esdac.jrc.ec.europa.eu/projects/lucas
19. European Monitoring of Biodiversity in Agricultural Landscapes: https://wikis.ec.europa.eu/pages/viewpage.action?pageId=25560696
20. Réseau de Mesures de la Qualité des Sols: https://www.gissol.fr/le-gis/programmes/rmqs-34
21. Pan-European Common Bird Monitoring Scheme https://pecbms.info/
22. Strengthening Pollinator Recovery through Indicators and Monitoring: https://www.ufz.de/spring-pollination/
23. Agreement on the Conservation of Populations of European Bats: https://www.eurobats.org/
24. Temporal Monitoring of Common Birds (France): https://www.vigienature.fr/fr/suivi-temporel-des-oiseaux-communs-stoc

3.2 THE INFORMATION CHAIN FOR A MULTI-LEVEL MONITORING SYSTEM

The need of an integrated and comprehensive monitoring system at several scales is acknowledged as being essential for an effective monitoring effort of biodiversity (Navarro *et al.*, 2017; Guerra *et al.*, 2019, Scholes *et al.*, 2012). As well, for informed decision-making purposes and to fulfil reporting obligations, information is required on different spatial scales: local and national (e.g. ministries), regional and EU (e.g. Habitats and Birds directives, Water Framework Directive, Marine Strategy Framework Directive), global (e.g. Convention on Biological Diversity) (Vihervaara *et al.*, 2017).

In the context of the statement, the following scales are considered, starting from the local scale and progressing to the upper scales (Fig 2):

» **Global scale**: The largest spatial level, which includes the entire planet Earth. At this scale, efforts are made to address international and global issues, such as biodiversity conservation on a worldwide basis.

» **European scale**: This scale involves covering the entirety of Europe as a continent, or political union, and may involve coordination and considerations at the level of the European Union or other pan-European initiatives.

» **Regional scale**: Referring to a larger area that may span across multiple countries within a region or continent (e.g. Scandinavia, the Caribbean, the Mediterranean Sea, etc.).

» **National scale**: Encompassing an entire country, this scale provides a broader perspective and covers a more extensive geographic area.

» **Sub-national scale**: The scale that covers larger areas within a country but is smaller than the national level. It may include provinces or other administrative divisions for example.

» **Local scale**: The smallest spatial level, typically referring to specific areas, communities, or sites within a region or ecosystem.

Fig 2: Scales involved in biodiversity monitoring schemes

Integrating biodiversity information in a scale-appropriate manner is essential for ensuring the usefulness and applicability of the data at various levels ([Proença *et al.*, 2017](#)). This report emphasises considering sub-national, national, regional, European, and global scales for a comprehensive and well-coordinated biodiversity monitoring approach. The term "upper scale" or "higher scale" is relative to the other scales mentioned, such as the local and sub-national levels. **Regional scale and above are all "transnational". For the following descriptions, the interaction between two scales is studied: national (as being the lower scale) and transnational (as being the upper scale)**.

Amid these considerations, two main approaches regarding the data management within the information chain taken by biodiversity monitoring programmes have been noted. A focal point revolves around determining the scale of aggregation of biodiversity information in order to generate conclusive monitoring results at larger scales:

Processing raw data at a transnational scale

In this strategy, raw data are directly submitted to a common centralised structure, operating at the upper scale, for a joint analysis for all countries involved to produce trends and indicators. The data are usually treated with modelling techniques to take into account the possible variabilities in sampling design.

Some of the benefits of this approach are mainly related to the consistency in the analyses and comparability of the results. There is an improved power and capacity to generate information that would not be feasible with a subset of data. The use of raw data allows the interested structure to gather the information that is specifically needed. Reliable estimates can be produced at the geographical level of choice.

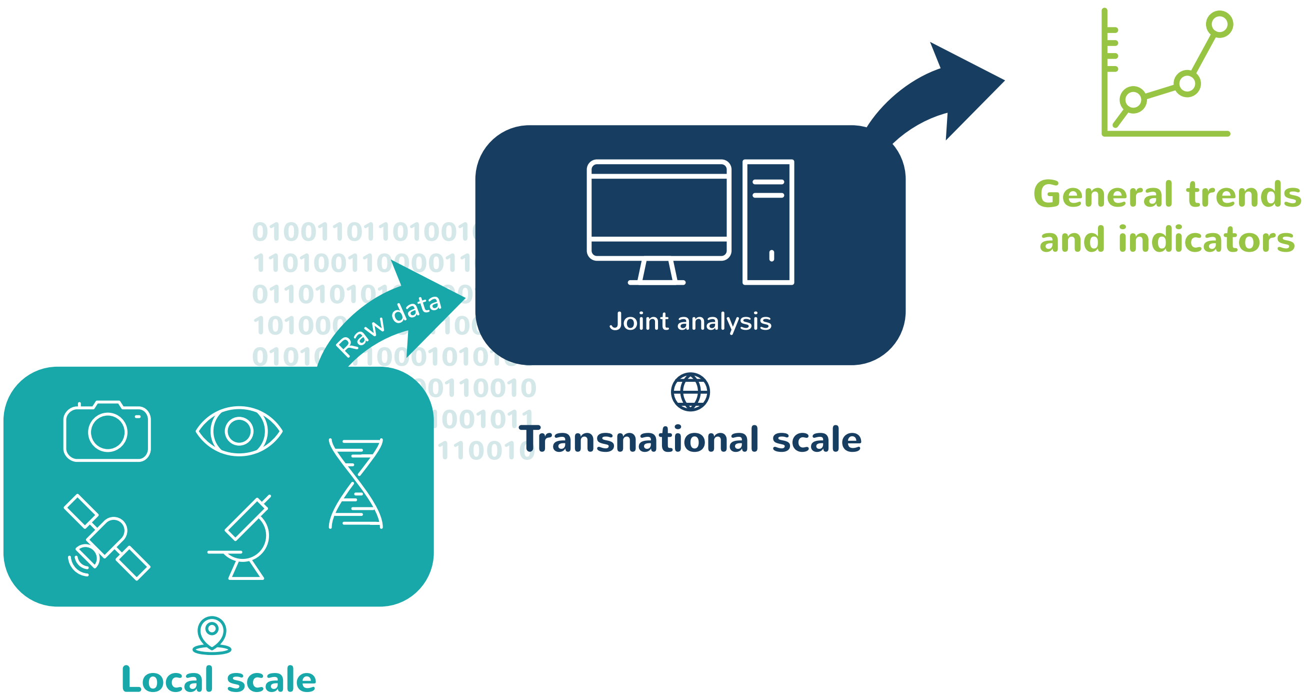

Fig 3: Process to transfer local raw data at transnational scale where these data are analysed to produce transnational/ global scale indicators

Aggregating nationally produced EBVs

This approach is based on the use of Essential Biodiversity Variables (EBV), which are produced nationally or at a local level following a standardised data collection protocol. Each country is in charge of collecting and treating the data via the protocol of their choice, then providing this standardised outcome to a structure operating at an upper scale that assembles the EBVs produced in different countries to have a transnational overview (Gonzalez *et al.*, 2023).

This approach seems to have positive results by fostering a sense of ownership, subsidiarity and preventing possible conflict among stakeholders, which will be aligned into a network.

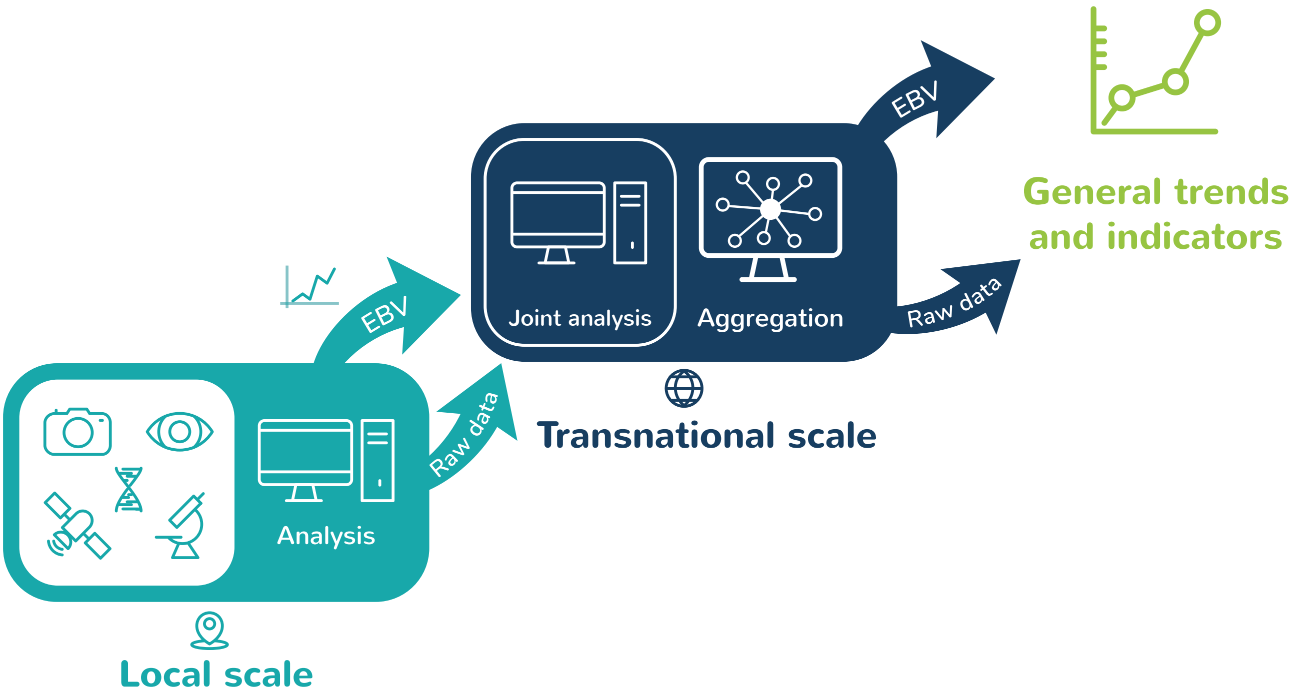

Fig 4: Process where local raw data are analysed at local or national level to produce EBVs. EBVs are then shared at transnational scales.

3.3 MAIN STRATEGIES IDENTIFIED

In the realm of biodiversity monitoring at transnational levels, the different monitoring programmes adopt particular strategies regarding the main principles presented above. Choices are made regarding the type of protocol employed and the scale at which biodiversity information is aggregated. Within this landscape, various combinations are possible (synthesised in table 2). However, based on the literature survey exploring the strategies adopted by transnational monitoring programmes (Silva del Pozo & Body, 2022), three main combinations or strategies appear to dominate the landscape. In this section, these strategies are presented, with their respective strengths, challenges, and potential applications.

Table 2. Combinations of strategies regarding protocols in transnational biodiversity monitoring programmes

Scale of data processing	**1 strict protocol** Applied everywhere in the same way	**1 flexible protocol** Adaptated to the biogeographical context and means of each country	**Flexible protocols** Different countries may use different protocols to monitor the same biodiversity entity
Global Produced raw data are gathered and treated at a transnational level	**A** Easy to implement and to compare results Inflexible to adapt to local priorities, unmotivation of local stakeholders *e.g. LUCAS soil*		
Both Produced raw data are shared to a trans-national level and treated locally in parallel for national use		**B** Satisfies local and global requirements, fils to different levels of expertise, chances to integrate new technologies Additional resouces for coordination and data processing/analysis to handle both raw datasets and EBVs *e.g. SPRING*	
Local Produced data are treated locally into EBVs, which are then shared to a transnational level			**C** Use of existing data and knowledge, boosts local motivation and sense of ownership, reduces redundancy Needs higher-scale coordination and agreement on analyses and objectives *e.g. PECBMS*

Biodiversity monitoring strategies identified in the literature review, taking into account whether the protocol type and the scales at which the data is processed. The three examples of transnational monitoring programmes presented in this guidance are placed on the table according to the strategy employed.

A One common strict protocol and a joint analysis of raw data

This first strategy consists in applying one common strict protocol in all countries involved and aggregating raw data for joint analysis, to deliver general trends and indices. In this strategy, raw data are directly submitted to a common centralised structure. The harmonisation comes into play at the data collection level in situ, which is collected following a standardised and strictly defined protocol. The following programmes can be cited as an example: Land Use/Cover Area frame Survey (LUCAS)[25] soil, Small Cetaceans in European Atlantic waters and the North Sea (SCANS)[26], European Monitoring of Biodiversity in Agricultural Landscapes (EMBAL)[27], A Planetary Inventory of Life (LIFEPLAN)[28].

Some of the strengths of this strategy are that the results are easily comparable. Concerning the protocol, since it is strictly and explicitly defined, in-situ data collection managers find it easy to know what has to be done and how. As well, when there is a new operator joining the monitoring effort, or if the monitoring is to be set on a new site, having this strictly defined protocol facilitates a faster implementation for an operational monitoring. Everybody knows what to do. Implementing a strict protocol can be advantageous in terms of obtaining political support, as it is easily comprehensible by politicians. The data and results generated through this approach are perceived as reliable and trustworthy.

However, this approach may encounter challenges at the local level, particularly in terms of inflexibility to adapt to local conditions. Adopting a truly systematic design to fit as many conditions as possible might lead to under sampling issues (e.g. of rare species). Local capacities might not always be sufficient to meet the high standards required by the protocol, resulting in implementation difficulties and increased costs. This could be especially noted in the case where a country has already invested in a monitoring programme, as adopting a strict new approach may necessitate halting or duplicating existing protocols, which is hard "humanly" (loss of investment, motivation) and costly. Misinterpretation of the protocol at the local level can further complicate matters, and there may be no guarantee that the protocol has been diligently followed. If the protocol has been discussed locally, it would be better understood and followed. Additionally, this strategy might lead to limited involvement from those who apply the protocol, due to the little say that they have in its implementation. Valuable insights from previous local studies may also be overlooked in the process. Additionally, the reliance on a centralised budget for the protocol's funding makes it vulnerable to changes in the political landscape or shifting priorities. Finally, a crucial question to consider is whether the proposed programme can effectively address the more localised questions (eg. regarding National priorities). For example, experience from the implementation of Soil BON[29] in France has shown that this agreed international protocol may be less comprehensive than the national one (RMQS[30] protocol). Therefore, a transition toward this common protocol may be viewed negatively as a degradation of the process.

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25. Land use and land cover survey: https://esdac.jrc.ec.europa.eu/projects/lucas
26. Small Cetaceans in European Atlantic waters and the North Sea: https://www.tiho-hannover.de/itaw/scans-iv-survey
27. European Monitoring of Biodiversity in Agricultural Landscapes: https://wikis.ec.europa.eu/pages/viewpage.action?pageId=25560696
28. A Planetary Inventory of Life: https://www.helsinki.fi/en/projects/lifeplan
29. Soil Biodiversity Observation Network: https://geobon.org/bons/thematic-bon/soil-bon/
30. Réseau de Mesures de la Qualité des Sols: https://www.gissol.fr/le-gis/programmes/rmqs-34

EXAMPLE BOX: LUCAS SOIL SURVEY- (2009-ONGOING)

Objective: The LUCAS Soil is a standardised field survey covering all 27 EU Member States. It aims to provide policy-relevant statistics on the impact of land use on soil characteristics. In 2013, it successfully created the first open-access dataset of topsoil properties for the entire European Union, with minimal missing data.

Organisation: Managed by Eurostat with technical support from the Joint Research Centre (JRC), the survey conducts sampling campaigns every 3 years (2009/2012 - 2015 - 2018 - 2021/2022). Decision-making and protocol management are handled by JRC, ensuring consistent quality control at different levels, involving local surveyors, JRC supervisors, Eurostat Central Office, and external Quality Control by private companies. Surveyors undergo specific training from Eurostat to ensure accuracy.

Protocol Type: A strict and uniform data collection protocol is followed in a single sampling period across all Member States. The initial protocol is based on the 2006 BioSoil sampling manual and the FAO Guideline for Soil Profile Description. The surveyors select sampling points from the LUCAS 2009 regular grid, considering land use and terrain information. Alternative sampling points are provided in case the primary site is inaccessible. From 2018 onwards, the survey includes soil biodiversity assessment using DNA metabarcoding.

Data Analysis: To ensure coherence and comparability, all soil samples are analysed by a single accredited laboratory, the SGS Hungária Kft in Hungary, using standard analytical methods. This approach reduces systematic errors and inter-laboratory bias between countries. The resulting data is accessible to the public through the European Soil Data Centre.

LUCAS soil grassland module: In 2018 a pilot grassland module was carried out within the LUCAS survey, being the first standardised methodology to collect ecological data on grasslands at the European level. Among the information collected, there was for example the presence of indicator species, or the number of flowering species. The parameters were recorded by trained surveyors on transects placed over a subset of LUCAS points randomly selected. In addition, to check the accuracy of the recording, botanists from the different countries were recruited to carry out full vegetation inventories on a subsample of the transects (Sutcliffe et al., 2019). The results of the pilot show an overall successful survey, and the continuation of the LUCAS grassland survey was encouraged (LUCAS, 2018).

Prospects and challenges: Ongoing research seeks to improve the representativeness of LUCAS points in forest areas. The number of sites to assess is under evaluation for a more comprehensive EU soil monitoring system. The EU Soil Observatory (EUSO), established in 2020 under the European Green Deal, explores integrating LUCAS soil into national monitoring schemes. Discussions with Member States aim to address specific sampling needs for LUCAS 2022.

This strategy seems, however, to confront certain challenges related to governance and the top-down approach employed. These issues have become evident, particularly concerning error retracement and rectification within the grassland module, due the struggles in identifying and engaging with regional coordinators. These challenges emphasise the critical importance of strong and transparent coordination, highlighting the necessity for effective communication and involvement across the various scales involved.

For more information: https://esdac.jrc.ec.europa.eu/projects/lucas

Sources: Orgiazzi *et al.*, 2017; Maréchal *et al.*, 2022; Jones *et al.*, 2020; Ziche *et al.*, 2022

B Flexible protocols and an analysis of locally-produced EBVs

This approach is based on the use of EBVs, or eventually other variables or indicators, which are produced nationally or at a local level following a defined data collection protocol. Each country is in charge of collecting and treating the data via the protocol of their choice, then providing this standardised outcome to the upper scale (i.e the larger spatial scale) where the EBVs produced in different countries are assembled to have a trans-continental overview and deliver general trends and indices. To cite a few monitoring programmes using this strategy: the Pan-European Common Bird Monitoring Scheme (PECBMS)[31], the Large Carnivore Initiative for Europe (LCIE)[32], and the monitoring programmes carried out for the reporting of the Birds Directive[33].

The use of existing protocols and old data brings the benefit of leveraging previous work and knowledge. By closely associating responsibility with the source of knowledge, it becomes easier to adapt monitoring efforts to national constraints, including ecological, political, socio-cultural, and economic factors, as well as the expertise and volunteers available. The production of data at the European level reinforces and complements national-level initiatives, creating a sense of community and enabling participants to benefit from the experiences of others.

The localised nature of this approach has the potential to attract the interest of local authorities in monitoring activities, as it directly concerns their region, and to fasten the implementation process, as there is no need for discussions with other subnational areas, other nations, or other regions. Moreover, it opens up opportunities for collaboration and resource-sharing among different monitoring projects. For instance, combining efforts to monitor various taxa, such as birds and mammals simultaneously, can result in cost-efficiency and improved data collection.

Despite the advantages, there are challenges related to data organisation and integration. Defining the EBV metrics and full specifications, and implementing minimum parameters require significant effort and coordination. The need to agree on analyses and aims may hinder progress. There is also a statistical challenge in integrating the data (according to the same variable) but with different sample sizes, population sizes and confidence intervals, a challenge linked to meta-analysis issues. Beginners or newcomers to the field may face numerous decisions that they have to make when navigating this approach, which could also be confusing. Adopting a more decentralised approach means having less control over field methods and analysis, as they vary across different regions and countries. At the same time, if countries use different protocols, it becomes less likely to share infrastructures, leading to missed opportunities for collaboration and higher costs related to the separate data analyses. Funding for such initiatives is heavily reliant on local institutions, which can vary widely across different countries and may be subject to fluctuations over time, leading to potential funding instability or cuts (Moersberger et al., 2022). Moreover, the variation in protocols can lower the confidence of policy makers, especially those who lack a deeper understanding of the reasons behind these differences, potentially hindering effective decision-making based on the results. Finally, the concept of EBVs is quite abstract and depending on how they are presented they might not always be easy to grasp for stakeholders who do not directly work with them.

31. Pan-European Common Bird Monitoring Scheme: https://pecbms.info/
32. Large Carnivore Initiative for Europe: https://www.lcie.org/
33. Birds Directive: https://environment.ec.europa.eu/topics/nature-and-biodiversity/birds-directive_en

EXAMPLE BOX: PAN-EUROPEAN COMMON BIRD MONITORING SCHEME (PECBMS) - (2002-ONGOING).

Objective: The PECBMS is an initiative that utilises long-term monitoring data on common birds to produce policy-relevant indicators of bird population abundance trends at the European level.

Organisation: The project is co-led by the European Bird Census Council (EBBC) and BirdLife International, and receives support from Statistics Netherlands and the Catalan Institute for Ornithology (ICO) for statistics and online tools development. PECBMS has a central coordination unit at the Czech Society for Ornithology, responsible of collecting and harmonising the national monitoring outputs to calculate European trends and indicators, making them available to decision-makers, assisting national coordinators with various tasks (field-work, volunteers, data calculation), and maintaining an active network of national coordinators and experts. Each Member State manages its national monitoring schemes through various institutions, often involving NGOs, volunteers and research institutes. Currently involving 30 countries and 34 monitoring schemes, the PECBMS produces population trends of 170 bird species.

Protocol type: PECBMS uses independent national monitoring schemes, with Member States employing their own protocols for bird monitoring, as long as it is based in one of the three main standard methods: territory mapping, line transect, and point counts. The sampling plot selection is free and differs between countries (stratified-random, semi-random, free of choice, systematic, …), as well as the number of species covered (from 45 to 420). The national schemes own the raw data, produce yearly national trends, and share this outcome according to agreed standards (EBV) with PECBMS. All national trends received are then aggregated by PECBMS to produce the European species indices and trends.

Data Analysis: National coordinators aggregate the national data and calculate national species indices using the specialised statistical software TRIM (TRends and Indices for Monitoring data, Pannekoek & Van Strien, 2001) and R scripts provided by PECBMS. These indices are then combined into supranational indices by the international coordinator, weighted by national population estimates, and summed up to produce European totals, using TRIM as well, which considers field method differences and site and year coverage. The supra-national species indices are then treated to provide multi-species indicators (e.g. farmland bird indicator[34]).

Prospects and challenges: As most countries have developed their monitoring schemes rather independently, PECBMS started off with an array of different protocols employed across the different countries. Over time, though, three main standard types of methods used by national schemes have been identified (territory mapping, line transect, and point counts) and are now accepted within the PECBMS.

The challenges related to different file formats and missing information have been managed over time with the development of an online tool (in cooperation with ICO), facilitating data control, the visualisation of observations and sites and accessibility of documentation.

Volunteer fieldworkers' involvement has been successfully managed, making large-scale schemes feasible with relatively low running costs. Nevertheless, PECBMS faces lack of funding or non-sustainable funding issues. The national schemes do not all have secure funding (4 countries where the scheme is partially or short-termed secured, and 8 where it is unsecured. At the international level, the routine activities run on short-term fundings, and there is generally no support for development.

For more information: https://pecbms.info/

Sources: Voříšek *et al.*, 2008; Klvaňová *et al.*, 2007; De Blust *et al.*, 2012; Schmidt & Van der Sluis, 2021; PECBMS, 2023

34. PECBMS European Indicators: https://pecbms.info/trends-and-indicators/indicators/

C A unique but flexible protocol and a parallel data chain

Applying a flexible and parallel analysis allows for an adaptable implementation (e.g regarding sampling pressure and frequency, timing on phenology, etc.) tailored to each country's specific needs while considering data at both local and transnational levels. For example, can be cited: Strengthening Pollinator Recovery through Indicators and Monitoring (SPRING)[35], the BioSoil project[36], and the International Waterbird Census (IWC)[37]. This is, as well, the general approach used in EuropaBON[38].

Some reviewed programs have suggested combining both strategies by using the country specific variation of the common protocol, and a parallel data flow in the information chain. The collected data is sent for a joint analysis to a central structure, and in parallel is treated locally to produce national indices and trends, particularly to address specific directives. With this mixed approach, the upper scale analyses the received biodiversity information and can provide guidance through general methodologies and best practices documents.

The use of local knowledge and validation in this approach satisfies both national and EU level requirements. It provides information on two levels, and there is more flexibility in allocating resources such as human and budgetary support. This flexible approach offers options that can match different levels of expertise and encourages the involvement of all stakeholders. It also facilitates the integration of new technologies into data collection and analysis, as they can be added as possible options of techniques used in a given protocol.

However, there are specific challenges associated with this approach. Organising and communicating about multiple options can be costly and time-consuming, a challenge that is not encountered in strategy A because there is only one option of protocol, nor in B because there is no communication from the large- to smaller scales (upper to lower scales). Another challenge relates to the different management approaches of the raw data (not present in A since there is only one protocol, and not present in B since the raw data is not mandatorily shared). The integration of all data or existing protocols may not be possible, increasing the risk of bias in the results. There is a potential challenge in excluding certain datasets, which can result in uncertainty for those areas. Furthermore, implementing a parallel approach may require additional resources and efforts, both at the lower scale (e.g. national) and at the upper scale (eg. European level). It demands coordination, data processing, and data analysis capabilities to handle both raw datasets and EBV estimates effectively.

35. SPRING: https://www.ufz.de/spring-pollination/
36. BioSoil project: https://esdac.jrc.ec.europa.eu/ESDB_Archive/eusoils_docs/other/EUR24729.pdf
37. Wetlands International: https://www.wetlands.org/knowledge-base/international-waterbird-census/
38. EuropaBON: https://europabon.org/

EXAMPLE BOX: STRENGTHENING POLLINATOR RECOVERY THROUGH INDICATORS AND MONITORING (SPRING) - (2021–2023)

Objective: SPRING is a pilot project aiming to monitor pollinators at the European level, building on the work from the project Assessing Butterflies in Europe (ABLE) (2019–2020) on the establishment of new Citizen Science Butterfly Monitoring Schemes for the European Butterfly Monitoring Schemes (eBMS) (producing yearly population trends of butterfly species). SPRING seeks to complete the coverage in all 27 EU Member States and expand monitoring efforts to other pollinator groups beyond butterflies. The project aims to develop training courses and tools for volunteer participants. The results will be used to establish a sustainable EU Pollinator Monitoring Scheme (EU-PoMS).

Organisation: Under the coordination of DG Environment, this pilot project is executed through a collaborative effort involving 19 partners, with leadership provided by the esteemed Helmholtz Centre for Environmental Research (UFZ) in Germany. The project adopts a regional coordination approach, where each of the seven designated regions involves one participating country to spearhead the implementation of the pilot study. This project is based on citizen science participation, the monitoring efforts are carried out by volunteers.

Protocol Type: The SPRING monitoring schemes are based on eBMS protocols, and integrate a new monitoring approach: the Flower-Insect Timed (FIT) counts, which have been adapted to each country's species and habitats. The protocols for this monitoring programme have some flexibility, with each country implementing the same core elements of the protocol (4-8 sampling visits per season, 10 sets of pan traps + floral assessments, 2 transect walks of 500m) in a best-adapted way regarding the number of sites and sampling visits, accordingly to the territory's habitats and geographic conditions, and regarding the focus of the assessments, accordingly to the country's species. This project focuses on the Minimum Viable Schemes (MVS), piloting 1-24 sites per country, encompassing at least 209 sites across the EU. While the definitive sites are under consideration, SPRING aligns with existing schemes and harmonises methodologies, ensuring adaptability for each country.

Data analysis: Data originating from the dual methods are merged to generate trends at the EU scale. A dedicated platform facilitates streamlined data entry for the SPRING project, providing a centralised hub for information exchange. The collected data goes through a quality control check by regional coordinators, who then submit the data to the eBMS database. Seven regions of Europe have been defined for coordination of tasks. Statistical modelling techniques are applied to take into account uneven sampling. The data are treated as well at a national level by each Member State, and at a European level for the test phase of the methods.

Prospects and challenges: Although the definitive selection of long-term monitoring sites remains under consideration, it raises intriguing possibilities for potential synergy with initiatives such as LUCAS soil. The question of data storage remains open. For the moment, a few countries already have their own system, so probably it will be developed independently in each country and there will be no need to develop a central data storage infrastructure. This pilot project lays the groundwork for a harmonised approach, empowering Member States to implement and report on pollinator status.

SPRING faces some challenges regarding a lack of local experts to validate data, as well as some difficulties in engaging volunteers, as the protocol is rather technical, requiring some level of expertise and is time consuming. Support materials have been produced, along with a mobile App tool to facilitate volunteer participation. SPRING is aiming for a future hybrid-approach of professionals and volunteers, a blend of methods and models for the different pollinator groups, accompanied by an efficient use of technology.

For more information:

- SPRING: https://www.ufz.de/spring-pollination/
- eBMS: https://butterfly-monitoring.net/
- ABLE: https://butterfly-monitoring.net/able-results

Sources: Van Swaay *et al.*, 2015; Dennis *et al.*, 2017; Sevilleja *et al.*, 2020

4

PROPOSED RECOMMENDATIONS FOR HARMONISING BIODIVERSITY MONITORING PROTOCOLS

In this section, general recommendations are proposed in the perspective of enhancing the effectiveness of monitoring efforts by promoting harmonised practices and fostering collaboration among stakeholders, an initiative followed as well by EuropaBON.

As highlighted in the previous section, the main principles for harmonisation centre around striking a balance between the flexibility of protocols and optimising the flow of biodiversity information across scales. Now, recommendations are proposed under three key subtopics: protocol flexibility, biodiversity information workflows, and the establishment of common frameworks.

NOTE BOX

It should be noted that the harmonisation process will greatly depend on the overall objectives of the monitoring programmes and schemes. For instance, if the aim is to gather information on species distribution, integrating data from various sources, relying on presence-absence data, is comparatively straightforward, but complications arise when seeking to integrate datasets for purposes such as assessing species abundance, once-off estimates, and trends.

The intentionally broad recommendations in this guide serve as a foundation only and require further refinement tailored to specific objectives, needs, and contexts.

4.1 RECOMMENDATIONS ON THE PROTOCOL'S FLEXIBILITY

The choice between what type of protocol to apply for biodiversity monitoring should not be absolute, as no one-size-fits-all solution applies in this complex and diverse field. Stakeholders' haven't expressed a preference or willingness to adhere to a particular approach. Each strategy exists for valid reasons, and their existence is justified by different contexts, needs, and objectives of biodiversity monitoring initiatives. Therefore, in order to determine the most suitable level of flexibility for the monitoring protocol, it is crucial to consider the specific circumstances, the community involved, what is already being monitored and the level of development of the monitoring efforts. The choice of protocol to apply for a biodiversity monitoring programme depends on the starting point of the initiative.

» **When there are already several existing monitoring protocols in use**: it would be recommended to adopt a strategy based on flexible protocols, and drive them to adjust to meet new monitoring needs. Employing existing common, but flexible protocols and methodologies that are applied at multiple (national to regional to global) scales would be recommended, as suggested by the Convention on Biological Diversity (CBD, 2022)[39]. Countries that already have well-established monitoring programmes can continue using their existing protocols. One of the main advantages of keeping and adapting existing monitoring protocols is the preservation of historical time series data. As well, it allows avoidance of redundant efforts and capitalization on the experience gained from prior implementation. Furthermore, these existing protocols have been refined to enhance their relevance within specific geographic contexts. Also, the necessary resources, funding, and personnel required for upkeeping these protocols are already in place, streamlining the implementation process. It should be kept in mind that adaptation process may require additional resources, and that statistical support would be needed to ensure the proper adjustment of the data analyses to new monitoring needs without losing the historical series.

39. Issues related to the global monitoring of biodiversity. 2022. CBD/ID/OM/2022/1/INF/2. Available from: https://www.cbd.int/doc/c/0aef/09cb/0f9654d627222534df6c7a98/id-om-2022-01-inf02-en.pdf

- **In scenarios where there is partial or incomplete monitoring coverage**: the recommendation would be to establish a protocol that is as uniform as possible at the appropriate scales. To complete any gaps in the monitoring scheme, consideration should be given to integrating another existing protocol that can be easily adapted or supplemented with minimal effort. The first reflex should be to search for internationally established protocols, in particular those identified by the authorities of the corresponding BON (e.g Soil BON[40], MBON[41], FW BON[42], etc.). Another example on where to find existing protocols, for the marine realm, is *via* the MarBioME[43] project (Marine Biodiversity Monitoring study in Europe), where biodiversity monitoring programmes and methodologies used have been identified and listed (Annexes available)[44]. If such a protocol is available, efforts should focus on finding a compromise to include the desired objectives within the protocol. It should be noted that uniformizing the protocols, or establishing minimum data collection requirements, may not allow a full integration of past data, calling for an ad-hoc analysis able to combine past data (and specific to each situation) with the new harmonised protocol (Henry *et al.*, 2008; Proença *et al.*, 2017)
- **If there is no existing scheme that can be readily incorporated**: starting a new protocol from scratch may be necessary. In such situations, it would be recommended once again to use an existing protocol taken at the international scale, even if it requires modifications to suit the specific context and requirements. This approach of adopting common protocols is also perceived as an effective way to allow data integration in future monitoring programmes (Jürgens *et al.*, 2012). It should be noted, however, that launching new large-scale field-based monitoring programmes might be challenging, due to economic constraints and the difficulty of obtaining government funding's, and particularly long-term sustained funding, in many countries (Vihervaara *et al.*, 2017).

Emphasising the importance of protocol selection based on specific circumstances and existing monitoring schemes, these recommendations provide a first level of guidance for enhancing the compatibility of biodiversity monitoring efforts. Looking ahead, the harmonisation of data collection protocols will be a crucial area of focus, requiring the development of a more scientific framework to achieve consistency in data collection processes.

40. Soil Biodiversity Observation Network: https://geobon.org/bons/thematic-bon/soil-bon/
41. Marine Biodiversity Observation Network: https://geobon.org/bons/thematic-bon/mbon/
42. Freshwater Biodiversity Observation Network: https://geobon.org/bons/thematic-bon/freshwater-bon/
43. Marine Biodiversity Monitoring study in Europe: https://www.aircentre.org/projects/marbiome/
44. Overview and assessment of the current state of Marine Biodiversity Monitoring in the European Union and adjacent marine waters: https://zenodo.org/record/7641179#.Y-vnW8nMI2w

4.2 RECOMMENDATIONS ON THE BIODIVERSITY INFORMATION WORKFLOWS

The recommendation regarding the information workflows and data aggregation would be to adopt a parallel approach whenever possible (Fig 5). For each community of practice, sending both the raw dataset and the EBV -or other synthetic variables and indicators- result to the upper scale (e.g. national EBV sent to European level) can be a beneficial common strategy. This approach provides flexibility, enabling the stakeholders at the upper scale (e.g. European node) to choose between using all raw data to run a global analysis or to aggregate lower EBV values to estimate the EBV values at their own scale, based on specific needs and preferences. It also allows a better sense of ownership at lower scales as they have their chance to analyse their own data for their own needs, or to request the help of the upper level. EBVs provide a common language for results, and allow more flexibility regarding the protocols used behind. At the same time, a larger dataset size of raw data can enhance the analysis's ability to estimate larger-scale values (e.g. European) through modelling and, in turn, may lead to improvements in local estimates as well (e.g. national). This proposal can address various needs related to accessing monitoring data and information, while also supporting the development of common tools for managing such information.

However, it is essential to recognize that different situations may call for the application of different strategies in specific contexts. To determine which approach is best suited, certain considerations need to be taken into account during implementation.

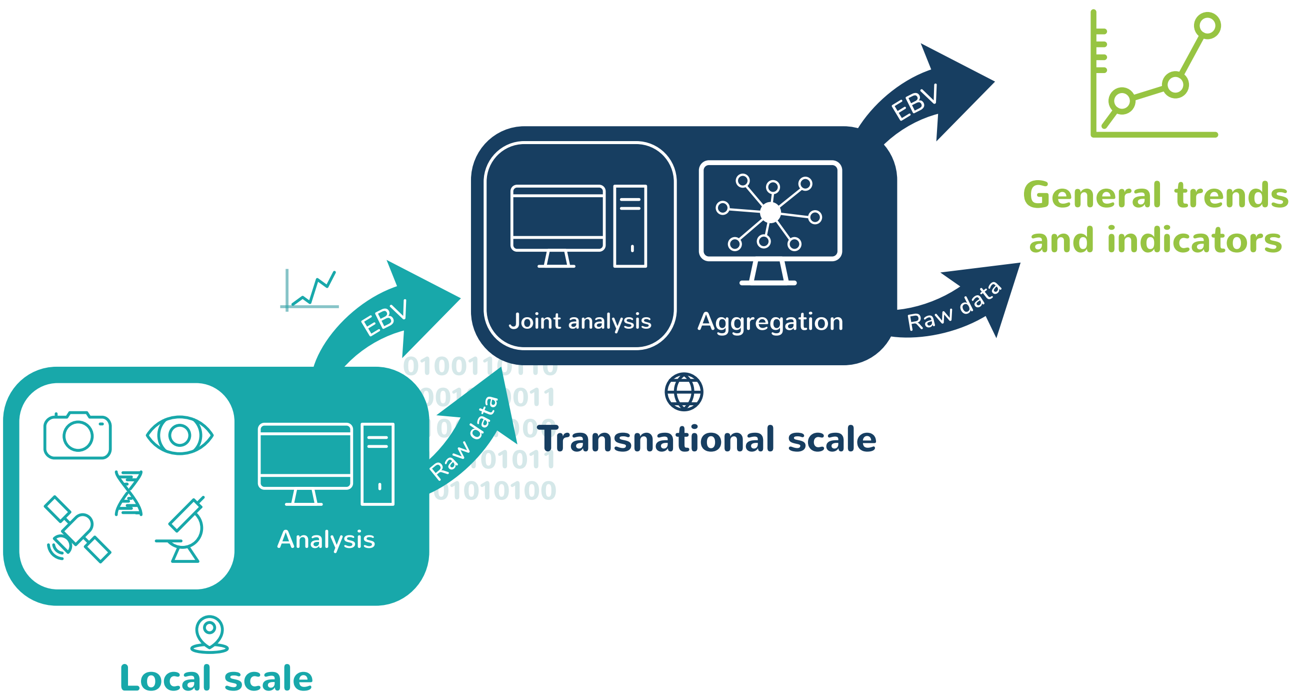


Fig 5: Proposed process for biodiversity information workflows.

For the strict protocol strategy this recommendation would involve focusing efforts on establishing nodes at lower scales. This approach aims to strengthen ownership and expertise within these nodes, for instance, in providing lower EBV values to each node, and facilitating their independent calculation. The expected outcome would be an increase in data quality and traceability as well as a stronger link with local needs, one of the observed shortcomings of this strategy. The nodes would have the role of facilitator at the lower scale (including sharing results and feedback), between regional coordinators of national protocols for example.

» **For the flexible protocols strategy** this recommendation would involve a two-step process. The initial step would prioritise the production and clarification of EBV values to securise them. Then, the focus would shift to enhancing the accessibility of raw data. This includes the standardisation of raw data and the provision of comprehensive protocol descriptions, thereby enhancing the ability of higher-level scales to effectively analyse the aggregated raw data. An example in this direction is the approach taken by PECBMS, which has successfully secured a strong community around EBVs. This sense of community has established a foundation of trust, enabling PECBMS to progress now towards improving access to raw data.

» **For the unique but flexible protocol strategy** this recommendation should correspond to the current practice, strengthening the lower scale nodes, acknowledging their own EBV production to not concurrence them, and working on raw data to derive new knowledge and new EBVs at the upper level.

It should be noted that these recommendations are applicable at any given scale. When considering a local perspective, both Essential Biodiversity Variables (EBVs) and raw data could be aggregated at the national level. This principle extends to regional biodiversity communities or nodes, which can aggregate EBVs and raw data from national levels, subsequently sharing them at the European level. While EBVs have predominantly found application on an international scale, the recognition of their value at national and even finer local scales has grown. This acknowledgment stems from their ability to yield coherent and widely applicable biodiversity monitoring outcomes, particularly suitable for diverse reporting needs (Vihervaara *et al.*, 2017; Turak *et al.*, 2017). As for transferring raw data, the needs and benefits of sharing the data among the community in the process of establishing harmonised monitoring systems has been highlighted (Schmeller *et al.*, 2017). Finally, with this unique strategy, which can be applied at any scale on any subject, a stronger voice is hoped to be achieved, processes are aimed to be streamlined, and opportunities for the development of common tools are sought after.

SUMMARY TABLE

This summary table outlines the recommended approaches for harmonising biodiversity monitoring protocols based on the initial context. It also provides general considerations for these options and directs readers to specific sections in the guide for further details on implications and additional information. The alternative options of protocol type choice should also be assessed. Before deciding, it's crucial to gather more information about its potential implications.

Table 3. Summary table of the recommeded approaches for harmonisig biodiversity monitoring protocols

Starting point	When there are already existing monitoring protocols in use	In scenarios where there is partial or incomplete monitoring coverage	If there is no existing scheme that can be readily incorporated
Recommendation	**Adopt a strategy based on flexible protocols (4.1)**	**Establish a protocol that is as uniform as possible at the appropriate scales by searching for internationally established protocols (4.1)**	**Start a new protocol from scratch on the basis of an existing protocol at the international scale (4.1)**
Proposed approach	**Flexible protocols and an analysis of locally-produced EBVs (3.3b)** Enables utilising existing data and knowledge, boosts local motivation, reduces redundancy, but requires higher-level coordination and agreement on analyses and objectives.	**A unique but flexible protocol and a parallel data chain (3.3c)** Satisfies both local and global requirements, fits to different levels of expertise, chances to integrate new technologies, but demands additional resources for coordination, data processing, and data analysis capabilities to handle both raw datasets and EBV estimates.	**One common strict protocol and a joint analysis of raw data (3.3a)** Easy to implement and to compare results, but inflexible to adapt to local priorities, possible lack of motivation of local stakeholders.
Note on the implementation	**For the flexible protocols strategy (4.2.2)** ▸ Define and agree on EBV values, ▸ Enhance the accessibility of raw data.	**For the unique but flexible protocol strategy (4.2.3)** ▸ Strengthen the lower-scale nodes with own EBV production, ▸ Work on raw data to derive new knowledge and EBV at the upper scale.	**For the strict protocol strategy (4.2.1)** ▸ Work on lower-scale nodes for EBVs, improving data quality, traceability, and alignment with local needs.

4.3 BUILDING COMMON FRAMEWORKS AMONG AND BETWEEN THE MONITORING COMMUNITIES

Finally, it is essential to highlight that protocol harmonisation calls for "community deals" to be made.

Different biodiversity monitoring communities (e.g for birds, soil, freshwater ecosystems, etc.) have different starting points in terms of existing monitoring schemes and traditions, and different data collection and analysis techniques that might be more or less adapted to implementation at different bio-geographical conditions. As well, the issues of flexibility will depend on the groups and on the different techniques that can be used. There cannot be a unique and uniform solution for all. Decisions on the monitoring programme's protocol design will have to be made by a specific expert working group. Harmonisation of the technical part of the protocol would be challenging for a generalist project without the necessary expertise. This approach has been followed by the European Commission for example, where they set up a technical expert group to support the development and testing of an EU-wide pollinator monitoring scheme via the SPRING project for the action 1A of the EU Pollinators Initiative (SPRING, 2023)[45]. There is also a need for long-term European community nodes to help facilitate and coordinate these communities, to perform European routine analysis, to improve practices and to share experience. PECBMS for common birds, EUROBATS for bats, HELCOM[46] working group on marine biodiversity (WG BioDiv)[47] are examples of community nodes. They often include topics larger than monitoring, for instance, conservation practices which help to link monitoring with action. However, they currently lack acknowledged mandates and proper long-term funding, and there is a need to map them properly.

A common framework should be established to integrate the results from different communities effectively. A particular attention should be given to transversal components, to ensure that results from the different communities are interoperable and of good quality. For instance, a strong attention should be given to sampling design procedure, to ensure all of them are representative of the same geographical elements, and to give them advice on how to deal with flexibility in selecting sampling sites. This could be translated into working towards a protocol stating some minimum requirements, for each community of biodiversity monitoring. This has been carried out, for instance, by the State of the World's Sea Turtles (SWOT)[48] community, which has specified minimum data standards for sea turtle nesting beach monitoring in a field handbook (SWOT, 2011). As well, consensual transformation of datasets and metadata through standardised vocabularies and measurement techniques is crucial for smooth interoperability (Basset *et al.*, 2023). It is essential to take validation and data curation into account for the harmonisation process. This aspect is intrinsically tied to determining the parties accountable for ensuring data quality across the entire monitoring workflow (Geijzendorffer *et al.*, 2015). Working on the standardisation of EBV data as close as possible to Eurostat recommendation is also an interesting area of progress to achieve comparable products of biodiversity monitoring, for

45. SPRING: https://www.ufz.de/spring-pollination/

46. Baltic Marine Environment Protection Commission: https://helcom.fi/

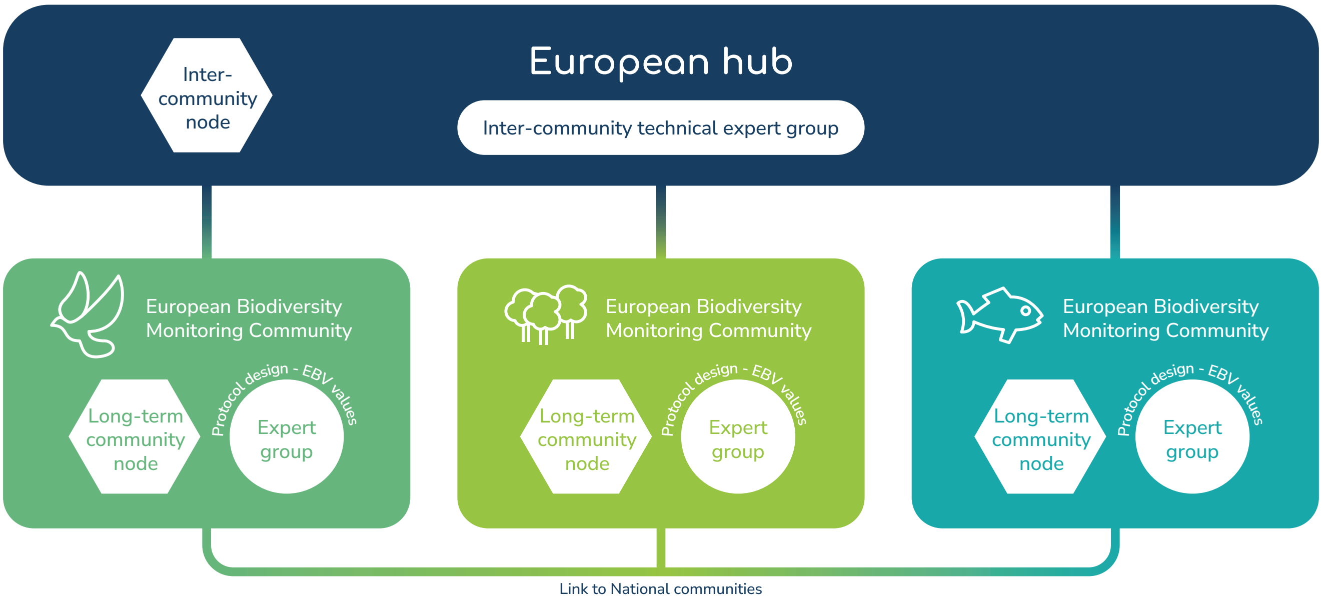
47. HELCOM Working Group on Biodiversity, Protection and Restoration: https://helcom.fi/helcom-at-work/groups/biodiv/

48. State of the World's Sea Turtles: https://www.seaturtlestatus.org/

instance on trend duration, based year of indexes, and smoothing parameters (Hoye *et al.*, 2022)[49]

The establishment of a network to create a global community of practice to exchange standards, methods, and tools for effective comparability and communication can be of great value. This could be imagined for example as a section of TDWG[50] about monitoring data. By aligning independent programmes into a coordinated network, large-scale biodiversity monitoring can be achieved while fostering ownership and cooperation among stakeholders. Strong partnerships between different realms and expertise levels further enhance the likelihood of a successful and coordinated effort (Kühl *et al.*, 2020; Livoreil *et al.*, 2016).

This process of codesign and co-management of the biodiversity monitoring in each community should focus on integrating interests of both local communities and large-scale monitoring efforts. Data management needs to provide information products that would be valuable to all stakeholders involved. Therefore, communication among the parties involved in all scales is key (Eicken *et al.*, 2021; Honrado *et al.*, 2016). Issues of ownership and distribution of responsibilities would need to be taken into consideration for the integration of these different stakeholders into a biodiversity monitoring system (Kühl *et al.*, 2020). Training and capacity-building programmes could also be implemented to enhance expertise.



A common framework

to integrate the results from different communities ettectively

Different biodiversitv monitoring communities (of different topics, e.g. for birds, soil, fresh-water ecosystems, etc.) have different starting points in terms of **existing monitoring schemes and traditions and different data collection and analysis techniques**.

Decision on the **target of monitoring** (e.g fully-specified EBVs) and technical harmonisation on the **protocol design** have to be made by **community expert groups**.

Inter-community technical expert group take care on specificies and minimum requirements; this allows **integration and harmonisation of monitoring results** across communities.

Long-term European community nodes help with facilitation and coordination in each community to perform European routine analysis, to improve practice and to share experience (-> they often cover topics larger than monitoring, e.g. conservaton)

49. Biodiversa+ report on biodiversity monitoring knowledge gaps, R&I priorities: https://www.biodiversa.eu/wp-content/uploads/2022/12/D2.1-Report-on-biodiversity-knowledge-gaps-VF.pdf

50. Biodiversity Information Standards: https://www.tdwg.org/

4.3.1 THE IDEA OF A EUROPEAN MONITORING CENTRE

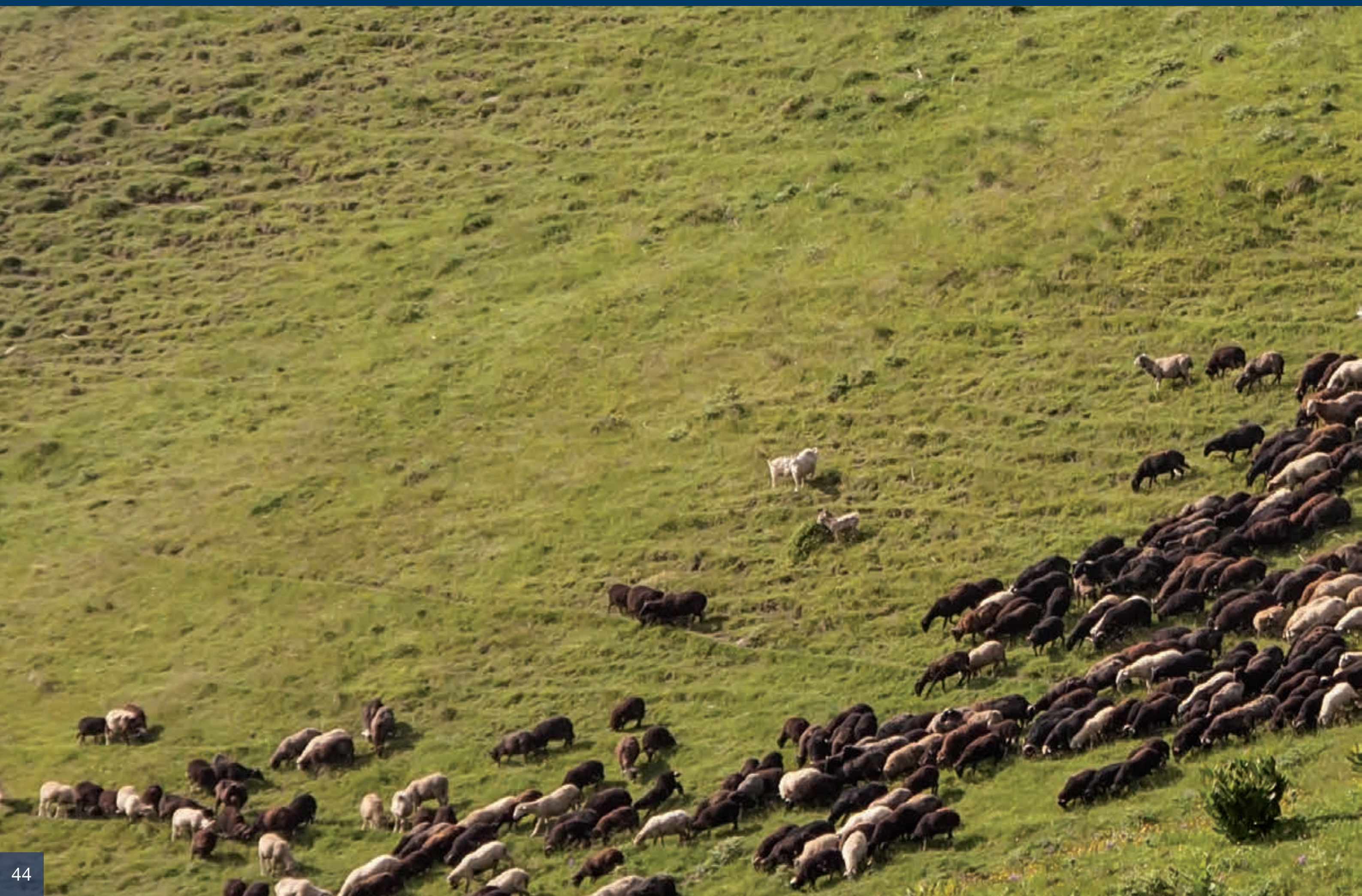
The growing desire for a collaborative advancement in multi-scale European biodiversity monitoring coordination underscores the need for an integrated approach (Vihervaara *et al.*, 2023)[51]. A European Monitoring Centre could assume the pivotal role of formulating shared and generic specifications, as well as establishing foundational organisational principles. This includes tasks such as selecting and defining EBVs, setting guidelines, coordinating the link of efforts at national and European scales, and ensuring the seamless flow of data and EBV information. EuropaBON is currently in the process of developing a Terms of Reference (ToR) for a proposed Biodiversity Monitoring Coordination Center (BMCC).

Concurrently, European community-based nodes could emerge as instrumental hubs responsible for creating operational and harmonised protocols within their respective domains. Their functions span the selection and development of operational protocols, the design of sampling strategies, the management of communities, the establishment of analysis workflows, the production of EBVs, and the maintenance of data and EBV flow inside the community. These functions will drive the community toward more harmonised protocols and multi-scale coherence. An inter-thematic coordinator could ensure the compatibility of all EBV results and maintain organisational coherence across various thematic areas (Navarro *et al.*, 2017). Moreover, these thematic units will engender connectivity and collaboration, both within the European context and beyond, interfacing with analogous global initiatives to fortify the overarching objective of biodiversity conservation and preservation. The interaction of these thematic units with the national nodes, which are also in contact with the European coordinator, needs to be further delineated to prevent unnecessary duplication of efforts.

51. https://www.biodiversa.eu/wp-content/uploads/2023/05/D2.8-Biodiversity-monitoring-strategic-Phase-I-report.pdf

5

GENERAL CONCLUSIONS



In conclusion, the realm of biodiversity monitoring at transnational scales presents a diverse landscape of strategies, each with its own strengths, challenges, and potential applications. The three dominant strategies—common strict protocol with joint data analysis, flexible protocols with locally-produced EBVs, and flexible protocol with a parallel data chain (both EBVs and raw data)—offer distinct approaches to harmonising monitoring efforts. While each strategy has its merits, they also pose unique barriers related to adaptability, data integration, resource allocation and governance.

To enhance the effectiveness of biodiversity monitoring, several recommendations are proposed. **Firstly**, the choice of monitoring protocol should be context-specific, considering existing schemes, gaps in coverage, and available resources. Adaptation of existing protocols or harmonisation of minimum standards can streamline efforts and promote compatibility. **Secondly**, a parallel approach to data sharing, involving both raw datasets and EBV estimates, can offer flexibility and broader insights while addressing data compatibility concerns. **Thirdly**, building common frameworks among monitoring communities is crucial. To integrate the results from different communities effectively, particular attention to transversal components to ensure interoperability and high quality of results is needed. This includes e.g. the sampling design procedure, the protocol, the transformation of datasets and metadata, the validation and data curation, and the standardisation of EBV data. **Fourthly**, next to community expert groups who work on the community specific target of monitoring and on the technical harmonisation within their community, inter-community technical expert groups are needed to work on the specificities and minimum requirements that allow the integration and harmonisation of monitoring results across communities. Such a collaborative approach ensures protocol quality, interoperability, and a sense of ownership among stakeholders.

Looking ahead, key directions for action include effective management and sharing agreements, capacity building, and continuous evaluation. It builds on the collective contributions of various realms, communities, and diverse forms of expertise, ranging from statistical analyses to sampling methodologies, and extending to sociological sciences. As efforts continue to evolve, a collective commitment to harmonisation, collaboration, and adaptive strategies will be essential to achieving the shared goal of conserving and understanding the continent's biodiversity.

In terms of biodiversity monitoring, the question is not to know what the shape of the boat is, and who is steering it, but rather to recognize ourselves as a fleet of multiple vessels with different characteristics for which we must give a common direction, rules of navigation, work on the consistency of roles within subsets, and convergence of practices between similar roles through subsets.

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ANNEX: GLOSSARY

These definitions were mainly gathered from existing glossaries produced by other international initiatives.

While this glossary might be helpful to assist readers in navigating some of the terminology used throughout the document, these terms need to be formally tested and completed in relation to the activities of Biodiversa+, and further discussed and agreed upon among Biodiversa+ partners.

Term	Definition	Source
Biodiversity	The variability among living organisms from all sources, including inter alia terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species, and of ecosystems. (cf. Article 2 of the Convention on Biological Diversity, 1992)	ESMERALDA, 2018
Biodiversity Observation Network (BON)	A network of observation sites or stations and a network of groups who produce and use biodiversity data across these sites for different needs. A BON coordinates observations and monitoring to support policy and environmental legislation prompting conservation action from national biodiversity strategies and action plans. A BON can be national, subnational or regional in its level of operation and can cover different biomes (for example, marine or freshwater) and dimensions of biodiversity (such as genetics, species and ecosystems) to fill specific knowledge gaps.	GEO BON, 2023
Capacity Building	A process of strengthening or developing human resources, institutions, organisations, or networks. Also referred to as capacity development or capacity enhancement.	ESMERALDA, 2018
Calibration	Harmonise to the same metric measure.	SYNCHROS, 2020
Community (human, local)	A group of people who have something in common. A local community is a fairly small group of people who share a common place of residence and a set of institutions based on this fact, but the word 'community' is also used to refer to larger collections of people who have something else in common (e.g., national community, donor community).	ESMERALDA, 2018
Cultural landscape	Cultural properties that represent the combined works of nature and of people. Adapted from World Heritage Committee	ESMERALDA, 2018
Data quality	The totality of features and characteristics of data that bears on their ability to satisfy a given purpose; the sum of the degrees of excellence for factors related to data.	U.S EPA, 2016
Data quality indicators	Quantitative statistics and qualitative descriptors that are used to interpret the degree of acceptability or utility of data to the user. The principal data quality indicators are bias, precision, accuracy, comparability, completeness, and representativeness.	U.S EPA, 2016

Decision support tools	Approaches and techniques based on science and other knowledge systems, including indigenous and local knowledge, that can inform, assist and enhance relevant decisions, policy-making and implementation at the local, national, regional and international levels.	IPBES, 2023
Decision-maker	A person, group or an organisation that has the authority or ability to decide about actions of interest.	ESMERALDA, 2018
Decision-making	The process of making decisions can happen at the individual level or amongst groups and entails the prioritisation of certain values. This prioritisation greatly influences which issues are found worthy of considera-tion, do and do not become part of the agenda, as well as determine which decision-makers are considered socially legitimate to participate in the process.	IPBES, 2023
Empowerment	The process by which people gain control over the factors and decisions that shape their lives. It is the process by which they increase their assets and attrib-utes and build capacities to gain access, partners, networks and/or a voice, in order to gain control.	IPBES, 2023
Essential Biodiversity Variables	Minimal set of biological state variables. The EBVs are an intermediate layer of abstraction between raw data, from in situ and remote sensing observations, and derived high-level indicators used to communicate the state and trends of biodiversity. There are six classes (genetic, species traits, species population, community composition, ecosystem struc-ture, and ecosystem function) and 21 distinct EBVs.	Adapted from GEO BON, 2022
Expert	Anyone who has acquired good knowledge of a subject through her/his life experience, including local or indig-enous knowledge holders in addition to scientists. It is assumed that the expert is a reliable source of informa-tion within a specific domain.	IPBES, 2023
Federated Analysis	Centralised analysis with individual-level data remaining on their local servers	SYNCHROS, 2020
Framework	A structure that includes the relationship amongst a set of assumptions, concepts, and practices that establish an approach for accomplishing a stated objective or objectives.	ESMERALDA, 2018
Governance	The process of formulating decisions and guiding the behaviour of humans, groups and organisations in formally, often hierarchically organised decision-making systems or in networks that cross decision-making levels & sector boundaries.	ESMERALDA, 2018
Harmonisation	The process of bringing something together in a way to facilitate comparability or consistency.	IPBES, 2023
Hubs	Hubs can be flexible entities/platforms or refer to a coordinating organisation that is responsible for, in this case, biodiversity monitoring. Hubs can include and host functions such as networking, funding, steering, coordination of biodiversity monitoring, and data management	Biodiversa+, 2023

Indicator	A number or qualitative descriptor generated with a well-defined method which reflects a phenomenon of interest (the indicandum). Indicators are frequently used by policy-makers to set environmental goals and evaluate their fulfilment. An indicator in policy is a metric of a policy-relevant phenomenon used to set environmental goals and evaluate their fulfilment. An indicator in science is a quantifiable metric which reflects a phenomenon of interest (the indicandum).	Adapted from ESMERALDA, 2018
Biodiversity indicator	Two definitions are relevant: 1. A quantitative or qualitative variable that provides reliable means to measure a particular phenomenon or attribute of biodiversity. 2. A quantitative or qualitative variable that provides a simple and reliable way to measure the state of biodiversity, assess progress to a conservation objective, or to help assess the performance of a policy derived action for biodiversity.	GEO BON, 2022
Environmental indicators	Environmental indicators are environment statistics (data that have been structured, synthesised and aggregated according to statistical methods, standards and procedures), that have been selected for their ability to depict important phenomena or dynamics. Environmental indicators are used to synthesise and present complex environments and other statistics in a simple, direct, clear and relevant way. Environmental indicators are generated because environment statistics are usually too numerous and detailed to meet the needs of policymakers and the general public, and often require further processing and interpretation to be meaningful	UN ECE, 2021
Integration	Usually falls within i) combining, ii) interpreting and iii) communicating knowledge from diverse disciplines.	Adapted from ESMERALDA, 2018
Interdisciplinarity	The act of combining two or more academic disciplines into one integrated activity to create new insights by crossing knowledge boundaries and linking ideas.	ESMERALDA, 2018
Interoperability	Interoperability has been defined as ‘the ability of two or more systems or components to exchange information and use the information that has been exchanged’. As regards biodiversity data and datasets interoperability can be defined as ’the capacity of computers and software to exchange and make use of data and information’. The properties of data and information systems, devices, and applications, which allow them to interact and share with other information products or systems within and across organisational boundaries to provide rapid and seamless information portability.	Biodiversa+, 2023
Knowledge sharing	the spectrum of activities through which information, skills, and expertise are exchanged.	The Nature Conservancy, 2018

Landscape	An area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. The term “landscape” is thus defined as a zone or area as perceived by local people or visitors, whose visual features and character are the result of the action of natural and/or cultural factors. Recognition is given to the fact that landscapes evolve through time and are the result of natural and human activities. Landscape should be considered as a whole – natural and cultural components are taken together, not separately.	ESMERALDA, 2018
Method	A reproducible process with the aim of achieving an objective (e.g. estimation of a population size) by data collection. A method mobilises one or more techniques for the acquisition of data in the field, and can be part of a standardised protocol.	Adapted from ESMERALDA, 2018
Methodology	The particular chain of methods, data and other relevant resources (e.g. stakeholders) that are involved in solving a specific problem.	ESMERALDA, 2018
Monitoring	1) The repeated observation of a system in order to perceive change in some quality or quantity. 2) A periodic standardised data collection or measurement of a particular set of biodiversity variables in specific sample areas. Biodiversity monitoring aims to highlight changes in the various forms of biodiversity (genes, taxa, ecosystems, etc.).	Adapted from EEA, 2010
Biodiversity monitoring	Biodiversity monitoring includes two facets (see monitoring in the glossary): 1) it is the process of gathering information about essential biodiversity and ecosystem variable(s)--and linked data on drivers of change--at different points in geographic space over time for the purpose of assessing their state and drawing inferences about changes in state over time, and 2) this information is used to estimate and report on the value of the indicators describing the change in those variables. Monitoring includes the collection of primary biodiversity data, synthesis of data into an indicator, and public dissemination of past and forecasted trends in the indicator. Both facets are tightly linked to and informed by a decision-support framework designed to guide actions to achieve conservation and restoration objectives.	GEO BON, 2022
Monitoring programme	For this study, a monitoring programme is understood in a broad way, being a project or a legal framework that provides periodic evaluations of biodiversity monitoring results. a large-scale monitoring programme should take into account the different levels of the information chain, these being: target setting for the programme, survey design for data collection (sampling methods, field protocols, techniques, sites selection procedure, number of sites and replicates, sampling frequency), data storage and management, and production of results for policy reporting.	GEO BON, 2022
Monitoring scheme	A recognizable protocol whose aim is to collect field data on long-term population trends in 1 or more species with a predefined method.	Moussy et al., 2022

Multidisciplinarity	Linking several academic disciplines or professional specialisations in an approach to a topic or problem; however, the disciplines retain their identity and perspective, unlike the situation with interdisciplinary approaches.	ESMERALDA, 2018
Operationalization	The process by which concepts are made usable by decision-makers.	ESMERALDA, 2018
Operational monitoring	Operational monitoring can be defined as the activity of systematic and long-term routine measurements of biodiversity, and their rapid interpretation and dissemination.	EuropaBON
Policy maker	A person with the authority to influence or determine policies and practices at an international, national, regional or local level.	ESMERALDA, 2018
Protocol	Detailed study plan explaining how data should be collected to answer a scientific question. It comprises: a sampling plan that defines the rules for selecting the units; one or more techniques and/or methods to be applied; additional application rules (e.g. frequency, weather conditions, etc.). A protocol is standardised when it is precisely defined in a reference document and applicable by different operators in various territories.	CAMPanule, 2023
Raw data	Unprocessed observations and measurements	UN ECE, 2021
Scale	Level of observation and can have several dimensions. Examining a phenomenon at multiple levels, usually referring to transcending spatial scales, as in "upscaling" (extrapolation from fine-scale data to a coarser scale) or "downscaling" (interpreting underlying patterns or mechanisms from coarse-scale data). Scale can also refer to sampling scale, as in the grain size and extent of field sampling. Sampling across scales often reveals critical information that is not apparent from a single-scale observation alone.	Gammon *et al.*, 2020
Stakeholder	Any group, organisation or individual who is involved in a project or in decision making processes and implementation, either as influencing the process and the outcomes, or as being dependent on, and facing the consequences of, the decisions (incl. Public, private and civil society actors).	IPBES, 2023
Technique	Designates all the specific processes and tools mobilised to collect data associated with a parameter to be observed. A technique is defined in relation to a target, as part of a protocol, it must be reproducible.	CAMPanule, 2023
Transdisciplinarity	A reflexive, integrative, method-driven scientific principle aiming at the solution or transition of societal problems and concurrently of related scientific problems by differentiating and integrating knowledge from various scientific and societal bodies of knowledge.	ESMERALDA, 2018
Workflows for biodiversity monitoring data	The workflows for biodiversity monitoring data start from the data acquisition and end up to the knowledge production.	Biodiversa+, 2023

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Reading this guide you will...

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Have an introduction to key concepts and approaches for biodiversity monitoring protocols

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Co-funded by the European Union