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How to implement and sustain long-term transnational biodiversity monitoring schemes?

Analysis report

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Authors:	Michele Bresadola (BOZEN) and Albin Bjärhall (BOZEN)
Contributors/ reviewers:	Aino Lipsanen (MoE_FI), Domhnall Finch (NPWS), Martina Pulieri (MUR), Laura Cherchi (BOZEN), Karel Chobot (NCA CZ), David Eichenberg (BfN), Michelle Silva del Pozo (OFB), Daniela Hamidovic (MESD), Petteri Vihervaara (MoE_FI), Jonas Gaigr (NCA CZ), Ron Winkler (NWO), Cécile Mandon (FRB).
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What is Biodiversa+

The European Biodiversity Partnership, Biodiversa+, supports excellent research on biodiversity with an impact for policy and society. Connecting science, policy and practise for transformative change, Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030. Co-funded by the European Commission, Biodiversa+ gathers 83 partners from research funding, programming and environmental policy actors in 41 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/

Table of Acronyms

eBMS	European Butterfly Monitoring Scheme
EBOCC	European Biodiversity Observation Coordinating Centre
EBV	Essential Biodiversity Variables
EEA	European Environment Agency
GEO BON	Group on Earth Observations Biodiversity Observation Network
GLORIA	Global Observation Research Initiative in Alpine Environments
HELCOM	Helsinki Commission (Baltic Marine Environment Protection Commission)
KMGBF	Kunming-Montreal Global Biodiversity Framework
LUCAS	Land Use/Cover Area frame Survey
PECBMS	Pan-European Common Bird Monitoring Scheme
SCANS	Small Cetaceans in European Atlantic waters and the North Sea
WFD	Water Framework Directive

Executive Summary

The European Biodiversity Partnership, Biodiversa+, plays a key role in advancing transnational biodiversity monitoring by identifying strategies to overcome governance, financial, and methodological challenges, as well as fostering collaboration and co-development of new systems. This report, informed by the Biodiversa+ pilots and two dedicated workshops, offers a discussion on the needs and strategies for establishing transnational and sustainable biodiversity monitoring schemes across multiple jurisdictions. It focuses on addressing the complexities of transnational coordination, governance mechanisms, and stakeholder engagement to ensure effective biodiversity monitoring at scale.

A central theme of this report is the need for a structured yet flexible approach to long-term biodiversity monitoring governance. The findings highlight the advantages and limitations of top-down and bottom-up models, emphasizing different starting points of biodiversity monitoring schemes and outlining strategies to develop them. The Biodiversa+ pilots have been instrumental in stress-testing governance structures, funding models, and methodological frameworks, offering valuable insights into the practicalities of transnational cooperation.

To facilitate implementation of transnational long-term monitoring schemes, the report explores the introduction of a criteria-based approach for evaluating biodiversity monitoring initiatives and achieving a shared vision within the network on resource allocation for transnational cooperation. These criteria include policy relevance, cost-effectiveness, feasibility, and scalability, serving as a foundation for reaching consensus within the Biodiversa+ partnership on which schemes to support for long-term sustainability.

Introduction

Background

Biodiversity decline across Europe and worldwide is an incontrovertible fact (EEA, 2019; IPBES, 2019). It constitutes one of the defining challenges of the contemporary era, unfolding visibly before us, with rapidly narrowing opportunities for effective intervention. Global environmental issues, including unsustainable land use, climate change, and biodiversity loss are at the centre of humanity's grand challenges, as reflected in policies at multiple scales such as the United Nations Convention on Biological Diversity Strategic Plan and Aichi Targets for 2020, the United Nations Sustainable Development Goals 13 and 15 (Haase et al., 2017) and the Kunming-Montreal Global Biodiversity Framework (KMGBF) which sets out an ambitious plan to halt and reverse biodiversity loss (CBD, 2022). A crucial step in addressing biodiversity decline is accurately quantifying its scope and severity, as well as to evaluate the efficacy of implemented remedial measures.

Long-term biodiversity monitoring provides the foundation for understanding changes in the natural world and informing conservation efforts (Buckland & Johnston, 2017). It involves the repeated, systematic collection of various data to detect and understand changes over time in the abundance and/or distribution of species (Moussy et al., 2021). Monitoring is fundamental to track and understand the biodiversity crisis, targeting conservation resources, and quantifying the impact of conservation investments (Lindenmayer & Likens, 2011; Silva del Pozo et al., 2023). Yet, the present monitoring landscape is characterized by a heterogeneous array of large-scale or pan-European schemes with varying methodologies, funding streams, governance arrangements, and types of entities involved (Liquete et al., 2024), hindering the ability to produce coherent trends at higher scales.

Despite the theoretical consensus on diversity metrics, standardised methods for measuring said metrics are lacking, especially at the scales needed to monitor biodiversity for conservation, restoration and management purposes. Establishing monitoring programs that can provide robust, long-term datasets is critical, as they are essential for understanding complex ecological relationships and the impacts of human activities on natural environments (Liquete et al., 2024; Silva del Pozo et al., 2023; Kühl et al., 2020).

While the importance of large-scale, long-term biodiversity monitoring is well-recognized, the practical implementation of such schemes faces numerous challenges (Buckland & Johnston, 2017; Lindenmayer et al., 2022). These include coordinating various stakeholders, integrating multiple data sources, effectively translating monitoring results into policy and management decisions, as well as securing sustained funding (Vihervaara et. al., 2023). Overcoming these barriers requires a strategic, multifaceted approach that draws on scientific expertise, policy engagement, and innovative governance models (Kühl et al., 2020).

To harmonise biodiversity monitoring metrics, the concept of Essential Biodiversity Variables (EBVs) has been introduced: a set of variables that capture biodiversity change at multiple spatial scales and time intervals (Pereira et al. 2013; Schmeller et al., 2017). EBVs aim to standardize biodiversity data collection, integrate multiple data sources, and facilitate cross-system comparisons of key

biodiversity features (Kissling et al., 2018). Still, many other aspects need to be tackled before reaching comprehensive monitoring systems (Gonzalez et al. 2023). Such challenges include limited data accessibility for end users, limited human and technical capabilities, biased data representation, insufficient long-term funding, and vast differences in governance models and maturity of monitoring systems. (Liquete et al., 2024; Lindenmayer & Likens, 2011; Lipsanen et al., 2023).

Report purpose and contents

This report is a stepping stone, based on the Biodiversa+ work, designed to support the Partnership in **establishing transnational and long-term biodiversity monitoring schemes**. The report draws on feedback from the Biodiversa+ pilots, and the outcomes of two workshops organised for the Biodiversa+ partners in September 2024 and January 2025 to address the challenges in transitioning from pilot monitoring projects to long-term biodiversity monitoring schemes.

To establish a set of common features and suggest alternative methods for effectively setting up and managing long-term, transnational biodiversity monitoring, the report examines key aspects of operational biodiversity monitoring schemes, reviewing them from a "top-down" versus "bottom-up" management perspective.

Methodology

The selection of case studies to review in this report is partially based on the work in compiling existing species monitoring schemes made by Moussy et al. (2022), and the Biodiversa+ literature survey on biodiversity monitoring protocols (Silva del Pozo & Body, 2022), complemented by additional research made by the report authors. A short-list of potential case study examples was created based on the following six criteria:

i. The scheme has been successfully implemented transnationally
ii. The scheme has existed for more than ten years
iii. The scheme has undergone a minimum of four re-sampling events
iv. The scheme is intended to continue indefinitely
v. There is good information and documentation available about the scheme
vi. Approach in governance and management structure of the scheme is well described

After an initial review of the available literature and documentation on the shortlisted monitoring schemes, we contacted the schemes or their partners to request participation in a semi-structured interview about their governance structure. The questions used as the basis for the interview are provided in Annex I. Two selected case study examples are exceptions to the six above-mentioned criteria: The LUCAS monitoring scheme has been carried out every three years between 2006 and 2018, and then again in 2022 with an updated protocol. A biodiversity aspect, with the collection and analysis of soil biodiversity, was not integrated until 2018. However, the scheme is included as a case study for its longevity and wide implementation in the EU. Furthermore, HELCOM coordinates many different monitoring schemes and activities with different timelines and intentions and should therefore be considered a monitoring program rather than a monitoring scheme. Some of the activities in HELCOM would qualify as long-term biodiversity monitoring schemes (e.g., the

monitoring of Small Cetaceans in European Atlantic waters and the North Sea, SCANS) but in this report, HELCOM in its entirety is considered to review the governance structure enabling the establishment and organisation of such monitoring schemes.

To support the development of key concepts in transnational biodiversity monitoring schemes and sustainability of long-term monitoring, Biodiversa+ organised two workshops:

The first workshop involved everyone contributing to the Biodiversa+ pilots' work, with the objectives of: (i) highlighting issues in the setup of transnational biodiversity monitoring schemes in the framework of the Biodiversa+ pilot studies, (ii) identifying administrative and logistic challenges for the setup of transnational monitoring schemes, and (iii) establishing good practices by discussing what works well within the pilots (workshops, meetings, protocols, etc.).

The second workshop gathered representatives from the ministries of environment (MoEs) and other institutions within Biodiversa+, to discuss the benefits and the drivers to engage in long-term, transnational biodiversity monitoring, and developing criteria for proper allocation of resources in shared monitoring systems. The objective of the workshop was to define ways to reach consensus within a partnership for biodiversity monitoring.

I) Useful concepts

I A) Definition of biodiversity monitoring

Biodiversity monitoring can be defined as periodic and standardised data collection or measurement in a specific sample area aiming to highlight changes in any form of biodiversity (Silva del Pozo et al., 2023). In the definition by GEOBON (2022), biodiversity monitoring contains the three integral parts of (i) collecting primary biodiversity data, (ii) linking the data to drivers of change through indicators, and (iii) contextualizing the information through past and forecasted trends. One of the most widely applied form of biodiversity monitoring is species monitoring, which Moussy et al. (2022) define as a *"recognizable protocol whose aim is to collect field data on long-term population trends in 1 or more species with a predefined method*", but biodiversity monitoring can also focus on other variables such as genetic or ecosystem biodiversity.

For this study, **we consider long-term biodiversity monitoring schemes** for application in transnational biodiversity monitoring programs, intended as an **operational framework for periodic evaluations of biodiversity monitoring results which encompass different levels of organisation**: target setting for the program, survey design for data collection (sampling methods, field protocols, techniques, site-selection procedure, number of sites and replicates, sampling frequency), data storage and management, and production of results for policy reporting (GEOBON, 2022).

To facilitate the discussion and analysis of biodiversity monitoring schemes, this report adopts the minimum 10-year timeframe, suggested by Lindenmayer et al. (2022) as a benchmark for defining

long-term monitoring, with some added consideration to the number of conducted re-sampling events and the intended duration of the scheme. See methodology for the full criteria used to select case study examples to review in this report. This approach avoids using an organism's lifespan as a reference point, as lifespans can range from days to centuries depending on the taxa, making them unsuitable for identifying drivers of biodiversity change.

I B) Types of biodiversity monitoring

As suggested by Lindenmayer et al. (2022), biodiversity monitoring can be categorized into three main approaches based on its initial purpose: question-driven monitoring, surveillance monitoring, and mandated monitoring.

Question-driven monitoring is focused on answering specific research questions, often related to evaluating the impacts of management interventions or policy decisions. This type of monitoring can provide robust evaluations of targeted actions but may lack broader contextual information about the overall state of biodiversity. An example of question-driven monitoring is long-term, replicated studies of the impacts of forest management on bird communities (Lindenmayer & Likens, 2011).

Surveillance monitoring aims to track the status and trends of biodiversity over time, without a specific research question in mind. It can involve multi-taxa sampling and a broad spatial scale, providing a big-picture of biodiversity trends (Burton et al., 2014). This approach can elucidate overarching patterns and trajectories but may struggle to attribute the observed changes to specific causes and link drivers of change to pressures. Examples of surveillance monitoring are the Breeding Bird Survey in North America and the European Breeding Bird Atlas, which has tracked bird populations for decades.

Mandated monitoring is often required by legislation or international conventions, such as the EU Habitats Directive or the Water Framework Directive. This type of monitoring is typically designed to assess progress towards pre-defined policy targets but may face challenges in capturing the full breadth of biodiversity and adapting to emerging threats and priorities. This type of monitoring is the priority for institutional bodies that have the responsibility and dedicated resources to support its implementation (Sparrow et al., 2019).

I C) Timescale of biodiversity monitoring

Biodiversity monitoring can also be categorised based on the temporal horizon it seeks to capture: short-term, medium-term, or long-term (see Fig 1).

According to the Habitats Directive Article 17 reporting, short-term trends should be calculated over 12 years (two reporting cycles) to ensure statistical robustness, while long-term assessments are recommended to be based on four reporting cycles (24 years) (DG Environment, 2023). Medium-term can be considered approximately 5 to 12 years, while longer periods fall under long-term monitoring.

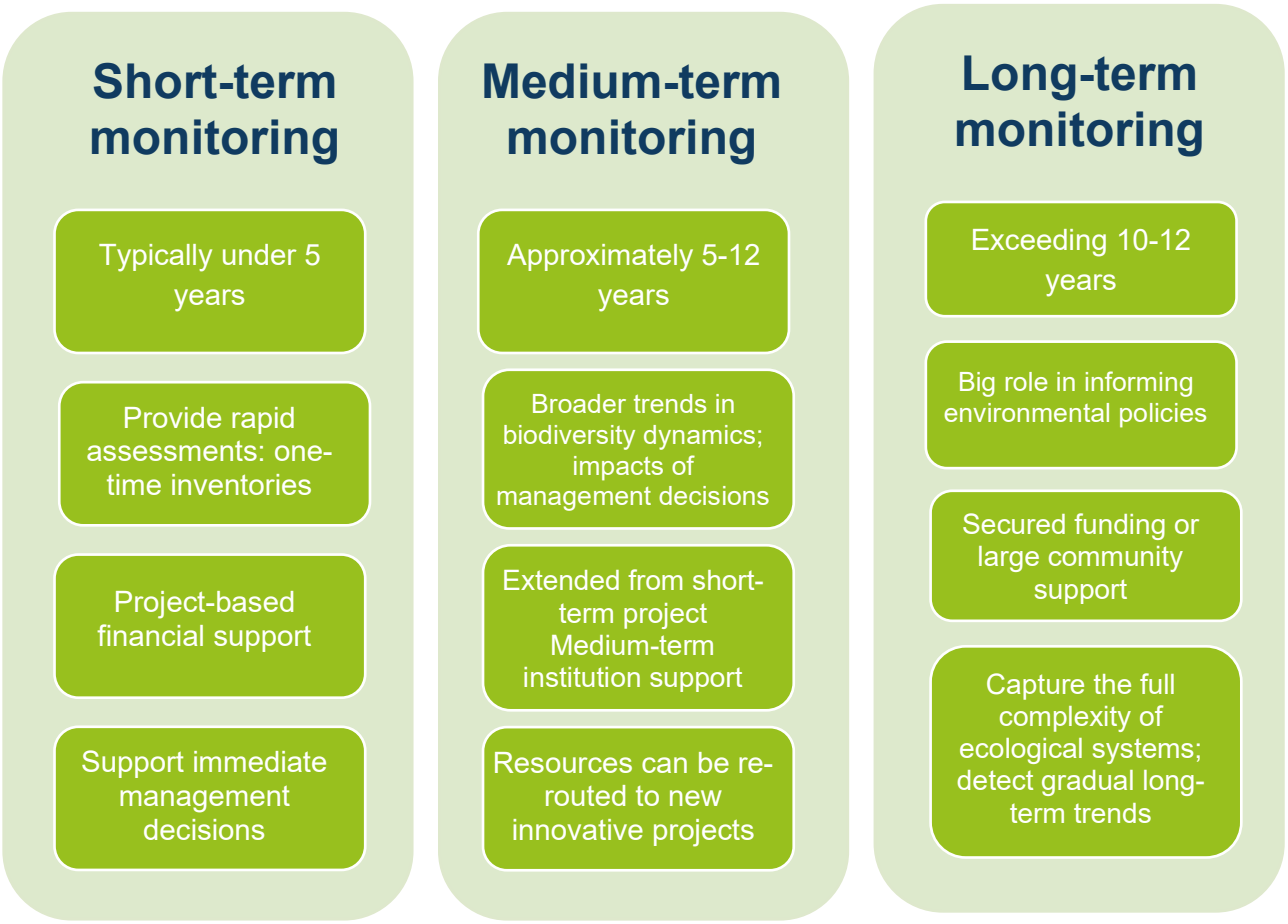

Fig 1: Different temporal horizons for biodiversity monitoring schemes: different time spans entail different objectives and achievable outcomes.

Ideally, a balanced portfolio of these three monitoring approaches and temporal scales is needed to comprehensively understand and manage biodiversity at multiple scales. While the proliferation of research grants has contributed to a wealth of question-driven short- and medium-term monitoring studies, long-term monitoring schemes for assessing status and trends of populations on a longer timeframe remain limited (Lindenmayer & Likens, 2011; Durant, 2013; Kühl et al., 2020).

It is worth noting that, while categorization of monitoring systems based on purpose and time-horizon provides a useful framework, it oversimplifies the complexity of real-world biodiversity monitoring efforts. In practice, monitoring programs often serve multiple objectives simultaneously, and the boundaries between the suggested monitoring types may become indistinct. Ultimately, the choice of monitoring approach should be guided by the specific objectives and scale of the program, as well as the capacities and resources of the implementing organisations. A one-size-fits-all solution is unlikely to be effective, and a nuanced understanding of the trade-offs and limitations of each monitoring type is necessary to develop a comprehensive biodiversity monitoring strategy.

I D) Two facets of pan-European biodiversity monitoring: transnationality and long-term sustainability

Establishing a network of pan-European sustainable biodiversity monitoring schemes requires addressing **two key aspects** that differentiate them from national schemes: **transnationality** and **long-term joint support**.

Establishing transnational biodiversity monitoring schemes requires collecting data across multiple countries through a harmonised and/or standardised protocol. This may involve storing the data in a harmonisation database that is accessible to all contributing partners, or establish robust workflows for prompt data exchange among partners. Additionally, it is crucial to establish robust data agreements that outline clear procedures for sharing benefits and achieving a common vision for the monitoring program. For physical samples, the approach of utilizing a harmonisation or de-harmonisation facility needs to be carefully evaluated. Factors such as the anticipated testing volume, existing infrastructure, transportation and shipping costs, legal constraints, and accreditation possibilities should all be taken into consideration when determining the optimal facility model. In addition, it is crucial to consider the risk of catastrophic events—such as wildfires and floods—that could compromise the integrity of the facility and lead to significant data loss.

While some challenges are inherent in biodiversity monitoring schemes regardless of their scale, the transnational aspect introduces additional complexities and magnifies certain issues. These include, but are not limited to, establishing clear data ownership and benefit-sharing arrangements, securing long-term agreements between international partners, maintaining harmonisation databases for large volumes of data, ensuring consistency across laboratory facilities, and aligning monitoring objectives across different institutional and jurisdictional boundaries.

Beside the issues caused by the transnational aspect of biodiversity monitoring, the challenges posed by the long-term aspect are nonetheless hard to overcome. It is evident that the longer a data series is maintained over time, the more valuable it becomes for both ecological studies and understanding the impacts of management actions. However, achieving long-term and stable funding for such monitoring efforts is a rarity, occurring only in a few cases where simple and cost-effective schemes were coupled with great commitment from diverse stakeholders. These schemes were able to simultaneously respond to policy needs, growing to a point where long-term support was considered a benefit for the broader community.

Some of the key issues of long-term biodiversity monitoring are bound to the inherent uncertainties that stem from indefinite timescales. Factors such as the need for renewable sampling permits, especially for lethal and invasive methods, the challenge of securing long-term data management and storage, and the physical long-term storage of samples all contribute to the complexities involved. The rise of novel technologies for biodiversity monitoring such as audio, image, satellite and molecular methods also pose new challenges for long-term storage and management of data that require specific solutions. Additionally, retaining the required technical expertise to maintain the continuity of monitoring efforts is another significant challenge. Furthermore, the scenario of a growing number of samples and datasets over time places a strain on limited resources, making it increasingly difficult to sustain these long-term monitoring programs. Regardless of the large

contributions of long-term ecological studies to biodiversity monitoring, funding allocated for long-term studies is decreasing in favour of short-term projects (McGlone, 2014; Hughes et al., 2017).

II) Review of case study monitoring schemes

II A) Key aspects

In this section, five key aspects of long-term biodiversity monitoring schemes are reviewed from a top-down and bottom-up approach and put in context using examples from eight successfully implemented monitoring schemes as case studies (see Fig. 2). The five reviewed aspects are:

i. **Organisational structure**: The organisation structure focuses on the general governance structure of the scheme, what important stakeholders and decision-makers are involved, and how tasks and responsibilities are delegated within the scheme.
ii. **Funding model**: This aspect looks at potential funding sources for monitoring schemes, including what they offer in terms of financing sustainability, and how sourcing and application for funding is managed within the scheme.
iii. **Coordination mechanisms**: This aspect focuses on how communication between partners is enabled, and how the coordination unit communicates with the different partners. This also includes measures to motivate the partners' engagement in the scheme, and accountability for their responsibilities, and finally looks at the process of new members to join the scheme.
iv. **Data management**: Data management entails both questions related to the ownership, storage and access to scheme-collected data; as well as the management and potential analysis of data compiled from several partners' datasets.
v. **Policy impacts**: Finally, this aspect reviews how the scheme relates to stated policy objectives, as well as how it interacts with policy- and decision-makers.

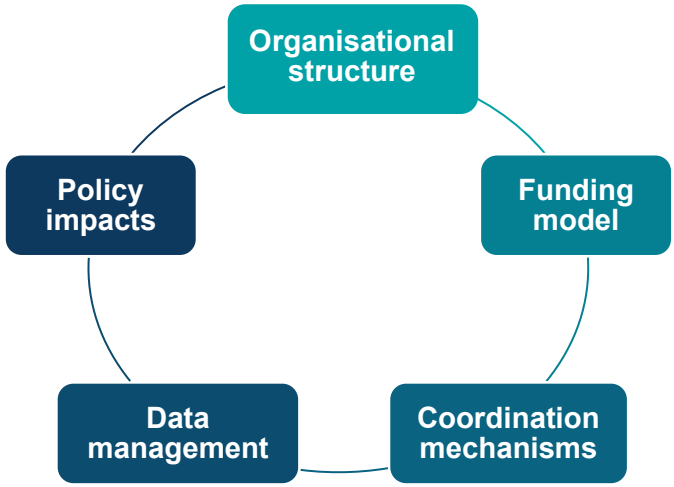

Fig 2: Five key aspects of transnational networks for biodiversity monitoring

II B) Case studies

Separate semi-structured interviews were conducted with representatives or partners from the following six long-term, transnational biodiversity monitoring initiatives, as selected according to the criteria listed in the methodology. In some cases, when contacts with general coordinators were not successful, national coordinators were contacted instead.

i. **eBMS**: The European Butterfly Monitoring Scheme (eBMS) was established by the Butterfly Conservation Europe organisation in 2018 and is coordinated by the UK Centre for Ecology and Hydrology. The initial goal of the scheme was to collate Europe's butterfly monitoring schemes in one database, but the eBMS has also helped initiate schemes in additional countries, and in developing butterfly indicators.
ii. **PECBMS:** The pan-European Common Bird Monitoring Scheme (PECBMS) is coordinated by the Czech Society for Ornithology and co-led by the European Bird Census Council and BirdLife International. Since 2006, the PECBMS collects and harmonises national bird monitoring data to calculate European trends and indicators.
iii. **GLORIA**: The Global Observation Research Initiative in Alpine Environments (GLORIA) is a monitoring scheme established in 2001 and coordinated by the Austrian Academy of Science and the University of Natural Resources and Life Sciences, Vienna. GLORIA looks at impacts from climate change on high-alpine areas, focusing primarily on changes in the vegetation community.
iv. **LUCAS**: The Land Use/Land Cover Area Frame Survey (LUCAS) is a scheme coordinated by Eurostat and aimed at monitoring land cover and land use across the EU using fixed sampling locations that are visited once every 3 years. The scheme, which started in 2006, was expanded to include biodiversity monitoring of soil organisms in 2018.
v. **WFD:** Article 8 of the Water Framework Directive (WFD) mandates every EU member state (MS) to establish and conduct biodiversity monitoring as part of assessing the water's ecological status. The monitoring data on biological quality elements (BQEs) is reported every six years.
vi. **HELCOM**: The Baltic Marine Environment Protection Commission was established by the Helsinki Commission (HELCOM), an international agreement between nine countries and the EU, created in 1974 to protect and restore the state of the Baltic Sea. Biodiversity monitoring in HELCOM is coordinated in several one-time assessments, short- and long-term schemes. In this report, rather than considering the individual schemes within HELCOM, it is reviewed as a framework program for biodiversity monitoring.

II C) Review of key aspects

1) Organisational structure

Top-down approach:

Top-down managed monitoring schemes are often organised in a clear hierarchical structure with a central body in charge of strategic decision and whose decisions are imposed on the network partners, although the partners can be consulted or provide propositions in the decision-making process. The decision-making body is typically made up of policymakers tied to the funding actors of the scheme, but can also contain representatives from e.g., research, local community and other relevant governmental or non-governmental organisations. Practical and localized decisions within the scheme, such as hiring project technicians or finding suitable field sites and local collaborators

can be delegated to the partners themselves. The system of having most of the decision-making made centrally, but delegating decisions on more practical implementation ensures that the scheme is grounded in the objectives set by the funding authorities, but still makes use of the local expertise in the separate countries. To ensure that partners are supplying data of the requested type, extent, quality and frequency, the central body should provide guiding documents clearly stating the delegation of responsibility and expected contributions from all parts of the structural hierarchy, including the central body, regional coordinators, and affiliated partners. It is important to consider that, moving from the international to the local scale, the use of English becomes less common and is often not a predominant skill among personnel. The central body should coordinate the translation of these documents across the network to ensure local-scale activities are effectively linked to transnational efforts.

The strategic goal and responsibilities of scheme partners in WFD and HELCOM are decided centrally on a ministerial level. The monitoring activities in the WFD are explicitly described in the directive, which has been jointly designed and endorsed by each member state, including which outcomes and what data submissions are expected from each partner and the consequences for non-compliance. However, as member states report using secondary data, there are numerous ways of complying with the regulations of the directive, and it is up to local experts in each member state to select a suitable collection method. In some countries, this data collection is divided between different regions, whereas in others it is nationally coordinated. Data is inter-calibrated between different member states to make the ecological status classifications comparable. A specific commission oversees analysing and producing the intercalibrations. The training is not explicitly centralised or mandated at the EU level, but structured responsibilities and mechanisms are in place to ensure capacity building and knowledge sharing.

In HELCOM, strategic decisions regarding biodiversity monitoring are made by the Helsinki Commission and the heads of delegations, which comprise ministerial representatives from all partners. However, within each scheme, an expert group represents each partner, collectively responsible for deciding how the scheme should be implemented. In some cases, this means selecting field sites and applying a strict protocol nationwide, in other cases it requires agreeing on methods to harmonise data from different monitoring schemes applied in different countries. The selection of separate schemes for implementation in the HELCOM program comes both from overarching objectives set on the ministerial level, as well as per suggestion from one of the individual partners of the program.

Bottom-up approach:

Bottom-up managed monitoring schemes typically feature a flatter hierarchical structure with more influence delegated to the participating partners rather than the central body of the scheme, and where the central body has more of a coordinating role, rather than a managerial and decision-making role. Consequently, the central organ is also smaller in relation to the number of partners, compared to top-down governed schemes. Role delegation varies from scheme to scheme and may also differ from partner to partner within the scheme depending on the level of engagement and participating abilities of the partners, but also on the level of benefits partners receive from partaking

in the scheme (see 3.2.3. Network). Any decisions made centrally in the scheme should be well-grounded and endorsed by the partners to ensure continued engagement in the scheme.

Bottom-up governed schemes are often reliant on citizen science or volunteer contributions in the field collection, which is the most labour-intensive and expensive part for many partners, to keep costs low. This also entails a dependency on finding and sustaining competent and able volunteers to contribute, which is easier for some taxa than others. Therefore, it is necessary to either offer training courses for the participating volunteers, or to adjust the field protocol so that it requires less specific expertise to carry out.

PECBMS, eBMS, and GLORIA are all tied to a partner research institute which acts as base for a small coordination unit, but they rely on strong engagement from the individual partners to partake in the scheme. Both the PECBMS and the eBMS rely heavily on citizen science contributions for the data collection, although in some cases volunteers are maintained by national institutions to grant some data consistency. In GLORIA, on the other hand, where data collection is carried out mostly in remote locations, and where each partner is responsible for organising the necessary financial resources to carry out the field surveys, some partners make use of citizen science and volunteer contributions, whereas others do not. The partners in PECBMS and eBMS submit data to national coordinators which are responsible for producing indicators. This approach involves more data handling by the individual partner (see 3.2.4 Data management) than in GLORIA, where partners submit their primary data. However, in both PECBMS and eBMS, the partners are provided a code script to facilitate the calculation of indicators. This form of data submission gives the partners freedom in choosing which bird and butterfly species to report and thereby adjust the protocol to local priorities or already existing monitoring efforts.

2) Funding model

Top-down approach:

Top-down governed schemes typically rely on the national budgets of the partner countries. To enable and sustain this model, it is necessary for the scheme both to be closely connected to policymakers in the respective countries, and to be perceived as a good investment of national funds, which in turn requires a demonstrated reliability and relevance of the scheme. Reliability entails demonstrating that the scheme can deliver the promised results in an effective way. Relevance involves staying aligned with the policy objectives of partner countries and proving that continuously maintaining the monitoring has an added value for the partners. The top-down models offer advantages in terms of stability of large-scale funding, often secured through mandates set by the European Union or by international commissions. For example, in the case of the Water Framework Directive, the strategic goal of reaching good ecological status is unlikely to lose relevance. Long-term monitoring schemes are poorly suited for continuous adjustments as they rely on consistency in the protocol to ensure integrity of the data series, but policy alignment can be improved either in the establishment of long-term strategic goals, or by the choice of collected data format (see Data Management). Furthermore, the involvement of decision-makers in the strategic planning of monitoring schemes ensures that partners are willing to allocate the necessary funds and resources, even in cases like HELCOM, where there are no legally binding requirements. A downside of the

top-down approach is that the reliance on central funding can create pressure to conform to predefined standards, limiting flexibility and innovation at the local level.

Bottom-up approach:

Bottom-approaches, like those adopted in PECBMS, eBMS and GLORIA, rely on individual partners to secure their own funding. There are few sustainable funding options for bottom-up governed monitoring schemes, which tend to be more closely connected to academia rather than national policies and are therefore less likely to receive direct national funding from the respective partners, relying instead on short-term funding and various forms of in-kind contributions from volunteers and smaller institutions. Consequently, the primary source of funding may vary significantly from scheme to scheme, and often needs to be continuously renewed or adjusted over time. Moreover, schemes are often heavily reliant on short-term project funding for carrying out major activities such as expanding the scheme to new countries, updating necessary material and infrastructure, or compiling different datasets for larger assessments. Costs from regular managerial and coordination activities, which are more difficult to receive project funding for, and which may instead be covered by a partnering institute that can serve as a base for the coordination unit of the scheme, are usually kept to a minimum. Aside from often involving volunteer contributions in the field data collection, bottom-up governed schemes are often also dependent on the voluntary engagement from e.g. board members, scientific advisors and from general outreach. GLORIA and eBMS both receive funding to cover the costs of the schemes' coordination units from their respective base partner institutes which also house the coordination units. However, both GLORIA and eBMS rely on additional short-term project funding to carry out key activities of the scheme: to compile national datasets to a global assessment, in the case of GLORIA, and to expand the scheme to European countries currently without an existing butterfly monitoring scheme, in the case of eBMS. PECBMS, on the other hand, receives funding from the EU to cover the coordination costs of the scheme. These EU funds, however, need to be continuously renewed and granted through application, (e.g. PECBMS renew their funds application for general coordination and management every 3 years). The PECBMS also implements a "data handling fee" in case an external institution or a research project makes a data request. The fee has the purpose of covering data management and coordination costs to process the requested data and even if not definitive, it contributes to sustaining the overall functioning of the coordination structure. Both of these funding alternatives are only possible thanks to the schemes already having a high number of partners and high level of implementation. In the case of eBMS, where short-term project funding is used to establish monitoring schemes in new countries, the initial investment to kick-start a national scheme is supposed to establish a solid base that can be eligible for national support and be maintained on its own.

The establishment of developed indicators as official metrics for assessing progress towards policy targets has enormous value, as it creates the conditions for mandatory indicators that generate support from national partners. The bottom-up approach is successful only if a program is capable of producing and maintaining a large dataset and developing robust indicators. This is more easily achieved for charismatic taxa groups.

3) Coordination mechanisms

Top-down approach:

Top-down governed schemes are often based on an existent international agreement or on policy objectives which may outline the target actions of the scheme and specify which partners should be engaged in what activities, and to what extent the legal mandates are binding the partners to the activities. In such a case, relevant partners are often engaged in the scheme already from the start, and actively looking to extend the scheme to new partners may not be a priority. In a case where the terms of participation and obligations in the scheme are based on a pre-existing mutual agreement between all parties, the accountability of each party can be enforced through penalties, including monetary fines or loss of credibility, for failing to provide the expected data. In this scenario, the most important within-scheme communication is that between the central, governing body and the individual national coordinators, to ensure that each partner has the necessary information, skills and resources to fulfil all expected obligations in a satisfactory way. However, enabling between-partner communication through regular meetings can facilitate exchange of experience and support between the partners in a way that carries no cost for the central body of the scheme, but may improve efficiency for each partner in the scheme.

Bottom-up approach:

There are generally no legal agreements in place to ensure participation; rather, partners engage based on their own motivation and perceived benefits. Typically, primary incentives for joining such a scheme are the ability to implement a structured data collection, the access to technical support- especially in the case of citizen science- and the chance to be part of a larger initiative, whose collective value exceeds the sum of its individual parts. Therefore, actively working to expand the scheme with new partners is particularly critical in the initial stages when these motivators represent the scheme's potential rather than its tangible benefits. Once a certain critical mass has been reached, the extension and engagement of partners become more self-sustaining, but also more demanding in terms of management and coordination.

Unlike top-down managed schemes, partner accountability cannot be enforced through penalties; instead, contributions must be secured through motivation. The level of partner engagement and their tolerance for stringent demands within the scheme are closely tied to the benefits derived from participation and from the capacities of coordinators to support them. Higher demands, such as strict data collection protocols, mandatory data cleaning, or quality assurance requirements, necessitate greater compensatory benefits, including central financing, high-quality outputs from the scheme, or retained rights to data ownership. Another important engaging aspect may be the sense of community within the scheme and the mutual assistance among partners; therefore, establishing effective communication within the network is essential to reinforce partner participation.

4) Data management

Top-down approach:

The data management protocol is largely affected by the type of monitoring scheme, and by the chosen data format and reporting protocol. Mandated monitoring often focuses on assessing

national species and habitat status and trends and may be more inclined to collect secondary data from the partners. In contrast, top-down monitoring schemes can also be more surveillance-focused and aimed at building a publicly available knowledge base, in which case they may be more inclined to collect primary data from the partners. Submitting secondary data, such as calculating indicator values based on national data observations or submitting summarized reports on species status and trends within the country, will require more data handling from individual partners, and may also require regional adaptation of the protocol, resulting in different data collection protocols in different countries, compared to collecting uniform primary partner data. However, even when partners provide primary data, there is usually some form of data cleaning, extraction, or quality assurance before submitting data centrally. This can be due to national field surveys collecting more data than needed for the transnational monitoring scheme, or as data quality assurance might be easier to carry out locally, or simply to lower the workload for centralised data compilation and analysis. In schemes where national funds are the main source of funding, a common pre-condition is that the data collected in the scheme will be jointly owned and publicly accessible, whereas the data submitted by the partners is usually collected in a centrally managed database. Data compilation and international analysis is usually done centrally by assigned experts.

Bottom-up approach:

Bottom-up managed schemes can also collect either primary or secondary data from their partners, depending on the purpose and agreed-upon design. Many such schemes are derived either from an ambition to pool existing sets of heterogeneous data for a taxonomic group or from efforts to introduce a new standard practice for collecting specific species data. If the scheme aims to compile already existing methods and datasets into a joint scheme, data is usually submitted in a more general form, such as using indicators, due to their heterogeneous nature. Trying to establish a new standard protocol, on the other hand, usually translates into a stricter protocol that allows compiling and comparing partner data as primary data.

Partner data can be collected in a centrally managed database hosted by the institute acting as base for the coordination unit. However, due to the often-protective agreements surrounding data ownership in bottom-up managed schemes, data can also be stored and managed in separate databases of the respective partners, and is then compiled only for joint international assessments and analyses. In many cases, these datasets are deposited in closed repositories, limiting accessibility. The main issue is not just data loss when a partner exits the scheme, but also the lack of a central access point, such as a federated search system across data catalogues. In modern data management systems, decentralization is often preferred to prevent data loss, but without proper discoverability mechanisms, the potential for collaboration remains limited.

5) Policy impacts

Top-down approach:

Top-down monitoring schemes, mandated by EU legislation, ensure compliance with mandatory reporting obligations through standardised methodologies and legal enforcement, including penalties for non-compliance. Individual states harmonise monitoring methods nationally, while data

integration occurs at higher levels, ensuring consistency across jurisdictions. This approach is ideal for large-scale, legally binding monitoring, such as the Water Framework Directive (WFD), which assesses the ecological status of a water body using standardised indicators. Similarly, LUCAS relies on centralised coordination to maintain methodological integrity while adapting to scientific advancements. A key strength of top-down schemes is their stable funding and institutional backing, ensuring continuity and policy relevance. However, their rigid structure can limit adaptability, requiring periodic evaluations — such as LUCAS's soil sampling refinements — to balance consistency with evolving scientific and policy needs.

Bottom-up approach:

In bottom-up monitoring schemes, achieving policy relevance depends on demonstrating the scientific robustness and practical usability of the indicators derived from the data. Unlike top-down schemes, which often benefit from a formal mandate that sets policy aims and ensures implementation, bottom-up initiatives typically lack legal obligations that guarantees their adoption. As a result, they must continuously prove their value to policymakers—often in alignment with budget cycles and policy windows. While top-down schemes may also undergo periodic evaluations to assess their effectiveness, their initial policy impact is usually secured by design through institutional mandates, which bottom-up schemes must work to build over time. This means that successful schemes must first establish broad participation and a solid data foundation across multiple countries before seeking official policy integration. Once a scheme is widely implemented and produces valuable outputs, harmonisation of methodologies and data processing can follow, ensuring even greater consistency and comparability. However, eBMS represents a key exception to this general pattern, as it adopted a standardised method — the Pollard Walk transect approach — from the outset. This early methodological alignment has ensured that butterfly monitoring data are already comparable across regions, strengthening the scheme's credibility and policy relevance. Other bottom-up schemes, particularly those relying on diverse partners with different collection methods, often prioritise participation and data accumulation before focusing on harmonisation. This approach is particularly suited to monitoring efforts that rely on voluntary contributions or partner-driven initiatives, where large-scale engagement must come before standardisation efforts. It works well for taxa that benefit from broad public participation, such as birds and butterflies, but may be more challenging for monitoring requiring specialised expertise or highly technical methodologies.

III) Biodiversa+ activities to support long-term transnational monitoring

III A) Biodiversa+ pilots

Among the different activities of the partnership, Biodiversa+ launches biodiversity monitoring pilots to test and refine biodiversity monitoring approaches across Europe (Biodiversity monitoring pilots – Biodiversa +). The "pilots" are a collaborative way of achieving higher levels of standardization, technological innovation, governance collaboration and data availability. The Biodiversa+ pilots' aim is to "test the water" for setting-up harmonised, transnational biodiversity monitoring schemes and can be considered the set-up phase where protocols are co-designed, partners are trained in shared methods for data collection, issues are highlighted, and the network is established. The strategy to transition the pilots into long-term monitoring schemes involves securing workflows, expanding and consolidating collaborations, exploring funding mechanisms, and establishing long-term coordination bodies.

The Biodiversa+ pilots bring to light an often-overlooked challenge in biodiversity monitoring: while scientific robustness is meticulously considered in research design and projects, the administrative and logistical issues of establishing a transnational network only become apparent during the implementation phase. These challenges can only be addressed and resolved through practical, on-the-ground biodiversity monitoring trials.

As of the beginning of 2025, there are four active Biodiversa+ pilots, one pilot which ended in 2023, and another round of pilots which are planned to commence in the beginning of 2026, starting from 6 candidates from which some will be selected for implementation (see Table 1). The five either active or finished pilots have all been coordinated by one (or, in the case of the Habitat pilot, two) partners of the Biodiversa+ partnership, and additional partners have been able to join the pilot either as an actively participating partner, or as observers. The five pilots have had different objectives, concerning different taxa, methodologies and fields of research, but all pilots are related to one or more of the stated Biodiversa+ priorities (Basille et al., 2023). Aside from the stated objectives of the different pilots, the participating pilot partners, and especially their coordinators, have also been able to test in practice the challenges and potential that come from organising and coordinating a transnational biodiversity monitoring scheme. To collect these experiences and be able to learn from them in understanding the necessary steps for successfully and sustainably implementing transnational biodiversity monitoring, two workshops were organised for the participants of the Biodiversa+ pilots.

Table 1: Summary table of the Biodiversa+ pilots.

Biodiversa+ pilot	Pilot short name	Years
Monitoring Invasive Alien Species with image-based methods	IAS	2023 (extended to 2025)
Soil biodiversity in protected, near-natural forests	Soil	2023 (extended to 2025)
Towards national biodiversity monitoring coordination centres	Governance	2023
Automated Biodiversity Monitoring Stations	ABMS	2024 - 2025
Toward a European rocky reef fish monitoring network	EURockFish	2024 - 2025
Remote sensing for habitat monitoring	Habitat	2024 - 2025
Biodiversity Monitoring of Ponds	BiodivPond	2026 - 2028 (candidate)
Non-indigenous Fish Monitoring in Transitional Coastal Ecosystems: eDNA versus Traditional Sampling	FishInDNA	2026 - 2028 (candidate)
Monitoring insects using Malaise traps and DNA metabarcoding	MetaBUG	2026 - 2028 (candidate)
Monitoring Genetic Diversity across the EU	MonGDiEU	2026 - 2028 (candidate)
Sensing forest-habitat conditions by remote sensing	SenseForest	2026 - 2028 (candidate)
Strategic harmonisation of invasive species early detection by network integration and eDNA techniques	ShieldNET	2026 - 2028 (candidate)

III B) Outcomes of the Biodiversa+ workshops

Workshop I – Towards a functioning transnational network

The workshop held in September 2024 was a significant step towards addressing the challenges and opportunities associated with establishing long-term biodiversity monitoring schemes under the Biodiversa+ initiative. This event brought together diverse stakeholders to discuss the transition of pilot projects into sustainable, harmonised, and transnational monitoring frameworks. Participants, including representatives from national monitoring schemes and European coordination bodies, explored strategies to resolve technical, administrative, and policy-related barriers. The outcomes of these discussions offer valuable insights into building robust and effective biodiversity monitoring systems across Europe. One of the most pressing challenges discussed was the issue of **data**

ownership and sharing. The lack of clearly defined roles and responsibilities in data management often results in hesitancy and inefficiency among partners. The implementation of FAIR (Findable, Accessible, Interoperable, and Reusable) principles is a critical prerequisite for fostering trust and collaboration. An effective strategy to promote transparency and accessibility is through mandatory agreements for network participation.

Participants acknowledged that long-term sustainability of monitoring schemes requires **robust legal arrangements** that go beyond informal partnerships. A phased approach is suggested, beginning with political agreements to secure commitments from participating countries, followed by the development of detailed legal frameworks. Such agreements would mitigate the risk of economic pressures prompting individual countries to reduce or withdraw their monitoring efforts. The role of European coordination bodies, such as the European Biodiversity Observation Coordinating Centre (EBOCC) proposed by EuropaBON (Liquete et al., 2024) and supported by a European Parliament preparatory action for its pilot phase (European Union, 2023), is considered vital in facilitating these agreements and ensuring their alignment with broader European Union policies.

The **management of data** and physical samples poses another major challenge. Transnational monitoring may rapidly increase the volumes of information generated by biodiversity monitoring activities, particularly in the case of novel technologies like automated image recognition, where large volumes of data are collected and subsequently analysed by an algorithm. The sheer volume of data can pose a challenge in a long-term monitoring scenario, where data is collected and stored indefinitely, but also the sharing of data could quickly become an issue if this aspect is not considered in data management. Centralised facilities for data storage and management are a possible solution to streamline access and ensure long-term sustainability, as well as providing cost-sharing benefits within the network. Also, here, participants underscored the need for cooperation with EU bodies like the European Environment Agency (EEA) and EBOCC to support the design and implementation of these facilities. While pilot projects have managed data effectively on a smaller scale, scaling up operations for long-term deployment will necessitate significant infrastructural investments. Identifying appropriate storage systems and degree of centralization of data and physical samples is essential for ensuring flexibility and organisation in ongoing monitoring efforts. In de-harmonisation systems, regular training sessions for involved teams can help maintain adherence to protocols and quality assurance across different laboratories and regions, while harmonisation calibration processes can mitigate variability between laboratories. Automated quality control mechanisms, combined with manual reviews where necessary, can also represent effective means to maintain data integrity.

A recurring theme throughout the workshop was the **integration of monitoring outputs into policymaking**. Participants highlighted that data collection efforts must be designed with policy relevance in mind to secure long-term funding and institutional support. Simplifying complex datasets into actionable indicators and creating accessible summaries tailored for policymakers were proposed as essential strategies. Additionally, fostering strong links between monitoring outputs and European Union policy priorities would ensure that biodiversity monitoring efforts are both impactful and aligned with broader environmental objectives. For instance, participants suggested developing dashboards, leaflets, and other communication tools to make the results easily understandable for decision-makers, thereby facilitating their translation into effective policy measures.

The first workshop provided a platform to explore what would be needed for pilot projects to transition into independently sustainable monitoring schemes. Several critical requirements are needed, including the establishment of clear governance structures, sustained funding mechanisms, and continuous technical and scientific support. Many emphasised the importance of a strong, EU-wide biodiversity monitoring community, where organisations like Biodiversa+, EEA, EBOCC, Eionet and national thematic networks work collaboratively under a shared vision. Ensuring alignment with EU policies and establishing clear links between monitoring outputs and local as well as European policy priorities were viewed as indispensable for obtaining long-term funding and institutional commitment.

A key lesson from the discussions was the importance of capacity building and expertise retention. The necessity of mentorship programs, specialized training courses, and professionalization of monitoring roles to maintain technical expertise within the network is considered fundamental. EU-certified courses on taxonomy and other relevant fields can be supportive to ensure both a steady supply of skilled personnel as well as help the harmonisation of taxonomies and monitoring methods. Additionally, fostering synergies between academic institutions and monitoring networks could help integrate habitat and species expertise into university programs, thereby securing the long-term viability of biodiversity monitoring initiatives.

By addressing these challenges and leveraging the lessons learned from pilot projects, Biodiversa+ and its partners can lay the foundation for a harmonised, transnational biodiversity monitoring framework that supports Europe's environmental goals for decades to come.

Workshop II – Drivers for commitment and transnational monitoring

The workshop on sustaining long-term transnational biodiversity monitoring schemes provided an opportunity to critically explore the complexities of effective collaboration among European nations and to address the persistent challenges of resource allocation and governance in biodiversity monitoring.

The benefits of joining a transnational biodiversity monitoring network are multiple, but sometimes they are not obvious. Monitoring efforts conducted at a national level often suffer from fragmentation, with methodologies, data formats, and focal species varying widely across countries, while cooperative transnational monitoring brings significant advantages in terms of data quality, comparability, and coverage, ensuring that data collected across borders is consistent and comparable (Vitkalova A.V. et al., 2018). This is particularly critical for addressing transboundary challenges such as tracking migratory species, monitoring invasive alien species, and understanding ecosystem dynamics. Networks like the Pan-European Common Bird Monitoring Scheme (PECBMS) and the European Butterfly Monitoring Scheme (eBMS) exemplify how standardised methods and shared resources can lead to improved ecological insights and better-informed policies.

Moreover, participation in transnational networks amplifies the visibility and impact of national biodiversity monitoring programs. The collaborative outcomes of such networks are more recognized at the European or global level, enhancing the political acceptance and legitimacy of their data, methods, and analyses. This increased visibility not only fosters greater public and governmental support but also helps secure long-term funding. The ability to contribute to shared European and global goals, such as halting biodiversity loss, restoring nature and meeting the objectives of EU

directives, further strengthens the case for collaboration, providing participating countries with a platform to demonstrate their commitment to international agreements and policy frameworks.

The financial and technical support provided by transnational networks can also be considered a key driver for participation. Many countries face limited resources for biodiversity monitoring, particularly for developing new methodologies or maintaining existing programs. By pooling expertise, infrastructure, and funding, transnational networks reduce individual burdens and create opportunities for capacity building. This shared approach can avoid duplication of efforts, while simultaneously accelerating the development and adoption of innovative methodologies, encouraging pooling of resources and access to advanced know-how, enabling the integration of newer partners with less-established monitoring systems.

Despite the compelling benefits, it's important to address the challenges of joining a transnational network. One significant concern is the potential resistance from national stakeholders who are deeply invested in existing, well-established monitoring programs at the national level. These stakeholders may be hesitant to adjust their methodologies or align with standardised protocols, fearing a loss of control or the erosion of long-term datasets built on specific national approaches, which is imperative to avoid. One possible way to address this challenge is using Essential Biodiversity Variables (EBVs), which can serve as a translation layer between nationally collected data and transnational indicators. Rather than requiring full protocol alignment, EBVs offer a harmonised conceptual framework that allows diverse datasets to contribute to shared biodiversity assessments, if data quality and compatibility are sufficiently addressed. However, they don't completely eliminate the need for harmonisation or investment, as EBVs still needs comparable input data that is not too divergent in quality or frequency, and some EBVs are less developed than others both in concept and operational framework. Additionally, the initial investment required to adapt national programs to transnational frameworks, including the need for staff training, with an emphasis on the administrative capacities, infrastructure updates, and methodological harmonisation, can be a barrier for many countries. Another challenge lies in the uneven distribution of resources among participating nations. Countries with limited financial or technical capacities may struggle to contribute equitably to the network, risking a reliance on more resource-rich partners. This imbalance can create tensions and raise questions about fairness and sustainability, particularly if co-funding mechanisms and governance structures are not robustly designed to address disparities.

The mechanisms for flexibility within harmonised frameworks ensure that countries can retain some autonomy over their methodologies while aligning with transnational objectives. Developing a common implementation strategy with technical support, capacity-building initiatives, and clear guidelines for integrating national systems into transnational networks can further alleviate concerns and facilitate participation.

Besides the practical benefits of committing to transnational biodiversity monitoring schemes, it's worth underscoring the ethical and ecological imperatives of collaboration. Biodiversity loss, climate change, and the spread of invasive species are challenges that transcend national boundaries, requiring coordinated, large-scale responses. Transnational networks provide the necessary infrastructure and frameworks to address these challenges, ensuring that monitoring data informs

effective conservation strategies and policy decisions, while building trust and resilience to economic shocks or international crises like COVID-19. By committing to these schemes, countries not only fulfil their international obligations but also contribute to a shared vision of a more sustainable and resilient future for Europe's ecosystems.

Not all biodiversity monitoring schemes, however, are equally suited for transnational collaboration. A clear framework for selecting strong candidates is essential to ensure that resources are allocated efficiently and that the chosen schemes have the potential to deliver meaningful ecological, scientific, and policy outcomes.

Criteria for policy

Policy relevance emerged as the most critical criterion for selecting transnational biodiversity monitoring schemes. Monitoring programs that align with key European and international obligations — such as the Kunming-Montreal Global Biodiversity Framework (KMGBF), the EU Biodiversity Strategy 2030, European Directives, the Common Agricultural Policy, the Pollinator Initiative, and the Nature Restoration Regulation — are more likely to secure both political backing and long-term funding. While policy relevance is almost a prerequisite for transnational collaboration, integrating it into a broader evaluation framework ensures that consideration to monitoring schemes excelling in other areas, such as scientific robustness or cost-efficiency, are also given due consideration.

Beyond policy alignment, **transboundary relevance** is another fundamental factor in determining a scheme's suitability for international collaboration. Monitoring programs that focus on taxa with strong transboundary dynamics — such as migratory species, invasive alien species, or species dependent on large-scale habitat connectivity — offer significant added value when harmonised across countries. While this aspect may seem like a prerequisite rather than an evaluation criterion, it is important to recognize that certain monitoring schemes without an immediate transboundary focus may still warrant long-term support. This could be due to the exceptional quality and consistency of the data they provide across multiple states or their high potential for scalability and integration into broader monitoring efforts.

In addition to these criteria, a scheme's **capacity to generate actionable knowledge** from its data should be carefully assessed. Programs that can effectively link observed trends to underlying pressures, or that provide clear assessments of management interventions, are inherently more valuable for transnational cooperation. However, while harmonizing direct conservation actions at a transnational scale can be complex due to differences in national policies and management strategies, evaluating pressures — such as habitat loss, climate change, or pollution — can be achieved more consistently across borders. Consequently, monitoring schemes that facilitate this type of analysis offer a strong foundation for evidence-based policymaking and should be prioritised accordingly.

Criteria for readiness

Readiness is another critical factor in selecting transnational monitoring schemes. This criterion evaluates whether a program has the necessary infrastructure, expertise, and capacity to scale up and integrate into a broader network. Strong candidates typically already possess a degree of readiness, such as established methodologies, evidence of statistical robustness (e.g., power

analysis to ensure adequate sample sizes for detecting trends), existing datasets, or a network of trained personnel and experts. Additionally, the feasibility of a scheme depends on its scalability and flexibility. The first one is the ability to expand, adapt, or integrate into broader monitoring efforts, while the second one is the ability to adapt its methods, protocols, or data collection approaches to different ecological contexts or to resource availability, all while maintaining data quality and methodological consistency. Silva del Pozo, M. & Body, G., (2022) have provided recommendations on protocol flexibility.

Criteria for cost-effectiveness

Transnational monitoring schemes must demonstrate that their benefits outweigh the costs, considering not only financial expenses but also the human and technical resources required for implementation and their availability. Evaluating the cost of data production is essential but can be challenging due to factors such as reluctance from partners to share financial details, legal constraints, or difficulties in extracting precise figures. Despite these challenges, cost assessment remains crucial for comparing and prioritizing monitoring schemes effectively. The presence of sustainable funding mechanisms in some countries provides a significant advantage, as having dedicated partners strengthens the overall resilience of the network. Additionally, capacity requirements must be carefully considered. Monitoring methods that rely on specialized expertise, advanced technical skills, or complex infrastructure may limit broad participation. To address this, joint training programs can be developed to build capacity, while grouping countries based on their expertise levels can facilitate mentorship and knowledge exchange within the network. Finally, the initial short-term costs of joining the network and establishing an operational monitoring scheme should be distinguished from long-term running costs. This is particularly relevant for novel technologies used in semi-automated monitoring, which may require higher upfront investment but offer lower maintenance and operational expenses over time.

Criteria for data management

Criteria for data management rely on the principles of good data management. Strong candidates must have clear and accessible data management practices, including adherence to FAIR (Findable, Accessible, Interoperable, Reusable) principles. The availability of shared repositories and tools for data quality checks ensures that the information produced by the scheme can be effectively utilized by multiple stakeholders and participants in the network. Programs with robust data sharing protocols and tools, such as APIs for access, stand out as reliable candidates for inclusion in a transnational network.

Another criterion, although not fitting into the previous categories, was still included in the final list and will be further reviewed. The degree of **community and stakeholder engagement** was also highlighted as a factor, though opinions varied on its weight depending on the type of scheme. Programs that involve local communities, NGOs, or citizen scientists often benefit from increased visibility, public support, and access to volunteer networks. This can reduce costs and foster a sense of shared responsibility for biodiversity conservation, contributing both to cost-efficiency and policy. However, this criterion may be less relevant for schemes that rely heavily on technical expertise or specialized methodologies.

In summary, the selection of strong candidates for transnational and long-term biodiversity monitoring schemes must balance ecological, scientific, and practical considerations. **Programs that align with policy objectives, deliver high-quality and harmonised data, demonstrate scalability and feasibility, and address transboundary challenges are the most promising candidates.**

Lessons learned & recommendations

The two workshops provided valuable insights into overcoming the complexities of establishing transnational biodiversity monitoring schemes. A central challenge lies in harmonizing methodologies and governance structures across multiple countries, each with differing national priorities, institutional capacities, and policy frameworks. Addressing this requires a multi-layered strategy that ensures policy alignment while allowing methodological flexibility.

One of the most significant contributions of the Biodiversa+ pilots has been their role in stress-testing governance models and operational structures for transnational monitoring. By acting as experimental frameworks, these pilots have revealed the administrative, logistical, and scientific hurdles that arise when attempting to integrate national efforts into a cohesive long-term system. They have also highlighted the need for early-stage agreements on data governance, stakeholder responsibilities, and financial sustainability.

A major takeaway from the workshops is that **achieving transnational coordination requires a dual approach: establishing common criteria for monitoring schemes while maintaining adaptability to national contexts**. The criteria covering aspects such as policy relevance, feasibility, cost-effectiveness, and scalability can provide a foundation to develop a framework that will support the partnership in reaching consensus among participating countries. These criteria, once refined into a proper multi-criteria decision framework, can enable the partnership to evaluate which monitoring initiatives offer the greatest potential for long-term sustainability and policy impact.

Additionally, the workshops highlighted that integrating novel technologies into monitoring schemes can enhance efficiency and scalability. However, the absence of standardised methodologies for these technologies remains a major risk in the perspective of transnational harmonisation. The Biodiversa+ pilots have played a key role in identifying pathways to mitigate this risk by advocating for co-development processes where methodologies are defined collaboratively from the outset, ensuring compatibility across borders while maintaining scientific rigor.

Overall, the workshops reinforced that achieving a stable and effective transnational monitoring network hinges on structured collaboration, early agreement on key operational criteria, and an adaptable governance framework. The Biodiversa+ pilots have proven instrumental in laying the groundwork for this, providing tested strategies that can inform policy decisions and ensure long-term commitment from participating countries.

Comparative analysis of top-down and bottom-up approaches

Top-down approaches provide a structured and policy-driven framework for biodiversity monitoring, making them particularly suitable for mandated schemes. These schemes benefit from strong governmental backing and long-term funding stability, allowing for systematic data collection and cross-national standardization. However, implementing these approaches at scale requires extensive coordination and administrative capacity to ensure consistent methodologies across national borders. The rigidity of top-down structures usually limits adaptability to emerging scientific developments or conservation priorities, necessitating periodic updates to ensure continued relevance.

In contrast, bottom-up approaches thrive in environments where local expertise, research institutions, and citizen science play a significant role. These schemes offer flexibility in data collection and adaptability to specific regional needs, but they often struggle with funding continuity and methodological harmonisation. The reliance on short-term project funding and voluntary contributions can create instability, making it difficult to sustain long-term data collection efforts and policy integration.

A hybrid approach seeks to balance the strengths of both models, ensuring top-down policy alignment while maintaining the adaptability and engagement inherent in bottom-up initiatives. This approach is particularly beneficial for large-scale biodiversity assessments, where harmonisation governance ensures long-term sustainability, while de-harmonisation implementation allows for methodological innovation and regional customization. In hybrid models, governmental funding can be leveraged for core operations while enabling external grants, philanthropic contributions, and partnerships with research institutions are used to support specialized monitoring efforts. Coordination bodies should focus on maintaining a functional support infrastructure and keeping the community of practitioners engaged and connected. Incorporating the needs of conservation practitioners—who depend on specific monitoring actions to support informed site management—into a top-down monitoring approach can serve as an example of a hybrid model.

Table 2: Summary of top-down, bottom-up and hybrid approach

Approach	Best suited for	Strategic advantages	Challenges	Implementation
TOP-DOWN	Mandated monitoring schemes where compliance with international regulations ensures data consistency and alignment with policy objectives	Stable funding Governmental or EU commitments Facilitates standardisation across partner countries	Complex administrative structures to ensure consistency Rigid methodologies may limit adaptability to emerging conservation needs	Works best when applied to legally binding monitoring initiatives with long-term policy commitments, ensuring consistent financial and institutional support

Approach	Best suited for	Strategic advantages	Challenges	Implementation
BOTTOM-UP	Data-intensive monitoring schemes where partner organisations, research institutes, and citizen science efforts generate large volumes of biodiversity data	Cost-efficient High stakeholder engagement Leveraging existing expertise	Continuous grant applications for funding; heterogeneity in methodologies may impede data harmonisation	Well-suited for taxa monitoring schemes that already produce substantial data, allowing standardization efforts to emerge organically from within the network rather than being imposed externally
HYBRID	Monitoring schemes that require both structured policy integration and flexibility in data collection and implementation, such as large-scale biodiversity assessments where local expertise enhances national and transnational coordination	Ensures long-term funding and policy alignment while maintaining adaptability to scientific advancements and regional conditions	Requires careful governance structuring to avoid inefficiencies; may necessitate complex stakeholder agreements to balance harmonisation decision-making with local autonomy	Works best when establishing a harmonisation policy framework with embedded flexibility for regional customization, encouraging both institutional backing and grassroots scientific contributions

Strategies for establishing sustainable biodiversity monitoring schemes

1) Strengthen governance and coordination mechanisms

The choice between a bottom-up or top-down approach depends on whether the primary challenge is lack of harmonisation (existing but fragmented data) or lack of data collection itself (inconsistent or missing data):

- If multiple organisations, research institutes, or citizen science networks are independently gathering biodiversity data, but there is no overarching framework linking their efforts, a **bottom-up approach** can incentivise the formation of a coordination centre to harmonise methodologies, ensure interoperability, and integrate disparate datasets. Since data is

already being produced, the goal is to bring stakeholders together and ensure that locally collected data can be meaningfully integrated at a higher level.

- If data collection is lacking, inconsistent, fragmented, or carried out with no standardised protocol, a **top-down approach** is more appropriate. A harmonisation framework can define what, where, and how data should be collected to ensure it meets policy and conservation needs, before decentralization can happen. Once the monitoring framework is established, data collection, analysis, and coordination responsibilities can be transferred to regional or local stakeholders, shifting the role of the central body from direct management to oversight coordination.
- A **hybrid model** can ensure structured coordination at the transnational level while allowing adaptive governance at the national or regional level. Hybrid models become necessary when some regions or taxa have extensive monitoring while others lack sufficient coverage. A hybrid approach can allow bottom-up coordination in data-rich regions while implementing top-down-driven standardization in data-poor areas to create a fully integrated monitoring scheme. Hybrid models that leverage both top-down and bottom-up strategies can create a balance between harmonisation policy alignment and localised adaptability, though they require careful structuring to prevent inefficiencies.

2) Secure long-term funding

- Top-down models should focus on embedding biodiversity monitoring into existing and emerging policy frameworks such as the EU Biodiversity Strategy 2030 to ensure continued governmental support.
- Bottom-up initiatives should develop cost-sharing models among partner institutions and explore innovative funding mechanisms, such as fee-based access to standardised biodiversity datasets.
- A hybrid approach could leverage governmental funding for core operations while relying on external grants, philanthropic contributions, and private sector partnerships to support innovation and expansion.

3) Promote standardised and scalable methodologies

- For schemes with established datasets: prioritise alignment of data management and reporting standards through capacity-building workshops and knowledge-sharing platforms.
- For newly formed networks: ensure central coordination bodies define harmonised monitoring metrics including through the EBVs framework and related data needs before expanding data collection efforts.
- Leverage novel technologies: while the initial setup of technologies such as automated image recognition, eDNA, and remote sensing can be costly, they offer significant long-term cost-efficiency. These technologies can streamline data collection, reduce manual

labour costs (rubber-boots monitoring), and enhance standardization across transnational monitoring networks.

4) Ensure policy relevance and integration

- Schemes aligned with regulatory directives should operate within a top-down structure, ensuring that the resulting data informs EU-wide conservation policies and strategies. Schemes that can effectively link observed trends to underlying pressures would be particularly policy relevant.
- Schemes driven by scientific and citizen science contributions should build credibility by demonstrating data reliability before seeking formal policy integration.
- Develop transnational strategies for emerging monitoring methods: while novel technological solutions present a frontier for biodiversity monitoring, the lack of well-established methodologies poses a risk. Implementing these monitoring techniques at a transnational scale requires a co-development approach, fostering collaboration to standardize methods *a priori* before full deployment.
- A hybrid model would allow top-down integration of standardised metrics while incorporating bottom-up scientific expertise to refine and adapt methodologies to regional ecological conditions.

5) Build capacity and foster collaboration

- Top-down schemes should prioritise structured training programs to ensure compliance with standardised methodologies.
- Bottom-up initiatives should leverage community-driven engagement to build strong networks of regional expertise while maintaining flexibility in data collection methodologies.
- Facilitate harmonisation and standardization from inception: new technological monitoring methods provide an opportunity to establish common protocols early in development, minimizing later discrepancies. Improving transnational comparability can be a driver for shared monitoring schemes and an incentive to adopt common framework based on EBVs.
- A hybrid approach should incorporate EU-wide training initiatives while fostering regional knowledge-sharing networks, ensuring effective capacity-building across diverse monitoring landscapes.

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Annex I - Questionnaire to case studies

ORGANISATIONAL STRUCTURE

1) **Can you describe the governance structure of your network?**
   a) Who are the key decision-makers, and how are decisions typically made?
   b) How are responsibilities divided between the central coordinating body and regional or local units?
   c) What roles do different stakeholders (e.g., government agencies, NGOs, research institutions, local community) play in the network's governance?
   d) How is role clarity ensured?
   e) Any involvement from the broader community (i.e., citizen science, local communities etc.)?
2) **How frequently does the governing body meet, and what are the typical agenda items for these meetings (i.e., what's being discussed in these meetings)?**

FUNDING

3) **What is the funding model for the network?**
   a) What are the most stable funding sources in your network?
   b) What are the most demanding tasks in managing the scheme? (i.e.: ensure policy support, manage partners, manage data, …)
   c) Is sourcing/searching of funding managed or facilitated centrally within the network?

NETWORK

4) **Do you have legal agreements in place with members of the network?**
5) **How are new members or partners integrated into the governance structure?**
   a) How are new potential members or partners found? Is there active work to extend the network?
   b) Are there specific criteria or processes for joining the network?
6) **What strategies do you use to maintain effective communication and coordination among the network's stakeholders?**
   a) Are there specific tools or platforms you rely on for this purpose?
7) **What are the primary challenges you've encountered in managing the network?**
   a) How have these challenges been addressed?
8) **Can you share any lessons learned or best practices from managing the governance of this network that could inform similar initiatives?**
9) **How do you keep contributors engaged? What is the main driver for joining this monitoring scheme? (bottom-up consensus)**

DATA

10) **How is data access, availability and ownership dealt with?**
    a) Who owns the data?
    b) How is data accessed?
    c) Is the data available to other partners/third parties/general public?
    d) Who does data analysis on an international scale?
11) **How is data managed?**
    a) What kind of data format do you store?
    b) Do you get the primary/raw data or secondary data?
    c) Assuming that the scheme is intended to continue indefinitely, how do you secure long-term storage space for a continuously growing volume of data?
12) **What is the procedure for data quality check? (i.e.: correct identifications, data format consistency, …)**
    a) In case of strict protocol: how do you ensure protocol are respected?

POLICY AND SUPPORT

13) **Policy mandates are crucial for monitoring. How did you successfully demonstrate your network's importance, to gain and maintain support from policy mandates and decision makers? (top-down consensus)**
    a) What are the strategies in place to support the network's long-term sustainability and adaptability to change?
    b) Are the goals aligned with any (inter-)nationally stated monitoring goals?
    c) Are there plans for restructuring or improving governance in the future?
    d) What makes this scheme/network so successful?