biodiversa+
European Biodiversity Partnership

EUROPEAN PARTNERSHIP

Biodiversa+ strategic biodiversity monitoring governance document (Phase 1)

Co-funded by
the European Union

Document Information

Grant Agreement number:	101052342
Project acronym	Biodiversa+
Project full name	The European Biodiversity Partnership
Biodiversa+ duration:	7 years
Biodiversa+ start date	Start date: 1st October 2021
More information about Biodiversa+	Website: www.biodiversa.eu Email: contact@biodiversa.eu @BiodiversaPlus Biodiversa+

Deliverable title:	D2.8 Strategic document on the options towards governance structure of transnational biodiversity monitoring schemes, national Biodiversity Monitoring Coordination Hubs, European Biodiversity Monitoring Coordination Centre (BMCC) and other relevant initiatives (PHASE I)
Authors:	Biodiversa+: Petteri Vihervaara (MoE_FI), Aino Lipsanen (MoE_FI), Tanja Suni (MoE_FI), Cécile Mandon (FRB), Hilde Eggermont (BelSPO), Guillaume Body (OFB), Mathieu Basille (OFB), Mona Naeslund (SEPA), Michelle Silva Del Pozo (OFB), Alberto Basset (MUR), Senem Onen Tarantini (MUR), Lars Dinesen (IFB), Toke Hoye (MoE of DK), Rob Hendriks (LNV), Anna Heck (VL O), David Eichenberg (BMU). EuropaBON: Ian McCallum, Camino Liquete. EC: Joachim Maes. GBIF: Mélianie Raymond, Tim Hirsch. EEA: Jan-Erik Petersen, Markus Erhard, Janica Borg.
Contributors/reviewers:	Acknowledgements to the reviewers of the report for their valuable contributions: EC: Bastian Bertzky (RTD), Jessika Giraldi (ENV), Ute Goerres (ENV), Laura Palomo Rios (REA), Aletta Bonn (EuropaBON).
Work package:	WP2 Promote and support transnational biodiversity monitoring
Task or sub-task title:	Task 2.5: Establish a transnational network of national biodiversity monitoring schemes (for specific domains)
Picture credits:	© Pixabay (cover picture)
Release date:	May 2023

Table of contents

What is Biodiversa+

Biodiversa+ is the new 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/

Table of acronyms

BISE	Biodiversity Information System for Europe
BMCC	Biodiversity Monitoring Coordination Centre
EBCC	European Bird Census Council
eBMS	European Butterfly Monitoring schemes
EBVs	Essential Biodiversity Variables
EC	European Commission
EEA	European Environment Agency
EOSC	European Open Science Cloud
EPA	Environmental Protection Agency
EU	European Union
EuropaBON	Europa Biodiversity Observation Network: integrating data streams to support policy
FAIR	FAIR data principles: Findable, Accessible, Interoperable, Re-usable
GBF	Kunming-Montreal Global Biodiversity Framework
GBIF	Global Biodiversity Information Facility
GEO BON	The Group on Earth Observations Biodiversity Observation Network
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre (European Commission)
KCBD	Knowledge Centre on Biodiversity
LUCAS	Land Use/Cover Area frame statistical Survey Soil
MoE	Ministry of the Environment
MoU	Memorandum of Understanding
MS	Member State
NGO	Non-Governmental Organisation
PECBMS	Pan-European Common Bird Monitoring Scheme

Executive Summary

This report compiles a first overview of the European biodiversity monitoring governance landscape including both national and sub-national viewpoints as well as the outcomes of the EuropaBON project and its proposals for a BMCC, plus feedback from JRC (as a member of EuropaBON consortium), EEA and GBIF as bodies that already support the compilation of biodiversity monitoring data. In addition to them there are also other international networks, research infrastructures and initiatives, but they are not covered in this phase I report.

Biodiversa+ aims at developing a transnational network of national biodiversity monitoring schemes across Europe. This report is the first phase to describe the state-of-the-art of current national and sub-national biodiversity monitoring schemes, and to synthesise this knowledge to inform the more general development of a European biodiversity monitoring governance and coordination for the future. With this purpose, this report aims to combine both national and EU-level perspectives by presenting views of national experts from the ministries of environment and environmental protection agencies, and European viewpoints based on the biodiversity monitoring experts from academia, international organisations and the European Commission (EC). This work will also build on the findings of and collaboration with the EuropaBON project, as well as consultations and contributions with other relevant organisations and initiatives such as EEA, GBIF and DG ENV, as well as JRC as a member of consortium.

The material for this report has been collected via questionnaires and bi-lateral interviews with Biodiversa+ partners by country during April – June 2022. The Biodiversa+ relevant biodiversity monitoring task leaders have contributed to this report based on their themes, i.e., priorities and indicators, data and protocols harmonisation and interoperability, implementation of novel technologies, and use of monitoring data in research and decision-making. In addition, this report builds on the outcomes of a workshop with the Biodiversa+ Environmental Protection Agencies (EPA) and Ministries of Environment (MoE), EuropaBON and the several representatives of the European Commission organised on 15th September 2022 in Madrid, which provided valuable material for sketching of possible governance structures for an European biodiversity monitoring network. Input was also provided during an expert workshop on data analysis for assessing biodiversity status and trends, which was held online on 29th September 2022. Besides of those, further discussions were arranged during other international meetings, such as a joint workshop of GBIF and Biodiversa+ in Brussels in October 2022, followed immediately by the KCBD meeting and the EuropaBON Stakeholder Conference jointly organised with Biodiversa+ in November 2022, and scientific conferences, such as World Biodiversity Forum in Davos in June 2022, and European Conference on Conservation Biology in Prague in August 2022.

This report will provide an important building block for joint development of a multi-scale European biodiversity monitoring coordination. Recommendations for the next steps will feed into the Phase II report (deliverable 2.9) by February 2024, and development of the Work Plan of Biodiversa+ for years 3-4 from November 2023 to October 2025, and they will be aligned with the Terms-of-Reference of the European Biodiversity Monitoring Coordination Centre (BMCC) to be proposed by EuropaBON in 2024.

1. Elements of operational transnational biodiversity monitoring network

In this chapter, some general background and the key elements of transnational biodiversity monitoring schemes are presented.

1.1 Transnational biodiversity monitoring is needed

Stable and long-term time series on biodiversity are essential to describe key biodiversity trends as a basis for analysing the impact of socio-economic changes on it by connecting the different variables in one analytical framework. Biodiversity monitoring has been based for a long time on the work of natural history societies and researchers (earliest observations starting from the 17th century) as well as inventories organised by volunteer species experts. More systematic environmental monitoring started with natural resources during the early 20th century. For instance, the first national forest inventories were arranged in Finland 1921-1924 and Sweden 1923-1929, followed by France 1960-1980, Austria 1961-1970, and Germany 1984-1990. Monitoring of the visibility depth on the Baltic Sea started 1905. Most of the species monitoring schemes are launched relatively recently and they cover only time spans of 10-40 years so far. It is obvious to say that the availability of good forest inventory data has been the basis for the entire industry sector development and state economy; the same should be true now for all biodiversity, for the sake of comprehensive sustainability of society. “You can’t manage what you can’t measure.”

Big acceleration in environmental change has forced the development of harmonised monitoring of climate, land use changes, pollution etc. to mitigate negative impacts of those changes to society as well as to nature. For instance, harmonised climate measurements and definition of the Essential Climate Variables as well as establishment of networks of monitoring stations has been crucial for improved climate forecasts and climate scenarios. Biodiversity loss and degradation has been recognised as such a serious threat to human well-being, that improved monitoring systems are urgently needed. Biodiversity is even more difficult to monitor than climate due to its complexity and various dimensions, such as diversity of genetics, species and communities, and ecosystem structure and function. The Essential Biodiversity Variables (EBVs) approach developed by GEO BON provide a useful framework to monitor biodiversity, and its relevance for the future biodiversity monitoring governance in Europe has been also recognised by the large group of stakeholders in EuropaBON project (e.g., Moersberger et al. 2022; Junker et al. 2023) and globally, in the context of the Convention on Biological Diversity (CBD)[1].

Today, many biodiversity monitoring schemes are scattered, having spatial, temporal, and taxonomic gaps. Many currently ongoing monitoring schemes are designed for different purposes, with different methodologies used in different countries, and with different sampling set-ups and monitoring frequencies (cf. Morán-Ordóñez et al. 2023). In many countries, biodiversity monitoring

[1] GEO BON INDICATORS FOR THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK, https://www.cbd.int/doc/c/815b/9afa/941a22fc6c8760acbf3ab6a3/geobon-headline-indicators-en.pdf

schemes are entirely missing. Because of that, we are today in a situation that transnational biodiversity monitoring schemes need to be renovated and partially established for the missing fields, and comprehensively harmonised to make data comparable, interoperable, and usable for the increasing needs of the society. This calls for wide collaboration of all the biodiversity monitoring authorities and networks.

The European Commission (EC) and the EU Member States (MS) have adopted the EU Biodiversity Strategy to 2030 that aims at stopping the loss of biodiversity and improving the state of ecosystems by 2030. In addition, parties to the Convention on Biological Diversity (CBD) have now agreed on goals and targets within the Kunming-Montreal Global Biodiversity Framework (GBF) including concrete measures to halt and reverse biodiversity loss, such as putting 30% of the planet under protection and restoring 30% of degraded ecosystems on land and sea by 2030. Parties also agreed on a monitoring framework, and underscored the importance of national, regional, and global biodiversity monitoring systems, cooperation across borders and capacity building. Besides of these leading policy processes, there are vast need for biodiversity data across the society (e.g., Green Economy, EU Taxonomy on Sustainable Finance) and among the more specified policies (e.g., Invasive Alien Species Regulation).

The European Biodiversity Partnership (Biodiversa+) was launched as part of the implementation of Horizon Europe and to support implementation of the Biodiversity Strategy. It is co-funded by the EC and the partners, having altogether an over 800M€ budget for years 2021-2028. One of the aims of Biodiversa+ is to establish a transnational network of (sub-)national biodiversity monitoring schemes across Europe, to effectively measure progress towards the new targets. This provides a great opportunity to enhance and improve transnational collaboration on the working area of biodiversity monitoring, together with other relevant international key initiatives and organisations.

1.2 Design of the European biodiversity monitoring governance landscape is on-going

The European Biodiversity Partnership (Biodiversa+) has recognised development of biodiversity monitoring as one of the key working areas among its partners that include ministries of the environment and environmental protection agencies from 28 countries, who are also key implementers of environmental policies and international agreements. Biodiversa+ started its work in October 2021, in close cooperation with EuropaBON project that aims at developing a Terms of Reference for the European Biodiversity Monitoring Coordination Centre (BMCC) (Fig 1). More specifically, Biodiversa+ aims to:

- Understand national and subnational biodiversity governance structures and priorities, and potential synergies with European and global policy priorities and work;
- Enrich and test EuropaBON outcomes in different countries/contexts;
- Co-develop solutions to overcome the challenges and bottlenecks identified by EuropaBON, including on governance aspects[2];
- Increase ownership of proposed solutions by environmental policy actors/member state competent authorities as well as other important players and stakeholders in the field;

[2] Europa Biodiversity Observation Network: User and Policy Needs Assessment (2022): https://preprints.arphahub.com/article/84517/

- Provide a space for knowledge transfer and capacity building;
- Help to ensure long-term sustainability of biodiversity monitoring efforts in Europe.

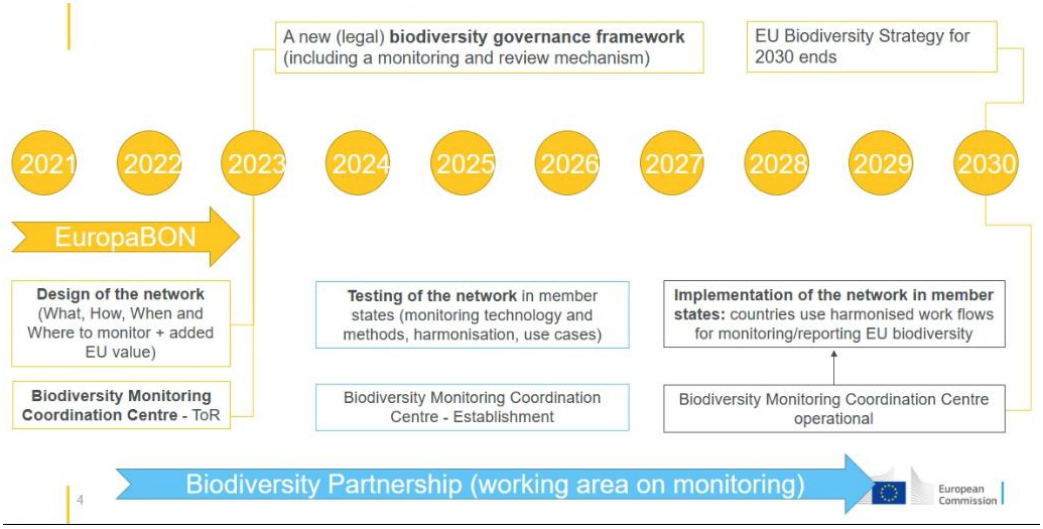

Fig. 1: Proposed timeline of the shaping of the European biodiversity monitoring framework (Source: The ad-hoc working group on monitoring, the EU's knowledge centre on biodiversity, by Camino Liquete).

1.3 A challenge: how to integrate national monitoring networks into a general European system?

Biodiversity monitoring networks are often local, and their practices vary a lot. Almost 1000 databases and monitoring networks have been recognised in EuropaBON[3] (including previous databases recognised in EBONE, EUBON and EuMon projects) (Morán-Ordóñez et al. 2023) and are reflected in the EuropaBON database (Monitoring database – EuropaBON) . Most of the species monitoring networks are rather independent and based on volunteer contributions of citizen scientists, and only seldom coordinated by international non-governmental organisation (NGO) or national governmental organisation. There are exceptions such as the European Bird Census Council (EBCC) compiling census data for atlas mapping, and Butterfly Conservation Europe coordinating European Butterfly Monitoring schemes (eBMS). These examples could provide a good model for other species monitoring schemes for synthesising their surveys and results and organising their collaboration.

The KCBD's ad-hoc group meeting on monitoring that took place in 2022 addressed various issues which need to be taken into consideration when developing European biodiversity monitoring governance. Biodiversa+ presented some issues being particularly relevant for the work, for instance:

[3] EuropaBON biodiversity monitoring database: https://monitoring.europabon.org/monitoring/

1. The unclear alignment between policy and management needs versus monitoring capacities, on biological and geographic scales: setting up biodiversity monitoring protocols that can provide answers at the European scale may not be useful for the Member States in their duty to report at their own scale.
2. When it comes to coordination of monitoring efforts, dataflows between governments and the private sector can also be improved.
3. For the standardisation, enhanced data gathering and sharing: Biodiversa+ sees potential in Essential Biodiversity Variables (EBVs). Yet, at this stage, EBVs remain rather poorly known by Ministries of environment and environmental protection agencies, thus limiting their application at this level. More time will be needed to explain their potential, and to align them with policy needs such as EU reporting and indicators for EU biodiversity strategy and global indicators (Kunming-Montreal Global Biodiversity Framework). Biodiversa+ is working on this. Nevertheless, the EBVs should not replace other policy indicators but indeed align with them to provide another layer of information that can be used for policy.
4. In relation to funding: sustainable funding will be needed to support long-term monitoring efforts. This is especially true for smaller and Central and Eastern European countries.
5. For capacity building, the link with natural history societies is important. For instance, one objective of the SPRING[4] and TETTRIS[5] projects is to enhance naturalist and taxonomist capacities in the long-term.
6. The coordination of NGO programmes might be very hard to achieve, and unrealistic without appropriate funding (currently at national and sub-national levels).
7. While the production of European and national reports on biodiversity trends is closely linked to biodiversity monitoring *sensu stricto*, the production of integrated assessments looking at policy drivers and sectoral pressures, for example, is a function already performed by others – including research institutions and bodies such as the EEA. It is important to avoid duplication in this regard. It is also important to ensure that the raw data used to develop those integrated assessments is made available and can be compared across the MSs.
8. Some countries are already developing national coordination hubs while others don't have such plans yet or are building on current structures. This variation/differentiation will need to be accounted for in the design of the European biodiversity monitoring governance structure.

Multiscale biodiversity monitoring landscapes need clear orchestration for coordinated observations. It is important to define functions and roles of national coordination centres/ hubs in accordance with the design of the European Biodiversity Monitoring Coordination Centre (Fig 2). One of the major obstacles for harmonised biodiversity monitoring has a tendency to divide strongly between terrestrial, freshwater and marine monitoring systems (Vihervaara et al. 2023). On a general level, attention should be paid to developing solutions related to three aspects of biodiversity monitoring governance:

[4] SPRING: https://pollinator-monitoring.net/
[5] European Citizen Science Association. TETTRIs | Transforming European Taxonomy through Training, Research, and Innovations. https://www.ecsa.ngo/cases/tettris/

1. Structure of overall coordination at (sub-)national and EU scales;
2. Harmonisation of the monitoring schemes, including both raw data (as far as possible) and the indicators, and filling the gaps in the current monitoring landscape;
3. Data interoperability and harmonised data infrastructures to enhance dataflows and provisioning of FAIR data, i.e., findable, accessible, interoperable, re-usable (Wilkinson et al. 2016; Silva del Pozo & Body 2022).

These viewpoints are explained more below. In addition to those aspects, it is also important to consider the role of the research, public and private sectors both as users and providers of biodiversity data.

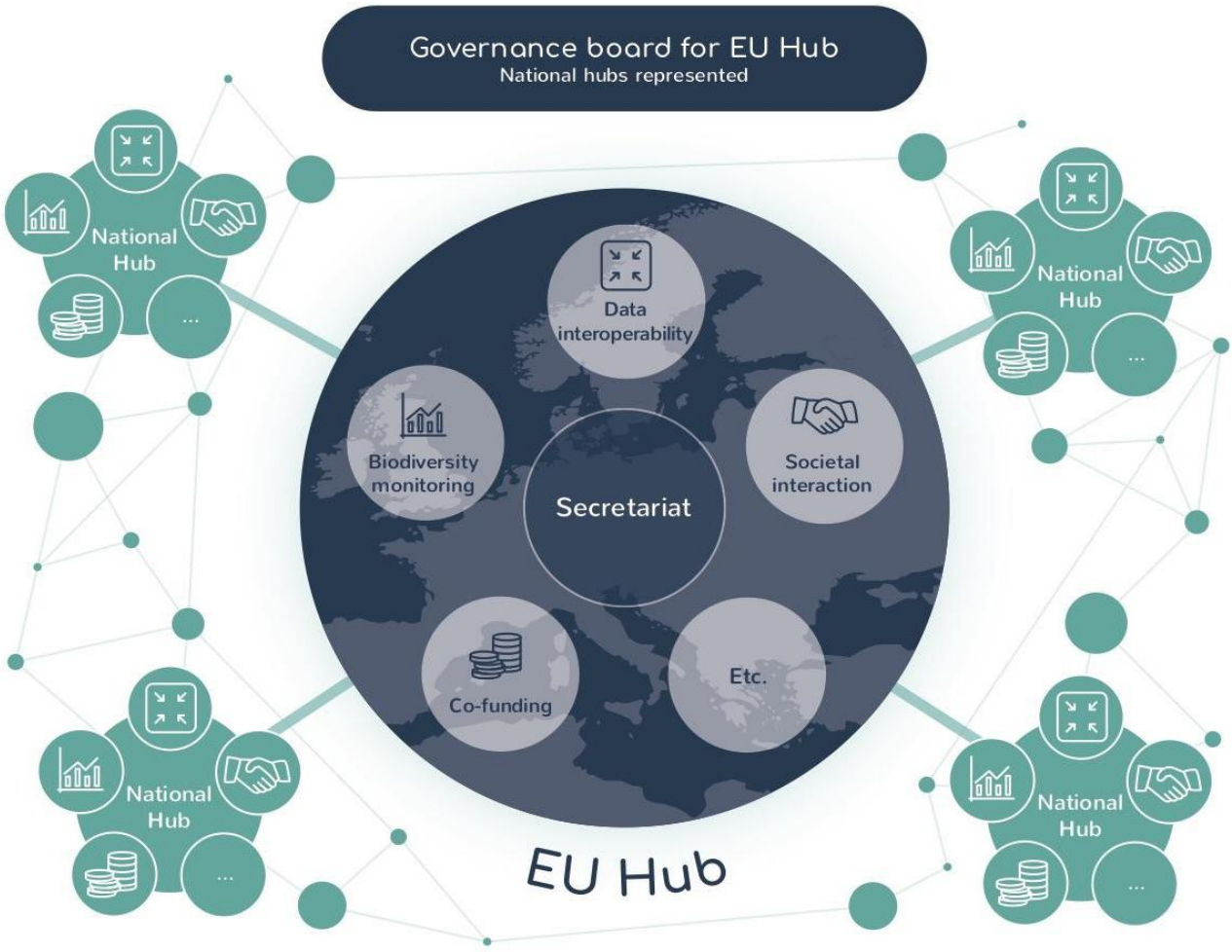

Fig. 2: Illustration of a multiscale governance model of the European biodiversity monitoring hubs. National hubs can be flexible entities/platforms or refer to a coordinating organisation that is responsible for biodiversity and ecosystem assessments and implementation of international environmental policies and agreements. Hubs can include and host functions such as networking, funding, steering, coordination of biodiversity monitoring, and data management. National hubs can provide synergies for national Eionet members, national GBIF nodes and national biodiversity observation networks (BONs).

This report compiles a first overview of the European biodiversity monitoring governance landscape including both national and sub-national viewpoints as well as the outcomes of the EuropaBON project and its proposals for a BMCC, plus feedback from EEA and GBIF as bodies that already support the compilation of biodiversity monitoring data. In addition to them there are also other international networks, research infrastructures and initiatives, but they are not covered in this phase I report.

1.4 The protocols used in existing monitoring programmes

Currently, different approaches for biodiversity monitoring at a transnational scale can be found in the literature and in existing monitoring programmes, noticeably in terms of protocol type and biodiversity information management (Silva del Pozo & Body 2022). Three main **protocol types** are used for the existing monitoring programmes:

1. **Strict**: one strict standardised protocol is applied equally in the entirety of the territory covered by the monitoring programme.
2. **Flexible**: one general protocol is applied, tolerating some flexibility on certain protocol implementation choices (e.g., defining the collection sites, the frequency at which the methods are carried out), which allows a better adaptation of the programme to the particular context of each country.
3. **Open**: independent protocols are applied in the different regions or countries.

Regarding the **data management** in the information chain, in particular the level at which the biodiversity information is aggregated to inform decision-making, two main strategies have been identified based on the literature, but which could also be implemented to steer European biodiversity monitoring data handling and integration:

1. Aggregating and processing nationally produced EBVs or indicators: each country is in charge of collecting and treating the data *via* a standardised protocol, then providing this standardised outcome (EBVs or indicators) to a higher structure that assembles them to have a trans-continental overview. This strategy fits, in particular, for in-situ collected EBV data workflows.
2. Processing raw data at a trans-national scale: raw data are submitted to a common centralised structure for a joint analysis for all countries involved to produce trends and indicators. This strategy fits, in particular, for remote-sensing enabled EBV data workflows.

In addition to these two main strategies, also a third strategy (resembling very much the current “real-world” situation) can be recognized where countries collect data using their own protocols and standards (e.g., habitat quality), then aggregate and assess that via a standardized protocol (e.g., favourable conservation status of the Habitat Directive) and after that, the country reports are aggregated at EU biogeographic level.

Different combinations of strategies are possible to deliver general trends and indices at the trans-national scale, with three main ones that seem to prevail: (1) applying one common strict protocol in all countries involved and aggregating raw data for joint analysis; (2) different protocols are applied across the different countries, each protocol gathering data which are treated locally to produce defined EBVs or indicators, which are then aggregated at the trans-national level; (3) applying a

protocol allowing some flexibility for an adapted implementation to each country, and treating data both locally and at the trans-national level.

For example, the Land Use/Cover Area frame statistical Survey soil module (LUCAS Soil) (2009–ongoing) follows the first combination of strategies (1). Data is collected according to a strict protocol for all EU Member States. All soil samples of the LUCAS surveys have been analysed by a single accredited laboratory since the beginning of the programme, the SGS Hungária Kft in Hungary. This choice was made by the programme to reduce unknown systematic errors and inter-laboratory bias between countries.

An example of a programme following the second combination of strategies (2) is the Pan-European Common Bird Monitoring Scheme (PECBMS) (2002–ongoing). EU Member States carry out independent monitoring schemes, having their own methods for their national bird monitoring programmes and following an already established monitoring tradition. Annually, the national coordinators send the national yearly indices per species and yearly all-sites total counts per species to the PECBMS central coordination unit based at the Czech Society for Ornithology, where supranational yearly trends are produced.

In addition to these two examples, the assessment of habitat quality for Habitat Directive reporting provides a third real-world example where raw data is very heterogenous or often based only on expert judgment, but still a harmonised protocol for interpretation of the condition is applied for reporting. Different approaches are found for a harmonised monitoring of biodiversity across countries, yet the question of harmonising and coordinating the different existing monitoring programmes remains.

1.5 The definitions for data interoperability

Biodiversity research e-infrastructures are key components of the research infrastructure landscape at both European and global level (Basset et al. 2023). They support the process of transferring the information content of the data into new knowledge, deeper understanding, and effective actions; the efficiency of this process is based on the extent at which data and datasets are interoperable.

Many different definitions have been proposed so far for the term interoperability when referring to data and datasets or to other categories of digital objects (e.g., Candela et al., 2013). Generally, 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*' (Geraci, 1991). 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*' (Hardisty et al., 2019). Interoperability is also one of the pillars of the FAIR principles, requiring a complete description and a semantic documentation in order to allow computer and software exchange of data and information. Therefore, a first categorical distinction can be done into a *syntactic interoperability*, where two or more systems use the same data formats and communication protocols (Hardisty et al., 2019), and a *semantic interoperability*, when data are transferred in a way that allows the receiving system to correctly understand and use the data exchanged (Heller, 1995; in Hardisty et al., 2019).

By following the EOSC Interoperability Framework (European Commission, 2021), the interoperability can be analysed by four main points of view (as depicted in Fig 3):

- Technical: the ability of different information technology systems and software applications to communicate and exchange data by using the same data formats and communication protocol(s).
- Semantic: the ability of computer systems to transmit data with unambiguous, shared meaning. Data can be hence transferred meaningfully in a way that allows the receiving system to correctly understand and use the data exchanged (Heiler, 1995). The usage of controlled vocabularies and relevant ontologies is a key to achieve semantic interoperability (Stocker et al., 2018).
- Organisational: the way in which organisations align their business processes, responsibilities, and expectations to achieve commonly agreed and mutually beneficial goals.
- Legal: it deals, in particular, on how data should be re-used. Legal interoperability can be achieved when the conditions of use for each dataset are met, and when users can legally access and use each dataset without seeking authorization from data rights holders on a case-by-case basis.

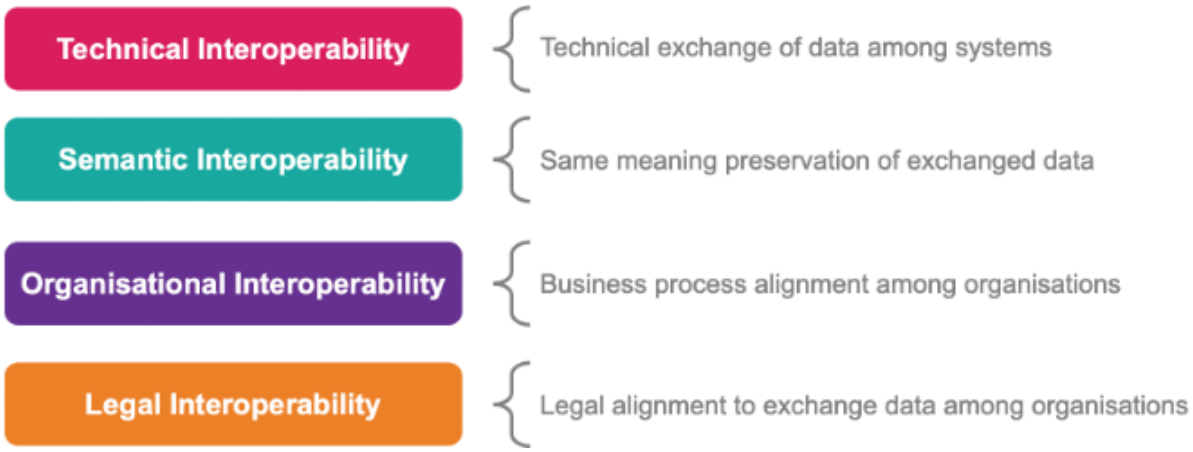

Fig. 3. The interoperability levels according to the EOSC Interoperability Framework

Summary of the main ways to overcome data interoperability and harmonisation challenges were conducted by Basset et al. (2023). The development areas are divided into the following categories:

i) **Knowledge sharing and capacity building**, that includes

- Sharing guidelines and best practices to tackle data interoperability and tool for calculating budget for data management
- Working across disciplines to build capacity within different research communities
- Helping create and mobilising an expert team to data harmonisation
- Mapping existing tools

ii) **Governance**, that includes

- Easing the coordinating interactions between national level nodes and multi-country networks
- Collaboration between key European and national initiatives

iii) **(Meta) Data Standards**, that includes

- Providing guidance on how to harmonise data for: data; dataset metadata; programme metadata
- Supporting the use of standards for monitoring protocols, vocabularies and results
- Funding programmes for data management plans
- Incorporate expertise and trainings

1.6 Use of data for research and decision-making

The workflows for biodiversity monitoring data start from the data acquisition and ends up to the knowledge production. Use of biodiversity monitoring data relates to the knowledge production and there are numerous potential end-users for biodiversity information in the society. Roughly, the use cases of biodiversity data are divided here to research applications and to public and private decision-making.

Use of biodiversity monitoring data in research

Enhanced data flow and increased IT support towards research is needed to overcome current knowledge and capacity gaps regarding:

- Integration of biodiversity monitoring data derived from different methods and tools. (Such as: Field (count) data; eDNA and other molecular biology-based approaches; functional ecological parameters (biological traits, ecosystem function rates); satellite remote sensing; airborne surveys and/or drones; bio-acoustics; camera traps; automated and standardised biodiversity sensor networks; mobile applications for recording and identifying biodiversity);
- Algorithms and machine learning.
- Biodiversity status, dynamics, and trends (with the aim to safeguard biodiversity and to reverse biodiversity loss), including better characterisation of the uncertainties associated.
- Understanding of the effects of combined threats, multiple stressors, and extreme events.

Further needs include both:

- Improved statistical methods for the analysis of biodiversity monitoring data (including spatial patterns and past trends -> For policy evaluation and raising awareness);
- Enhanced use of biodiversity monitoring data in modelling exercises of biodiversity related scenarios (-> Future trends, policy development).

Knowledge development needs to go hand in hand with knowledge transfer in order to stimulate improved application of the research outcomes. For this, capacity building and -development is important. Specific capacities to develop are:

- Those needed to address major issues that directly impact biodiversity and its related contributions to people as well as capacity to address the underlying drivers of change.
- Capacity to identify and replicate good practice, building on experience, and expanding and scaling up what is known to work.
- Capacity to use technology (to stimulate empowerment of less powerful groups, to increase transparency, to mobilise action and to hold actors accountable).
- Capacity to communicate effectively and to tell a good story, so that the true values of biodiversity and ecosystem functions and services are understood and embraced.
- Capacity to locate the necessary resources.
- Capacity to increase human resources and to make better use of citizen science and stakeholder engagement within the monitoring process.
- Capacity to combine ecological and statistical expertise, as well as to combine biodiversity data with long term driver data.

Knowledge transfer and capacity development should have a specific position within the design of biodiversity monitoring governance. It could take the form (or function) of a European level knowledge hub / scientific advisory body / centre of expertise / technical unit (or more generally 'expertise entity') (Fig 2). Or such a role could also be organised as a federated network of such entities, each being part of the different (sub-)national biodiversity monitoring governance structures. In any case it makes sense to avoid duplication of efforts. So rather than installing new entities it may be better to integrate and federate existing bodies responsible for monitoring and research infrastructures.

Use of biodiversity monitoring data in private (and public) decision-making

The demand for use of biodiversity monitoring data in the public and private sector is increasing a lot, while at the same time lack of appropriate monitoring data has become evident. During the first year of Biodiversa+ special attention has been paid to the role of the private sector as potential end-users of biodiversity data, while in the future it is also important to consider use cases from public and civil society. Private sector can play an important role for mainstreaming biodiversity protection in society. Some examples of potential use cases include ecological compensation or different biodiversity footprint indexes for assessing the sustainability of the private sector. Access to biodiversity data will be very important to implement the Sustainable Reporting Directive and the EU Taxonomy on Sustainable Finance. Green economy highlights the importance of biodiversity data, but capacity building of the private sector might be necessary. Here some of the current gaps in the use of biodiversity monitoring data in private decision making are elaborated in detail:

Lack of accessibility/ availability/ findability

- The benefits (for instance, professional, reputational, financial) of FAIR data should be demonstrated, whether it be for use or for sharing. Through exchanges between private and

public actors, best practice examples and success stories, reluctant actors can be motivated and concerns or fears from stakeholders can be addressed.
- Sharing according to a standard through a single access/ entry point should be encouraged. This could be either encouraged/incentivized or done via regulatory mechanisms, to achieve faster uptake (see, the example of DEPOBIO in France[6]. The role of GBIF as the host for this access point is a key element here. Their role should be made known to wider stakeholder audiences.
- Tailored training needs to be ensured so the standard can be followed easily. Private actors need not only to be made aware of these standards but also armed with the right knowledge to follow these standards and utilise this single access point.

Biodiversa+ could help in coordinating and mobilising of public and private stakeholders through the national hubs (e.g., the networking function). Furthermore, the national hubs could provide guidance for the use of standardised data for different purposes.

Lack of resources

- (Part of) the costs (of producing data products that are relevant for public or private decision-makers) could be transferred to the customer.
- Costs in this area can be turned into benefits or opportunities and should thus be considered from a different perspective than purely cost. Shareholders should be convinced to include other than just financial values, which would permit private actors to make investments in data sharing infrastructure that might not increase financial profit but instead increase reputation (increase corporate social responsibility, being a trailblazer) or afford other opportunities, like setting standards or increasing attractivity for collaboration with other organisations. In addition to the reputational benefits, such investments could increasingly be seen as aspects of compliance or 'licence to operate' in emerging frameworks such as Target 15 of the GBF, the Taskforce on Nature-related Financial Disclosures[7], Equator Principles[8], etc.
- Governments should create incentives (tax advantages, loan structures, subsidies, etc.) for companies that invest in this area.
- Private actors should find ways to collaborate with academia, NGO, etc. to profit from their expertise in lieu of trying to provide everything in house.

To address this barrier, Biodiversa+ should share expertise and support good practices. This could possibly be done via mobility schemes, through which experts from academia, NGOs, etc. could be mobilised for the private sector. Furthermore, Biodiversa+ could provide not just expertise but also resources, for instance to help upload data to GBIF and/or other data repositories, the idea being that private sector actors who are unable to secure resources for data sharing would still be able to do so through the help of Biodiversa+.

[6] DePoBio: https://depot-legal-biodiversite.naturefrance.fr/ (in French)
[7] Task force on Nature-related Disclosure: https://tnfd.global/
[8] Equator principles: https://equator-principles.com/

Lack of standardisation and actionability

- Regarding existing data, guidelines should be provided on how data is used to ensure alignment.
- Regarding future data, guidance on how to generate/ collect data in the future should be provided, to ensure the best possible data quality. This guidance should include format of data, key principles of generation/ collection, and ensure a link to existing key metrics and indicators so data is aligned to potential use.
- Guidance should also be provided on best practices for action, meaning data on actions that could be taken to conserve biodiversity, or how to include/ utilise biodiversity data to measure effectiveness of actions.

In this capacity, Biodiversa+ would be well placed to provide an overview of the different initiatives and schemes. Biodiversa+ could help to create the specific guidance documents mentioned in the three above barriers.

2. Governance of (sub-)national biodiversity monitoring schemes

In this chapter, an overview of the national and sub-national biodiversity monitoring networks is presented. Challenges and solutions for establishing the transnational network of biodiversity monitoring schemes are described.

2.1 Current situation across the countries

During April-June 2022 national biodiversity monitoring experts and authorities from 23 countries (see Fig 4) filled in questionnaires on their current situation in biodiversity monitoring governance and after that they were interviewed. An overview of those interviews with more detailed country descriptions is published in Biodiversa+ mapping of national and sub-national organisations that fund and steer biodiversity monitoring schemes (Vihervaara et al. 2023).

Fig. 4: Altogether 23 countries were interviewed during April-June 2022. For Portugal, the Azores were interviewed.

Interviews with the representatives from the ministries of environment and/or environmental protection agencies were conducted during 1-hour online meetings. Three topics were discussed following a semi-structured list of topics: i.e.,

1) On the current state of the biodiversity monitoring in a particular country, that included discussions on:
    a. responsible authorities for monitoring and reporting to the international agreements and implementation of environmental policies,

b. key organisations contributing to monitoring,
c. number of monitoring schemes in place,
d. overall size of national budgets for biodiversity monitoring actions,
e. data interoperability solutions;

2) Awareness on the concept of Essential Biodiversity Variables (EBVs) and opinions on their use for harmonising transnational biodiversity monitoring schemes;
3) Expectations towards Biodiversa+ work and willingness to join for joint pilots on biodiversity monitoring during the coming years.

Most of the countries stated that steering and funding of biodiversity monitoring schemes happens at national level (Fig. 5), while only two countries, Belgium and Italy (Fig. 6), were coordinated at sub-national level. However, in federal states such as Germany and Spain, responsibilities of concrete monitoring and overall coordination varied between national and sub-national level.

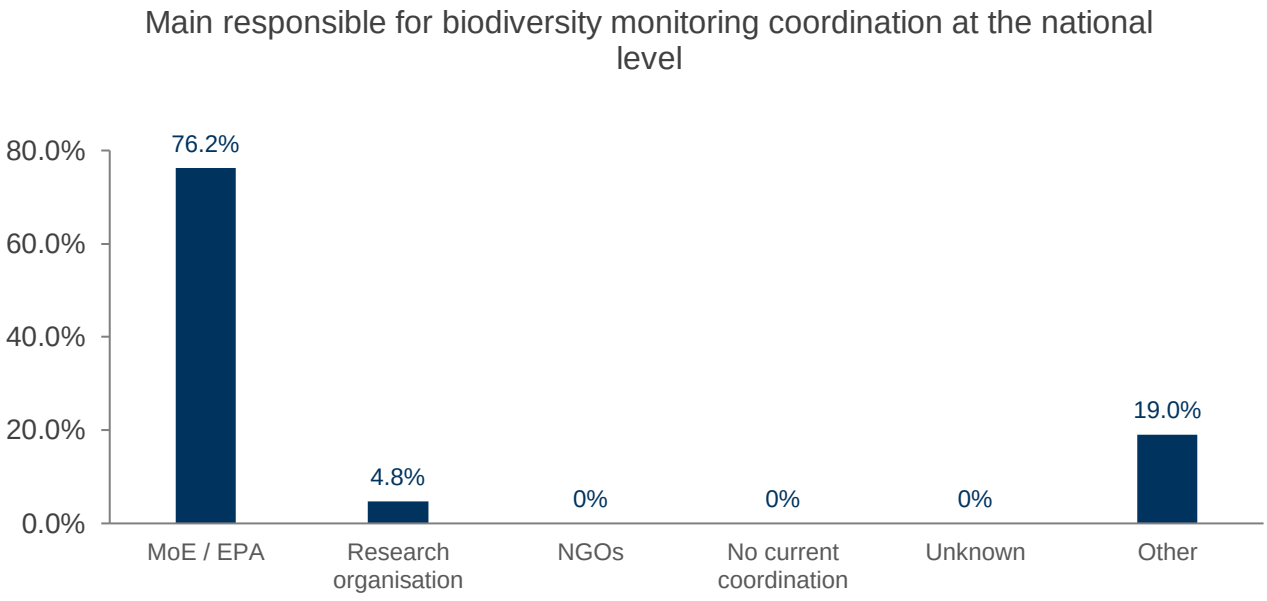

Fig. 5: Most countries (N=21) described that their biodiversity monitoring was coordinated on a national level. Countries included: Austria, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Israel, Montenegro, Morocco, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden and Turkey.

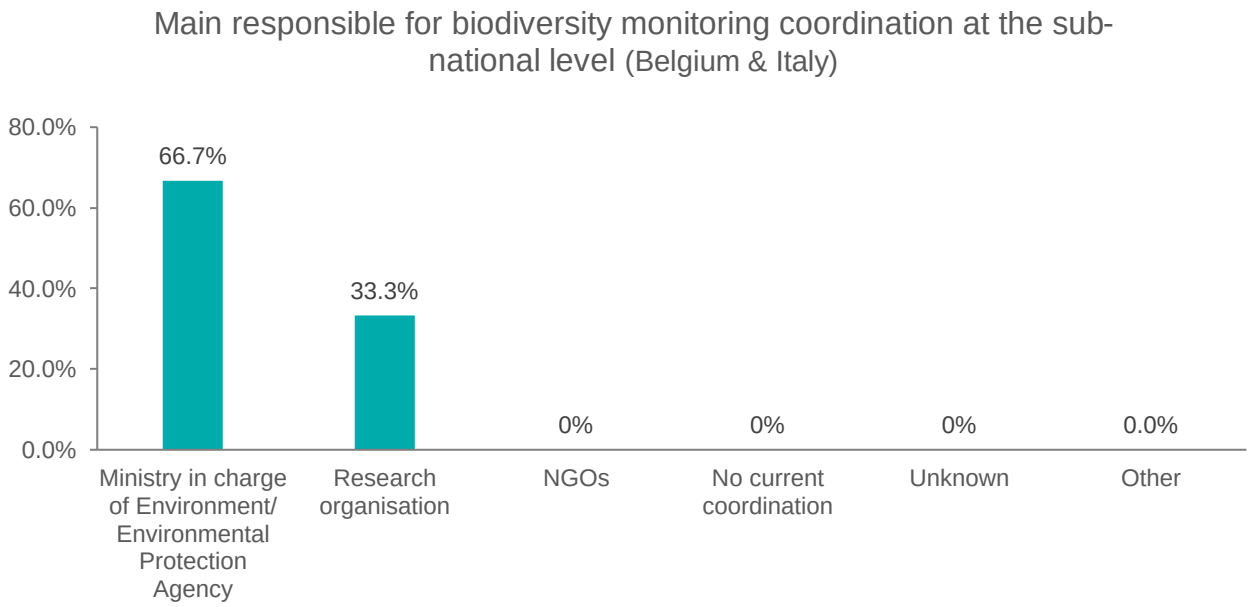

Fig. 6: Some countries (N=2) described that their biodiversity monitoring was coordinated on a sub-national level.

National representatives were also asked what kind of activities were performed by the national biodiversity monitoring entities. Networking activities between monitoring actors were done in 22 countries, reporting to EU directives was done in 20 countries and centralising results from monitoring programmes was done by 19 partner organisations. Centralising of raw data and funding of monitoring were also mentioned by 18 partners. Monitoring on the ground was done by 17 partners and creating biodiversity indicators by 14 partners (Fig 7).

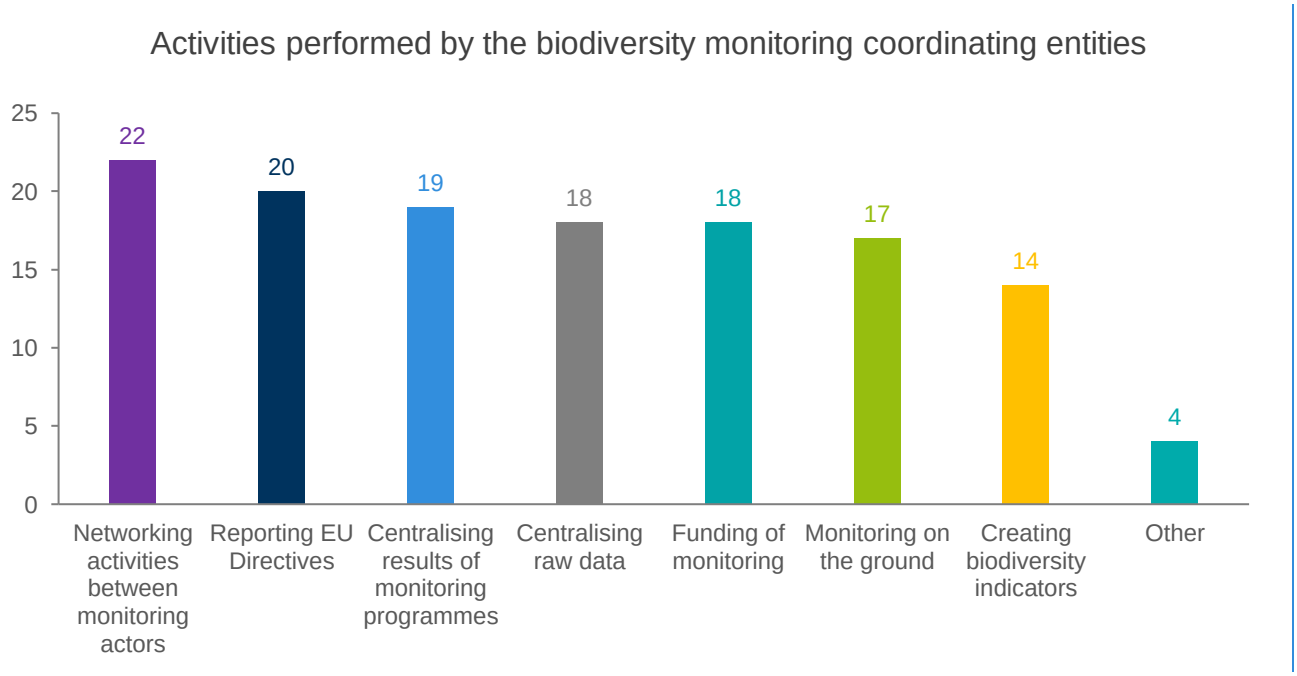

Fig. 7: Activities performed by the (sub-)national biodiversity monitoring coordination entities.

The main expectation towards Biodiversa+ was a transnational collaboration in biodiversity monitoring coordination (Fig 8). Collaboration with development of methods, indicators and data interoperability solutions were also recognised by many partners.

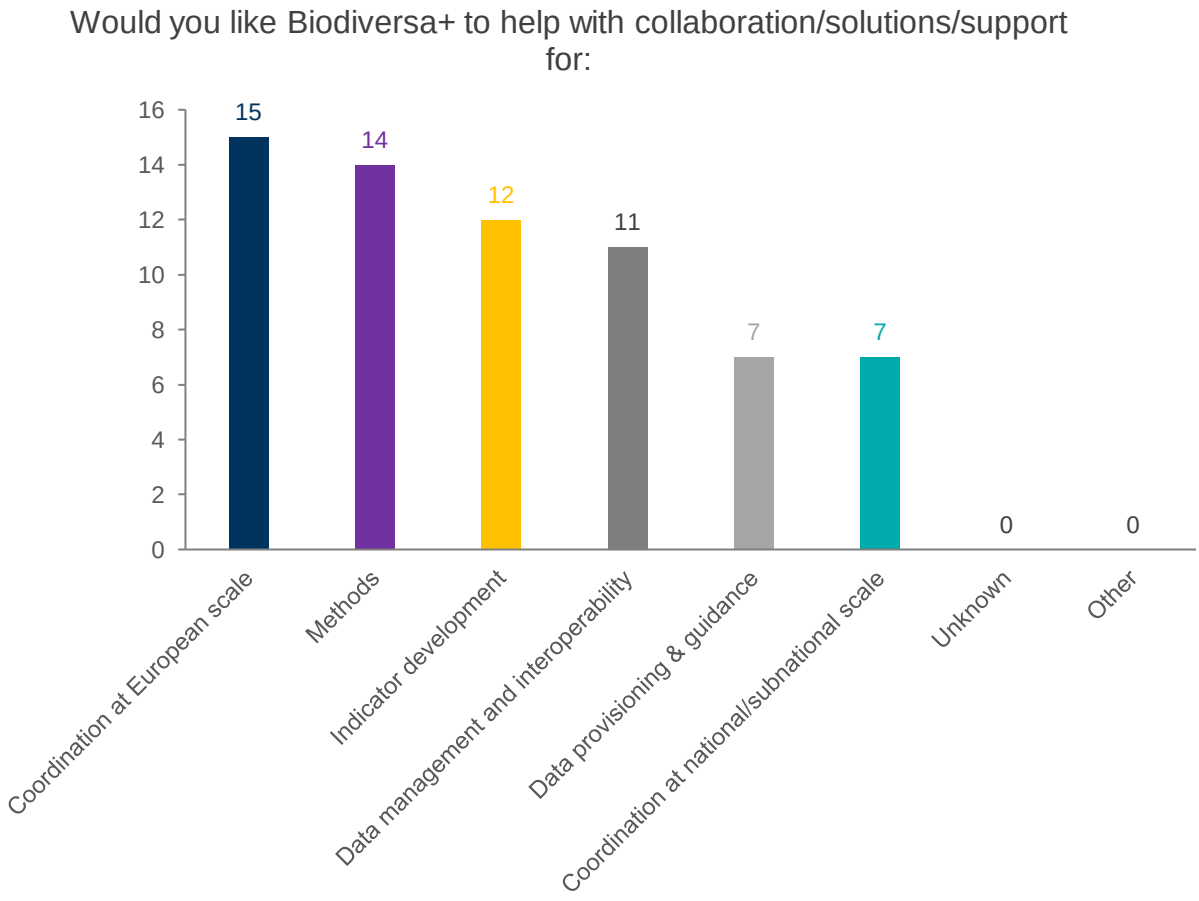

Fig. 8: Main expectations of MoEs and EPAs towards collaboration within Biodiversa+. Support for coordination at European scale was on the top of the list followed by topics such as method harmonisation, joint indicator development, and data management and interoperability.

2.2 Challenges and potential solutions

Challenge 1: Lack of coordination

Lack of coordination across various national and sub-national monitoring schemes was recognized as one of the most urgent challenges in which support from Biodiversa+ (Fig 8) as well as from EuropaBON was expected in the future. In some countries, there were already attempts towards improved biodiversity monitoring governance at national scale. For instance, Germany has already established a national biodiversity monitoring coordination centre (see Box 1 below). Finland, France, and Catalunya (Spain), for example, are currently in the process of developing (sub-)national

coordination centres, and in several regions/countries such as Autonomous Province of Bolzano (South Tyrol, Italy) and Israel there was strong coordination between some monitoring schemes and wishes to increase cooperation across the schemes. Besides increasing needs and activities for biodiversity monitoring in several countries, there are also countries where neither biodiversity monitoring coordination nor even monitoring schemes are yet ongoing, but still high biodiversity values may occur such as in Montenegro.

Capacity building across the transnational network of (sub-)national biodiversity monitoring schemes is strongly supported by the interviewed national experts and authorities. A flexible, multi-scale governance model for biodiversity monitoring should be developed as soon as possible in a close dialogue between national biodiversity monitoring governance bodies and EU-scale entities. Thematic expert networks and hands-on monitoring experts must be closely involved in the co-designing process, and such work has already been started by Biodiversa+ as well as stakeholder workshops of EuropaBON (see Moersberger et al. 2022).

Challenge 2: Lack of comparable biodiversity monitoring data and schemes

Biodiversity information is currently collected at different geographical scales (local/ national/ European/ global) through different protocols and methods. Harmonisation of data products has a lot of variation across the countries from raw data to indicators. The concept of Essential Biodiversity Variables (EBVs) is suggested to be used for harmonisation of various data sources, but it is rarely used as a standard format of biodiversity data at coordinated monitoring or official reporting (Vihervaara et al. 2017). Most ongoing European biodiversity monitoring programmes concern only certain taxonomic groups (birds, mammals, and plants), whereas habitats are monitored to a much lesser extent. Pilot studies such as the pollinator habitat monitoring project: EMBAL and the EU pollinator initiative: SPRING are examples of harmonised European monitoring schemes run by the EC DG Environment and financed by EU Parliament across the EU member states. Some projects, such as EUMON, the European biodiversity observation network (EBONE[9]), the pan-European Marine Biodiversity Observatory System (EMBOS), or the European Biodiversity Observatory Network (EUBON[10]), have aimed to design and test a biodiversity observation system over large scales of time and space. The feasibility of developing such a monitoring network at a pan-European scale has been discussed, and the outcomes of these projects have mostly highlighted the difficulties of such an approach. They provide a positive perspective for achieving a European-wide biodiversity monitoring scheme, but they also conclude that a considerable effort of harmonisation remains.

The harmonisation process is challenging, as many countries have long traditions for doing national monitoring schemes based on their own standardised protocols. These monitoring systems are adapted to the local territory and have the specific human, material and financial means to be carried out. So, a harmonisation process should avoid losing the existing data and means as well as avoid duplication of effort with those ongoing activities. For these reasons, some programmes aiming to carry out a harmonised biodiversity monitoring scheme across Europe have opted for an approach where each country keeps using their existing protocols to produce national EBVs or indicators, which are then aggregated at the trans-national level to produce European trends and indices. Yet

[9] European Biodiversity Observation Network: https://www.wur.nl/en/Research-Results/Research-Institutes/Environmental-Research/Projects/EBONE.htm
[10] EU BON: http://www.eubon.eu/

these schemes do not exist in every country, so generally, for this approach new schemes have to be created and implemented for continental coverage.

Another approach is also quite common for biodiversity monitoring programmes, consisting in applying one common strict protocol in all countries involved and aggregating raw data for joint analysis (laboratory and/or statistical), this way ensuring data comparability and/or avoiding interlaboratory variability in the analysis of the collected data. Nevertheless, this approach generally does not consider the existing national monitoring schemes, as discussed above.

Without harmonisation there will be no real comparability of the results. It should be highlighted that these harmonisation strategies depend on the possible international cooperation and on the different countries' means, in terms of budget as well as the existence or not of experts and volunteer networks.

Challenge 3: Lack of resources for biodiversity monitoring

Lack of funding and un-stable resources for biodiversity monitoring were mentioned as one of the key challenges by most of the countries. This refers also for the citizen science providing lot of data for the biodiversity monitoring schemes. More specifically, the project-based funding model was mentioned as a key threat to support long-term monitoring schemes – that was mentioned also by those countries who had rather good resources available already. Exact numbers of budgets were not easily available for country representatives (Fig. 9), and comprehensive assessment of national biodiversity monitoring budgets may need another survey, but at general level the estimations of national biodiversity monitoring budgets varied from some hundreds of thousands of euros to a few millions, and in some bigger countries even tens of millions. Yearly variation was also great as for instance before the reporting round for Habitats Directive (every six years) there was a peak of resources allocated for biodiversity monitoring, while between those peaks some years might have got zero funding in some countries. In Bulgaria, for instance, the variation in monitoring budgets varied from 1 to 10 M€ depending on the project-based funding. It was also recognised that without obligatory EU reporting demands such as Water Framework Directive or Nature Directives, there is seldom a pressure to establish national monitoring schemes. Most partners emphasised that EU funding is very important to secure funding for continuous biodiversity monitoring, and for example, LIFE funding instrument was often mentioned as a successful example, despite providing only project-based support. Though, there would be opportunities to allocate EU funding such as regional funds or European Maritime, Fisheries and Aquaculture Fund for biodiversity monitoring, but the overarching funding model of European biodiversity monitoring needs further attention in the future.

Another funding issue mentioned was the marine and terrestrial monitoring schemes: marine monitoring is often dependent on expensive research infrastructure such as research vehicles and ships, while some terrestrial monitoring schemes (especially for many species monitoring schemes) were often based on large volumes of volunteer contributions by citizen scientists. These are the two extremes of how monitoring could be arranged, which should be taken into consideration when developing, steering, and financing the European biodiversity monitoring framework. Terrestrial species monitoring schemes were often coordinated by academicians or institutions despite the fact that a lot of data came from volunteers, while habitat and ecosystem monitoring schemes were both coordinated and conducted by professionals.

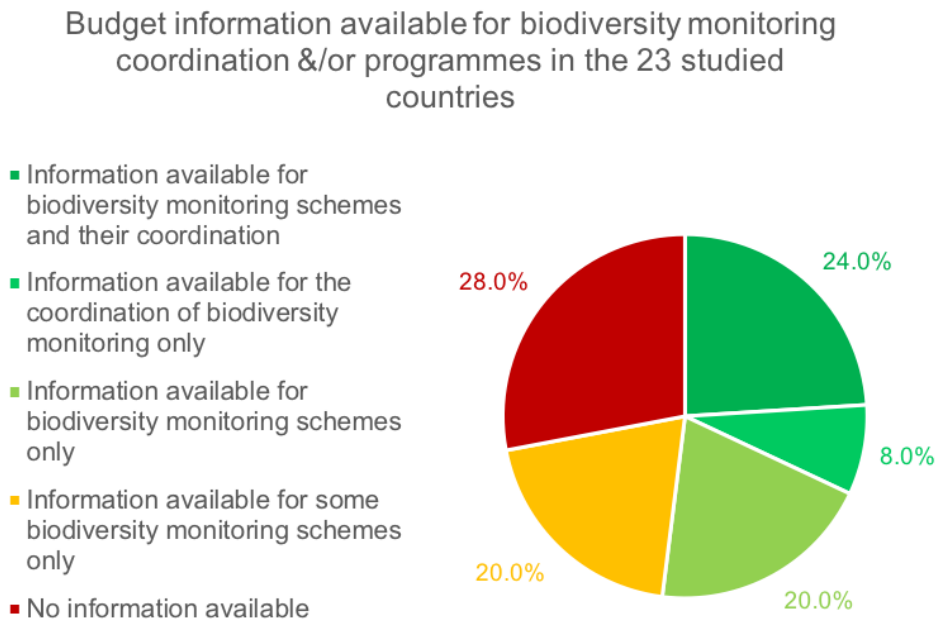

Fig.9: Number of interviewed countries having information on biodiversity budgets.

Challenge 4: Data interoperability

Data interoperability solutions are a crucial part of a successful biodiversity monitoring governance model. However, there are currently only a few examples of how biodiversity data management is organised on a national level. For instance, GBIF provides some good examples of the operational national nodes such as Finland and France (e.g., Schulman et al. 2021), which gather species observations either directly by data providers or via other data infrastructures (see more about GBIF governance model later in Chapter 3). The curated and annotated observations are further made available via GBIF services. Other recent examples are the ongoing ARISE project[11] in the Netherlands and the Finnish Ecosystem Observatory (FEO)[12] which both aims to build national biodiversity data infrastructure platforms. However, such biodiversity data infrastructures are rare, despite many countries having some kind of databases and various data models already in everyday use. More information is needed about the variation across countries and the options for connecting national data streams with EU-level data systems, such as EEA (e.g. BISE), Eurostat, JRC, BMCC or the EBV Portal of GEO BON.

[11] ARISE: https://www.arise-biodiversity.nl/about
[12] Finnish Ecosystem Observatory: https://feosuomi.fi/en/

2.3 Harmonisation of national observations with Essential Biodiversity Variables

Following the example of scientific communities working on the climate, the oceans, geodiversity, ecosystem services and agriculture, the academic community connected to GEO BON has defined a number of EBVs, aiming to harmonise biodiversity observations and to play a key role between monitoring programs and policy makers[13]. EBVs describe a biological component (not a physical or chemical one) as a state variable (not a pressure, impact, or response), are sensitive to change, ecosystem agnostic (terrestrial, marine, and freshwater), and technically realistic.

Conceptually, 21 EBVs have been proposed by GEO BON in six broad classes across two levels of organisation:

1. Species
    - genetic composition (4 EBVs: genetic diversity, genetic differentiation, inbreeding, effective population size)
    - species populations (2 EBVs: species distributions and species abundances)
    - species traits (5 EBVs: morphology, physiology, phenology, movement, reproduction)
2. Ecosystems (including habitats)
    - community composition (4 EBVs: community abundance, taxonomic/phylogenetic diversity, trait diversity, interaction diversity)
    - ecosystem functioning (3 EBVs: live cover fraction, ecosystem distribution, ecosystem vertical profile)
    - ecosystem structure (3 EBVs: primary productivity, ecosystem phenology, ecosystem disturbances)

This organisation on two levels is relevant for monitoring since biological entities to measure directly correspond to those used and evaluated in public policies (i.e. species in Birds and Habitats Directives, in the IUCN Red List of Threatened Species, in hunting/fishing regulation, etc.; ecosystems in the IUCN Red Lists of Ecosystems, forest/wood policies, and habitats in Habitats Directive) by means of reference lists (e.g. the IUCN Global Ecosystem Typology or the list of European natural habitat types; Pan-European Species Inventory).
The EBV list provides a common language as a basis for transversal monitoring activities, that can also be completed according to specific contexts or needs. Variables such as the physical and chemical properties of ecosystems (used in the evaluation of ecosystems for the IUCN Red List for instance), the abundance of dead wood in forests (used in forest policies), and all pressure and response variables can easily be added. This EBV list, once completed with biological and spatio-temporal information, forms a common language allowing a precise description of monitoring targets that can be easily shared and understood by others, and by extension, harmonised.

From a workflow perspective, EBVs represent an intermediate abstract level between raw data from monitoring programs and broad indicators for evaluation: at the end of the line, EBVs allow to describe indicators or policy needs in terms of data needs by means of EBVs, without having to

[13] GEO BON. What are EBVs? https://geobon.org/ebvs/what-are-ebvs/

relate to the specifics of monitoring programs that actually produce them (e.g. the Living Planet Index requires the EBV population abundance of as many species as possible). Conversely, results from monitoring programs can be described without having to identify further uses of them in public policies (e.g. PECBMS provides population abundance of over 150 common bird species at the European level).

In principle, biodiversity monitoring should rely on the entire set of EBVs. However, both current knowledge and the development of required monitoring programs are limited, and a comprehensive approach of all EBVs can only happen step by step. Currently, both species populations EBVs, i.e. species distributions and species abundances, are the most common and consistently monitored on both geographical and temporal extents.

In practice within the Biodiversa+ consortium, the majority of the partners had never heard of—or did not fully understand—the concept of EBVs, and hence are not using EBVs explicitly. The survey included a brief introduction of the EBV concept, which actually helped Partners identify how EBVs were used implicitly, for instance by storing and sharing data aggregates or syntheses that are actual EBVs (most often, as underlined before, in the form of Species populations EBVs): 16 partners indicated that at least a few EBVs were stored at the national or subnational level, and 9 of them underlined being in the process of storing additional EBVs; conversely, 12 partners indicated no storage of EBVs or that they did not know, and added that they are considering the opportunity to do so in the near future. Finally, the survey also highlighted the decisive role EBVs could play at the European scale: 13 partners recognised that centralising EBVs would be a key stone for building a transnational monitoring system in Europe, while 2 Partners thought that this would have a minor impact only; on the other hand, 10 Partners did not have an opinion on the matter at the time of the survey. It was also noticed that in the future, it is important to further explore EBVs' linkages to existing legal biodiversity monitoring obligations.

2.4 National Biodiversity Monitoring Coordination Hubs – a way forward

The Biodiversa+ partners were asked whether they preferred only national or only EU-level coordination or both, and the majority of respondent were in favour of mixed model where both EU-level coordination centre occurs together with well-defined functions and roles of national (or in some cases sub-national) coordination centres/ hubs (Figs 2 & 10). Designing of the governance model needs careful thought and extensive stakeholder consultations, as countries are in very different situations in terms of how biodiversity monitoring is organised and coordinated if at all. This suggests that the developed governance model for the BMCC and a transnational network of national hubs needs to be flexible, taking into account different circumstances across countries.

It is important to recognise that there are already relevant international networks with various models of national nodes, such as EEA's Eionet having groups of thematic expert groups nominated by countries, and GBIF having a well-developed governance model of national hubs (see Part 3). Building on these ongoing structures could provide significant synergies between various monitoring schemes and support benchmarking of potential data infrastructure and interoperability models.

Other relatively mature research and monitoring communities are eLTER and LifeWatch infrastructures which are playing an important role in many countries.

The main challenge is how to bring the existing initiatives and monitoring networks together in closer collaboration at national and European level. How to increase the synergies and coordination between them and at the same time start some new monitoring of what does not yet exist, and maybe not even having responsible national authorities or monitoring groups? There are also obvious challenges to integrate different data streams such as *in situ* species observations and Earth Observation / satellite -based monitoring of ecosystems, as an example. Some countries have recognised this challenge already and started to increase national coordination of biodiversity monitoring schemes, as for instance described in the example of German Biodiversity Monitoring Coordination Centre (NMZB) (Box 1 below). There is also another relevant initiative NDFI4Biodiveristy in Germany that is focusing more on data interoperability solutions and doing collaboration with the NMZB.

Ministries of environment, and in some countries environmental protection agencies, are in charge of steering and funding of national biodiversity assessments, implementation of environmental policies, and reporting for international agreements (e.g., Convention on Biological Diversity) and for the EU (e.g., Habitats, Birds, Water Framework directives). Thus, it is obvious that those bodies take responsibility for developing the coordination of national biodiversity monitoring schemes, considering that they can allocate such responsibility to third parties or some other constellation of relevant biodiversity monitoring organisations. Biodiversa+ aims at supporting the development of the concept of national biodiversity monitoring centres, in close collaboration with the designing of the BMCC by EuropaBON.

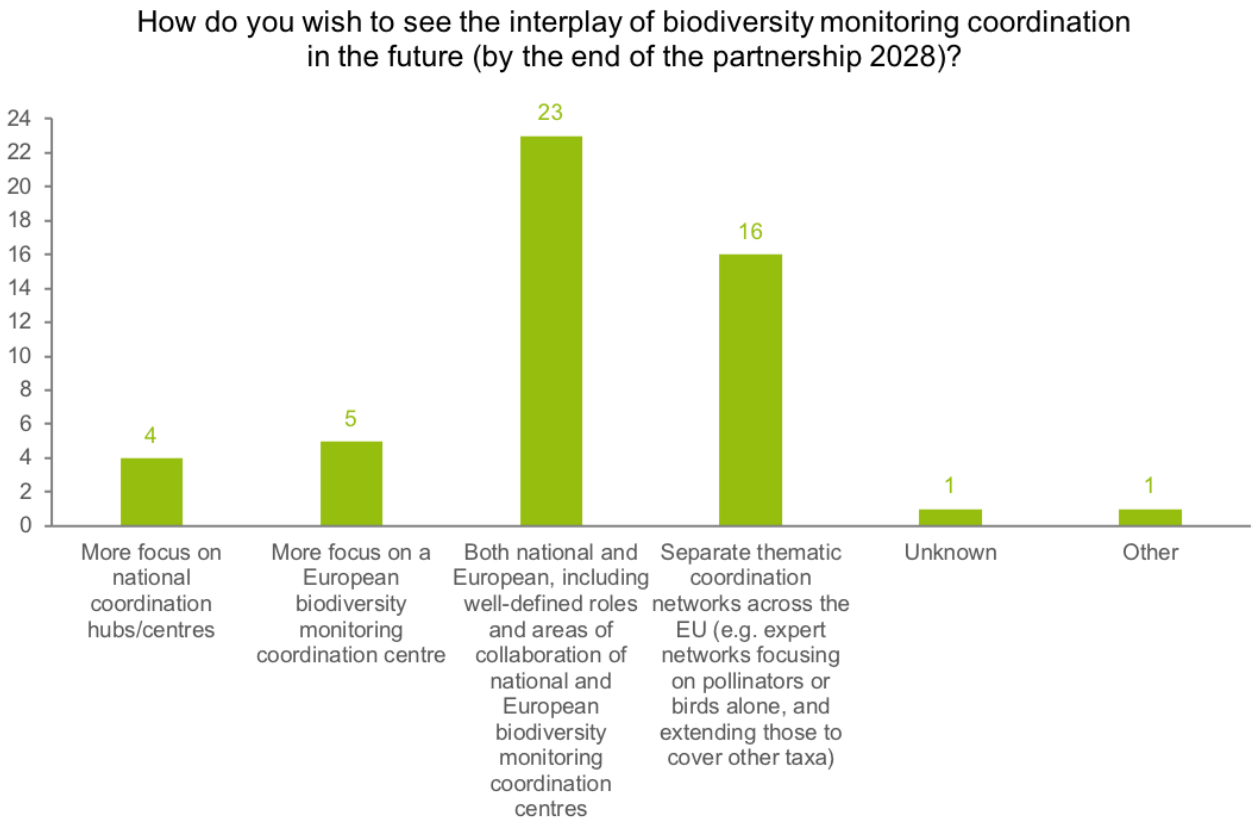

Fig. 10: Most of the national respondents thought that the best option would be “both national and European biodiversity monitoring coordination, including well-defined roles and areas”. The second favoured answer emphasised collaboration through thematic coordination which provides comparable possibilities to enhance trans-national cooperation on biodiversity monitoring across Europe.

Box 1: German model for biodiversity monitoring coordination and data interoperability cooperation.

The German National Monitoring Centre for Biodiversity (Nationales Monitoringzentrum zur Biodiversität, NMZB) was established in March 2021. Its creation is based on a common agreement of the German Federal Government, and the foundation of the NMZB has been legally fixed in Germany‘s Coalition agreement for the 19th legislative period (2012 – 2021). At the time of writing this report, NMZB is undergoing a build-up phase after which the work and structure of the Monitoring centre will be revised and adapted, if necessary.

1. Aims of the German Monitoring Centre for Biodiversity

The goal of NMZB’s work is to advance the expansion and adaptation of the German federal biodiversity monitoring on the basis of existing monitoring programs. It will ensure a long-term sustainability of biodiversity monitoring in Germany. Through its work, NMZB will support the

Box 1: German model for biodiversity monitoring coordination and data interoperability cooperation.

responsible stakeholders to establish a profound basis of biodiversity-related data and information. This basis will be comprehensive and statistically robust; it will be retrievable whenever needed and enables further, well-founded analyses on the causes of biodiversity change as well as the identification of possible courses of action to promote, protect and ensure the sustainable use of biodiversity. The NMZB's field of action towards a comprehensive nationwide biodiversity monitoring will comprise the terrestrial, the marine as well as the inland freshwater realm.

A further objective of NMZB's work is to identify the needs of national monitoring stakeholders and to provide methodological standards and uniform definitions, taking into account existing procedures. By this, NMZBs work also ensures that monitoring data is compatible and comparable. The monitoring centre advises on the application of new technologies and supports their testing and integration into federal biodiversity monitoring. In addition, the monitoring centre will make monitoring data and technical information such as mapping instructions and standards as well as scientific publications more easily accessible.

NMZB's aim is to involve and empower and all (national) monitoring actors, i.e., all institutions related to biodiversity monitoring – the federal government, federal states, science and research, professional societies, associations, and the voluntary sector – by creating a strong and durable network between these partners. By doing so, its aim is also to make existing and future data on biodiversity in Germany more easily accessible.

2. Structure of the German Monitoring Centre on Biodiversity

The structure of the NMZB is composed of the **Secretariat**, the **inter-agency steering committee**, the **General Expert Committee**, as well as a number of further **topic-specific Expert Committees** (see Fig. 11). NMZB's **Secretariat** is the central management body and is aiming to become the central contact address for questions concerning the nationwide biodiversity monitoring in the future.

In the **Inter-ministerial Steering Committee**, all federal ministries involved in biodiversity monitoring are represented. In Germany biodiversity monitoring is mostly conducted by the federal states. Therefore, regarding the importance of the federal states for biodiversity monitoring, representatives of federal states are present in the Inter-agency Steering Committee, where they have an advisory role. The **Inter-ministerial** Steering Committee defines the general framework within which the Monitoring Centre's activities take place. All fundamental questions concerning the monitoring centre, including organisational or strategic, technical policy issues, are decided by consensus.

The **General Expert Committee** includes federal authorities subordinate to the ministries, expert institutes commissioned by the institutions and agencies commissioned by the federal ministries. Furthermore, state authorities and research institutions are represented. In addition, representatives of the federal ministries are free to attend meetings of the General Expert

Box 1: German model for biodiversity monitoring coordination and data interoperability cooperation.

Committee as guests. The General Expert Committee discusses fundamental and technical questions, such as on the orientation of the nationwide biodiversity monitoring and in this regard makes strategic decisions. An important part of the work of this committee is to ensure that the monitoring activities in the business areas of the environment and agriculture ministries as well as other ministries complement each other and that duplications are avoided.

In the **topic-specific Expert Committees**, relevant federal authorities or topic-centred institutions commissioned by the federal ministries, state authorities, associations and other institutions are represented. They serve to provide technical information and expert advice on specific biodiversity monitoring topics to the General Expert Committee. They are involved in the preparation of essential publications of the national monitoring centre. The topic-specific Expert Committees are supported by NMZB's Secretariat.

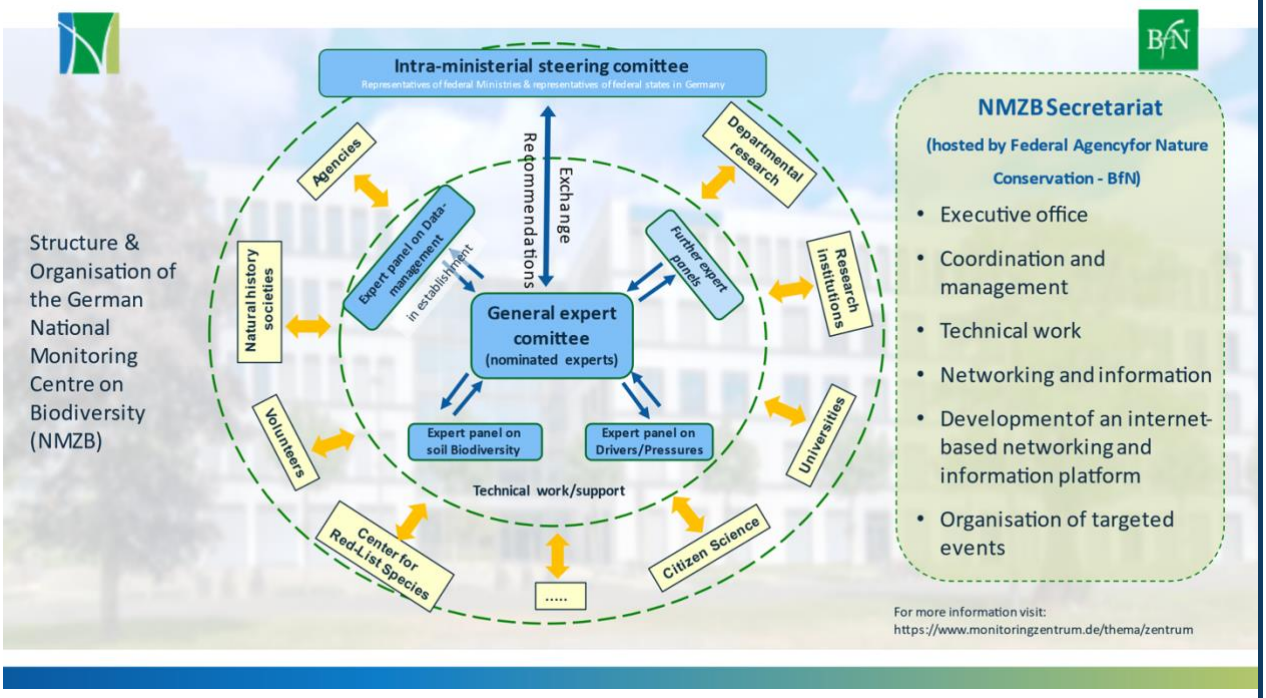

Fig. 11: Structure and organisation of the German National Monitoring Centre on Biodiversity (NMZB). German National Monitoring Centre received a funding varying from 4.3 M€ to 6.2 M€ per year from the State budget.

3. Integration of (sub-)national schemes and coordination hubs with a European Biodiversity Monitoring Coordination Centre (BMCC) and other international initiatives

In this chapter, some of the key international biodiversity monitoring initiatives are represented and their linkages to (sub-)national level biodiversity monitoring are described.

3.1 EuropaBON design for the BMCC

EuropaBON task 2.4 aims at establishing the terms of reference for a permanent Biodiversity Monitoring Coordinating Centre (BMCC) for Europe that could implement and oversee a European Biodiversity Observation Network. This is ongoing work as the deliverable is due by the end of 2023. To fulfil this task, EuropaBON partners, together with a broad network of collaborators, are assessing the options and the opportunities to set up such a BMCC in Europe. The following describe the results of an initial consultation on the technical and legal mandate and the potential governance and financial models. This all-inclusive consultation offered a wide range of options (presented below) that are being analysed and narrowed down to present some concrete terms of reference. In any case, data integration and harmonisation emerge as the main task for the BMCC.

Technical mandate

The technical mandate will determine the scope and the future tasks of the BMCC. The role of the centre may cover just coordination of activities, include monitoring and data management tasks, and/or develop some assessments. This is an open list of possible roles for the BMCC:

a) International coordination of national or subnational nodes for monitoring biodiversity (to improve coordination, cooperation, and information exchange; each country should ideally establish a unique authority/voice for biodiversity monitoring instead of the existing multiple authorities).

b) International coordination of the non-governmental initiatives on monitoring biodiversity

c) Provide technical guidance and advice to improve and harmonise biodiversity monitoring (to give advice, consider practical means and make proposals to improve the coherence of monitoring activities across Europe)

d) Technically support the monitoring and assessment performed nationally/sub-nationally (coordination, training, capacity building, sharing good practices…)

e) Support the actual *in situ* monitoring and assessment performed nationally/sub-nationally (running, paying and/or implementing part of the monitoring programmes) – this has large and serious consequences on the budget

f) Identification of gaps and direction of efforts, design of new monitoring programmes and inclusion of novel methods and techniques

g) Re-design and harmonise existing monitoring programmes on the ground. Here different views arise, from harmonising data collection to simply making datasets compatible.

h) FAIR and open data management (collection, integration, ingestion, interoperability, etc.) as well as provision of a central infrastructure and easy reporting pipelines. It can include the support of an IT infrastructure for biodiversity monitoring among different players (e.g., European research infrastructures, EOSC, Copernicus, EEA, JRC, GBIF etc.)

i) Produce national and EU ecosystems' assessments based on the monitored data.

Legal mandate

This is a list of potential legal mandates for the BMCC:

a) Advisory role within EU context

b) Advisory role external

c) Mandated by an international agreement including non-EU countries

d) Mandated by a non-binding legal instrument, like the EU Biodiversity Strategy

e) Mandated by a new binding legal instrument (including implementing acts, delegated acts, a decision) or a revised binding legal instrument

Governance model

Several different non-exclusive governance models are conceivable for a BMCC:

a) Network approach based on NGOs, natural history societies and/or scientific networks (strengthening taxonomic knowledge and volunteer recording)

b) Network approach based on the coordination of all EU countries

c) Centralised approach from the EU to Member States' competent authorities

d) Centralised approach from EU bodies to experts' networks

e) Technical experts' groups per taxa

Independently of the governance model selected, a new BMCC should have some centre of operations that could be:

f) New secretariat within European Commission

g) New secretariat within EEA

h) Independent secretariat in close collaboration with EC and EEA

i) Use of one of the governance structures of key EU environmental legislation (e.g., the departments and groups in charge of the implementation of the Nature Directives).

Financing model

Substantial extra funding will be necessary to cover many of the proposed tasks of the BMCC, and to better coordinate the rather scattered and poor biodiversity monitoring across the EU. Potential sources of finance are:

a) European Research Infrastructures or similar set-up (normally long-term sustainability by R&I funds)

b) Delegation agreements similar to Copernicus service funding

c) New budget line/activity by the EU (including the new commitments under the Green Deal), including statistical (rather than research) programmes

d) Direct & indirect funding from EC programmes

e) Member States' budget

f) Partly financed by fees from the private sector, e.g., via funding from biodiversity offset schemes, or auditing system similar to the one in USA for environmental impact assessment.

3.2 Role of EEA and Copernicus Services in support of the European biodiversity monitoring landscape

The European Environment Agency (EEA) and its member country network Eionet (32-member countries and 6 cooperating countries) have a wide range of tasks related to the compilation of environmental data, environmental reporting, and assessment as well as data dissemination. The EEA's role and obligations have grown over time. While it was initially designed to compile data reported by its member countries (mainly under EU legislation) and produce related assessments it has taken on additional tasks in terms of data generation and curation over time. Key examples are an EU delegation agreement to host the Copernicus Land Monitoring Service and the Copernicus in situ data service and the compilation and validation of EU Member State data under the LULUCF Regulation.

EEA engages closely with the services of the European Commission, whether it be policy users such as DG ENV or DG CLIMA, or other data or assessment providers, such as Eurostat and the EU Joint Research Centre (JRC). A recent example is the collaboration establishing ecosystem accounting in the EU, which *inter alia* has resulted in guidance for an ecosystem typology for accounting purposes.

EEA collects and disseminates data and information across all environmental domains. The collected (reporting) data is used for EU-wide thematic assessments such as the State of Nature, State of Water or State of Marine reports as well as integrated State of Environment Reports, in addition to indicators and other information products designed for a social media environment.

EEA's involvement with biodiversity data occurs mainly in the context of reporting obligations under EU legislation (e.g., Birds and Habitats Directives, Water Framework Directive, Marine Strategy Framework Directive etc.). Via a dedicated biodiversity team and the EEA topic centre(s) dealing with biodiversity it has supported the development of reporting standards under the Birds and

Habitats Directives, compiled and analysed data reported by EU Member States, and provided training and other assistance to EU Member States in support of reporting under these directives. EEA has also developed the EUNIS habitat classification as a comprehensive pan-European system for habitat identification, see https://eunis.eea.europa.eu/

EEA has always put emphasis on working closely with all its member countries via Eionet, whether in the design of reporting flows, consultation on assessment products and identification of work priorities. One outcome of that is the investment in Reportnet 3.0 which is designed to enable a further digitisation and streamlining of environmental data flows.

One key objective for EEA's work is to provide information to policy makers and the public. For this purpose, the EEA on behalf of the European Commission has established several thematic Information Systems, covering biodiversity (BISE), forest (FISE), freshwater and marine (WISE). EEA also makes accessible all the data underpinning its indicators and assessment reports and/or related to its reporting obligations. To make it better suitable for modern data access demands this data interface is currently undergoing modernisation.

EEA is identified as one of the key users of Copernicus services and constantly evaluates the use of remote sensing data for ecosystem and biodiversity monitoring and assessments in cooperation with Member States, ESA, and research projects. It acts as facilitator for linking in-situ biodiversity monitoring with earth observation for better biodiversity and habitat monitoring and mapping for uptake by the service providers for further improvements of the service portfolio.

Connected to the work on using Copernicus and many other geo-spatial assessment purposes EEA has invested for over 15 years in a geo-spatial data infrastructure and related processing tools. The aim is to build up a geo-spatial database that includes biodiversity, ecosystem, and many other data layers to be able to generate integrated assessment products and a data pool available to others.

EEA/Eionet in their role as collector and distributor of environmental information have developed a network and knowledge to coordinate and host complex data flows, involving a wide range of thematic areas, actors, spatial and temporal scales as well as end users. This would enable EEA to support the setting up of a Biodiversity Monitoring Coordination Centre (BMCC) with the respective content management, dissemination tools and IT infrastructure.

Being part of the EU institutional landscape makes EEA a potential recipient body for the resources required for building up a sustainable biodiversity monitoring scheme. Making use of the knowledge and expertise in hosting and managing a biodiversity monitoring coordination scheme requires building-up of respective capacities for the implementation.

3.3 National GBIF nodes as a core part of national coordination centres

GBIF—the Global Biodiversity Information Facility[14]—is an international network and data infrastructure funded by the world's governments and aimed at providing anyone, anywhere, open access to data about all types of life on Earth. Since GBIF's founding in 2001, the participating countries and organisations have been testing and developing models for coordinating the mobilisation, management, and reuse of biodiversity data at the national level or within an organisation's scope. The formation of Participant 'nodes' has been central to these efforts.
Participants in GBIF are countries, international organisations or economies having signed the GBIF Memorandum of Understanding (MoU). Signatories to this agreement express their commitment to establish a coordinated effort to support open access and use of biodiversity data, to advance scientific research, and to promote technological and sustainable development.
A GBIF Participant node is a team designated by a Participant to coordinate a network of people and institutions that produce, manage, publish and use biodiversity data, collectively building an infrastructure for delivering biodiversity information. They are supported by organisational arrangements and informatics solutions, working to improve the availability and usefulness of biodiversity data for research, policy, and decision-making.

Participant nodes have four main functions (see further details):

- Coordinating a community of initiatives relating to biodiversity, including making connections to the international GBIF network
- Promoting and supporting the mobilisation of biodiversity data within the country or organisation's scope
- Encouraging the reuse of the available data to support biodiversity-related science and support decision-making for sustainable development
- Providing expertise on biodiversity data management and improving data quality to support users' needs

In their facilitating role, nodes help a wide range of biodiversity data holders publish their data using common standards and protocols. This ensures interoperability and open access, making the data available for the widest possible reuse. It also contributes to commitments that promote transparency and open access to scientific data, helping data holders comply with open data regulations and requirements.

Nodes play a valuable role in promoting data management practices and in encouraging the community of biodiversity knowledge-holders to pool their expertise. This work can in turn continuously improve the quality and fitness-for-use of available biodiversity data.
By making the connection to GBIF, nodes enable the integration of data mobilised at the national level with relevant data published by other countries and organisations. This also raises the visibility

[14] GBIF information is built on these documents:

https://docs.gbif.org/effective-nodes-guidance/1.0/en/

http://www.gbif.fr/page/partenaires/fournisseurs-de-donnees

of the Participant's data publishing institutions and mobilisation efforts and tracks the use of the data via GBIF's cutting-edge data citation mechanism and literature tracking efforts.
In their coordinating role, nodes are well positioned to assess biodiversity data availability and gaps (taxonomic, spatial, and temporal), to understand data and information use and needs, and to implement strategies in response. Thus, nodes can contribute to setting biodiversity research priorities.
Participant nodes help develop capacity in the use of collective biodiversity data resources. Their efforts support both basic and applied research relevant to policy decisions across a range of issues of primary economic and social importance, including food security, agricultural livelihoods, disease risk and the impacts of climate change. This also supports information requirements for meeting national and global commitments including biodiversity-related conventions and sustainable development goals.
A Participant node is typically hosted by an existing biodiversity-related institution or institutions in the Participant country, or by Participant organisations. GBIF provides guidance on establishing effective Participant nodes, which includes a summary of potential advantages and disadvantages of various hosting arrangements for national nodes. Ultimately, the decision on the specific mandate, hosting, and funding of the node is taken by the Participant country. As a result, the nodes are a diverse community with varying priorities and levels of capacity.

For marine biodiversity observations, the OBIS: Ocean Biodiversity Information System is also important to recognize despite of that they are closely connected with GBIF. OBIS is a global open-access data and information clearing-house on marine biodiversity for science, conservation and sustainable development (see more: https://obis.org/about/). In Europe, the European Marine Observation and Data Network (EMODnet)[15] and the new European Digital Twin of the Ocean (European DTO)[16] are also relevant initiatives related to marine biodiversity observations and their linkages to GBIF as well as the European biodiversity monitoring networks should be further investigated in the future.

Nodes in Europe and Central Asia

Collectively, all the GBIF Participant nodes form the nodes committee, which operates a self-designated regional structure, which can be reviewed and changed over time. Currently, the nodes have grouped GBIF Europe and Central Asia as a single region, which includes countries in the following sub-regions used in the IPBES regional assessments, described here[1]: Central and Western Europe, Eastern Europe, and Central Asia.
At the time of writing, there are 39 GBIF Participants in the ECA region, each with a designated node (Table 1). These comprise 20 Voting country participants, 6 Associate country participants, and 13 international or regional organisations (referred to as "other associate participants"). The latest details are always available on the GBIF website.

[15] European Marine Observation and Data Network: https://emodnet.ec.europa.eu/en
[16] European Digital Twin of the Ocean: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/restore-our-ocean-and-waters/european-digital-twin-ocean-european-dto_en

Table 1: The hosting institutions of the national nodes in the ECA region vary, as shown in the table. Further information on the nodes and their activities can be found from the country pages linked in the table.

Node	Node Host Institution	Location of Head of Delegation
Nodes hosted by natural history museums and collections		
Denmark	Natural History Museum of Denmark, University of Copenhagen Digital Collections Section, in collaboration with the Faculty of Science and Technology, Aarhus University; and the Faculty of Science, University of Southern Denmark.	Copenhagen University
Estonia	Natural History Museum and Botanical Garden University of Tartu	Natural History Museum and Botanical Garden University of Tartu
Finland	Finnish Museum of Natural History LUOMUS	Finnish Museum of Natural History LUOMUS
France	Unit Natural Heritage (Patrinat: National Natural History Museum, French agency of Biodiversity, French National Research Institute for Sustainable Development)	French National Research Institute for Sustainable Development
Germany	Split across multiple institutions	Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung Deputy Director General – International cooperation and Science Policy
Iceland	Icelandic Institute of Natural History	Ministry for the Environment and Natural Resources, Department of Land-quality and Natural Heritage
Luxembourg	Musée national d'histoire naturelle	Musée national d'histoire naturelle
Netherlands	Naturalis Biodiversity Center	Ministry of Education, Culture and Science
Norway	University of Oslo	University of Oslo

Node	Node Host Institution	Location of Head of Delegation
	Natural History Museum	
Sweden	Swedish Museum of Natural History	Swedish Research Council
Ministries of science, research, education		
Andorra	Andorra Research + Innovation	Andorra Research + Innovation (Government entity)
National academies of sciences		
Belarus	Scientific and Practical Center of the National academy of Sciences of Belarus for bioresources	Scientific and Practical Center of the National academy of Sciences of Belarus for bioresources
Slovakia	Slovak Academy of Sciences Institute of Botany Department of the Taxonomy of Vascular Plants	Slovak Academy of Sciences Institute of Botany Department of the Taxonomy of Vascular Plants
Slovenia	Not currently appointed	Slovenian Academy of Sciences and Arts
Tajikistan	Tajikistan National Academy of Sciences, Institute of Botany, Plant Physiology and Genetics	Tajikistan National Academy of Sciences, Institute of Botany, Plant Physiology and Genetics
Uzbekistan	Uzbekistan Academy of Sciences, The Institute of Botany	Uzbekistan Academy of Sciences, The Institute of Botany
Ministries of environment		
Croatia	Institute of Environment and Nature, Ministry of Economy and Sustainable development	Institute of Environment and Nature, Ministry of Economy and Sustainable development
Switzerland	Centre Suisse de Cartographie de la Faune (CSCF) under the Federal Office for the Environment (FOEN)	Federal Office for the Environment

Node	Node Host Institution	Location of Head of Delegation
Integrated biodiversity science policy units		
Belgium	Belgian Biodiversity Platform	Belgian Biodiversity Platform Belgian Federal Science Policy Office
Ireland	National Biodiversity Data Centre, a programme of the Heritage Council	National Parks and Wildlife Service
Spain	GBIF Spain Coordination Unit (GBIF.ES – CSIC (Spanish Research Council)	Ministry of Science and Innovation Internationalisation of Science and Innovation General Secretariat for Research
University departments or faculties		
Armenia	Armenian National Agrarian University International Research Programme Coordinating Unit	Ministry of Environment of the Republic of Armenia Department for Specially Protected Areas of Nature and Biodiversity Policy
Poland	University of Warsaw Faculty of Biology, Institute of Functional Biology and Ecology Biological and Chemical Research Centre	University of Warsaw Faculty of Biology, Institute of Functional Biology and Ecology Biological and Chemical Research Centre
Portugal	Instituto Superior de Agronomia Universidade de Lisboa	CIBIO-InBIO, Universidade do Porto
NGOs and Charities		
United Kingdom	National Biodiversity Network Trust	Royal Botanic Gardens Kew Science Directorate

The roles of GBIF national nodes in integrating monitoring data

Nodes aim to support the standardisation and publishing of all sources of primary biodiversity data within the country, which include data from biodiversity monitoring schemes. The data then become interoperable with all other sources of biodiversity data available through the GBIF infrastructure and can therefore be of greater value for reporting and research use. Many nodes also enable data shared by national stakeholders to be accessed and visualized both through the global GBIF.org platform and via national portals, using shared tools and facilities such as the Living Atlases programme[17] and the more recent GBIF Hosted Portal service programme[18].
The nodes in the Europe and Central Asia region span from well-established nodes with high levels of capacity to very new nodes that are just beginning to develop a national community of data publishers.

Future perspectives

In 2018, five European GBIF nodes in Belgium, France, Ireland, Norway, and Portugal initiated the BiReMe project to describe and understand nature-related reporting processes and data flows with the aim of identifying how GBIF can facilitate improved reporting. The project produced recommendations that could improve the GBIF network's ability to contribute to EU reporting on the Habitats Directive, the Birds Directive, Water Framework Directive, the Marine Strategy Framework Directive and the Invasive Species Regulation.

Along with the final project report, the team prepared detailed use cases from:

- Belgium
- France
- Ireland
- Portugal
- Norway

The project concluded that national reporting for EU obligations for the status of biodiversity remain largely independent from coordination with the national GBIF nodes. The project urged the open publication in GBIF of all data sources used in the preparation of national reporting to improve transparency and encourage the reuse of data from investments in biodiversity monitoring efforts. The project team also noted that GBIF's data citation mechanism could substantially improve the citation of data contributors to the reports. The project team also urged the GBIF nodes to be aware of the national reporting calendar, process, and stakeholders and to offer support in mobilising data sources.
GBIF has since improved the visibility and accessibility of sampling event data within the global infrastructure and has recently started work to further diversify the data model to enable even richer integration of monitoring data in the future.
The expertise residing in GBIF nodes will often represent a valuable national resource for coordinating biodiversity monitoring data in Europe. The structures being built by Biodiversa+ and

[17] GBIF Living atlases: https://living-atlases.gbif.org/
[18] GBIF Hosted Portal service programme: https://www.gbif.org/hosted-portals

associated projects could be an important opportunity to consolidate regional coordination among GBIF nodes in Europe.

3.4 What kind of options could there be for the governance model that integrates national networks with BMCC?

Biodiversa+ organised a workshop in Madrid on 15th September 2022 where possible options of the European biodiversity monitoring governance structure and the future perspectives to transnational network of biodiversity monitoring schemes were discussed. Outcomes of the workshop were synthesised into a general graphical illustration of a European hub (representing, for instance, the BMCC) and a network of national (or sub-national) hubs (Fig 2). National hubs were having similar functions that were recognized in the European hub, such as coordination of biodiversity monitoring schemes, support of data interoperability and IT solutions, and capacity building of the data uptake by the public and private sector.

Technical mandate of the BMCC (section 3.1) covers several aspects where synergies between EU level and national level hubs are concrete. For instance, biodiversity monitoring coordination and design of the interoperable data infrastructures across the scales can benefit from European level guidance and implementation of data standards. A special focus should be on defining harmonisation strategies for various monitoring schemes, for instance, how to steer: i) in situ species monitoring schemes (often based on volunteer contributions), ii) habitat and ecosystem process monitoring schemes where integration of different data types (e.g., remote sensing, intensive in situ measurements, and models) are needed, and iii) marine and freshwater monitoring schemes that need expensive monitoring infrastructure (such as ships and monitoring sensors). The concept of EBVs was recognised as a useful way forward to compare different raw data and varying observation systems across the countries, while further investigations were still needed.

Acceptability of the various options of legal and governance mandates of the BMCC may need further investigations across the national level experts. This relates also to the financing model of the future European biodiversity monitoring governance structure. It was highlighted by many national representatives of Biodiversa+ that one of the major bottlenecks for sustainable, long-term biodiversity monitoring is lack of funding, and often only project-based funding is available (despite that is better than nothing). It was also stated that the national hubs and the EU member states had to be represented in the governance structure of the European hub (for instance, in a steering committee). However, the form depends on the functions that the European hub is expected to provide.

4. Conclusions

The ultimate aim of Biodiversa+ for biodiversity monitoring activities is to **"**establish, by mobilising the relevant ministries, agencies, European Commission services and initiatives (including the EU Biodiversity Platform), a transnational network of harmonised national biodiversity monitoring schemes". Using the strategic framework jointly developed with EuropaBON with the collaboration of key bodies (JRC, EEA, GBIF), this will include:

- The implementation of the (ideally stable) operational models and structures, and flexible governance system for sharing information and best practices;
- The long-term co-development of harmonised monitoring practices;
- Testing and piloting upscaling of the data from national hubs to regional data centres and knowledge centres, and vice versa validation of general data products and the outcomes of the regional and/or global synthesis centres;
- Continuous learning and exchange of ideas via organisation of yearly symposia of the EU wide biodiversity monitoring community.

To achieve these targets, a summary of key issues to be addressed by Biodiversa+ together with EuropaBON and other relevant bodies includes:

- Refining of the governance model of national and EU level biodiversity monitoring coordination centres (Fig 2). A flexible, multi-scale governance model for biodiversity monitoring should be developed as soon as possible in a close dialogue between national biodiversity monitoring governance bodies and EU-scale entities.
- An analysis of the possibilities, preferred options and acceptance of different options of the legal and governance mandates to be presented in the terms of reference of BMCC by EuropaBON by the end of 2023, as well as a more concrete identification of tasks (technical mandate).
- Piloting the transnational implementation of biodiversity monitoring schemes and transversion of their results to the EBVs. Harmonisation of the monitoring schemes and filling the gaps in the current monitoring landscape.
- Capacity building across the transnational network of (sub-)national biodiversity monitoring schemes will be continued with a special emphasis on the applicability of the novel technologies. A European biodiversity summit that includes, for instance, a science fair and a meeting point for transnational biodiversity monitoring authorities should be established.

A list of key recommendations and an overview of the next steps in the future is as follows:

- Continuing to **develop harmonised protocols** for prioritised biodiversity monitoring schemes and testing the **applicability of EBV framework** for integrated assessment of the biodiversity change across the countries. It is important to pay attention that the suggested new biodiversity monitoring schemes are applicable across the different biological and

geographical scales, so that the data collected is relevant both at national and European purposes. So far, the EBVs remain rather conceptual and poorly known by Ministries of Environment and Environmental Protection Agencies. More time, pro-active engagement, and emphasis will be needed to explain their potential for wider audiences and for operational monitoring and reporting schemes.

- Developing interoperable **data infrastructures for national and EU levels**. This should also consider the need for data management of big data volumes provided by novel technologies. Further investigations are needed to study options of **universal data models** (such as GBIF) and facilities of current international data infrastructures to support national data solutions. It **still remains unclear how the hosting of biodiversity monitoring data could be arranged in Europe**. This will need further investigations and discussions between the MSs and EU, and the key initiatives.
- Dataflows between governments and the private sector should be improved, and ways forward investigated how to improve the **use of biodiversity monitoring data for sustainability** assessments (including product life cycle assessments and footprint indicators).
- More concrete next steps will be **continuous exchange of ideas** among the key biodiversity monitoring entities, the Biodiversa+ governance pilot workshop 23-24th May 2023 in Helsinki followed by national workshops in more than 10 countries that will deepen the understanding of the bottlenecks and possibilities for biodiversity monitoring governance and a contribution to the EuropaBON network activities.
- **A better overview of the costs** of national biodiversity monitoring schemes, data integration and coordination is needed. This will be surveyed across the organisations that steer and fund biodiversity monitoring. This is also important to realise how the in-kind funding of Biodiversa+ can leverage harmonised and more comprehensive European biodiversity monitoring, and how to sustain the long-term monitoring, for instance, by the support of EC's top-up for Biodiversa+. Funding options should be expanded.
- Biodiversa+ aims at supporting the development of the concept of **national biodiversity monitoring centres**, in close collaboration with the designing of the **BMCC** by EuropaBON.

The main focus for the Phase II report to be released in 2024 will be to concretise the main elements of the transnational biodiversity monitoring schemes listed also in this report. Describing the functions of the national and European hubs will be continued. Recommendations for the terms of reference of BMCC by EuropaBON will be evaluated from the point of view of national and sub-national biodiversity monitoring hubs.

References

Basset, A., Onen Tarantini, S. Eggermont, H., Mandon, C and Vihervaara, P. (2023) Report on the harmonisation and interoperability of datasets across regions and countries. Biodiversa+ report. Available at:

Candela, L., Castelli, D. & Pagano, P. (2013). Data Interoperability. Data Science Journal. 12. 10.2481/dsj.GRDI-004.

European Commission, Directorate-General for Research and Innovation, Corcho O., Eriksson M., Kurowski K. (2021) EOSC interoperability framework: report from the EOSC Executive Board Working Groups FAIR and Architecture. Publications Office. Available at: https://data.europa.eu/doi/10.2777/620649

GBIF nodes guidance: https://docs.gbif.org/effective-nodes-guidance/1.0/en/

Geraci et al. (1991). IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries.

Hardisty A.R., Michener W.K., Agosti D., Alonso García E., Bastin L., Belbin L., Bowser A., Buttigieg P.L., Canhos D.A.L., Egloff W., et al. (2019) The Bari Manifesto: An interoperability framework for essential biodiversity variables. Ecological Informatics. Vol. 49. pp 22-31. https://doi.org/10.1016/j.ecoinf.2018.11.003

Heiler S. (1995) Semantic interoperability. ACM Computing Survey, Vol. 27, No 2, pp. 271-273. https://doi.org/10.1145/210376.210392

Junker, J., Beja, P., Brotons, L., Fernandez, M., Fernández N., Kissling, W.D., Lumbierres, M., Lyche Solheim, A., Maes, J., Morán-Ordóñez, A., Moreira, F., Musche, M., Santana, J., Valdez, J., Pereira, H.M. (2023). List and specifications of EBVs and EESVs for a European wide biodiversity observation network. EuropaBON report.

Moersberger H, Martin JGC, Junker J, Georgieva I, Bauer S, Beja P, Breeze T, Brotons L, Bruelheide H, Fernández N, Fernandez M, Jandt U, Langer C, Lyche Solheim A, Maes J, Moreira F, Pe'er G, Santana J, Shamoun-Baranes J, Smets B, Valdez J, McCallum I, Pereira HM, Bonn A. (2022). Europa Biodiversity Observation Network: User and Policy Needs Assessment. ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e84517

Morán-Ordóñez, A., Villero, D., Fraixedas, S., Herrando, S., Miret, G. and Brotons, L. 2023: D3.3 Identification of current monitoring workflows and bottlenecks. EuropaBON report.

Schulman, L., Lahti, K., Piirainen, E. et al. The Finnish Biodiversity Information Facility as a best-practice model for biodiversity data infrastructures. *Sci Data* 8, 137 (2021). https://doi.org/10.1038/s41597-021-00919-6

Silva del Pozo, M. & Body, G. (2022). Literature survey on biodiversity monitoring protocols used across regions and countries. Biodiversa+ report. Available at: https://www.biodiversa.eu/wp-content/uploads/2022/12/MS55-Literature-survey-biodiversity-monitoring-protocols.pdf

Stocker M., Paasonen P., Fiebig M., Zaidan M.A., Hardisty A. (2018). Curating Scientific Information in Knowledge Infrastructures. Data Science Journal, 17, p. 21, https://doi.org/10.5334/dsj-2018-021

Vihervaara, P, Basille, M., Suni, T., Mandon, C., Lipsanen, A., (2023). Mapping of national and sub-national organisations that fund and steer biodiversity monitoring schemes. Biodiversa+ report. Available at: https://www.biodiversa.eu/wp-content/uploads/2023/03/D2.3-Report-on-the-mapping-of-organisations-that-fund-and-steer-biodiversity-monitoring-schemes.pdf

Vihervaara, P., Auvinen, A.-P, Mononen, L., Törmä, M., Ahlroth, P., Anttila, S., Böttcher, K., Forsius, M., Heino, J., Heliölä, J., Koskelainen, M., Kuussaari, M., Meissner, K., Ojala, O., Tuominen, S., Viitasalo, M., & Virkkala, R. 2017: How Essential Biodiversity Variables and remote sensing can help national biodiversity monitoring. *Global Ecology and Conservation* 10: 43-59.

Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al.* The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18