biodiversa+
European Biodiversity Partnership

EUROPEAN PARTNERSHIP

Guidance note on specifications for cross-scale inclusion of harmonised biodiversity monitoring protocols

Significance of Thematic Hubs and common specifications

Co-funded by the European Union

Grant Agreement number
101052342

Project acronym
Biodiversa+

Project full name
The European Biodiversity Partnership

Biodiversa+ duration
7 years

Biodiversa+ start date
1st October 2021

Deliverable title
D2.20 Guidance note on specifications for cross-scale inclusion of harmonised biodiversity monitoring protocols: Significance of Thematic Hubs and common specifications

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Work package title
WP2 Promote and support transnational biodiversity monitoring

Task or sub-task title
Subtask 2.2.1: Harmonise operationalised protocols and inventory methods across regions and countries

Lead partner
Office Français de la Biodiversité (OFB)

Date of publication
August 2025

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Citation
Silva del Pozo, M., Rerig, G., Seeber, J., Onen Tarantini, S., Body, G. (2025). Guidance note on specifications for cross-scale inclusion of harmonised biodiversity monitoring protocols: Significance of Thematic Hubs and common specifications. Biodiversa + report.

Acknowledgements
This report draws on the valuable contributions of many individuals and organizations. We are particularly grateful to the experts who dedicated their time and insights through numerous interviews, discussions, and responses to our survey. We extend our sincere thanks to all who participated in the “Expert workshop on the common minimum requirements for a biodiversity monitoring protocol”, held on April 2-3, 2025, in Montpellier, France. Their active participation and feedback were crucial for the development of our findings. Finally, we would like to express our deepest gratitude to our partners from Biodiversa+ and MARCO-BOLO (MARine COastal BiOdiversity Long-term Observations) for their collaborative spirit and unwavering support throughout this project.

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What is Biodiversa+

The European Biodiversity Partnership, Biodiversa+, supports excellent research on biodiversity with an impact for policy and society. Connecting science, policy and practice for transformative change, Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030. Co-funded by the European Commission, Biodiversa+ gathers 81 partners from research funding, programming and environmental policy actors in 40 European and associated countries to work on 5 main objectives:

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

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

List of acronyms

ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area

ASCOBANS: Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas

CBD: Convention on Biological Diversity

EBOCC: EU Biodiversity Observation Coordination Centre

EBV: Essential Biodiversity Variable

EIONET: European Environment Information and Observation Network

EU: European Union

EUNIS: European Nature Information System

FAIR: Findability, Accessibility, Interoperability and Reusability of data

FAO: Food and Agriculture Organization of the United Nations

GBF: Kunming-Montreal Global Biodiversity Framework

GBIF: Global Biodiversity Information Facility

GEO: Group on Earth Observations

GEO BON: Group on Earth Observations Biodiversity Observation Network

HELCOM: Baltic Marine Environment Protection Commission – also known as the Helsinki Commission

ICES: International Council for the Exploration of the Sea

ICG-COBAM: Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring

INTERREG: European Territorial Cooperation

IPBES: Intergovernmental Science-Policy Panel on Biodiversity and Ecosystem Services

IUCN: International Union for the Conservation of Nature

LIFE: Financial Instrument for the Environment - EU's funding instrument for the environment and climate action

MSFD: Marine Strategy Framework Directive

NGO: Non-Governmental Organization

OBIS: Ocean Biodiversity Information System

OSPAR: Convention for the Protection of the Marine Environment of the North-East Atlantic - also known as the Oslo and Paris Conventions

SMART: Specific, Measurable, Achievable, Relevant, Time-bound

WFD: Water Framework Directive

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Executive Summary

The European Biodiversity Partnership, Biodiversa+, continues its guiding efforts in harmonising existing biodiversity monitoring protocols and integrating biodiversity information across scales. This report builds directly on previous guidance, advancing discussions on strategies for effective harmonisation by providing practical insights for stakeholders aiming to align monitoring efforts across diverse territories and scales.

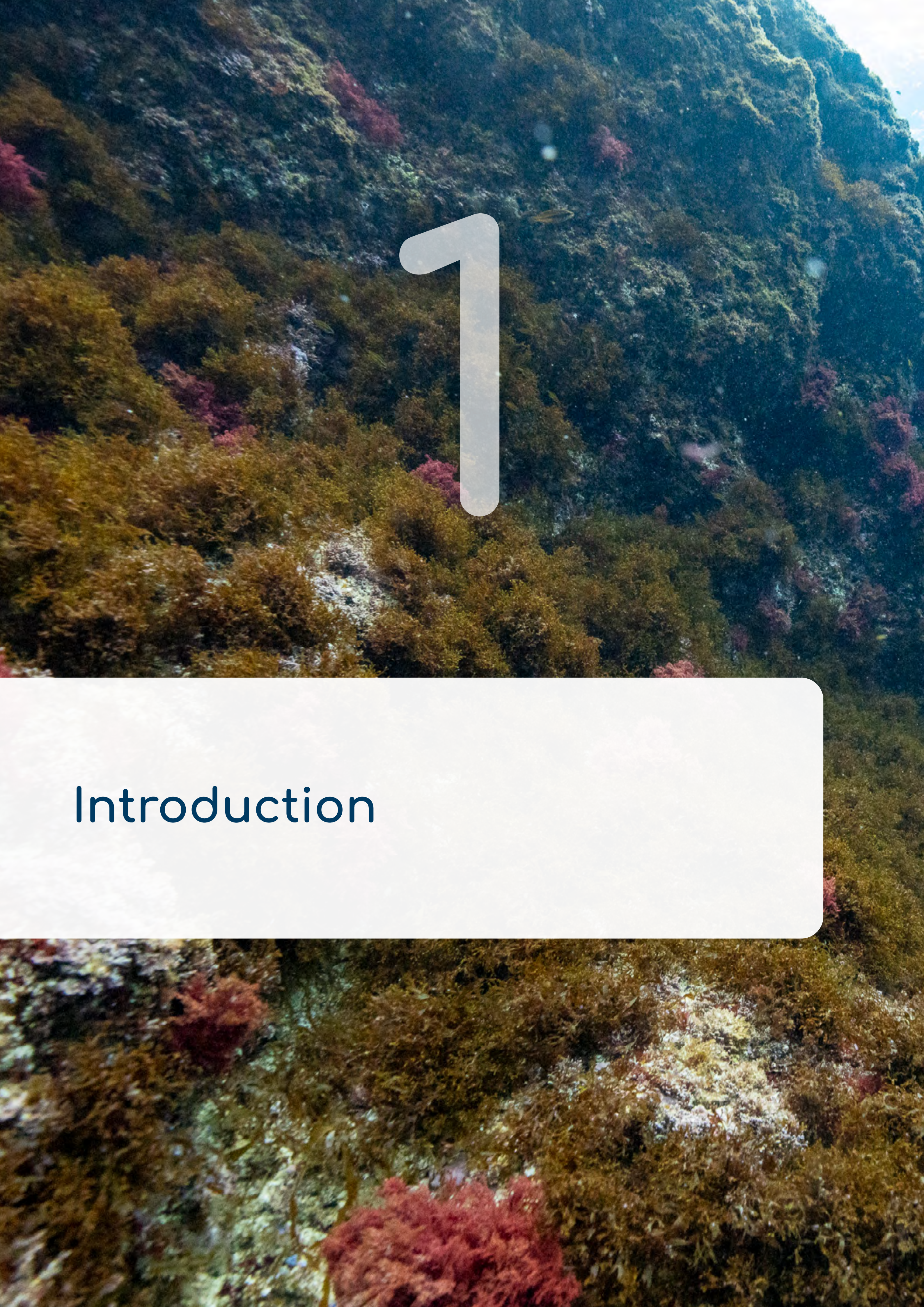
This document first maps and characterizes the existing landscape of **biodiversity monitoring communities** across Europe. We define these communities as thematic expert networks, comprising a diverse collective of stakeholders dedicated to specific biodiversity domains (e.g., pollinators, marine mammals, soil biodiversity) operating transnationally across at least two European countries. Our findings confirm that these communities, despite varying degrees of coordination, represent a solid and dynamic base of expertise, actively engaged in operational monitoring and vital for driving harmonisation.

Complementing this, the report defines **common minimum requirements** for biodiversity monitoring protocols. This crucial element identifies which aspects of monitoring protocols are most critical to harmonise – such as monitoring objectives, core variables measured, terminal sampling units, and reporting formats – advocating for a strategic alignment of key elements rather than rigid standardisation. This approach ensures methodological consistency necessary for comparability and statistical robustness, while still allowing the flexibility required to accommodate diverse national and local contexts.

While defining these minimum requirements is fundamental, their effective and consistent application across various scales necessitates a robust conceptual framework that can facilitate coordinated action and integration. Recognising that achieving cross-scale harmonisation demands more than aligning isolated protocols, our work identifies the need for a common foundation that allows diverse monitoring efforts to interoperate meaningfully.

Our conclusion is that to effectively leverage the existing expertise within monitoring communities and ensure the coherent application of minimum requirements, **Biodiversa+ proposes the development of Thematic Hubs (see chapter 5)**. These hubs are envisioned as expert-driven, cross-scale platforms that serve as guides to collaboration, supporting structured dialogue, the alignment of protocols, and technical exchange within and between monitoring communities. They form a critical component of a coordinated yet distributed architecture, connecting national, regional, and European efforts, aligning with the mandate of National Biodiversity Monitoring Coordination Centres, and to the overarching coordination led by the European Biodiversity Observation Coordination Centre (EBOCC).

Ultimately, this proposed framework strives to align diverse stakeholders' interests and establish a robust network that facilitates collaboration, data sharing, and enhances the quality, comparability, and utility of biodiversity monitoring data across all scales, significantly strengthening Europe's capacity for effective conservation.



1

Introduction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1.1 Context and objectives

Harmonising biodiversity monitoring protocols across scales is increasingly recognised as a critical step toward improving data interoperability, policy relevance, and conservation impact (Kissling *et al.*, 2024; Moersberger *et al.*, 2024). In the face of fragmented monitoring efforts and diverse institutional contexts, structured collaboration offers significant opportunities to align approaches, reduce redundancies, and enhance the collective value of biodiversity data. On the other hand, harmonisation efforts face the challenge of taking the best possible account of individual circumstances and maintaining the continuity of methods, particularly in the case of long-term surveys.

This report contributes to the broader harmonisation efforts led by the European Biodiversity Partnership, Biodiversa+, in line with the EU's vision for integrated and scalable biodiversity monitoring. It aims to provide practical guidance on how harmonisation can be effectively advanced within and across monitoring communities, focusing on specifications that facilitate cross-scale integration of biodiversity data.

1.2 Scope of the report

The report centres on the **role of monitoring communities** as key actors in the harmonisation process. Rather than promoting a one-size-fits-all model, it proposes the definition of **common minimum requirements** that can be applied flexibly across diverse monitoring initiatives. These specifications aim to support comparability and data integration while preserving local relevance and autonomy.

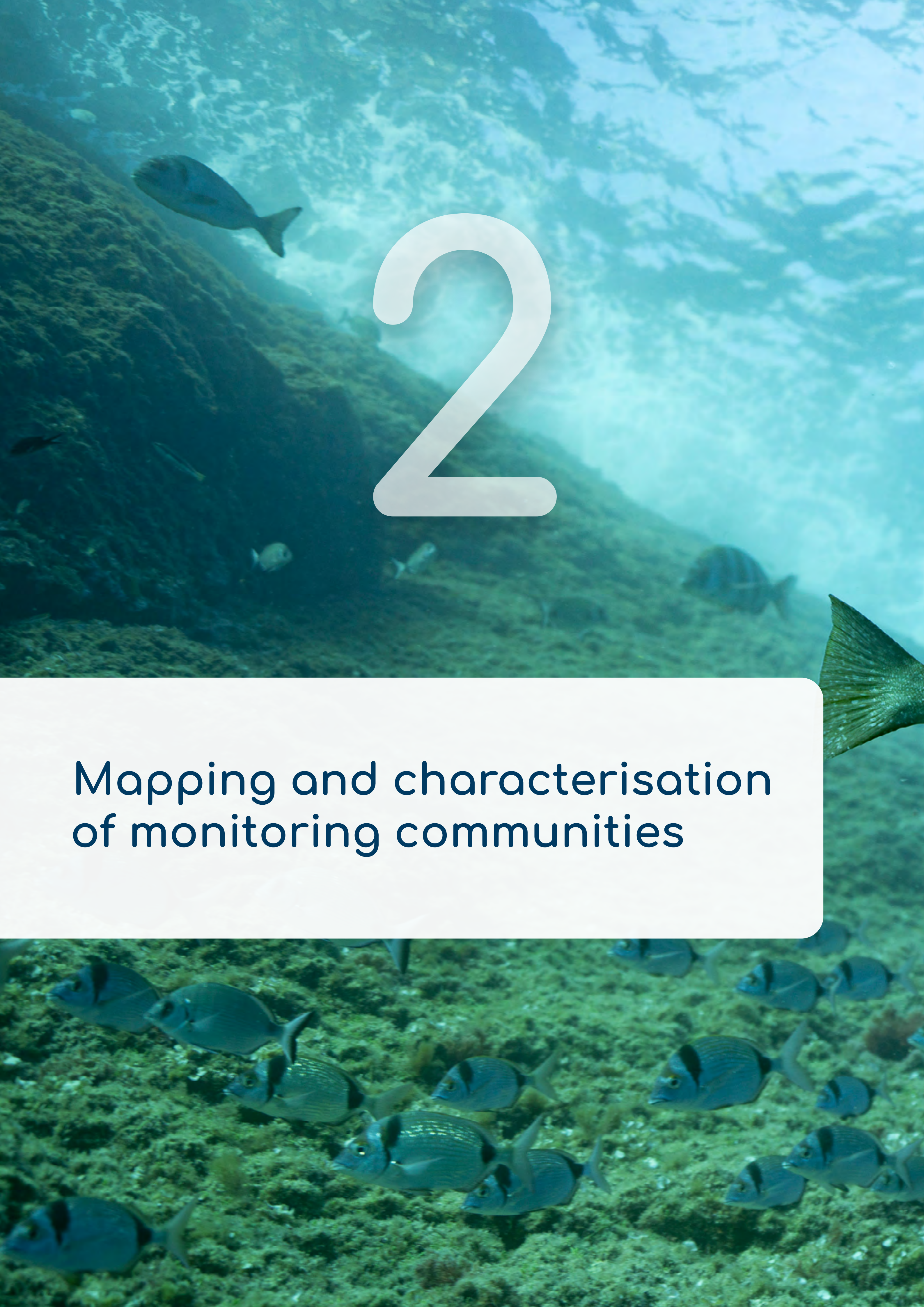
1.3 Relationship with the Biodiversa+ guide on harmonising biodiversity monitoring protocols across scales

This guidance builds directly on the first harmonisation guide (Guide on harmonising biodiversity monitoring protocols across scales. Biodiversa+ report, 2023[1]), which introduced core concepts and strategic approaches for alignment. That document proposed three key recommendations:

1. **Protocol flexibility** – enabling adaptation to local contexts while promoting compatibility;
2. **Parallel data workflows** – encouraging the collection and sharing of both raw data and derived products such as Essential Biodiversity Variables (EBVs);
3. **Common frameworks** – supporting coordination within and among monitoring communities.

Building on these foundations, the present report goes a step further by exploring how **monitoring communities** can serve as the most relevant and effective scale for implementing harmonisation. In particular, it elaborates on the **Biodiversa+ proposal for Thematic Hubs**, which would facilitate the coordination of harmonised efforts within thematic domains, and an analysis of the harmonisable elements of monitoring protocols, identifying where flexibility can be.

1. Silva del Pozo, M., Body, G., Rerig, G., Basille, M. (2023). Guide on harmonising biodiversity monitoring protocols across scales. Biodiversa+ report. 60 pp. https://www.biodiversa.eu/wp-content/uploads/2023/10/Biodiversa_Harmonising-monitoring-protocols.pdf



2

Mapping and characterisation of monitoring communities

2.1 What might be considered a monitoring community?

2.1.1 Definition used by Biodiversa+

Biodiversa+ defines monitoring communities as thematic expert networks dedicated to particular biodiversity domains (e.g., soil biodiversity, pollinators, marine turtles, freshwater ecosystems).

In the context of Biodiversa+, a monitoring community refers to a collective of stakeholders who share a common focus on monitoring a specific component of biodiversity

By addressing the specificities of their domains, these communities ensure that monitoring efforts remain scientifically robust while contributing to a broader, harmonised framework.

These communities are increasingly recognised as essential actors in the development of coherent and interoperable biodiversity monitoring systems across Europe.

2.1.2 Key characteristics of monitoring communities

Monitoring communities can be identified by several core characteristics:

- Thematic Cohesion: A shared focus on a specific biodiversity component or ecological system, such as wetlands, forest birds, or pollinators. These networks often have a larger focus than just monitoring, including conservation and restoration.
- Multi-actor Collaboration: Inclusion of a diverse range of stakeholders, including researchers, monitoring institutions, national agencies, non-governmental organisations, and citizen science initiatives. This diversity enhances the legitimacy and reach of monitoring efforts.
- Operational Monitoring Activities: Engagement in regular data collection, fieldwork campaigns, and coordinated monitoring efforts. These communities often have structured workflows, data pipelines, and quality control procedures, and produce biodiversity information at different scales.
- Knowledge Exchange and Coordination: Organisation of regular meetings, technical workshops, training events, and conferences to foster knowledge sharing and maintain coherence in methods and objectives.
- Commitment to Data Integration: Use of interoperable tools and platforms to facilitate the integration of collected data into national and European information systems linked to biodiversity. This includes alignment with relevant standards and metadata frameworks.

2.1.3 Their role in biodiversity data collection and harmonisation

Monitoring communities serve as key drivers for operationalising harmonisation efforts. Their technical expertise, contextual knowledge, and long-term engagement make them well-positioned to:

- Tailor harmonised protocols to specific ecological and taxonomic contexts;
- Act as bridges between national efforts and European-level coordination;
- Test and explore new monitoring approaches in response to emerging needs;
- Provide insights into feasibility, data quality, and implementation constraints;
- Contribute to the design of minimum requirements and comparable indicators.

Their integration into the wider Biodiversa+ framework enhances the effectiveness, relevance, and uptake of harmonisation processes. By enabling vertical (local to EU-level) linkages, monitoring communities reinforce the resilience and coherence of Europe's biodiversity monitoring infrastructure.

2.2 Methodology for mapping monitoring communities

Mapping biodiversity monitoring communities is an important first step towards achieving the broader goal of cross-scale inclusion of harmonised biodiversity monitoring protocols. These communities form the backbone of operational biodiversity monitoring across Europe, they are the key actors for fostering collaboration and aligning protocols.

2.2.1 Exploring the monitoring landscape

The first step in our methodology was to analyse the existing monitoring universe in Europe to understand what communities are already active. This initial scoping involved identifying formal and informal groups focused on specific taxonomic, thematic, or habitat-based monitoring efforts. It entailed exploring networks functioning at transnational levels.

This mapping exercise aimed to go beyond individual experts or isolated projects and focus on groups that demonstrate ongoing coordination, shared standards or practices, and potential to contribute to transnational harmonisation efforts.

2.2.2 Survey of existing monitoring communities

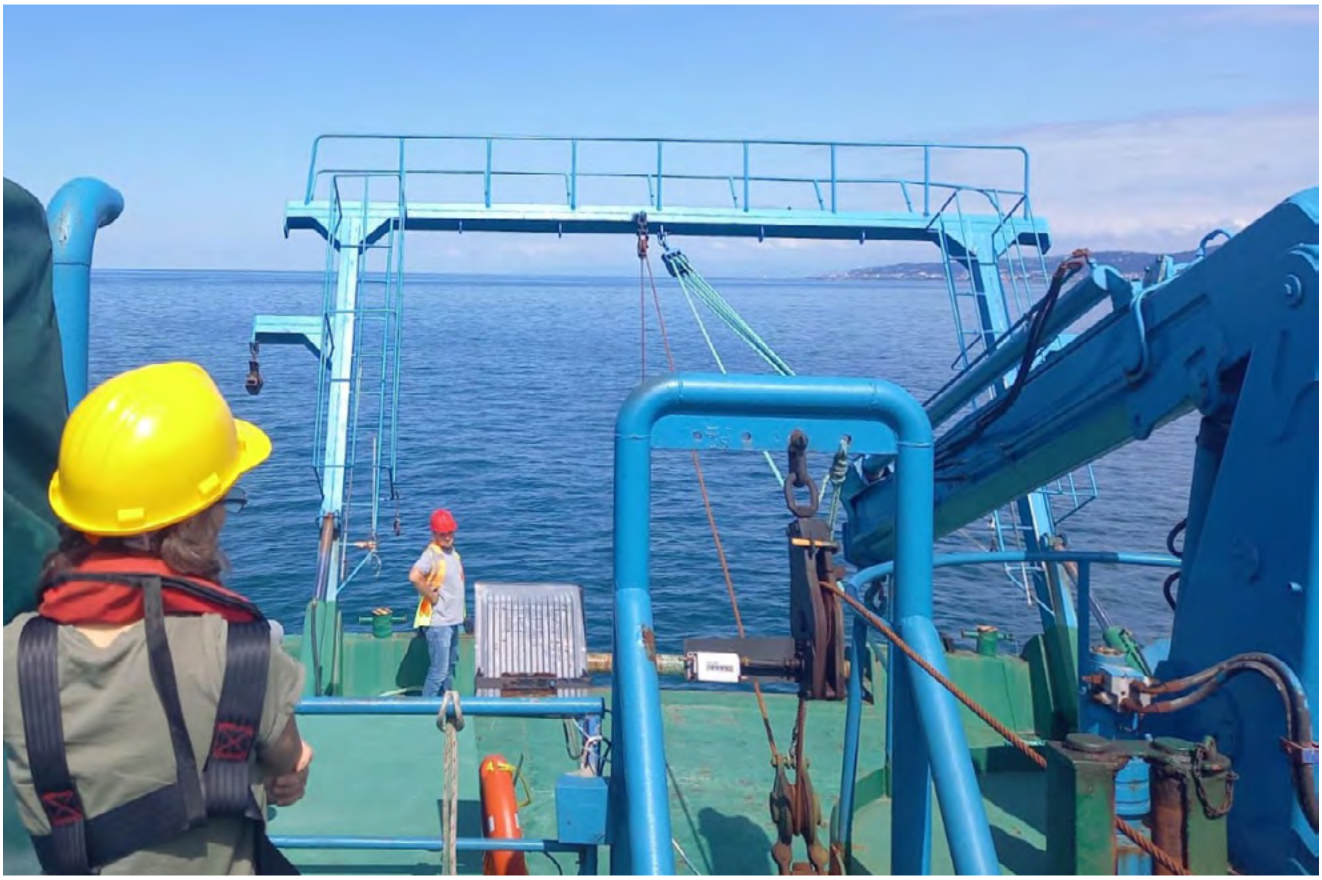
To identify and characterise existing monitoring communities, a dedicated survey was developed and widely disseminated across European networks. The survey was designed to be simple and accessible, encouraging a broad and diverse range of responses.

Survey structure and distribution

The survey, hosted on Google Forms, included the following key components (Annex 1):

- Identification of biodiversity monitoring communities known or participated in;
- Information on any associated European-level coordination group;
- Contact details for potential follow-up;
- Examples of how monitoring data is used within these communities.

The survey was circulated to Biodiversa+ partners, encouraging them to respond and share the survey widely across their professional networks, institutions, and social media platforms. The importance of reaching diverse communities beyond the existing Biodiversa+ partnership was emphasised.



Challenges and possible biases

While the survey provided valuable initial insights, several methodological limitations and challenges were identified:

- Reception and response Bias: As participation was voluntary, there may be an overrepresentation of well-established or English-speaking communities with stronger links to European projects or networks.
- Language Constraints: The survey was available only in English, potentially limiting participation from non-English-speaking regions or stakeholders.
- Disciplinary and Geographic Gaps: Despite dissemination efforts, we likely did not reach all relevant biodiversity monitoring communities across Europe—particularly those in underrepresented disciplines (e.g., microbiota, urban biodiversity) or in countries with less involvement in EU-funded biodiversity research.

These limitations suggest that the survey results represent only a partial snapshot of the European biodiversity monitoring landscape. Continued efforts are needed to expand outreach and build a more complete picture of existing communities.

2.2.3 Other existing catalogs and mapping efforts

In addition to the primary survey, the mapping process leveraged other relevant databases and literature sources:

- EuropaBON's Inventory of Monitoring Initiatives[1] (Morán-Ordóñez *et al.*, 2023) : This resource was used to cross-reference known communities and identify institutional-level monitoring schemes across Europe.
- Scientific Literature and Grey Literature Review: A targeted review of published and grey literature helped uncover information on community structure, data flows, and transnational collaborations not captured through survey responses.

These complementary sources helped to validate the survey results, fill in thematic gaps, and ensure a more comprehensive understanding of biodiversity monitoring communities and their current or potential contributions to harmonisation efforts.

1. EuropaBON Monitoring database : https://monitoring.europabon.org/monitoring/

2.3 Results: overview of monitoring communities in Europe

2.3.1 Characterisation and approximate number of monitoring communities in Europe

An initial mapping identified approximately 60 established biodiversity monitoring communities operating at a European or broader scale (Fig.1 & Fig.2). This number is likely an underestimate, as the mapping is based on publicly available and easily accessible information. The list should therefore be viewed as indicative rather than comprehensive. If you're aware of other communities not on this list, or if you're part of one and don't see it identified, please feel free to contact us; your input would greatly help us expand and refine this mapping.

For many biodiversity topics, multiple communities or networks exist (see Annex 2 for the full list). These often emerge due to regional distinctions or differing policy and historical contexts. For example, within the marine mammal community, networks such as ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas) and ACCOBAMS (Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area) operate in parallel, each with a specific regional focus, but with some level of coordination or mutual awareness.

This mapping focused primarily on communities with a European scope—defined as operating transnationally across at least two European countries. Some groups also function at the global level; in such cases, we included them only when their influence and collaboration were clearly relevant to the European biodiversity monitoring landscape.

To facilitate a clearer understanding of existing efforts and support future strategies for coordination and harmonisation, we characterised monitoring communities using the following typologies:

Monitoring communities can be first classified by the ecological realm they focus on:

- Terrestrial: e.g., insects, forests, birds.
- Freshwater: e.g., aquatic macroinvertebrates, freshwater fish, ponds.
- Marine: e.g., marine mammals, sea turtles, benthic habitats.

Within each realm, communities can be further distinguished by thematic scope or focal taxa (e.g., soil biodiversity, large carnivores, pollinators, or seabirds). Some themes naturally span multiple realms (e.g., shore birds, amphibians and reptiles which may use both terrestrial and marine or terrestrial and freshwater habitats. Same goes for interface habitats, such as mangroves or peatlands), and communities may need to be flexibly categorized to reflect this trans-realm nature, such as done in the IUCN[2] (Keith *et al.*, 2020).

2. IUCN global ecosystem typology 2.0 : https://iucn.org/resources/publication/iucn-global-ecosystem-typology-20

Established monitoring communities

	TAXA	HABITATS	REGIONS
FRESHWATER (FW)	· FW Fish · FW Macroinvertebrates · Salmon · Sturgeon	· FW ecosystems · Lakes	· Danube River · Rhine River
MARINE	· Cephalopods · Coastal/rocky fish · Elasmobranch · Fish · Jellyfish · Macroalgae · Marine mammals · Phytoplankton · Posidonia · Sea Turtles · Seabirds · Zooplankton	· Benthic habitats · Coral reef · Pelagic habitats · Seagrass	· Baltic sea · Black sea · Mediterranean sea · North Atlantic
TERRESTRIAL	· Bat · Bird · Butterfly · Fungi · Ibex · Large Carnivores · Lynx · Mammals · Pollinators · Raptors · Stag Beetle	· Alpine ecosystems · Dunes · Forest · Grassland · Soil	· Alps · Carpathians · Pyrenees
INTERFACE	· Amphibians & reptiles · Invasive Alien Species · Waders (shorebirds) · Waterbirds	· Lagoons · Mangroves · Peatlands · Ponds · Wetlands	· Arctic · Central and Eastern Europe
OTHER, UNCERTAIN	· DNA/Genomics · Microorganisms		

Figure 1: List of the identified established biodiversity monitoring communities, classified by realm (terrestrial, marine, freshwater, interface) and focus (taxa, habitat, region)

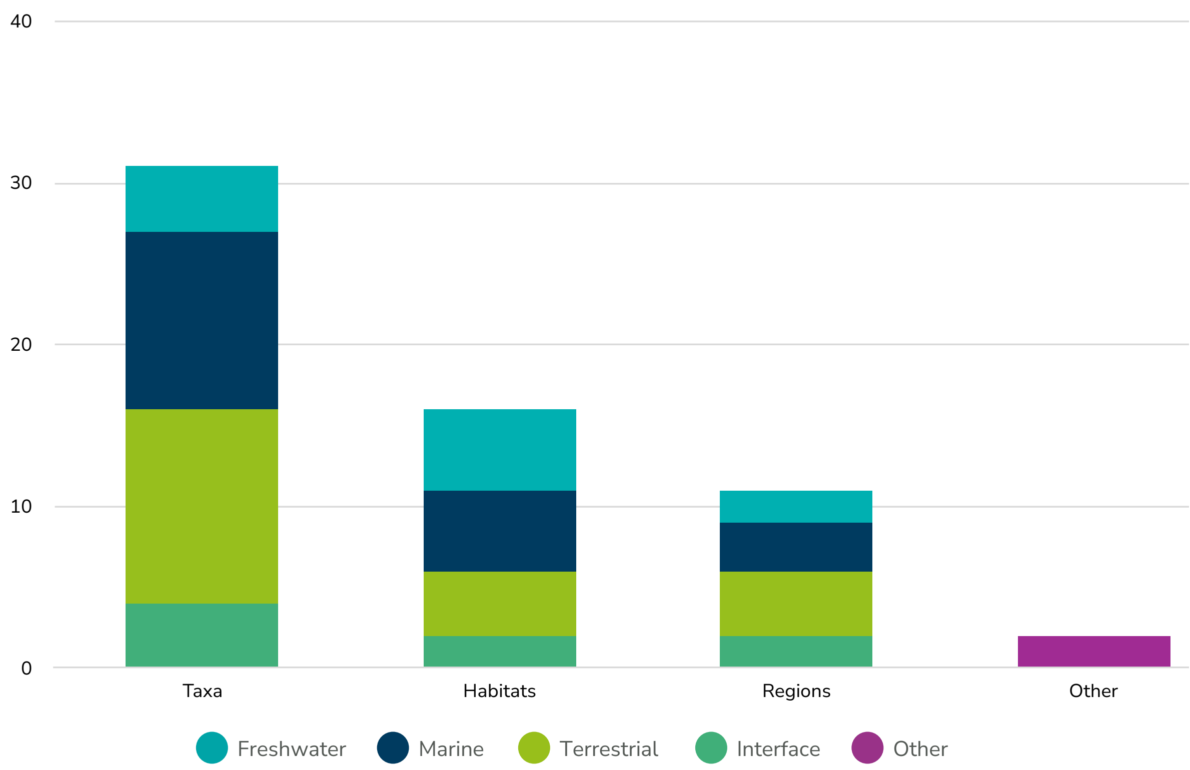


Figure 2: Estimated number and proportion of biodiversity monitoring communities by realm (terrestrial, marine, freshwater, interface) and focus (taxa, habitat, region)

2.3.2 Structural diversity

Level of definition of the theme

The clarity and consistency with which a monitoring community defines its scope is an important criteria for efficient engagement. This can be assessed at three levels:

- Well-defined: The community has a clearly articulated and commonly understood scope (e.g., "marine turtles" defined by a shared list of species and methods and protocols used for monitoring them).
- Moderately defined: The scope is somewhat clear, but boundaries may vary between countries or institutions (e.g., "small mammals" may include different species depending on context).
- Poorly defined or broad: The thematic focus is vague, or overlapping with several other communities (e.g., "biodiversity in forests" without specifying taxa or functions).

Maturity and organisation of the community

Communities also differ in their degree of maturity and organisation which induces visibility and institution-alisation. This can be expressed through the following categories:

- Key actor status: The community is recognised nationally or internationally as a reference or leader for its monitoring theme (e.g., informing indicators, feeding into international assessments).
- Structured and coordinated: The community has an established identity, leadership, communication channels, and regular collaborative activities (e.g., working groups, conferences).
- Emerging or informal: A loosely connected group with thematic overlaps but limited coordination or shared infrastructure.

Structure and governance

Biodiversity monitoring communities in Europe are highly diverse in structure and governance (Fig.3). Based on our mapping, they can be grouped into the following broad categories:

1. Expert Groups

These are often convened by European or international institutions (e.g. OSPAR, HELCOM, ICES) to provide scientific advice, develop indicators, coordinate assessments, or guide data collection protocols. Expert groups are typically composed of specialists nominated by national authorities, research institutes, or observer organisations. Their outputs are often directly integrated into policy processes, such as the EU Marine Strategy Framework Directive (MSFD) or the Convention on Biological Diversity (CBD).

2. NGOs and volunteer-based networks

Numerous monitoring efforts are led or supported by NGOs and citizen science communities. These networks often have wide geographic reach and long-term data series. Examples include the European Bird Census Council (EBCC), Butterfly Conservation Europe (BCE), and the European Mycological Association. Their work complements institutional monitoring by filling gaps in spatial coverage and taxonomic scope and often contributes to European-level indicators (e.g. through EIONET or Eurostat).

3. Institutional partnerships

These include formal collaborations between research institutions, environmental agencies, and national ministries. Many are supported through EU funding instruments (e.g. LIFE, Horizon Europe, INTERREG) and contribute to shared methodologies and databases.

4. Intergovernmental and agreement-based networks

Some monitoring communities operate under formal international agreements or conventions. For example:

- PoMS (Pollinator Monitoring Scheme) – initiative that is informing EU-level design of pollinator monitoring strategies.
- General Fisheries Commission for the Mediterranean – a FAO body coordinating fishery-related monitoring in the Mediterranean and Black Sea.
- ASCOBANS / ACCOBAMS – regional agreements focused on cetacean conservation and monitoring.
- Bern Convention Expert Groups – which also oversee monitoring efforts for specific species groups.

These communities often hold an official or advisory role in supporting Member States' reporting obligations and the implementation of regional or global biodiversity targets.

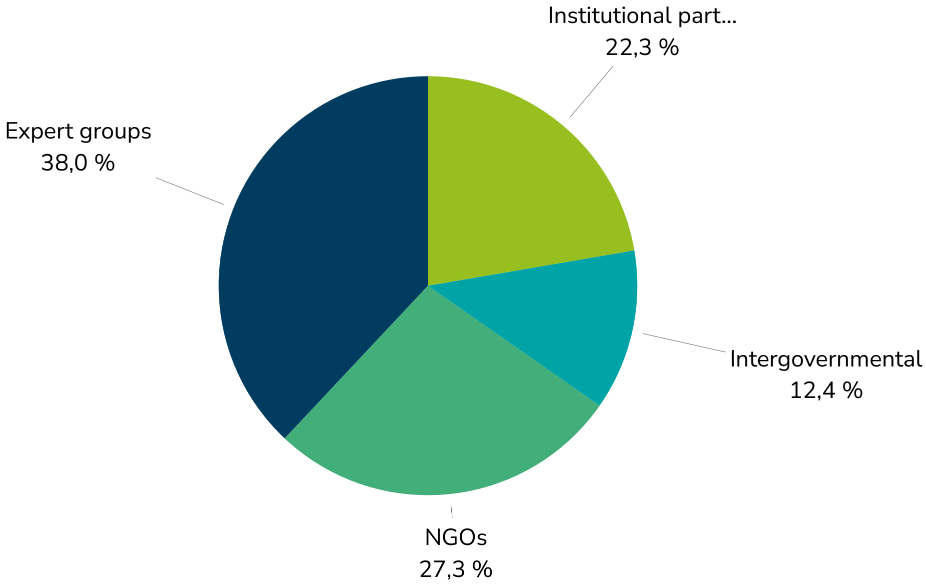


Figure 3: Proportion of types of governance (experts groups, NGOs, institutional partnerships, Intergovernmental and agreement-based networks) of the identified biodiversity monitoring communities

Not all thematic communities operate in the same way or with the same influence. We can distinguish two main types:

1. Institutionalized networks or working groups with Strong EU Mandates

These include, for example, European Commission working groups or task forces established under EU directives or frameworks. They are:

- Highly formalized and politically recognized;
- Often carry obligatory guidance or strong normative influence on national implementation;
- Considered authoritative reference bodies across EU Member States.

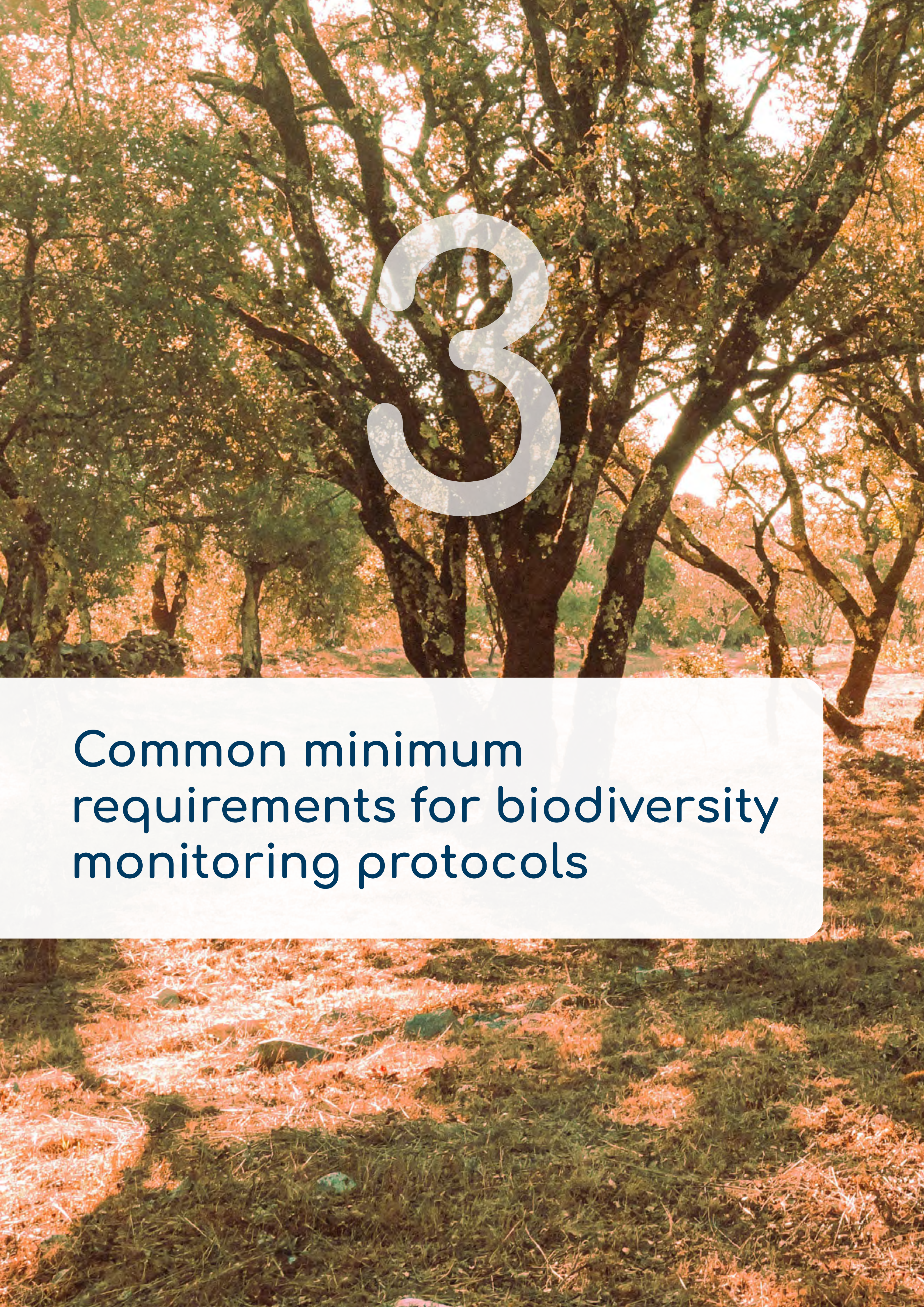
2. Communities from Regional Agreements or Scientific Networks

These are expert groups or platforms operating under regional conventions, international partnerships, or scientific communities. Their characteristics include:

- Varied visibility and capacity across countries;
- Voluntary engagement and non-binding recommendations;
- Sometimes not recognized as key actors by all national authorities, but still valuable for scientific credibility, innovation, and filling thematic gaps.

These criteria help prioritise which communities might be immediately ready to engage in harmonisation efforts, and which may need additional support to build coordination capacities.

While harmonisation is most effective at the scale of individual communities, an important question remains: can we identify common elements across diverse monitoring protocols that could be harmonised regardless of the specific community? This leads us to define the common minimum requirements for biodiversity monitoring—essential foundational elements that can provide a shared baseline for all initiatives.



3

Common minimum requirements for biodiversity monitoring protocols

3.1 Methodological basis

Defining common minimum requirements is a central step toward achieving harmonisation of biodiversity monitoring across spatial and governance scales. These requirements are not intended to enforce full standardisation but rather to establish a shared baseline, ensuring that data collected by different monitoring initiatives are comparable, interoperable, and of sufficient quality to contribute to larger-scale analyses.

The following core components, identified across key references (Oakley *et al.*, 2003; JNCC, 2004; Elzinga *et al.*, 1998), are widely recognised as essential elements for establishing common minimum requirements in biodiversity monitoring protocols:

Box 1 – Items of a monitoring protocol

- **Objective of the monitoring protocol:**
  - Object: define the biological entity or ecological process to be monitored; e.g- single specimen, habitat or process.
  - Scale: determine the spatial dimensions, geographic scope, and scale of the monitoring program.
  - Variables: identify specific attributes and/or metrics measured.
- **Sampling design strategy:**
  - Sampling units: define the basic observational units (e.g., specific points, surface areas, individuals, grid elements, plot sizes, transect lengths, ...).
  - Sampling strategy (e.g. random, systematic, stratified, combined).
  - Sampling frequency and replication (Intervals, e.g. annually, after storm events,, number of individual samples per site,).
  - Sample size (Overall data yield, defines the total anticipated volume of collected data across the entire project)
- **Field protocol:**
  - Method (e.g., transect surveys, point counts, capture-mark-recapture, ...).
  - Techniques (e.g., visual observation, remote sensing, acoustic monitoring, trapping).
  - Calendar: timing and scheduling of data collection activities, time during the season, ...
  - Equipment/Tools (e.g., cameras, nets, binoculars, ...). Transport and storage of samples.
- **Analysis protocol**
  - Methods for analysing collected data, defining appropriate including statistical techniques and modeling approaches. to address the research questions.
  - Data workflow
  - Sharing of raw data, aggregating data.
- **Data storage and management**
  - Develop a good data management plan (DMP) that thoroughly describes how the data are going to be handled, from the sampling to the analysis, storage and publication.
  - Systems for organising, storing, and securing collected data.
  - Standardised formats for data entry and metadata documentation.
  - Platforms for public access and data sharing (e.g., national databases).

While various initiatives and networks (e.g., GEO BON, EuropaBON, EU Nature Directives reporting) have provided guidance or frameworks on biodiversity monitoring, very few studies or tools offer practical, operationalised definitions of common minimum requirements that can be implemented across diverse contexts.

Expert Workshop: objectives and structure

To address this gap and advance the definition of common minimum requirements, Biodiversa+ organised an expert workshop focused specifically on identifying which elements of biodiversity monitoring protocols are most critical to harmonise, and how to define flexible yet robust minimum requirements.

The workshop (April 2-3, 2025) brought together around 30 experts—including representatives from various monitoring communities, statisticians, and coordinators of Biodiversa+ pilot projects—to collaboratively explore and define minimum requirements for biodiversity monitoring protocols. A particular emphasis was placed on sampling design and statistical integration, as these are key to enhancing the interoperability of biodiversity data.

The workshop was structured using collective intelligence methods to stimulate creative thinking, knowledge exchange, and consensus-building.

Full details of the workshop structure, exercises, and results are available in Annex 3.

Why focus on sampling design?

The workshop deliberately focused on sampling design, a foundational component of any biodiversity monitoring protocol. Several reasons justified this choice:

1. Sampling design governs data comparability: Differences in spatial scale, sampling effort, frequency, or replication can significantly affect the interpretability and integration of monitoring results.
2. It is relatively independent of taxonomic groups (unlike the field protocols): While species identification or indicators may differ, many principles of good sampling design (e.g., stratification, randomisation, temporal consistency) are applicable across taxa and habitats.
3. It is often overlooked in harmonisation efforts: While there is a tendency to focus on indicator selection or taxonomic standards, sampling design is less visible but just as crucial for ensuring data robustness and interoperability.
4. It enables flexibility: By setting minimum requirements for design—rather than prescribing one protocol—we allow different communities and countries to adapt their methods while maintaining a harmonised backbone.

By focusing on sampling design, we aimed to define a practical and cross-cutting entry point for operationalising harmonisation.

3.2 Defining minimum requirements

3.2.1 Foundations for harmonisation

A key mechanism for achieving harmonisation is the definition of common minimum requirements within monitoring protocols. These minimum requirements serve as baseline standards that safeguard data quality, facilitate integration across regions and governance levels, and provide the structural coherence needed to support cross-country assessments and long-term trend analysis.

By clearly establishing these shared requirements, it becomes possible to maintain methodological consistency across diverse monitoring initiatives, while still allowing room for contextual flexibility in implementation. This approach recognises that not every aspect of a protocol must be identical to achieve harmonisation. Instead, the emphasis lies in identifying which elements must be aligned or standardised to ensure comparability and statistical robustness, and which elements can remain adaptable to suit national or local circumstances.

Importantly, harmonisation does not imply rigid standardisation of every protocol component. Rather, it involves a strategic alignment of critical elements, supported by transparency and well-documented metadata. This enables diverse datasets to be meaningfully interpreted and aggregated, even when collected under different conditions.

Based on the collective work undertaken during our workshops, expert consultations, and literature review (Yoccoz *et al*., 2001; Fairweather *et al*., 1991, Elzinga *et al*., 1998, Legg & Nagy, 2006, Field *et al*., 2007, Lindenmayer & Likens, 2010, White, 2019, Reynolds *et al*., 2016), several key recommendations have emerged. The next essential step is to translate these harmonisation principles into actionable tools and operational support mechanisms—guidelines, templates, training resources, coordination hubs—that can assist practitioners across countries and governance levels in implementing harmonised monitoring in practice.

Objectives drive everything
Clear, shared objectives are essential—they influence what is monitored, how, and at what resolution. However, defining these objectives can be challenging, especially across governance contexts.

Flexibility vs comparability
Flexibility is necessary to adapt to national and ecological contexts, but comparability requires a shared backbone. Harmonisation is essential at the reporting level; protocol implementation can vary if transparently documented.

Minimum vs optimal effort
Statistical robustness: effort and frequency must meet minimum thresholds (e.g., via power analysis) to detect trends. Beyond this, countries can upscale efforts based on capacity and priorities.

From the past via the present into the future
High importance of long-term monitoring series, however, a rapidly changing world makes it necessary to widen the focus on monitoring species/indicators that have previously received little attention. A good coverage in space and time and gap filling in monitoring activities has to be considered against the background of scarce resources in different countries and on the long run. Rapid dissemination of monitoring results is crucial to inform timely policy responses.

Governance matters
Monitoring is constrained or enabled by governance structures, funding, and trust. Open data, clear responsibilities, and transparent reporting are essential to facilitate collaboration and interoperability. Pilot projects have proven to be invaluable not only for testing the technical aspects of protocols and adapting designs as needed (Elzinga *et al*., 1998) but also for assessing and refining implementation at a governance level (Seeber, 2024; Lispanen *et al*., 2024).

Trust building in politics and society
Harmonised monitoring schemes conducted by well trained ecologists and/or citizen scientists with a good coverage of sites and high number of repetition, transparency in methodology and measures to reduce uncertainties and quality control of data can contribute to an increased confidence in monitoring data and results. However, a better understanding of the trust building process and a better communication of monitoring results in politics and society is essential to improve trust on monitoring in politics and society for a long-term support for necessary measures.

3.2.2 Key elements of a monitoring protocol: harmonisable elements, focus on the Sampling Design

Defining monitoring objectives

Objectives are foundational
Objectives determine variable selection, sampling design, resolution, and analysis. They influence what is monitored (species, traits, ecosystem functions), how it is done, and at what spatial and temporal scale. A shared understanding of objectives and baselines is essential before protocols are designed.

Objectives can vary
Monitoring goals may reflect EU legal obligations, national priorities, or local conservation needs. Even when countries monitor the same variables, their objectives may differ—such as detecting long-term trends vs. tracking short-term changes—leading to different designs.

Challenges in aligning objectives
The definition of a monitoring objective is not always clear-cut. Whether objectives should be harmonised across countries remains open for discussion. Monitoring data are often repurposed over time, raising questions about how adaptable protocols need to be.

Alignment with frameworks (e.g., EBVs)
Essential Biodiversity Variables (EBVs) provide a useful backbone for harmonising monitoring targets. However, EBVs alone may not satisfy the full range of EU legislative requirements (e.g., Habitat Directive). Therefore, EBVs can serve as a foundation, supplemented by additional layers specific to policy needs.

Monitoring objectives are non-negotiable foundations for harmonised biodiversity efforts. Flexibility in implementation is necessary, but clarity in objectives, baselines, and alignment with overarching frameworks ensures comparability and policy relevance.

Sampling units & strategies

Understanding sampling units
A sampling unit refers to the smallest measurable entity—typically a defined plot or transect—used to observe biodiversity trends. Its definition depends on ecosystem type, species of interest, and monitoring goals. Units should be consistent and enable change detection rather than exhaustive coverage.

Designing sampling units
Sampling units vary in shape and size based on habitat and monitoring objectives. Consistency in area or volume is key, even if shape is adjusted. Fixed areas promote comparability, while effort should be standardised as time × space. The choice between permanent and temporary plots depends on monitoring goals.

Sampling strategies
Strategies may be random, systematic, stratified, or adaptive. Stratified approaches, once defined, should remain fixed for comparability. Sampling strategies should reflect ecological realities and monitoring goals, with room for local adaptation during design, but consistency during implementation. Intercalibration is essential when integrating data from different regions.

Sampling unit design must strike a balance: fixed where needed for comparability, flexible where necessary for ecological relevance. Clear documentation allows for analytical reconciliation of differences.

Sampling frequency & sample size

Balancing statistical robustness and flexibility
Minimum sampling frequency and size must be sufficient to detect change. Power analyses can set thresholds based on desired sensitivity. Adaptive frequency—based on seasonal variability or key indicators—can improve efficiency, provided statistical requirements are still met.

Core and expanded efforts
A harmonised monitoring system should consist of:

» A core network of harmonised sites and standard protocols

» An expanded, flexible set of sites reflecting national priorities and capacities

More intensive sampling at selected sites (e.g., phenology stations) can enhance this dual-layer design.

A shared understanding of statistical requirements underpins robust biodiversity monitoring. While effort and frequency can flex around a minimum threshold, further guidance is needed to address unresolved statistical and design questions.

Sampling design & governance Interactions

Governance as a structuring force
Governance frameworks determine monitoring objectives, funding, legal obligations, and data-sharing policies. Early alignment with national and EU authorities ensures outputs are both scientifically robust and policy-relevant.

Prioritising harmonisation at the right level
Full harmonisation of field protocols may not be necessary. Instead, efforts should focus on reporting-level consistency. Countries can implement protocols flexibly, provided outputs are transparent, comparable, and aligned with shared goals.

Navigating governance trade-offs
National priorities, political variability, and trust in science all influence what's feasible. A governance coordination hub could help align designs, pilot harmonisation, and foster collaborative adaptation across borders.

Governance shapes every aspect of biodiversity monitoring—from design to data dissemination. Harmonisation should be pursued at the reporting level, supported by flexible national implementation and anchored in shared principles of transparency, openness, and trust.

Summary of the main recommendations for the harmonisable elements of a biodiversity monitoring protocol

Building on these shared principles for harmonisation, the following elements and recommendations are proposed as part of a draft common protocol structure.

These should guide the harmonisation process by identifying which protocol elements must be standardised ("STRICT"), which allow flexibility ("FLEXIBLE"), and where further debate is required:

Table 1. Guiding Elements for Biodiversity Monitoring Protocol Harmonisation: proposed Strict and Flexible Requirements

Element	Requirement	Justification & Recommendation
1. Objective	STRICT	The objective sets the foundation of the protocol—it defines the purpose and guides all downstream decisions (what, how, when, where). This must be clearly stated and aligned with policy or scientific goals. » **Recommendation:** Define SMART objectives (Specific, Measurable, Achievable, Relevant, Time-bound). To do so, use a shared vocabulary, we recommend to follow the EBV grammar[1], and align with existing frameworks (e.g. EU directives, GBF, CBD).
2. Object of Monitoring	STRICT	The "what"—species, communities, habitats, or processes—must be precisely defined to ensure consistency in data collection and interpretation. » **Recommendation:** Define core monitoring objects based on a referential list (e.g. GBIF backbone taxonomy[2], IUCN global ecosystem typology[3], EUNIS habitat classification list[4], ...), and allow optional additions if well documented.
3. Scale (Spatial/ Temporal)	STRICT (core) + FLEXIBLE (optional)	Ecological, logistical, and political contexts vary across countries. Thus, scale must be adaptable—but minimum spatial and temporal coverage is needed to ensure comparability and allow aggregation. » **Recommendation:** Define minimum scale on which you expect results (e.g., national or regional coverage, frequency), according to the policy needs. Independent scaling up is possible where feasible.
4. Variables Measured	STRICT (core) + FLEXIBLE (optional)	Variables (e.g., species richness, abundance, biomass) are central to analysis. Fixing core variables allows harmonisation; optional ones can enrich interpretation. » **Recommendation:** EBVs are a useful backbone, but any variable is fine as long as the definitions and units are agreed upon. Extended versions of the protocol can include additional variables.
5. Sampling Unit (e.g., plot size)	STRICT	Consistency in terminal sampling units (or the smallest unit to which a value is attributed) is vital for comparable measurements. While ecosystem-specific units may differ, a harmonised definition (e.g., minimum area, homogeneity) must be used across sites. » **Recommendation:** Establish standard unit templates, with clear guidance for implementation.
6. Sampling Strategy (e.g., stratified, systematic, random..)	FLEXIBLE	Strategy depends on habitat conditions and objectives. Flexibility during design is acceptable within a statistical framework, but once defined, it must remain fixed for implementation. » **Recommendation:** Connect with a bio-statistician for developing and updating the strategy. We recommend a stratified sampling for robustness, including substitution options to handle sites accessibility.
7. Sample Size & Frequency	STRICT (core) + FLEXIBLE (optional)	Minimum effort must ensure statistical power to detect change. Beyond that, expanded sampling frequency or number of sites can increase at any scale according to needs. » **Recommendation:** Conduct or refer to power analyses to define and adjust minimum sampling effort. Extended protocols can be applied on a subset of sites. Balance between scale and in-depth analysis of the variable could be achieved through the application of an extended protocol on a subset of sites.
8. Reporting	STRICT	Countries must report their results using shared formats and timelines that apply to the EBVs and indicators, even if protocols vary. » **Recommendation:** Define reporting templates, define data standards that apply to results, for instance one smooth trend and linear trends for 6, 10, 24 year periods in accordance with the nature Directives and Red Lists.
9. Governance	FLEXIBLE	The monitoring schemes are often governed at national or sub-national scales. Keeping a close link with the observers is valuable for data quality and cultural adaptation. » **Recommendation:** There is no need to harmonise the implementation of the monitoring schemes.

1. EBV grammar: When (temporal definition) x Which (biological level) x What (EBV) x Where (spatial definition). Mathieu Basille, 2023 GEO BON Global Conference: https://cdn.fourwaves.com/static/media/formdata/f598e28c-6fc8-4ac8-b47f-2a169bae905b/acda1927-d4b4-4d64-bec9-ca08d89d4f3f.pdf

2. GBIF Backbone Taxonomy : https://www.gbif.org/dataset/d7dddbf4-2cf0-4f39-9b2a-bb099caae36c

3. IUCN global ecosystem typology 2.0 : https://iucn.org/resources/publication/iucn-global-ecosystem-typology-20

4. EUNIS habitat types classification : https://eunis.eea.europa.eu/habitats.jsp

3.2.3 Addressing key challenges

Defining common minimum requirements for biodiversity monitoring protocols involves navigating a series of challenges related to spatial, temporal, and variable dimensions of sampling design. Here we highlight some of the critical methodological considerations to address these challenges and improve cross-scale data comparability.

Spatial dimension

One of the foundational steps in harmonising monitoring protocols is the clear definition of the spatial population to be sampled. This includes specifying the size, geometry, and boundaries of the area under observation. Without a well-defined spatial frame, the comparability of data across regions and studies is severely compromised.

To support spatial harmonisation:

- Grid-based sampling designs were discussed as a practical and scalable approach to integrate multiple spatial scales while maintaining statistical robustness.
- Randomised site selection was strongly recommended to reduce sampling bias and enhance representativity.
- Stratified sampling, based on relevant ecological gradients (e.g., elevation, land use), was also recognised as a flexible and harmonisable strategy to account for habitat heterogeneity while enabling comparability.

Experts emphasized the importance of clearly defining what constitutes a site and a statistical unit, as these foundational choices affect downstream analyses and integration possibilities.

Temporal dimension

The temporal component of monitoring protocols presents another layer of complexity. Sampling frequency and timing must be carefully calibrated to the life cycles of the species or dynamics of the ecosystems being studied. For example, seasonal variations in species detectability may influence the optimal monitoring period.

Unlike spatial parameters, temporal dimensions are often less easily harmonised across regions due to differences in ecological contexts and operational constraints. Nevertheless, temporal clarity remains essential. Common recommendations included:

- Clearly defining the sampling interval and duration (e.g., annual, seasonal, continuous).
- Adapting protocols to phenological patterns or ecological events that are critical to the monitoring objective (e.g., breeding seasons, migration).

Variables

The type and structure of monitored variables significantly influence harmonisation potential. Experts recommended prioritising variables that are more easily standardised, such as:

- Presence–absence and abundance data, which are relatively straightforward to collect and compare.
- Additive variables (e.g., counts, biomass), which can be meaningfully aggregated and analysed across different scales.

In contrast, non-additive variables like density or diversity indices may require additional assumptions or transformations for cross-study integration.

The group also discussed the need to clarify whether variables are:

- Unidimensional (e.g., single species counts), or
- Multidimensional (e.g., species assemblages with environmental covariates), which adds complexity to harmonisation but can enrich analysis when well-structured.

Cross-cutting issues

A few overarching issues emerged that intersect the spatial, temporal, and variable dimensions:

- **Scale:** Harmonisation is more difficult at finer scales, which demand higher sampling intensity and granularity. The group emphasised aligning scales where possible and ensuring that scale definitions are explicit.
- **Randomisation:** Avoiding site selection bias remains a challenge in ecological monitoring. Participants agreed that protocols should encourage objective, systematic randomisation rather than relying on convenient or legacy sites.
- **Error minimisation:** Understanding the types of sampling errors (e.g., detection errors, misclassification, spatial autocorrelation) is key to improving data quality. Minimum requirements should help practitioners identify, quantify, and minimise such errors.

3.2.4 Remaining issues & open questions

Despite progress in identifying avenues for cross-scale harmonisation, several challenges remain unresolved and would need further attention.

Terminology harmonisation
Persistent ambiguities in terminology—such as with what is understood by "objectives," "objects," "variables," and "scales"—are a significant barrier to effective communication and methodological alignment. These terms are often used interchangeably or with divergent meanings depending on national context, disciplinary traditions, or scientific communities. As such, there is a need to develop a terminological harmonisation framework that can support clarity, consistency, and interoperability in monitoring design and reporting.

This could be achieved through the co-creation of a controlled vocabulary and glossary, developed in collaboration with national and thematic stakeholders. A key open question is who should lead this development—whether at the European level (e.g. under the EBOCC or relevant EC bodies) or through coordinated national efforts—and how to ensure acceptance and adoption of the shared terminology across the diverse communities involved.

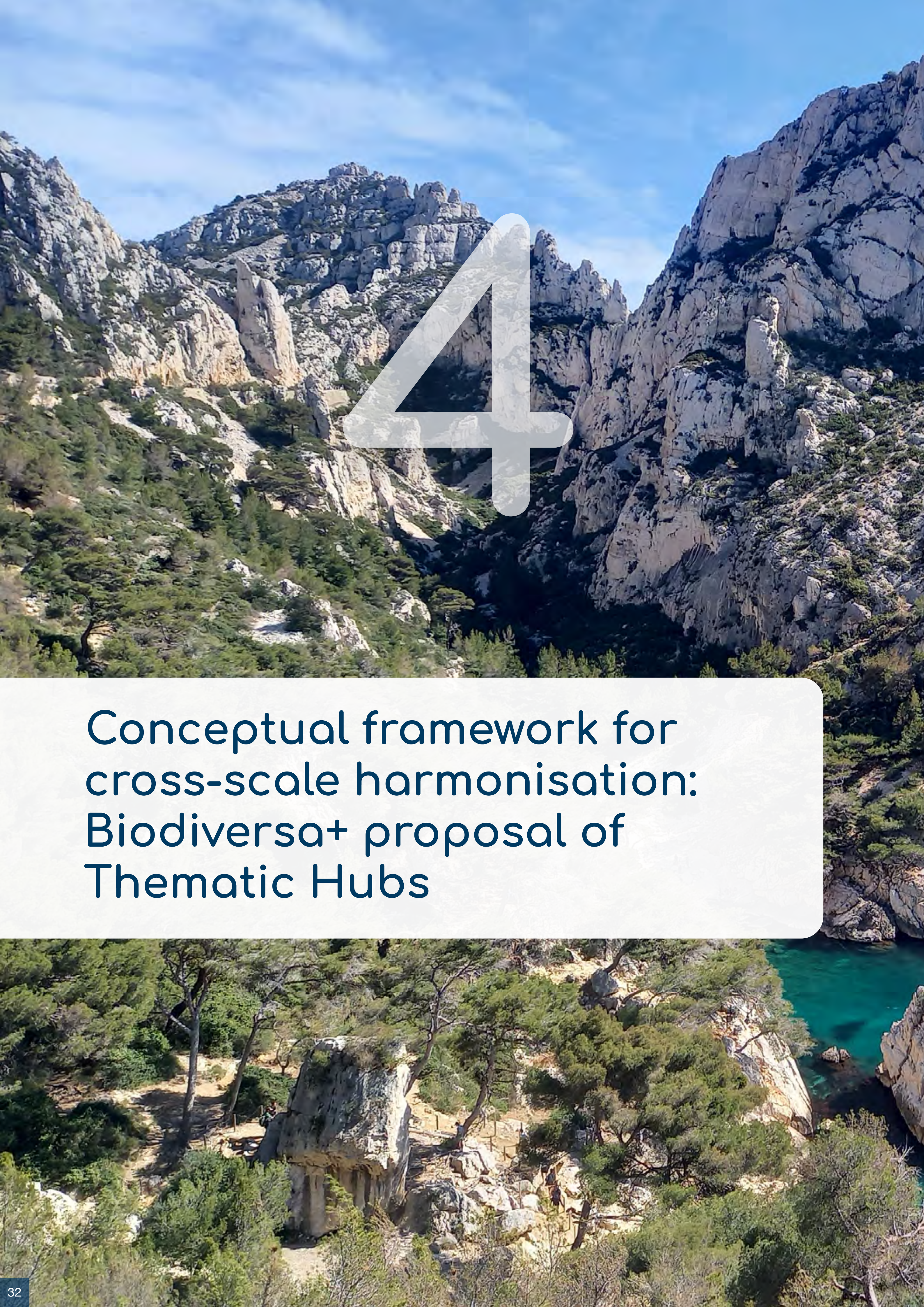
Reusability of opportunistic data
More discussion is needed on when and how legacy or non-standard data (e.g. citizen science, museum records) can be used for new objectives. There is a demanding interest in the use of these types of data, however, issues such as data quality, metadata completeness, spatial - temporal information remain unclear. Further discussions and guidance are needed to define the criteria on how to harmonise, validate, integrate such datasets to be aligned with ongoing standardised monitoring frameworks. The quality of metadata is of great importance. In addition to its original purpose of enabling the categorisation and thus further use of collected data, it is becoming increasingly important in a changing world; yesterday's metadata can be tomorrow's data.

Baseline definition
All newly initiated monitoring programs will establish a real baseline in their first round of sampling, ideally following a standard protocol. For example, the Biodiversity Monitoring South Tyrol (Province of Bolzano/Bozen) began in 2019 and established a real baseline in its first cycle. The benefit of a real baseline is that it is specific to the country or region, though it requires a minimum number of cycles to identify true trends.

Statistical guidance
Countries need support to understand variability and define detection thresholds. Biodiversity data types are highly variable (e.g presence absence, abundance, trait base) and heterogene spatially. This complexity makes it difficult to choose appropriate statistical methods to detect real trends. Particularly when datasets are not standardized, collected data are sparse, unbalanced across taxa and/or geographical regions. There is a need for clear statistical guidelines to support appropriate models and analysis frameworks that interpret trends in biodiversity interactions. Without this support there is a risk of failing to detect true signals and misinterpretations.

There is a strong case for developing statistical guidance tools, which may include: decision trees to support model selection based on objectives and data types; workshops or training programs to build national capacity; a dedicated Statistical Advisory Hub at the European level; communication guidelines to translate statistical findings into meaningful insights for policymakers.

Having defined the minimum requirements for harmonisation within biodiversity monitoring protocols—from foundational elements to key aspects of sampling design—and addressed the inherent challenges in achieving comparability across diverse contexts, the focus now shifts to the practical implementation of these principles. While establishing what needs to be harmonised is crucial, its effective and consistent application across various scales necessitates a robust conceptual framework that can facilitate coordinated action and integration. The subsequent section therefore outlines such a framework, detailing how the proposed Biodiversa+ Thematic Hubs offer a structured approach to foster cross-scale harmonisation and ensure the coherent application of the minimum requirements identified.



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Conceptual framework for cross-scale harmonisation: Biodiversa+ proposal of Thematic Hubs

Achieving cross-scale harmonisation of biodiversity monitoring requires more than aligning isolated protocols; it calls for a common foundation that allows diverse monitoring efforts to interoperate meaningfully across scales. This includes establishing a shared understanding of minimum requirements, and fostering inter-community expertise to guide technical alignment without losing the relevance of place-based approaches. While the relevant unit for harmonisation is often the monitoring community itself, these communities currently operate with varying degrees of coordination, scope, and methodological maturity. Still, they represent a solid and dynamic base of expertise already active across Europe. To build on this existing landscape, we propose the development of Thematic Hubs. These hubs serve as cross-scale platforms that support structured dialogue, alignment of protocols, and technical exchange within and between monitoring communities. In this Biodiversa+ proposal of Thematic Hubs, we are building on EuropaBON proposal for an EU Biodiversity Observation Coordination Centre (Liquete *et al.*, 2024), which introduces Thematic Hubs as established communities of experts, that serve as the backbone of EBOCC's technical and operational framework, focusing on specific biodiversity variables and drawing members from competent national and international institutions, scientific experts, and large-scale monitoring schemes.

To enable cross-scale harmonisation of biodiversity monitoring, a coordinated yet distributed architecture is essential, one that connects national, regional, and European efforts while respecting thematic and ecological specificities. This architecture should also align with the mandate of the National Biodiversity Monitoring Coordination Centres (Fig.4). Within this landscape, Thematic Hubs play a key role as technical and collaborative stepping stones, guiding both harmonisation and integration processes.

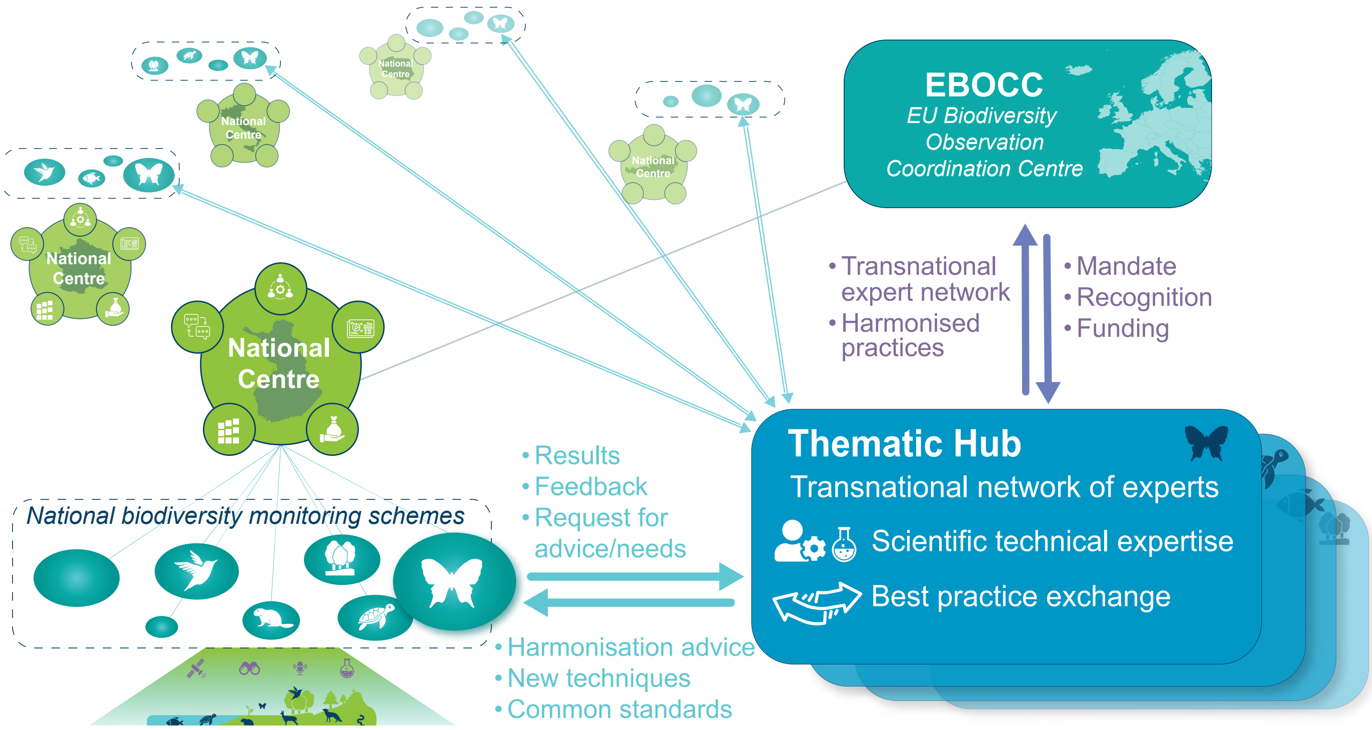


Figure 4 Thematic Hubs in the transnational governance for biodiversity monitoring.

4.1 Thematic Hubs as guides to collaboration: what are they?

Thematic Hubs are expert-driven communities centered around specific biodiversity domains—such as pollinators, soil biodiversity, or marine mammals. They operate as platforms for coordination and knowledge exchange, where experts converge to:

- Define monitoring objectives for their thematic focus;
- Develop and align standards on protocols and tools;
- Produce at European scale trends and biodiversity information and align them across scales;
- Share best practices and lessons learned;
- Facilitate data harmonisation and integration within and beyond their thematic area;
- Serve as entry points to the wider biodiversity observation system, especially for stakeholders less connected to European coordination bodies.

These communities form the technical backbone for thematic monitoring and contribute to the overarching coordination led by the European Biodiversity Observation Coordination Centre (EBOCC).

Example of existing Thematic Hubs

The OSPAR biodiversity expert groups serve as an excellent illustration of how Thematic Hubs can function effectively in practice.

Box 2 – OSPAR Biodiversity Expert Groups

OSPAR biodiversity expert groups bring together specialists from Contracting Parties and observer organisations to share knowledge, develop indicators, and coordinate biodiversity monitoring across the North-East Atlantic. These groups include experts from government agencies, academia, and NGOs, offering a mix of applied and scientific perspectives that help produce outputs relevant to regional conservation policy.

Most of the current groups have been active since the 2011 OSPAR workshop on MSFD biodiversity descriptors. Their work is coordinated by ICG-COBAM (Intersessional Correspondence Group on the Coordination of Biodiversity Assessment and Monitoring), which helps align approaches, facilitate discussions and support collaboration.

Although expert groups are informal (not governed by specific rules under OSPAR's Rules of Procedure), they are expected to operate consistently with other OSPAR subsidiary bodies and follow the Commission's code of conduct. A guidance document also outlines their roles and ways of working.

Contracting Parties are requested to: (i) support an active national engagement in the relevant expert groups and ICG-COBAM through ensuring dedicated expert time to contribute to work and providing resources to attend workshops and meetings and carry out related work, which as a guide would equate to a minimum of 2 weeks per expert per year; ii) support experts' work to develop monitoring and assessment methods that are to the benefit of all parties, and; iii) facilitate the required data flows for indicator development and assessments.

What expert groups do:

- Develop indicators and integrated assessment methods
- Support preparation of robust, regionally relevant assessments
- Define data needs in line with OSPAR's data management standards (OSPAR Agreement 2024-03)
- Contribute to wider OSPAR work, such as Regional Action Plans

How they work:

- Experts are nominated by Contracting Parties or observers and are encouraged to contribute actively to all group tasks
- Each group has a lead (or leads), who facilitates discussions and ensures the group stays aligned with its objectives
- Contracting Parties collectively ensure that one or more experts have the resources to lead each expert group.
- Workload should be shared among all members, with Contracting Parties supporting their experts accordingly
- Group leadership is rotated to balance effort and promote equitable geographical and gender representation
- Meetings are usually online, with in-person meetings held annually when possible

Current Expert Groups:

- Marine mammals
- Benthic habitats
- Pelagic habitats
- Fish
- Marine birds
- Sea Turtles
- Non-Indigenous Species

Reference:

OSPAR Commission. (2024). Guidance on responsibilities and ways of working in the biodiversity expert groups (BDC 24/12/01, Annex 15; OSPAR Agreement 2024-08). https://www.ospar.org/documents?v=58065

Having explored the foundational concept of Thematic Hubs as expert-driven communities, the next step is to outline how these hubs can be strategically integrated into a broader framework for harmonised monitoring protocols. The success of such an integration hinges on leveraging existing, well-established biodiversity monitoring communities, as our preliminary mapping efforts have clearly shown. To fully empower these hubs, it's essential that they receive an official mandate, ensuring strong links to the EBOCC and national biodiversity monitoring coordination centers. This comprehensive integration strategy, focusing on inter-community coherence within EBOCC, will be vital for ensuring data comparability and consistency, such as through the application of common minimum requirements across all thematic areas.

4.2 Proposed integration strategies for harmonised monitoring protocols

Integration strategies must balance top-down coordination with bottom-up engagement, leveraging the strengths of Thematic Hubs, national coordination bodies, and European institutions.

Encouraging EU-wide dialogue on harmonisation

A key priority is to promote regular discussions on harmonisation and integration within the broader European biodiversity monitoring landscape. These discussions should be encouraged both within and across thematic communities to ensure alignment with overarching EU biodiversity goals and policy instruments. Open, inclusive dialogue will support a shared understanding of priorities, gaps, and opportunities for convergence.

Facilitating interoperability and dialogue

Interoperability, both technical and institutional, relies on coordinated efforts to standardize and integrate monitoring practices. This requires:

- A common language for describing objectives, variables, scales, and methods;
- Shared tools and data infrastructures;
- Alignment between policy needs and monitoring objectives;
- Sustained dialogue between practitioners, researchers, and decision-makers.

Thematic Hubs play a central role in facilitating this dialogue, acting as bridges between domain-specific expertise and wider coordination mechanisms.

Common minimum requirements as a harmonisation strategy

One effective strategy for cross-scale harmonisation is to define common minimum requirements for monitoring protocols. Such minimum requirements ensure baseline comparability, while still allowing for national and regional flexibility. They provide a foundation upon which more complex or tailored protocols can be built, enabling interoperability without imposing uniformity.

Establishing baseline monitoring protocols

Baseline protocols are essential for producing coherent long-term data. These protocols should:

- Be developed in collaboration with Thematic Hubs and national experts;
- Be adaptable to local ecological and logistical contexts;
- Define the minimum data required to establish a reliable monitoring baseline.

In the long term, Thematic Hubs are envisioned to act as strategic partners to the European Biodiversity Observation Coordination Centre, to embed technical coherence and cross-thematic consistency into the wider European biodiversity monitoring system.

Their collaborative function supports:

- Facilitating collaboration across countries and sectors;
- Developing and sharing methodological standards, tools, and protocols;
- Defining monitoring priorities and targets for their respective topics;
- Ensuring data harmonisation and integration within and beyond their focal areas;
- Serving as entry points for broader biodiversity observation networks.

Linking Thematic Hubs with coordination structures

The integration of monitoring efforts requires a strong connection between Thematic Hubs, the EBOCC, and national coordination centers (e.g., National Biodiversity Monitoring Coordination Centres).

- Many national centers host experts who are directly involved in Thematic Hubs, enabling knowledge transfer and alignment.
- National centers are expected to work closely with the EBOCC, ensuring that harmonisation parameters—agreed at the EU level with the support of Thematic Hubs—are effectively transferred and implemented nationally.
- National Biodiversity Monitoring Coordination Centres should play a strategic role in enforcing harmonisation, with the authority to advise and support the uptake of harmonised protocols.
- It is anticipated that National Biodiversity Monitoring Coordination Centres will include representatives from major Thematic Hubs, reinforcing feedback loops between national and thematic coordination levels.

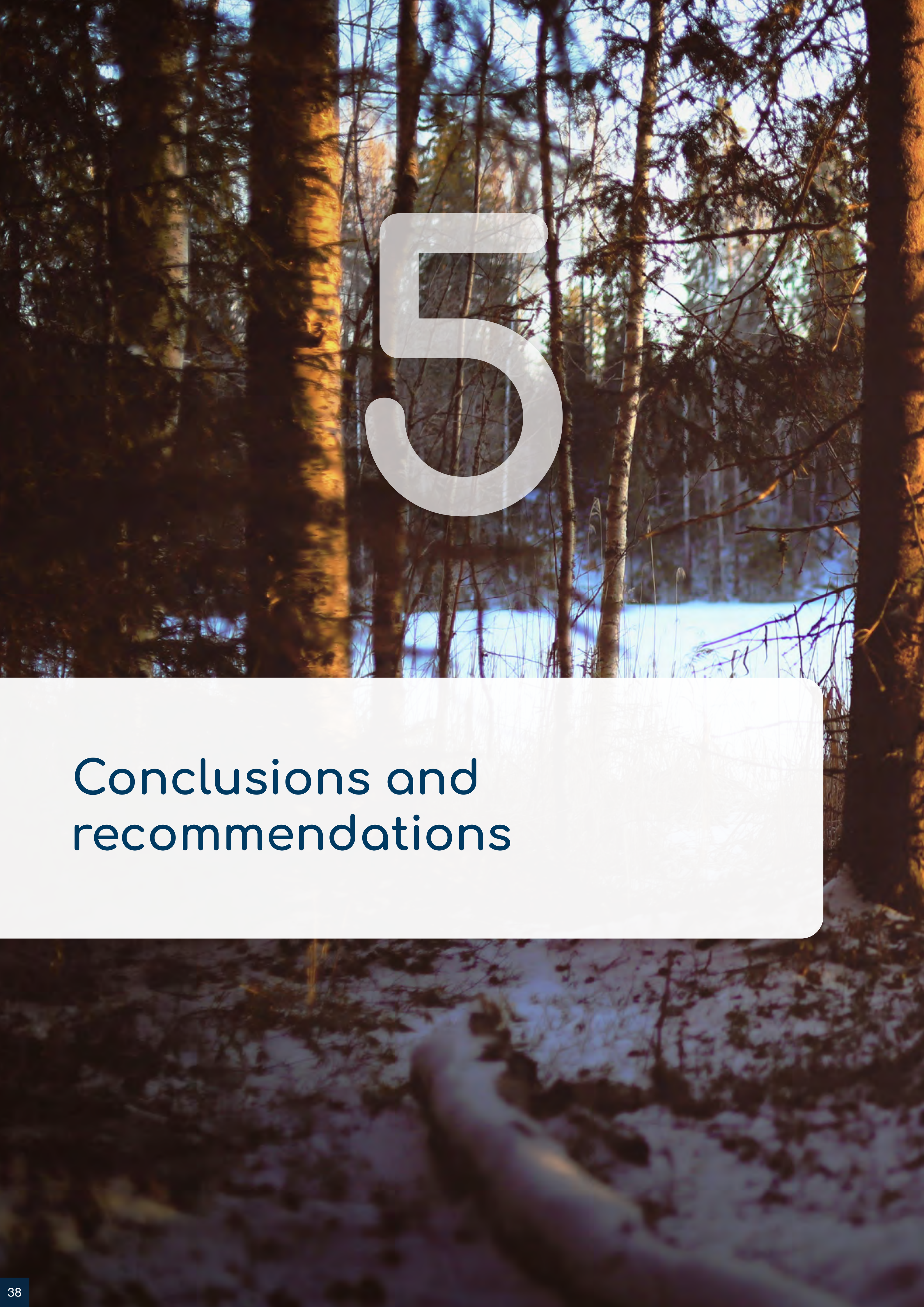
Enabling structures: community facilitation and resources

To support and sustain this integration process, there is a strong need for:

- An official mandate: It's vital that Thematic Hubs receive formal recognition from the European Commission and participating countries. This mandate legitimises their role, empowers their actions, and ensures their outputs are integrated into the broader European biodiversity monitoring landscape;
- A facilitator or community manager role: someone tasked with connecting actors across hubs, national centers, and EU coordination bodies;
- Budgets to support in-person collaboration;
- Dedicated resources to support:
  - Protocol harmonisation, grounded in both generic principles and real-world constraints;
  - Capacity building and quality assurance;
  - European-level synthesis and analysis of monitoring data.

Towards cross-sector integration

Finally, harmonised monitoring should not be seen in isolation. Integration strategies of monitoring and assessment should also explore synergies with adjacent domains, including conservation planning and restoration efforts, ecological research and innovation, Nature Based Solutions, societal transformation. By connecting monitoring communities with these related sectors, it becomes possible to create a more cohesive and impactful biodiversity knowledge system—one that supports evidence-based action and link monitoring with action across Europe's socio-ecological landscape.



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Conclusions and recommendations

Effective and comparable biodiversity monitoring is paramount for understanding environmental change, informing policy, and guiding conservation action across Europe and beyond. This report has underscored that achieving meaningful harmonisation in biodiversity monitoring protocols is not merely a technical exercise but a collaborative endeavor. It requires a robust framework that balances essential standardisation with necessary flexibility, fostering trust and transparency among diverse stakeholders. The proposed Thematic Hubs are central to this vision, offering a decentralised yet coordinated approach to address the complexities of biodiversity observation.

5.1 Thematic Hubs and recommendations for future work and practice

Expert-driven communities are vital for defining clear monitoring objectives, developing and aligning harmonised standards, producing crucial biodiversity information at a European scale, and facilitating data integration. Thematic Hubs serve as critical entry points for stakeholders, ensuring broader engagement within the biodiversity observation system.

For these hubs to reach their full potential, we recommend:

- Formal Mandate and Integration: Officially establish Thematic Hubs with a clear mandate, linking them explicitly to the EBOCC and relevant national coordination bodies. This formalization will provide the necessary authority and connectivity for effective operation.
- Dedicated Resources: Ensure consistent and sufficient funding, expert time, and logistical support for each hub. Active national engagement, including dedicated expert time, is non-negotiable for success.
- Clear Operating Guidelines: Develop comprehensive, yet flexible, guidelines for their roles, responsibilities, and ways of working, building on successful models.

5.2 Strengthening collaboration within and across communities

True harmonisation transcends technical specifications; it thrives on strong collaboration. The success of biodiversity monitoring depends on leveraging the existing wealth of expertise and dedication within national and regional communities.

Key recommendations for strengthening collaboration include:

- Inter-Community Coherence within EBOCC: EBOCC should actively facilitate dialogue and coordination among different Thematic Hubs and broader biodiversity communities. This includes ensuring data coherence and consistent application of common minimum requirements across diverse thematic areas. While our focus here is on a European scale, some of these Thematic Hubs already have a wider or global reach. Therefore, Thematic Hubs' role could extend to exploring potential alignments and future integration pathways for these European hubs with global monitoring networks, such as GEO BON, allowing some to evolve into global focal points for specific biodiversity domains.
- Thematic Hubs as Knowledge Exchange Platforms: Establish robust platforms for regular knowledge exchange, best practice sharing, and lessons learned between experts from various communities and thematic areas.
- Shared Principles: Continue to anchor all collaborative efforts in shared principles of transparency, openness, and trust, fostering an environment where data and methodologies can be freely exchanged and critiqued.
- Protocol harmonisation: The detailed work of protocol harmonisation will be carried out by technical expert groups operating within or alongside the Thematic Hubs. These groups are essential for translating broad principles into actionable monitoring protocols. Ensure that technical expert groups comprise a diverse range of disciplines, including ecologists, statisticians, data managers, and policy experts, to ensure holistic and practical solutions.

5.3 Next steps

To move these recommendations from concept to practice, the following next steps are proposed:

1. Resource Mobilisation: Secure dedicated financial and human resources required for the sustained operation and coordination of Thematic Hubs and supporting technical expert groups.
2. Mandate Finalisation: Work with relevant European and national bodies to formalize the mandate and governance structures for Thematic Hubs, ensuring their official recognition and integration into existing biodiversity observation networks.
3. Community Engagement Roadmap: Develop a comprehensive roadmap for engaging existing biodiversity monitoring communities, ensuring their active participation in the development and implementation of harmonised protocols.

This conceptual framework will be further operationalized and tested in the coming years within Biodiversa+'s ongoing work. This includes launching biodiversity monitoring pilots, which will serve as concrete testing grounds for harmonized schemes and the functionality of Thematic Hubs. We'll also work closely with the future EBOCC pilot to test and formulate the links between EBOCC and national centers. Efforts will focus on developing generic support packages for these hubs, exploring long-term sustainable funding models for monitoring schemes, and creating essential resources like mandates, protocol standards, reporting templates, EBV integration guidelines, and training materials for implementing various elements. Case study communities from this preliminary mapping will be selected with input from other European projects, with the final choice based on a strategic analysis of different scenarios. Crucially, Biodiversa+ will organize Biodiversity Monitoring Weeks—a European conference on biodiversity monitoring for discussion and shared practice—starting in spring 2026 and held every two years. These weeks will provide vital platforms for Thematic Hubs to convene, collaborate, and drive harmonisation forward.

By collectively investing in the establishment and effective functioning of Thematic Hubs, and by fostering a culture of collaboration and shared responsibility, we can significantly enhance the quality, comparability, and utility of biodiversity monitoring data across Europe, ultimately strengthening our capacity for effective conservation.

6

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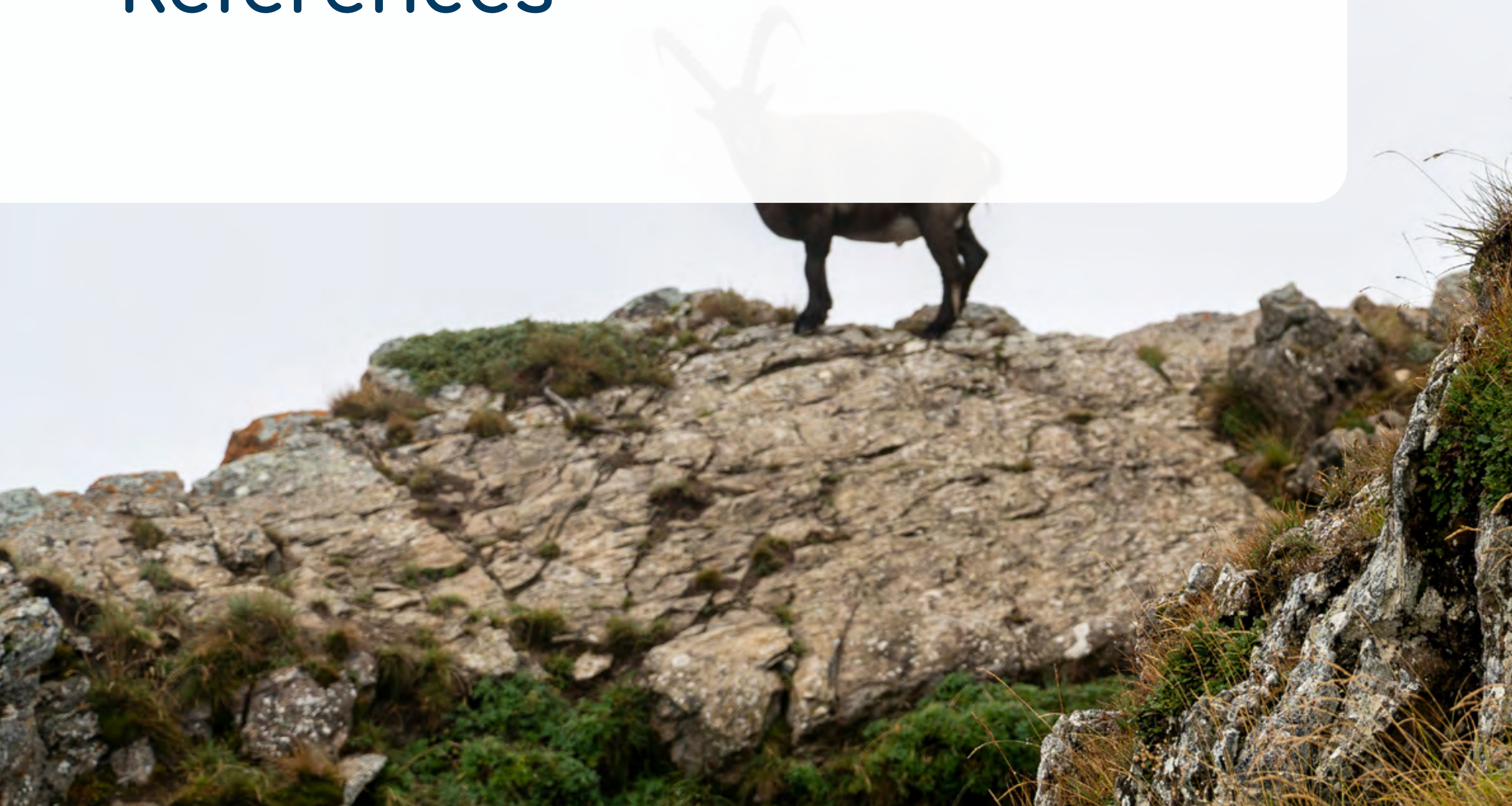

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Annexes

ANNEX 1. Survey on the monitoring communities

Mapping Biodiversity Monitoring Communities

As part of its broader goal of establishing a transnational network of national biodiversity monitoring schemes, Biodiversa+ identified biodiversity monitoring communities as a key level for transnational collaboration and harmonisation.

A biodiversity monitoring community is defined as a group of individuals, organizations, and institutions involved in the monitoring of specific taxa or habitats (e.g birds, soil biodiversity, bats, freshwater ecosystems, etc.), often contributing to broader conservation initiatives. This survey is a first step to identify and reach out to these communities.

Are you involved in - or do you know of any biodiversity monitoring communities?
Your input is invaluable in helping us identify collaborative groups dedicated to monitoring biodiversity, specifically focusing on European-level coordination networks within these communities.

Thank you for taking the time to participate in our survey!

About Biodiversa+: https://www.biodiversa.eu/biodiversity-monitoring/

A biodiversity monitoring community you know of:
[short answer]

Name of a European-level coordination group associated with the biodiversity monitoring community mentioned above (If you are not aware of any, please indicate)
[short answer]

A contact person for this community and/or group?
[short answer]

If you are involved in this community, how do you use biodiversity monitoring data and results? (please provide examples)
[free text]

[A section "+" to add another set of answers if possible on google forms?]

The survey data contains 91 responses with a total of 8 questions. Here's a breakdown of the statistics:

1. General Information:
- Total Responses: 91
- Fully Blank or NA: 3

Number of forms with a second set of answers (optional to fill in, page 2, questions 5-8): 27

2. Responses per Question:
- A biodiversity monitoring community you know of:
  - 3 blank
  - 1 "no"
  - From the 87 answers:
- Name of a European-level coordination group associated with the biodiversity monitoring community:
  - 10 blank
  - 2 "no"
  - 8 "not aware of any"
  - 2 "no cooperation/coordination"
  - From the 68 answers:

> 11 times BirdLife international / BirdLife Europe / PECBMS / EBCC

> 9 times Butterfly Conservation Europe / BMS

> 4 times iBOL

A contact person for this coordination group?: 23 responses
- 12 blank
- 5 "no"
- From the 74 answers, in total:
  - 2 "myself", but contact not given & anonymous survey...
  - 10 link to the website contact page / generic address / "any coordinator"
  - 4 times David Roy: Butterfly monitoring community, BMS
  - 2 times Gabriela Dankova: iBOL
  - 2 times Josiane Lips: Bats (Cosci member and Biospeleology referent - josiane.lips@free.fr)
  - 16 contacts for Bird community
  - 3 for Pollinators
  - 9 for Butterfly
  - 2 for beetles
  - 3 for Soil
  - 1 for fungi
  - 1 for Invasive Alien species
  - 1

ANNEX 2. List of the monitoring communities & identified networks

Theme	Type	Realm	State of the community	ID Europe	ID Global	Type of networks
Marine taxa						
Sea Turtles	Taxa	Marine	Structured	OSPAR STEG: Sea Turtle Experts Group		WG / expert groups
					SWOT: State of the World's Sea Turtles	NGO, volunteers network
					IUCN MTSG: Marine Turtle Specialist Group	WG / expert groups
Seabirds	Taxa	Marine	Structured	JWGBIRD: Joint OSPAR/HELCOM/ICES Expert Group on Seabirds		WG / expert groups
					BirdLife International	NGO, volunteers network
Marine mammals	Taxa	Marine	Structured		IWC: International Whaling Commission	Inter-governmental / Agreement / convention
				HELCOM EG MaMa: Expert Group on Marine Mammals		WG / expert groups
				OSPAR OMMEG: Marine Mammal Expert Group		WG / expert groups
				ASCOBANS: Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas		Inter-governmental / Agreement / convention
				ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area		Inter-governmental / Agreement / convention
				ICES WGMME: Working Group on Marine Mammal Ecology		WG / expert groups
Phytoplankton	Taxa	Marine	Structured	HELCOM PEG: Phytoplankton Expert Group		WG / expert groups
Zooplankton	Taxa	Marine	Structured	HELCOM EG Zoo: Expert Group on Zooplankton		WG / expert groups
				ICES WGZE: Working Group on Zooplankton Ecology		WG / expert groups
Elasmobranchs [sharks, rays and skates]	Taxa	Marine	Structured		Manta Trust's network	NGO, volunteers network
					IUCN Shark Specialist Group	WG / expert groups
				MEDLEM: Mediterranean Large Elasmobranchs Monitoring		institutions partnership
				EAA: European Elasmobranch Association		NGO, volunteers network
				MECO project: Mediterranean Elasmobranch Citizen Observation		NGO, volunteers network
Posidonia	Taxa	Marine	Structured	The Mediterranean Posidonia Network		institutions partnership
Cephalopods	Taxa	Marine	Structured	ICES WGCEPH: Working Group on Cephalopod Fisheries and Life History		WG / expert groups

Jellyfish	Taxa	Marine	Unstructured	CIESM JellyWatch Program		institutions partnership
Coastal fish / rocky fish	Taxa	Marine	Unstructured	HELCOM WG BioDiv Expert Group on Coastal Fish		WG / expert groups
Fish /fisheries	Taxa	Marine	Unstructured	Control Expert Groups (CEGs) of the regionalisation of the Common Fisheries Policy (CFP):Scheveningen (North Sea); BALTFISH (Baltic Sea); North-western waters; South-western waters		WG / expert groups
				Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries		WG / expert groups
Macroalgae	Taxa	Marine	Unstructured		HAB consortium: Harmful Algal Bloom from the Intergovernmental Oceanographic Commission (IOC) of UNESCO	WG / expert groups
Marine Habitat						
Seagrass	Habitat	Marine	Structured		IUCN SSC Seagrass Species Specialist Group	WG / expert groups
					C-GRASS: Coordinated Global Research Assessment of Seagrass System	WG / expert groups
					UN International Seagrass Expert Network	institutions partnership
					SeagrassNet: Seagrass Monitoring Network	institutions partnership
					Seagrass-Watch Global Seagrass Observing Network	NGO, volunteers network
Coral reef	Habitat	Marine	Structured		GCRMN: The Global Coral Reef Monitoring Network	institutions partnership
					Reef check	NGO, volunteers network
					Reef Life Survey	NGO, volunteers network
Benthic	Habitat	Marine	Structured	HELCOM EG Benthic: Expert Group on Benthic Habitats and Biotopes		WG / expert groups
				OSPAR OBHEG: Benthic Habitat Expert Group		WG / expert groups
				ICES BEWG: Benthos Ecology Working Group		WG / expert groups
Pelagic habitats	Habitat	Marine	Unstructured	OSPAR Pelagic Habitats Expert Group		WG / expert groups
Terrestrial taxa						
Bird	Taxa	Terrestrial	Structured	BirdLife Europe	BirdLife International	NGO, volunteers network
				EBCC: European Bird Census Council		NGO, volunteers network
Pollinators	Taxa	Terrestrial	Structured	EUPoMS Pollinator Monitoring Scheme		WG / expert groups
				European Habitats Forum (EHF) WG Pollinators		WG / expert groups
Butterfly	Taxa	Terrestrial	Structured	eBMS - Butterfly Conservation Europe (BCE)		institutions partnership
Stag Beetle	Taxa	Terrestrial	Structured	ESBMN: European Stag Beetle Monitoring Network		NGO, volunteers network

Lynx	Taxa	Terrestrial	Structured	Linking Lynx network		WG / expert groups
				SCALP project - KORA Carnivore Ecology and Wildlife Management		institutions partnership
Ibex	Taxa	Terrestrial	Structured	GSE-AIESG: Alpine Ibex European Specialist Group		WG / expert groups
				EUROIBEX (from EUROMAMMALS)		institutions partnership
Bat	Taxa	Terrestrial	Structured	EUROBATS		Inter-governmental / Agreement / convention
				BatLife Europe		NGO, volunteers network
					IUCN SSC Bat Specialist Group	WG / expert groups
Mammals	Taxa	Terrestrial	Medium		IUCN Species Survival Commission (SSC) Specialist Groups and Working Groups (Bear, Bison, Canid, Caprinae, Cat, Cetacean, Chiroptera, Deer, Lagomorph, Otter, Pinniped, Polar Bear, Primate, Small carnivore, Large carnivore)	WG / expert groups
				EUROMAMMALS network: (EURODEER, EUREDDEER, EUROBOAR, EUROLYNX, EUROWILDCAT, EUROIBEX, EUROJACKAL, EURORACCOON, EUROSMALLAMMALS)		institutions partnership
				MCE: Mammal Conservation Europe		NGO, volunteers network
				MammalNet		institutions partnership
				European Mammal Foundation: European Mammals on Maps		WG / expert groups
Raptors	Taxa	Terrestrial	Unstructured		GRIN: Global Raptor Impact Network - The Peregrine Fund	NGO, volunteers network
Large Carnivores	Taxa	Terrestrial	Structured		IUCN SSC Wolf, Bear and Cat Specialist Groups	WG / expert groups
				LCIE: Large Carnivore Initiative for Europe IUCN specialist group		WG / expert groups
				Dinaric-Balkan-Pindos Regional Platform on Large Carnivore		Inter-governmental / Agreement / convention
				KORA: Carnivore Ecology and Wildlife Management		institutions partnership
				WISO Large Carnivores, Wild Ungulates and Society Working Group - WG from the Alpine Convention		WG / expert groups
Fungi	Taxa	Terrestrial	Medium	EMA: European Mycological Association		NGO, volunteers network
					FunCC: Fungal Conservation Committee - Fungal Specialist Group IUCN	WG / expert groups

Terrestrial Habitat						
Grassland	Habitat	Terrestrial	Medium	EU grassland watch - Copernicus		institutions partnership
				EGF: European Grassland Federation		NGO, volunteers network
Soil biodiversity	Habitat	Terrestrial	Structured		GSBI: Global Soil Biodiversity Initiative	institutions partnership
					SoilBON	NGO, volunteers network
				EU Soil Observatory (EUSO) with the WG biodiversity & WG monitoring, through LUCAS soil Biodiversity module		institutions partnership
Forest	Habitat	Terrestrial	Unstructured	ICP Forest: International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests		Inter-governmental / Agreement / convention
				FOREST EUROPE: Ministerial Conference on the Protection of Forests in Europe		Inter-governmental / Agreement / convention
				EFI: European Forest Institute		Inter-governmental / Agreement / convention
					ForestGEO (Global Earth Observatory Network)	institutions partnership
Dunes	Habitat	Terrestrial	Unstructured	BEACH and DUNE NETWORK - from The Coastal Union Baltic (EUCC)		NGO, volunteers network
Alpine ecosystems	Habitat	Terrestrial	Structured		GLORIA: Global Observation Research Initiative in Alpine Environments network	institutions partnership
Freshwater Habitats						
Lakes	Habitat/ecosystem	Freshwater	Structured		GLEON: Global Lake Ecological Observatory Network	NGO, volunteers network
Freshwater ecosystem	Habitat/ecosystem	Freshwater	Medium		FWBON: Freshwater Biodiversity Observation Network	NGO, volunteers network
Freshwater Taxa						
Macroinvertebrates	Taxa	Freshwater	Structured		GLOSAM : Global microinvertebrates sampling protocols task force (IUCN)	WG / expert groups
Salmon	Taxa	Freshwater	Structured		NASCO: North Atlantic Salmon Conservation Organization	Inter-governmental / Agreement / convention
					ICES WGNAS: Working Group on North Atlantic Salmon	WG / expert groups
Sturgeon	Taxa	Freshwater	Structured	HELCOM EG STUR: Expert Group on Sturgeon Remediation		WG / expert groups
				DSTF: Danube Sturgeon Task Force		WG / expert groups
					WSCS: World Sturgeon Conservation Society	NGO, volunteers network
					IUCN Sturgeon Group	WG / expert groups

Freshwater fish	Taxa	Freshwater	Structured	TEN-S: Trans-European Swimways Network - Wetlands International		NGO, volunteers network
Interface Taxa						
Waders (shorebirds)	Taxa	Terrestrial/ Marine / Freshwater	Structured		International Wader Study Group (IWSG)	WG / expert groups
Waterbirds	Taxa	Terrestrial/ Marine / Freshwater	Structured		International Waterbird Monitoring - Wetlands International	NGO, volunteers network
				Mediterranean Waterbirds Network		NGO, volunteers network
Herpetology (amphibian & reptile)	Taxa	Terrestrial/ Marine / Freshwater	Structured		IUCN SSC Amphibian Specialist Group	WG / expert groups
				RACE: Reptile and Amphibian Conservation Europe		NGO, volunteers network
				SEH: Societas Europaea Herpetologica		NGO, volunteers network
				The Bern Convention Group of Experts on the Conservation of Amphibians and Reptiles		WG / expert groups
Invasive alien species	Taxa	Terrestrial/ Marine / Freshwater	Medium	EASIN: European Alien Species Information Network - EC's Invasive Alien Species Expert Group (IASEG) / Working Group on Invasive Alien Species (WGIAS)		WG / expert groups
				NOBANIS: North European and Baltic Network on Invasive Alien species		WG / expert groups
				Bern Convention Group of IAS Experts		WG / expert groups
					INVASIVESNET: International Association for Open Knowledge on Invasive Species network	NGO, volunteers network
					IUCN ISSG: Invasive Species Specialist Group	WG / expert groups
Interface Habitats						
Mangroves	Habitat	Terrestrial/ Marine / Freshwater	Structured		Global mangrove Alliance	NGO, volunteers network
Peatlands	Habitat	Terrestrial/ Marine / Freshwater	Structured		IUCN CEM Peatland Specialist Group	WG / expert groups
					Global Peatlands Initiative	institutions partnership
					International Peatland Society (IPS) - Peatlands and Biodiversity expert group	NGO, volunteers network
					The International Mire Conservation Group (IMCG)	NGO, volunteers network
Ponds	Habitat	Terrestrial/ Marine / Freshwater	Structured	European Pond Conservation Network (EPCN)		NGO, volunteers network
				Ponderful		institutions partnership

Wetlands	Habitat	Terrestrial/ Marine / Freshwater	Structured		The Global Wetland Watch	institutions partnership
					Wetlands International	NGO, volunteers network
				Mediterranean Wetlands Initiative of the Ramsar Convention (MedWet)	Ramsar - Convention on Wetlands	institutions partnership
Lagoons	Habitat	Terrestrial/ Marine / Freshwater	Medium	Baltic Lagoon Network (BALLOON)		NGO, volunteers network
Regions						
Arctic	Regions	Terrestrial/ Marine	Structured		Circumpolar Biodiversity Monitoring Programme (CBMP) of the Arctic Council biodiversity working group, Conservation of Arctic Flora and Fauna (CAFF)	WG / expert groups
Alps	Regions	Terrestrial	Structured	Alpine Conference/Alpine convention. WG: Alpine Network of Protected Areas (ALPARC), Large Carnivores, Wild Ungulates and Society Working Group (WISO)	NA	Inter-governmental / Agreement / convention
Pyrenees	Regions	Terrestrial	Structured	Working Community of the Pyrenees with The Pyrenees Observatory (The Pyrenees Climate Change Observatory (OPCC), Interreg POCTEFA)	NA	institutions partnership
Carpathia	Regions	Terrestrial	Structured	Carpathian Convention WG Biodiversity	NA	Inter-governmental / Agreement / convention
Central and Eastern European region	Regions	Terrestrial / Marine / Freshwater	Structured	CEEweb for Biodiversity	NA	institutions partnership
Mediterranean sea	Regions	Marine	Structured	UNEP/MAP–Barcelona Convention: Convention for the Protection of the Mediterranean Sea Against Pollution - Mediterranean Action Plan of the United Nations Environment Programme SPA/RAC	NA	Inter-governmental / Agreement / convention
				CIESM Mediterranean Science Commission	NA	institutions partnership
Black Sea	Regions	Marine	Structured	Black Sea NGO Network (BSNN)	NA	NGO, volunteers network
North Atlantic	Regions	Marine	Structured	OSPAR - Oslo and Paris Conventions	NA	Inter-governmental / Agreement / convention
Baltic Sea	Regions	Marine	Structured	HELCOM - Baltic Marine Environment Protection Commission	NA	Inter-governmental / Agreement / convention
Danube River	Regions	Freshwater	Structured	International Commission for the Protection of the Danube River (ICPDR) - Monitoring and Assessment Expert Group (MA EG) & TransNational Monitoring Network	NA	institutions partnership
Rhine River	Regions	Freshwater	Structured	International Commission for the Protection of the Rhine (ICPR) - ICPR Rhine Monitoring Programme Biology	NA	Inter-governmental / Agreement / convention

Other						
Microorganisms	other	other	Unstructured	The DIVERSITY OF EUKARYOTIC MICROORGANISMS research consortium (DEMON)		institutions partnership
DNA / genomics	other	other	Structured	BGE - Biodiversity Genomics Europe: which brings together the iBOL Europe network and The European Reference Genome Atlas (ERGA) network	iBOL (international Barcode of Life)	institutions partnership

ANNEX 3. Expert workshop on the common minimum requirements for a biodiversity monitoring protocol: detail of the collective intelligence activities and results

DAY 1

Collective intelligence Session: Identification of generic protocol elements that would ensure interoperability - Brainstorming Discussions: 4 groups

Step 1: Extreme Opposite Thinking - The anti-problem (15 minutes)
Each group is asked to imagine the worst possible case for the biodiversity monitoring protocol, one that completely fails at interoperability. "*How can we make sure that different monitoring protocols are completely incompatible?*"

Step 2: Reverse the Insights into Actionable Solutions (30 minutes)
After generating extreme examples, the groups now work on flipping their answers into positive, actionable protocol elements that enhance interoperability.

Step 3: Group Synthesis & Sharing
Each group presents their key findings, focusing on:

1. Top 3 "Bad Protocol" Elements they identified.
2. Top 3 Reversed "Good Protocol" Solutions ensuring interoperability.
3. One concrete recommendation.

Results

Step 1: Worst-Case Scenarios – "How to Ensure Total Incompatibility?"
Across all groups, key characteristics of a bad monitoring protocol were:

- Lack of clarity and consensus on objectives (why, what, how to monitor)
- Unclear or inconsistent definitions (e.g., habitat, sampling unit, taxonomic resolution)
- Incompatible sampling designs: different spatial scales, units, frequencies, and methodologies
- No metadata or data standards, leading to unusable datasets
- Mismatch in tools, techniques, and equipment
- No communication or collaboration
- Legal and political barriers to data sharing
- Inaccessible or expensive methods, no training or quality control
- Overreliance on unpaid volunteers without sustaining networks

Step 2: Flipping to Actionable Solutions
Groups worked to identify minimum requirements and harmonisable elements:

Core Elements to Standardise
- Monitoring Objectives: Clear, shared purpose across protocols
- Definitions: Agreed glossary for key concepts (habitat, area, sampling unit, etc.)
- Metadata Templates: Minimum information required for dataset usability
- Sampling Design: Core structure (e.g., terminal sampling unit), spatial/temporal coherence
- Data Management: FAIR principles, open access where possible, clear ownership

Recommended Flexible Elements
- Sampling effort and frequency (if within defined ranges)
- Tools and methods (as long as core outputs are comparable)
- Integration of different funding or policy contexts

Key Enabling Actions
- Pilot studies to explore feasibility and variability
- Capacity building & training sessions (including legal/political contexts)
- Intercalibration efforts across sites/teams
- Community and political engagement
- Communication strategy for internal (scientific) and external (societal, political) audiences

Concrete Recommendations
1. Consensus on objectives + definitions
2. Define minimum metadata template per Thematic Hub
3. Run EU-level sub-pilot studies to inform protocol design
4. Set core sampling requirements while allowing methodological flexibility
5. Build strong communication and capacity support across stakeholders

Collective Intelligence Session: Harmonisable Dimensions of Sampling Design - Theoretical approach

Session Format:

- World Café Format: Groups rotate every (20', 15', 15', 15') minutes to discuss a specific topic and then come together to share insights (25').
- Solid / Soft / Fuzzy: This methodology helps assess aspects of protocols that have to be strictly standardized (solid), those that can be flexible (soft), and those for which it might depend from case to case or that you are not sure about (fuzzy).

Group Topics (4 groups):

Each group will focus on one of the following dimensions.

Table 1: Defining Monitoring Objectives

Questions to explore:

- How do objectives influence variable selection and sampling design?
- How can we align objectives with frameworks like Essential Biodiversity Variables (EBVs)?

Solid / Soft / Fuzzy Classification:

- Which aspects must be fixed for comparability?
- Where can protocols allow flexibility?
- What remains unclear and needs further discussion?

Results

1. Objectives Drive Everything

- Objectives are central to variable selection, sampling design, spatial and temporal resolution, and data analysis.
- They influence what is monitored (species, traits, functions), how it is monitored, and at what scale.
- Objectives must be clearly defined before designing protocols—but even before that, a shared understanding of baselines is needed.

2. Objectives Can Vary Widely

- May differ depending on policy requirements, societal needs, or management goals (e.g. tracking trends vs. detecting changes).
- Objectives from EU nature directives may share the same variables, but apply different sampling designs.

3. Challenges with Objectives

- What constitutes an "objective" can be unclear.
- Should we harmonise objectives across countries? This remains a point for discussion.
- Monitoring efforts may be re-used or repurposed for new objectives, raising questions about adaptability.

Alignment with Frameworks (e.g. EBVs)

- EBVs can guide variable selection and help build a common "grammar".
- However, EBVs are not sufficient to cover all EU legislative needs (e.g., Habitat Directive requirements).
- Suggestion: objectives could rely on EBVs as a backbone, but additional layers are needed for specific reporting obligations.

Solid / Soft / Fuzzy Classification

Solid (Fixed) Elements

- Clear definition of objectives
- Temporal resolution: the level of change to be detected
- What is sampled (core taxa or components)
- Taxonomic backbone
- Core sampling questions
- Work distribution over time (monitoring rhythm)
- For some taxa (e.g., migratory birds): field dates

Soft (Flexible) Elements

- Spatial sites (where monitoring occurs)
- Seasonality: may vary depending on phenology (e.g., blooming periods)
- Some aspects of protocol application (local adjustments)

Fuzzy (Unclear or Needs Discussion)

- Whether and how to harmonise objectives across countries
- What indicators should be used to monitor ecosystem status
- How to define a baseline (reference point vs. theoretical state)
- To what extent we can reuse opportunistic data for evolving objectives

Conclusion

Defining objectives is a foundational and non-negotiable step for harmonised biodiversity monitoring. While some flexibility is needed for local implementation, a common vocabulary, clear baselines, and strategic alignment with frameworks like EBVs are essential to ensure data interoperability and policy relevance.

Table 2: Sampling Units & Strategies

Questions to explore:

- What is the terminal sampling unit (smallest measured unit)?
- How does choice of unit impact data integration?
- How flexible can sampling strategies be? (random, systematic, stratified...)

Solid / Soft / Fuzzy Classification:

- Which elements must be standardised? (e.g., fixed sampling unit size?)
- What can be adapted regionally without losing comparability?
- What elements are still uncertain?

Results

1. What is a Sampling Unit?

» The terminal sampling unit is the smallest unit measured in space and/or time — often a plot or transect, but varies by ecosystem, species, and objectives.

» It's context-dependent, but ideally refers to a defined area or volume that is homogeneous.

» Biodiversity monitoring focuses on detecting change rather than being exhaustive; thus, sampling units must enable tracking of trends over time.

2. Sampling Unit Design

» Shape and size of units (e.g. 10x10 vs 20x5 m) can vary depending on habitat homogeneity and objectives.

» Fixed area is ideal for comparability, but slight flexibility can be addressed during analysis.

» Effort is defined as time × space — standardisation of effort (rather than method) can aid harmonisation.

» Temporal dimension matters: permanent vs temporary plots can be chosen depending on variability and goals.

Sampling Strategies: Flexibility & Constraints

» Strategies include random, systematic, stratified, or adaptive stratified sampling.

» Random was seen as not optimal; stratification is a more robust approach and should be fixed once defined.

» Strategies should reflect local ecological needs, condition of habitat, and objectives (e.g., detecting change in good vs. bad condition).

» Sampling strategy should be soft during design, but fixed during implementation to ensure comparability.

» Intercalibration is essential when integrating diverse strategies across regions or partners.

Solid / Soft / Fuzzy Classification

Solid (Fixed) Elements

» Terminal sampling unit size (minimum viable area/volume)

» Homogeneity of unit (in space/time)

» Reference systems (e.g., EUNIS at EU level)

» Sampling strategy: once selected, should not change

Soft (Flexible) Elements

» Number of terminal units

» Exact shape of sampling unit (as long as area is consistent)

» Local adaptation of strategy (e.g., adaptive stratification)

» Plot permanence (temporary vs permanent depending on context)

» Integration of different sizes: can be compensated analytically

» Complementary sampling efforts (regional extensions beyond the fixed base area)

» Base year/reference time for harmonisation (e.g., 2010 as Year 0)

Conclusion

Sampling units and strategies must strike a balance between standardisation for comparability and flexibility for ecological relevance. While fixed units and stratified strategies are essential pillars, regional context, adaptive needs, and analytical adjustments can offer necessary flexibility.

Table 3: Sampling Frequency & Sample Size

Questions to explore:

- Can we allow flexibility in effort while maintaining statistical robustness?

Solid / Soft / Fuzzy Classification:

- What must remain fixed? (e.g., minimum sample size?)
- What can be adjusted depending on context?
- Where do we lack clear guidance?

Results

1. Statistical Robustness vs Flexibility

- Flexibility in sampling effort is possible, provided it aligns with minimum statistical requirements for detecting ecological change.
- Power analysis: the minimum sample size and frequency depend on the desired sensitivity (e.g., detecting a 1% change within one year). Sets the bottom-line threshold
- An adaptive approach—adjusting frequency based on temporal variability, critical variables, or seasonality—is encouraged where feasible.

2. Core vs Expanded Efforts

- The monitoring framework should include:
- A core set of harmonised sites with standardised sampling frequency and methods across all countries.
- A broader, flexible subset of sites that can vary depending on national context or capacity.
- Intensive sampling at selected sites (e.g., for phenology or extreme events) can complement this design.

Solid / Soft / Fuzzy Classification

Solid (Must Be Fixed)

- Minimum sample size.
- Core sites and timeframes for cross-country comparability.

Soft (Context-Dependent, Flexible)

- Sampling frequency (e.g., annual in one country vs biennial in another), provided minimum thresholds are met.
- Sampling effort beyond the minimum (e.g., for national use).
- Timing of fieldwork within an acceptable window (e.g., peak season), not fixed calendar dates.
- Adaptation to local logistical constraints, such as availability of volunteers or staff.
- Selection of additional monitoring sites beyond the core network.

Fuzzy (Unclear or Needs Further Discussion)

- Guidance on reassessing sampling design over time is lacking.
- Understanding of temporal variability for many variables is still limited, highlighting the need for better statistical advice.
- Thresholds for minimum detectable change and how to agree on these across regions remain open questions.

Conclusion

Robust biodiversity monitoring requires a core level of harmonisation—especially for minimum sample sizes—while allowing contextual flexibility in effort and frequency. Current uncertainties point to the need for clear statistical guidance, better understanding of temporal variability, and more clarity on integrating diverse data sources.

Table 4: Sampling Design & Governance Interactions

Questions to explore:

- How does governance influence sampling design?
- How do we balance regional flexibility with the need for comparable data?
- Harmonisation challenge: Can we agree on core design principles across monitoring communities?

Solid / Soft / Fuzzy Classification:

- What governance aspects need strict standardisation?
- What governance/sampling interactions can be context-dependent?
- Where do uncertainties remain?

Results

1. Governance Strongly Shapes Monitoring Design

- Governance frameworks define objectives, allocate funding, set reporting requirements, and influence data policies—all of which directly affect sampling design.
- Clear, early alignment with funders and authorities is essential to ensure that monitoring outputs meet both national and EU-level objectives.

2. Harmonisation Priorities

- Harmonisation is most critical at the reporting level, not necessarily at the level of sampling protocols or sites.
- Countries can maintain flexibility in implementation (sampling design, density, effort, etc.) as long as reporting remains comparable and transparent.
- Success requires agreement on core principles, such as minimum requirements, data openness, and clear documentation of deviations.

3. Governance-Driven Trade-offs

- Cost, political uncertainty, and trust in scientific data vary across contexts and influence what's feasible in practice.
- There's a need for a cross-country governance hub or coordination platform to support design alignment, pilot studies, and collaborative adaptation.

Solid / Soft / Fuzzy Classification

Solid (Must Be Fixed)

- Reporting periods and requirements: what is monitored and how it is reported should be aligned across countries.
- Basic unit definitions: minimum mapping/sampling unit sizes must be standardised for cross-comparison.
- Transparency of methodology: if protocols are not harmonised, countries must clearly document what was done and how conclusions were drawn.
- Open data and methodology policy to foster transparency and trust.
- Governance authority: responsible entities must publish and guide adherence to shared frameworks.

Soft (Context-Dependent, Flexible)

- Sampling strategies and site selection can differ, provided core objectives are still met.
- Sampling effort, density, and regional design may vary by country or ecosystem, especially where land-use or ecosystem dynamics differ.
- Choice of citizen science vs expert-driven monitoring, depending on costs and goals.
- National prioritisation: countries may choose how to meet both EU and national monitoring goals within their constraints.
- Use of different protocols across bioregions, as long as minimum harmonisation requirements are fulfilled.
- Fuzzy (Unclear or Needs Further Discussion)
- Balancing EU and national goals: how to operationalise both levels effectively remains a challenge.
- Trust and political variability: uncertainties around long-term political commitment and trust in science influence implementation but are hard to control.
- Role of spatially nested vs random sampling and how to scale these approaches across regions.

Conclusion

Governance is a central driver in biodiversity monitoring, shaping not only design but feasibility and comparability. While harmonisation at the reporting level is essential, flexibility in protocol implementation allows adaptation to national contexts. Moving forward, coordination efforts should focus on defining minimum common standards, supporting open methodologies, and creating spaces for collaborative governance, such as regional hubs or EU-wide working groups.

Collective Intelligence Session: Designing a Protocol Template

Objective
Draft a sampling protocol template adaptable to biodiversity monitoring contexts.

Format
Stickers voting system (15 min) + Small group work (4 groups) (40 min) + plenary feedback (20 min).

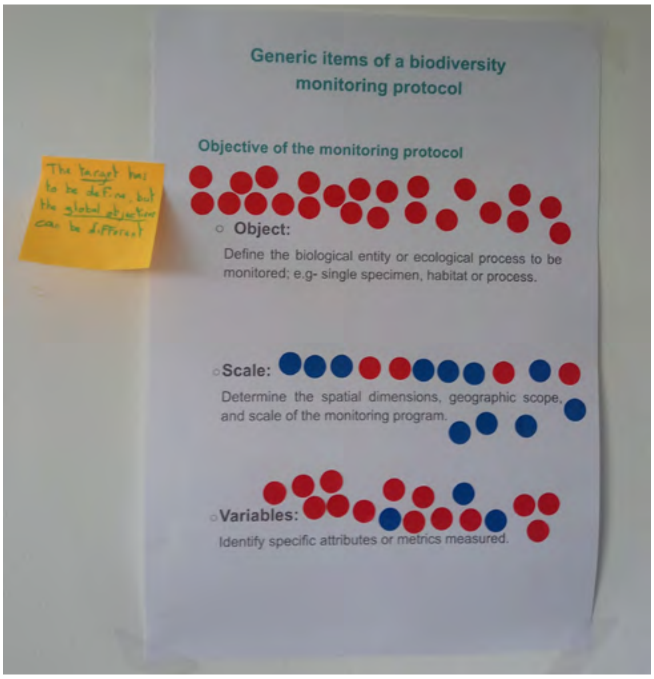
Voting system
2 colours of stockers: red = priority, must appear on a protocol and must be harmonised & blue = must appear on the protocol, not necessarily harmonised/allows flexibility.

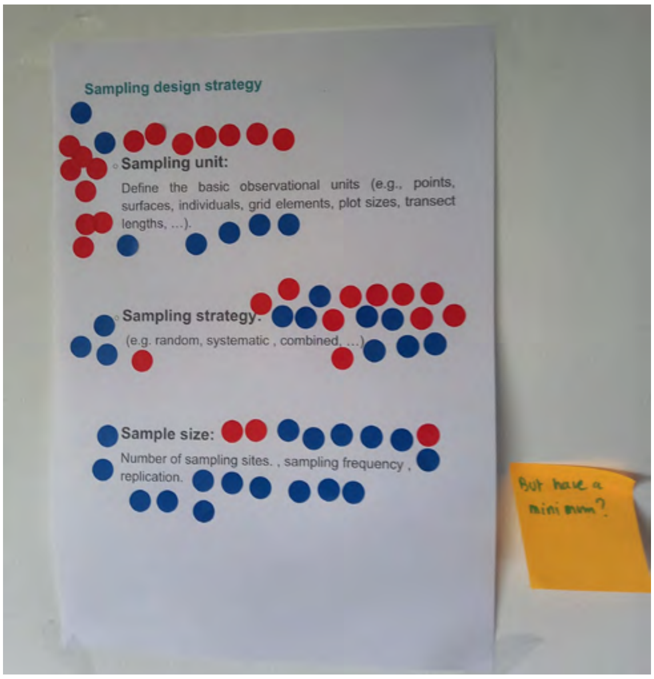
Group work
Compile the elements with most votes, for each element propose some recommendations.

Plenary feedback
Each group presents their refined template (2-3 min per group).

Discussion
- What elements are fully agreed upon?
- Where are the remaining points of divergence?
- Next steps: What needs further refinement?

Results





Generic items of a biodiversity monitoring protocol:

Objective of the monitoring protocol:
23 red

» Object: define the biological entity or ecological process to be monitored; e.g- single specimen, habitat or process.
Comment: the target has to be defined, but the global objectives can be different.

» Scale: determine the spatial dimensions, geographic scope, and scale of the monitoring program.
4 red 11 blue

» Variables: identify specific attributes or metrics measured.
14 red 3 blue

Sampling design strategy:

» Sampling unit: define the basic observational units (e.g., points, surfaces, individuals, grid elements, plot sizes, transect lengths, ...).
15 red 7 blue

» Sampling strategy (e.g. random, systematic , combines, ...).
11 red 11 blue

» Sampling size: Number of sampling sites. , sampling frequency , replication.
3 red 17 blue
Comment: flexible but have a minimum.

Draft Protocol Template for Biodiversity Monitoring

Based on collective input and consensus levels from group discussions

1. Objective of the Monitoring Protocol

STRICT

» Clearly define the purpose of the monitoring scheme (e.g., tracking trends, assessing impacts, early warning).
» Must align with policy, societal, or ecological priorities.
» Sets the foundation for all following elements.

2. Object of Monitoring (What is Being Monitored)

STRICT

» Define the target (e.g., species, habitat, ecological process).
» While overall scheme objectives can vary, the object must be clearly and consistently defined for comparability.
» Reassessment is possible but must be documented.

3. Scale

FLEXIBLE with minimum requirements

» Define the spatial and temporal dimensions of the monitoring (e.g., local, national, regional).
» Flexibility is allowed based on context (geography, governance), but must meet agreed minimum thresholds for comparison and scaling up.

4. Variables to Measure

STRICT

» Specify the attributes or indicators to be measured (e.g., abundance, biomass, species richness).
» Core variables must be fixed to allow for data harmonisation.
» Optional variables may be added if clearly documented.

5. Sampling Design Strategy

a) Sampling Unit

STRICT

» Define the basic observational unit (e.g., plot size, transect length, surface area).
» Must be standardised across implementations to avoid introducing methodological noise.
» Units can be ecosystem-specific but should follow harmonised guidance.

b) Sampling Strategy

SEMI-FLEXIBLE

» Choose a sampling method (random, systematic, stratified, etc.).
» Must be defined and justified in relation to the objective.
» Some flexibility is acceptable, particularly to account for field realities (e.g., terrain, access), but must be transparent and well-documented.

c) Sampling Size & Frequency

FLEXIBLE with strict minimum

» Define number of sites, replication, and monitoring frequency.
» Minimum thresholds should be set (based on power analysis or expert guidance).
» Flexibility beyond the minimum is acceptable and encouraged if documented.

Summary Table

Element	Requirement Level	Notes
Objective	Strict	Central guiding element; must be clearly stated
Object	Strict	Clearly define the biological entity or process
Scale	Flexible	Must meet a minimum; scalable up/down depending on context
Variables	Strict	Essential for comparability; can add optional metrics
Sampling Unit	Strict	Harmonised definitions essential for comparability. Terminal Sampling Unit
Sampling Strategy	Semi-Flexible?	Needs justification; can adapt to local context if transparently done
Sampling Size & Frequency	Flexible	Must meet minimum statistical thresholds

1. Elements with Strong Consensus (Solid Core of the Protocol)

The following elements were broadly considered essential and should be harmonised (red stickers):

- **Objective** 23 red
  All groups agreed that the objective is central—it defines what is being monitored, how, and why. It's the foundation for designing all other protocol elements.

- **Object - Target of Monitoring**
  Defined as the biological entity, habitat, or process to monitor. Generally considered a fixed component, though re-evaluation is allowed in some cases.

- **Variables** 14 red 3 blue
  Closely tied to the objective. Groups emphasized the need to fix variables to ensure comparability, while allowing some additions or updates over time.

- **Sampling Unit** 15 red 7 blue
  Strong agreement on the need for a common minimal definition (e.g., size, type). Consistency is key to avoid introducing unnecessary variability.

2. Elements with Mixed Views (Require Flexibility)

These were seen as important but context-dependent, often receiving a mix of red and blue votes:

- **Scale** 4 red 11 blue
  Considered flexible, especially regarding geographic extent. However, some level of standardisation or agreed minimum is needed for comparability.

- **Sampling Strategy** 11 red 11 blue
  Diverse perspectives. Some argued for flexibility to account for local conditions (weather, permits, terrain), while others highlighted the need to define strategy early and keep it consistent.

- **Sample Size & Frequency** 3 red 17 blue
  Broad agreement that this can remain flexible if it meets a minimum threshold for statistical detectability. Suggestions included power analyses and pilot studies to set appropriate minima.

3. Remaining Divergences & Open Questions

- **Terminology and Definitions**
  Calls to clarify and harmonise definitions (e.g., what counts as "biomass" or a "sampling unit") to avoid misinterpretations.

- **Object vs Objective vs Variable**
  Some confusion and overlap in terms. Groups recommended clearly differentiating between the objective (why), object (what), and variables (how it's measured).

- **Flexibility vs Comparability**
  Concerns that too much flexibility may threaten cross-site or cross-country comparability. Groups debated how much deviation should be allowed and under what conditions.

- **Adaptability vs Integrity**
  The need to allow adaptive designs (e.g., weather-dependent strategies) while maintaining the protocol's core integrity was a recurring theme.

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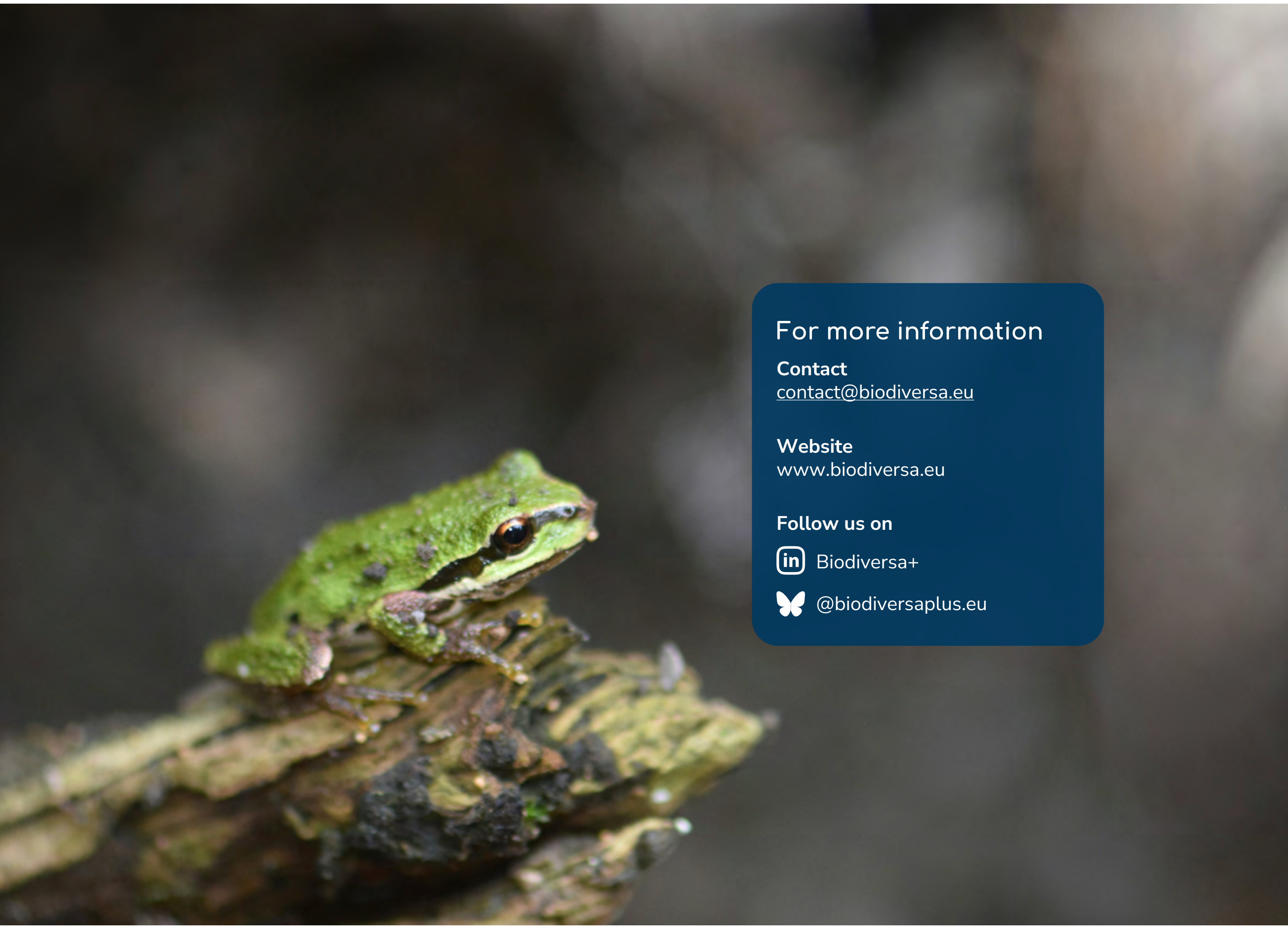

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