BIODIVERSITY BUILDING BLOCKS FOR POLICY

# ALIGNMENT OF B3 WITH EUROPEAN BIODIVERSITY INITIATIVES:

## Insights from EU policy

Version 1 31/05/2024
Version 2 06/02/2025

Author(s): Lina M. Estupinan-Suarez, Quentin Groom, Henrique Pereira, Cristina Preda, Andrew Rodrigues, Yanina Sica, Heliana Teixeira, Nikol Yovcheva, Miguel Fernandez

Funded by the European Union

**Prepared under contract from the European Commission**
Grant agreement No. 101059592
EU Horizon Europe Research and Innovation Action

| | |
|---|---|
| Project acronym: | **B3** |
| Project full title: | **Biodiversity Building Blocks for policy** |
| Project duration: | 01.03.2023 – 31.08.2026 (42 months) |
| Project coordinator: | Dr. Quentin Groom, Agentschap Plantentuin Meise (MeiseBG) |
| Call: | HORIZON-CL6-2021-GOVERNANCE-01 |
| Deliverable title: | ALIGNMENT OF B3 WITH EUROPEAN BIODIVERSITY INITIATIVES |
| Deliverable n°: | 1 |
| WP responsible: | WP1 - PENSOFT |
| Nature of the deliverable: | Report |
| Dissemination level: | Public |
| Licence of use: | [Licence under which the deliverable is available] |
| Lead partner: | MLU/iDiv |
| Recommended citation: | Estupinan-Suarez, L. M., Groom, Q., Pereira, H., Preda, C., Rodrigues, A., Sica, Y., Teixeira, H., Yovcheva, N., Fernandez, M. (2024). ***Alignment of B3 with European Biodiversity Initiatives:Insights from EU policy***. B3 project deliverable D1.5. |
| Due date of deliverable: | Month n° 12 |
| Actual submission date: | Month n° 15 |

Deliverable status:

| Version | Status | Date | Author(s) |
|---|---|---|---|
| 0.1 | Draft | 29 Apr. 2024 | Lina M. Estupinan-Suarez (MLU), Quentin Groom (APM), Cristina Preda (UOC), Andrew Rodrigues (GBIF), Yanina Sica (JLUG), Heliana Teixeira (UAVR), Nikol Yovcheva (PENSOFT), Henrique Pereira (MLU), Miguel Fernandez (MLU) |
| 1 | Final | 29 May 2024 | Lina M. Estupinan-Suarez (MLU), Quentin Groom (APM), Cristina Preda (UOC), Andrew Rodrigues (GBIF), Yanina Sica (JLUG), Heliana Teixeira (UAVR), Nikol Yovcheva (PENSOFT), Henrique Pereira (MLU), Miguel Fernandez (MLU) |
| 1.1 | Adjusted to comments | 06 Feb 2025 | Lina M. Estupinan-Suarez (MLU), Quentin Groom (APM), Cristina Preda (UOC), Andrew Rodrigues (GBIF), Yanina Sica (JLUG), Heliana Teixeira (UAVR), Nikol Yovcheva |

| | | |
|---|---|---|
| | from reviewers | (PENSOFT), Henrique Pereira (MLU), Miguel Fernandez (MLU) |

## Table of contents

## Key takeaway messages

- Over the last decade, biodiversity policy has not only increased, but has been broadened and connected through the EU Biodiversity Initiative for 2030 and the EU Green Deal to face the current challenges of biodiversity loss due to environmental conditions and climate change.
- The complexity of the interconnected network of biodiversity policies requires a clear identification of key nodes and synergies. This is essential to prioritise tasks effectively and avoid duplication of efforts across different initiatives.
- The comprehensive set of EU policies faces challenges in effectively and repeatedly addressing the current status and trends of biodiversity at national and regional levels. A significant obstacle is the integration of the latest data and technologies into policy frameworks.
- Research, innovation and technology application are often decoupled from direct policy implementation due to the inherent temporal characteristics of the policy cycle, reinforcing the science-policy divide.
- There is a great need for scientists and science-based projects to mobilise their expertise and knowledge towards improving biodiversity assessment and reporting. Making such information more accessible and actionable for policy and decision-makers is key to bridging the science-policy divide.

## Executive summary

The Biodiversity Building Blocks for Policy (B3) project aims to increase the impact and broaden the use of biodiversity information to inform policy making through clear, informative and replicable biodiversity analytics. Through close collaboration with stakeholders, B3 is scaling up the implementation of biodiversity data cubes, bridging the gap between the needs of policy makers, big data analyses and bioinformatics. B3 is achieving this by facilitating the flow of species occurrences into interoperable data cubes to assess biodiversity status and change, while establishing reproducible open data workflows aligned to FAIR principles. Notably, B3 integrates global biodiversity infrastructure, data cube concepts for environmental data, Essential Biodiversity Variables, and leverages cloud computing to deliver rapid, up-to-date monitoring data for informed policy-making.

This manuscript outlines the key activities and outcomes of Task 1.5: "Alignment of B3 with European biodiversity initiatives," which encompassed two primary components. Firstly, we sought to gain a comprehensive understanding of biodiversity and ecosystem regulations within the European Union (EU), followed by a detailed examination of species-oriented legislation. Secondly, we identified stakeholders and projects relevant to B3, particularly those closely associated with species occurrence cubes, to assess where the project could make significant contributions.To achieve this, we reviewed and synthesised the main biodiversity policy, species-oriented legislation, and its complexities in terms of data access, harmonisation, and taxonomic issues. In addition, we drew on previous assessments to identify policy needs and gaps in biodiversity workflows, and engaged in stakeholder consultations to select the stakeholder-driven case study.

We began with a review of biodiversity legislation focused on species-oriented policies that could be connected to species occurrence cubes. In particular, the Birds and Habitats Directives, together with recent initiatives such as the European Biodiversity Strategy 2030 and the European Green Deal, highlighted the high level of compliance by Member States. In this respect, there is an urgent need to leverage new technologies that allow efficient processing and analyses at species level. Furthermore, the European Commission's ongoing call for evidence-based policy has led to initiatives such as the Knowledge for Policy Platform, and new institutions such as the Science Service for Biodiversity and the EU Biodiversity Observation Coordination Centre. Connecting with institutions at the science-policy interface, as well as exploring their frameworks, could significantly increase the impact of B3 in the long term.

From our stakeholder consultation, we identified a common vision for harmonised datasets, interoperable infrastructures and a strong interest in achieving significant policy impact. Nevertheless, major constraints remain in introducing new technologies into repeatable assessments of biodiversity status and trends. Based on our review of biodiversity policy and results from the stakeholders consultation, the reporting of Nature directives every six-years requires major efforts by Member States, which are highly dependent on the availability of data, infrastructure, team capacities and expertise. After analysing the results from the stakeholder consultation, we determined that harnessing data cubes for species assessment could directly benefit the reporting on the Habitats Directives. Ultimately, our aim is to support workflows that are easily findable, accessible and repeatable for all,  which could speed up processing for a large number of species, especially in cases where these analyses are considered bottlenecks.



# Non-technical summary

The Biodiversity Building Blocks for Policy (B3) project aims to facilitate biodiversity information for policymakers making it more accessible and useful. By working closely with different groups involved in biodiversity, B3 is smoothing workflows to use the largest data infrastructure for decision-making. B3 is doing this by turning large species datasets into a new data format that speeds up computation to see biodiversity patterns and changes over time. This advanced data storage is called “data cubes” and aims at easier interaction with other data sources. The project follows principles for openness and fairness in sharing data, ensuring that everyone can access and use “data cubes”. B3 also collaborates with global networks and uses cloud computing to share the latest data with policymakers in a timely manner, helping them make informed decisions about protecting biodiversity.

This document summarises the main activities and results of Task 1.5: "Alignment of B3 with European biodiversity initiatives." This task had two main parts. Firstly, it presents an overview of the main biodiversity and ecosystem laws in the European Union (EU), focusing mostly on laws concerning species. Secondly, we looked for stakeholders and projects related to B3, especially those linked to species occurrence, to see where the project could help the most. In short, we reviewed the biodiversity policy related to species, looked at how data is managed and shared, and checked what help was needed. We also were in contact with stakeholders to choose a case study based on their needs where B3 can facilitate and advance analysis of large species datasets.

We initiated our analyses by digging  into biodiversity legislation, and their potential linkages to species occurrence cubes. Importantly, the Birds and Habitats Directives, along with recent initiatives like the European Biodiversity Strategy 2030 and the European Green Deal, showed the high reporting commitment of Member States. This remarked the immediate need to implement emerging technologies capable of efficiently processing and analysing data at the species level to help Member States achieve their reporting tasks. Moreover, the European Commission's willingness for evidence-based policy-making has promoted initiatives like the Knowledge for Policy Platform, along with the establishment of new entities like the Science Service for Biodiversity and the EU Biodiversity Observation Coordination Centre. Collaborating with such institutions, and exploring science-policy collaboration frameworks, could significantly enhance the long-term impact of B3's outcomes.

Through our stakeholder consultation, we found good agreement on the importance of clear and user-friendly data, and a strong interest in communicating better results to  policy makers. However, there are a number of challenges; for example, integrating new technologies while making consistent national and regional assessments over time, or homogenising data while preserving key local details to meet both local and global demands. We also identified that data cubes could improve reporting on certain environmental laws, such as the Birds and Habitats Directives, which require a great deal of work and ongoing commitment from countries to report on their wildlife every six years. By facilitating the processing of data, especially analyses of large data sets, B3 can help speed up the whole reporting process.

# List of abbreviations

| | |
|---|---|
| B3 | Biodiversity Building Blocks for Policy Project |
| BISE | Biodiversity Information System for Europe |
| DG ENV | Directorate-General for Environment |
| EASIN | European Alien Species Information Network |
| EBVs | Essential Biodiversity Variables |
| EC | European Commission |
| EEA | European Environmental Agency |
| Eionet | European Environment Information and Observation Network |
| ERIC | European Research Infrastructure Consortium |
| ESFRI | European Strategy Forum on Research Infrastructures |
| ETC | European Topic Center |
| ETC BE | European Topic Center on Biodiversity and Ecosystems |
| EU | European Union |
| EUNIS | European Nature Information System |
| EuropaBON | Europa Biodiversity Observation Network |
| FAIR | Findable Accessible Interoperable Reusable |
| GEO BON | Group on Earth Observations Biodiversity Observation Network |
| GES | Good Environmental Status |
| GBIF | Global Biodiversity Information Facility |
| IAS | Invasive Alien Species |
| IPBES | Intergubernamental Panel for Biodiversity and Ecosystem Services |
| IUCN | International Union for Conservation of Nature |
| JRC | Joint Research Centre |
| KCBD | Knowledge Centre for Biodiversity |
| MLU | Martin-Luther-University Halle-Wittenberg |
| MSFD | Marine Strategy Framework Directive |
| SSBD | Science Service for Biodiversity |
| WFD | Water Framework Directive |
| WISE | Water Information System for Europe |
| WoRMS | World Register of Marine Species |

# 1. Introduction

For over four decades, Europe has developed a comprehensive body of environmental and biodiversity legislation, spanning a wide array of topics such as habitats, birds, forests, pollinators, invasive alien species (IAS), freshwater and marine ecosystem conservation, green infrastructure, and most recently restoration. These robust legislative measures have been bolstered by the establishment of knowledge centres and the development of research infrastructures, with recent additions including the provision of scientific services. Building upon this solid legislative base, the European Union (EU) has launched two critical initiatives: the EU Biodiversity Strategy for 2030 and the European Green Deal. These initiatives spearhead regional efforts to preserve the planet's biodiversity and tackle climate change, offering a clear roadmap for transformative actions and sustainable transitions. They acknowledge the complex relationship between biodiversity, human well-being, and economic prosperity and set ambitious targets accordingly. The EU Biodiversity Strategy for 2030 focuses on maintaining natural balance, whereas the European Green Deal aims to integrate economic growth with environmental sustainability, thereby synthesising Europe's diverse environmental efforts into a unified and coherent vision.

Despite these significant advances, nature faces numerous and urgent challenges, including increasing pressures from habitat degradation, pollution, overexploitation, IAS, and climate disruption that threaten species and ecosystems in Europe and beyond. Addressing these multifaceted issues demands support from the latest knowledge, innovative solutions, collaborative partnerships, and unwavering commitment from all sectors of society. The growing amount of biodiversity data, coupled with rapid advancements in informatics and cloud computing, presents a remarkable opportunity. However, this evolution also poses challenges in terms of timely and scalable IT adoption. The Biodiversity Building Blocks for Policy (B3) project capitalises on the Essential Biodiversity Variables (EBVs) framework concept proposed by GEO BON (Pereira et al., 2013, Hardisty et al. 2019a, Hardisty et al. 2019b) and bridges the gap between policy needs and the capabilities of bioinformaticians and scientists by focusing on integrating and processing diverse data sources, available via the Global Biodiversity Information Facility (GBIF[1]), through the development of species occurrence data cubes and collaborative tools (Kissling et al., 2018, Jetz et a., 2019, Oldoni et al. 2024). This approach not only makes the use of transparent and reproducible bioinformatics but also supports an agile, accessible, and responsive process to effectively inform policymakers (Groom et al. 2019, Seebens et al. 2020). This integrated effort ensures that scientific advancements are effectively translated into policy actions, enhancing biodiversity conservation and sustainable development (Groom et al. 2018).

In this report, we present a comprehensive analysis of EU policies, stakeholder needs, and the challenges associated with aligning B3 with the requirements of European environmental and biodiversity-related legislation. Our investigation focuses primarily on species-related information because B3 is specifically designed to generate species occurrence cubes that will be used for improving the assessment of species status and trends, as well as for modelling and calculating various indicators (Kissling et al. 2018, Jetz et al. 2019, Oldoni et al. 2024) . This document is structured as follows: initially, we review the current EU biodiversity policies centred

[1] https://www.gbif.org/

on species and their complexities, aiming to provide an overview of the requirements for Member States to assess and report at the species level. Next, we explore the gaps and bottlenecks identified by European stakeholders that B3 could address to facilitate the flow of biodiversity data essential for informing policy. Finally, we detail the stakeholder consultation process and discuss the selection of a stakeholder-driven case study where B3 is poised to make a significant impact by unlocking biodiversity data flows and enhancing species assessment. This approach underscores how B3 is integrated into broader biodiversity management and policy-making efforts across Europe.

# 2. EU-Policy institutions and supporting bodies

Evidence-based policy-making is paramount for safeguarding the planet (IPBES 2019), and has become a cornerstone of EU environmental policies (European Commission, 2020). In this context, it is imperative for scientists and projects to develop a comprehensive understanding not only of how policy priorities shape research questions but also of the intricacies of the legislative process and its implications for biodiversity assessment and monitoring. This understanding can facilitate a continuous exchange of knowledge and effective science-policy feedback (European Commission DG RTD, 2021). This section provides an overview of the key EU institutions and stakeholders relevant to B3, focusing on core institutions from a knowledge for policy perspective.

## 2.1. EU political bodies and policy cycle

Biodiversity conservation and management involves a wide range of stakeholders from various sectors in the EU. Starting with EU institutions, the European Commission (EC) plays a central role, first in proposing biodiversity policies and then in monitoring Member States' implementation. These tasks fall under the department of the Directorate-General for Environment (DG ENV), which leads these efforts. Notably, DG ENV has embraced the Knowledge for Policy initiative[2], leveraging cutting-edge scientific insights to address biodiversity and ecosystem threats, fund conservation efforts, promote ecological restoration, and advocate for sustainable practices across all sectors (IPBES 2019, European Commission 2020). Policy formulations are subject to the scrutiny of the European Parliament, which refines them through deliberations, negotiations and ultimately votes for adoption.

EU Member States are tasked with the critical role of implementing EU biodiversity policies within their jurisdictions through direct policy actions (see section 3.2). These include establishing legislative and regulatory frameworks that underpin a wide range of conservation efforts, from designating protected areas to initiating species reintroduction programs and facilitating research and monitoring activities; as well as a variety of policy-enabled activities such as public awareness and education programs, cross-border initiatives, and private sector engagement, among others. Supporting these national efforts, the European Environment Agency (EEA) stands as a key player in developing, implementing, and evaluating EU environmental policies, and serves as a primary coordinating body for the European

[2] https://knowledge4policy.ec.europa.eu/about-knowledge4policy_en

Environment Information and Observation Network[3] (Eionet), a large partnership with more than 400 institutions from all Member States that collaborate with the goal of producing the knowledge and information to reach targets of environmental sustainability. Despite the mandate of the EEA, this organisation has limited capacity to meet the needs of the Member States and at the same time respond to the demands of the EC. That is why different Topic Centers (ETC) have been created to alleviate the work of the EEA in different areas such as climate change, circular economy, and health. In our particular case, the most relevant ETC is the one on Biodiversity and Ecosystems[4] (ETC-BE), a consortium of prime organisations with expertise in terrestrial, freshwater, and marine biodiversity. Providing expert advice and supporting the EEA's mission by aiding in the implementation of EU environmental directives and strategies, including contributions to monitoring and assessment efforts that track progress towards key EU initiatives like the European Green Deal and the Biodiversity Strategy for 2030. Together, these entities foster a dynamic and informed approach to biodiversity conservation across Europe, engaging with national focal points and stakeholders to ensure timely reporting and the success of Nature Directives and related policies (Lemaitre et al. 2018).

In addition, various research infrastructures have been designated to facilitate collaborative research among Member States, enhancing scientific and technological advancements (section 2.2). Furthermore, web-platforms aimed at disseminating knowledge to policymakers have been established. Examples include Biodiversity Information System for Europe (BISE)[5], Water Information System for Europe (WISE) Marine[6], WISE Freshwater[7], Eklipse[8], BiodivERsA[9], and the EU Repository of Nature-Based Solutions Oppla[10], which have been deployed by the EEA.

Notably, recent efforts have led to the designation of the keystone institutions for science-based policy making such as the Knowledge Centre for Biodiversity (KCBD). The KCBD aims to strengthen the impact of EU policies by making the latest knowledge on biodiversity available (European Commission GD RTD 2021). Furthermore, it supports policy-making by guiding and developing tools for the EU Biodiversity Strategy implementation, curating accessible information for diverse stakeholders, and communicating findings in a transparent, and concise manner[11]. Significantly, the ongoing development of the Scientific Service for Biodiversity (SSBD), led by the BioAgora Project, will support the work of the KCBD (European Commission DG RTD, 2021, section 2.4.4). KCBD has worked on a chart representation of the EU Biodiversity Knowledge Governance; it mapped the EU institutions into two sectors; the "knowledge use (policy)" sector and the "knowledge provision" sector. This governance figure (Figure 1) states the links between institutions and offers an overview of the multiple actors involved emphasising the mobilisation of knowledge for decision-making.

[3] https://www.eionet.europa.eu/
[4] https://www.eionet.europa.eu/etcs/etc-be
[5] https://biodiversity.europa.eu/
[6] https://water.europa.eu/marine/about/wise-marine
[7] https://water.europa.eu/freshwater
[8] https://eklipse.eu/
[9] https://www.era-learn.eu/network-information/networks/biodiversa
[10] https://oppla.eu/
[11] https://knowledge4policy.ec.europa.eu/biodiversity_en

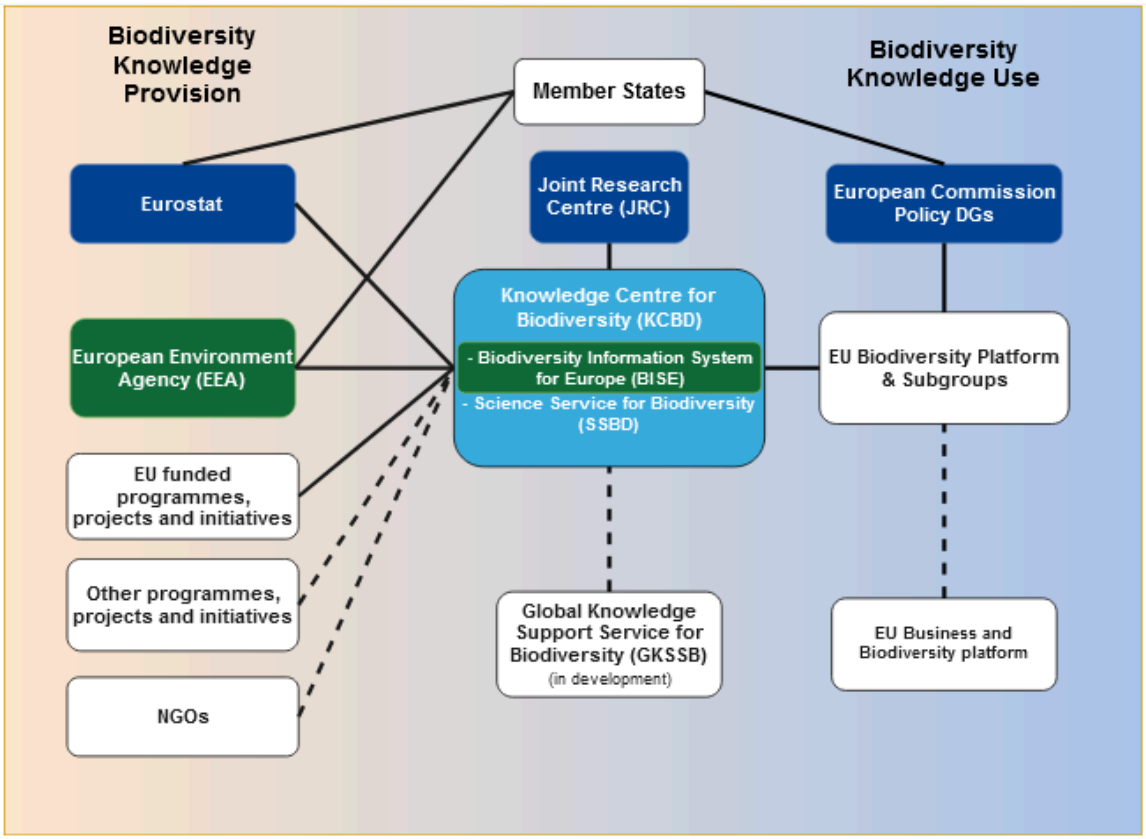



**Figure 1: Knowledge governance supporting the EU Biodiversity Strategy. The colour of the box indicates the institution. Blue: European Commission. Light blue: Knowledge Centre for Biodiversity. Green: European Environmental Agency. White: Other bodies and institutions. Solid line: Formal collaboration. Dashed line: Consultative role. (Source KCBD 2024, available at [https://knowledge4policy.ec.europa.eu/biodiversity/about_en](https://knowledge4policy.ec.europa.eu/biodiversity/about_en)).**

The policy cycle for reporting under Europe's nature directives, specifically the Birds Directive (2009/147/EC) and the Habitats Directive (92/43/EEC), represents one of the most well-established and structured processes within the EU's environmental policy framework. These directives, being among the oldest and most foundational elements of EU nature conservation law, have set a precedent for effective biodiversity monitoring, evaluation, and conservation efforts across the continent. The cycle is comprised of several key phases:

1. Data Collection and Monitoring: Member States are responsible for monitoring the status and trends of habitats and species protected under these directives. This involves extensive fieldwork to collect data on the conservation status, threats, and pressures facing these natural assets.
2. National Reporting: Every six years, Member States compile and submit national reports to the EC. These reports are based on the data collected during the monitoring phase and provide a comprehensive overview of the progress and challenges in implementing the directives at the national level.
3. Data Analysis and Synthesis: The EEA, often with the support of the ETCs like the ETC-BE, analyses the data and reports submitted by the Member States. This analysis

aims to identify trends, assess the overall conservation status of species and habitats, and evaluate the effectiveness of protection measures across the EU.

4. EU Summary Reports: The EEA, in collaboration with the European Commission, produces summary reports that synthesise findings from the national reports. These EU-wide assessments offer insights into the status of Europe's natural heritage and the collective progress towards the directives' objectives.
5. Feedback and Recommendations: Based on the findings of the EU summary reports, the European Commission, often in consultation with the EEA and other stakeholders, identifies areas for improvement, best practices, and recommendations for future actions. This feedback is shared with Member States to guide the refinement of conservation strategies and measures.
6. Implementation of Recommendations: Member States are expected to use the feedback and recommendations to adjust and enhance their conservation efforts. This may involve revising national legislation, updating management plans for protected areas, increasing conservation funding, or implementing targeted actions to address specific threats and pressures.
7. Public Consultation and Engagement: Throughout the policy cycle, there is an emphasis on transparency and stakeholder engagement. Information about the status of habitats and species, as well as the effectiveness of conservation measures, is made available to the public. Moreover, stakeholders, including NGOs, academic institutions, and the private sector, are often involved in consultations to gather input and foster collaborative conservation efforts.
8. Review and Adaptation: The cycle is iterative, with each round of reporting and evaluation providing an opportunity to review policies and practices. Insights gained from the process inform the adaptation of strategies to better address emerging challenges, changing environmental conditions, and scientific advancements.

This policy cycle ensures a structured and adaptive approach to nature conservation in Europe, enabling continuous improvement in the protection and management of biodiversity.

## 2.2. Research Infrastructure (ERICS/ESFRIS)

Research infrastructures established and funded by EU Member States have profoundly shaped the landscape of scientific practice in Europe, prioritising collaboration, inclusivity, and open access (European Commission 2023). Within the scope of our manuscript, we exclusively focused on the European Strategy Forum on Research Infrastructures (ESFRIs) and the European Research Infrastructure Consortium (ERIC). ESFRIs are strategic instruments that prioritise the development of research infrastructures in Europe, they identify priority areas for infrastructure development and facilitate collaboration among EU Member States and the Union[12]. On the other hand, the ERIC is a legal entity designed to streamline the creation and management of research infrastructures (European Union Regulation No 723/2009). ERIC enables the formation and operation of new or established research infrastructure and promotes collaboration across European countries. By 2023, 60% of ESFRIs transitioned to ERICs through the ESFRI Roadmap (European Commission, 2023). ERICs provide resources and

[12] https://www.esfri.eu/

services for scientists in academia and industries to conduct research and foster innovation to tackle scientific and societal challenges. Upon the Commission's decision to establish an ERIC, it becomes a legal entity with no commercial purpose and limited economic activities in line with its research-focused objectives. ERICs covered different topics such as energy, food, health, environment, data, social and culture, among others[13]. A summary list of the ERICs related to biodiversity is presented in Table 1, for additional information on other research infrastructures refer to Manrique et al. (2021).

**Table 1: List of the main ERICs and ESFRIs connected to biodiversity. RI: Research Infrastructure.**

| RI name | Acronym | Status | Aim |
|---|---|---|---|
| Distributed System of Scientific Collections[14] | DiSSCo | ERIC Pending (project started 2004) | Digital unification of all European natural science assets, sharing common access, curation, policies and practices |
| Integrated Carbon Observation System[15] | ICOS ERIC | ERIC 2015 | Standardised greenhouse gas measurements throughout Europe |
| e-Infrastructure for Biodiversity and Ecosystem Research[16] | LifeWatch ERIC | ERIC 2017 | Facilitate e-science research for biodiversity and ecosystem function research addressing societal and planetary challenges |
| European Marine Biological Resource Centre[17] | EMBRC ERIC | ERIC 2018 | Hub of marine resources and cutting-edge services and facilities for researchers from academia and industry |
| International Centre for Advanced Studies on River-Sea Systems description[18] | DANUBIUS -RI | ERIC step 1 | Interdisciplinary research centre and innovation on River-Sea Systems |
| Integrated European Long-Term Ecosystem, critical zone and socio-ecological Research[19] | eLTER | ESFRI | Monitor long-term changes in terrestrial ecosystems |

The scope of LifeWatch ERIC is the most relevant to B3, given its e-science focus on enabling IT technology, i.e. innovation in big data and compute-intensive research (UC3 2012) for biodiversity and ecosystems research. Establishing a communication channel to explore and identify synergies between both projects would be advantageous for enhancing B3's long-term impact.

[13] https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/european-research-infrastructures/eric_en
[14] https://www.dissco.eu/
[15] https://www.icos-cp.eu/
[16] https://www.lifewatch.eu/
[17] https://www.embrc.eu/
[18] https://www.danubius-ri.eu
[19] https://elter-ri.eu/elter-ri

## 2.3. EU research projects for evidence based policy

In this section we present thematic EU-funded projects that are relevant for the Alignment of B3 with European biodiversity initiatives.

### 2.3.1. Research projects for the Green Deal Data Space

Several EU-funded projects aim to provide the best available data and information using state-of-the-art technology to collect large datasets and the necessary IT infrastructure for efficient processing. Here we present ongoing B3's sister projects with which B3 has continuous interaction.

#### 2.3.1.1. FAIRiCUBE

The FAIRiCUBE project aims to transform the landscape of Earth Observation by empowering a diverse range of governance and research institutions with the tools to leverage multi-thematic data cubes and Machine Learning[20]. Positioned at the intersection of technology and policy, FAIRiCUBE's mission is to facilitate access to, and processing of, gridded data in a FAIR and trustworthy environment. By developing the FAIRiCUBE Hub, the project seeks to establish a robust framework for data ingestion, provision, analysis, processing, and dissemination. This hub will serve as a vital cross-cutting platform, seamlessly integrating into European data spaces and enhancing the utility of environmental, biodiversity, and climate data. Through its commitment to using state-of-the-art technologies for large dataset management and efficient IT infrastructure, the goal of FAIRiCUBE is to equip decision-makers and data scientists with the necessary resources to inform and guide policy effectively.

#### 2.3.1.2. All data for Green Deal (AD4GD)

The All Data for Green Deal (AD4GD) initiative is a pivotal project orchestrated to architect the European Green Deal Data Space as a universally accessible hub for FAIR data and services built on standardised frameworks. This ambitious project aims to integrate a vast array of cross-sectoral data supporting the European Commission's initiatives focused on biodiversity, pollution reduction, circular economy, climate change, and more[21]. By establishing a cohesive and integrated data space, AD4GD will enhance the availability and utility of essential data through three pilot projects centred around biodiversity, air quality, and water management. These pilots are designed not only to demonstrate the practical applications of the data hub but also to forge pathways for data-driven decision-making in environmental and climate-related policies. Through the incorporation of diverse data streams—from remote sensing and Internet of Things to socio-economic and citizen science data—AD4GD will foster a dynamic environment where data accessibility and utility are significantly enhanced, thereby empowering stakeholders across Europe to make informed decisions based on robust, standardised, and interoperable data frameworks.

[20] https://fairicube.nilu.no/
[21] https://ad4gd.eu/

### 2.3.2. Research projects in the science-policy convergence

Over the last two decades, EU-funded research projects have been conducted to facilitate and enhance regional convergence between science and policy. Among these pioneering initiatives is the European Biodiversity Observation Network (EU BON) that worked on data harmonisation and outlined strategies for policy among others (EU BON 2017). Currently, three major EU-funded projects - EuropaBON, Biodiversa+ and BioAgora - operate collaboratively at the intersection of biodiversity policy and research. In general, they have engaged extensively with stakeholders and developed strategies for biodiversity monitoring, increasing scientific impact in the society, among other activities. These projects are detailed below.

#### 2.3.2.1. EU BON

The EU BON project was a comprehensive initiative aimed at advancing biodiversity research, monitoring, and policy development in Europe from 2012 to 2017. It encompassed various activities and services geared towards improving the integration and standardisation of biodiversity data across Europe (Hoffmann et al. 2014). These efforts included the development of a strategy roadmap for a citizen science gateway, provision of services for the European taxonomic backbone, and establishment of the European Biodiversity Portal to facilitate fast access to integrated data and products. EU BON also prioritised open data publishing and dissemination practices, developed frameworks and toolkits for biodiversity data management, and contributed to policy papers outlining strategies for effective data mobilisation in conservation efforts. Moreover, the project prototyped integrated biodiversity monitoring schemes and provided guidance for the development of EU-integrated national and regional biodiversity information infrastructures.

In addition to its focus on data integration and accessibility, the EU BON project aimed to foster sustainability and collaboration in biodiversity monitoring and conservation efforts (Hoffmann et al. 2019). It developed prototypes for scalable global biodiversity monitoring schemes and laid the groundwork for coordinated monitoring efforts at regional and global scales. Furthermore, EU BON provided strategies and plans for the sustainability of regional and global biodiversity information networks, ensuring their long-term viability and effectiveness.

#### 2.3.2.2. EuropaBON

The Europa Biodiversity Observation Network: integrating data streams to support policy (EuropaBON) is a EU Horizon project funded for three years that ends in 2024. EuropaBON has built a well-established network of biodiversity stakeholders that today has reached more than 1500 members[22] (Junker et al. *in prep*). EuropaBON has identified the priority EBVs for Europe and described the desired spatio-temporal and taxonomic resolution (Junker et al. 2023). In line with this, significant progress has been made on workflow development for operational EBV estimation, streamlining the automated extraction of biodiversity information from unstructured raw data (Lumbierres and Kissling 2023). In addition, it has showcased examples representing aquatic EBVs at both species and community level relevant for the WFD, and ready for further modelling, assessment and automation (Moe et al. 2023). Other important outputs are: the assessment of user and policy needs (Moersberger et al. 2022), the identification of current monitoring workflows and bottlenecks (Morán-Ordóñez et al. 2023), reporting on gaps and

[22] https://europabon.org/members/home

important new areas for monitoring in Europe (Santana et al. 2023), new technologies for biodiversity monitoring (Dornelas et al. 2023), among others. Lastly, EuropaBON developed guidelines for establishing an EU Biodiversity Observation Coordination Centre with corresponding infrastructural details covering activities, functions, structures and governance. Within this comprehensive framework, EuropaBON has provided valuable guidance from science to policy.

#### 2.3.2.3. Biodiversa+

This initiative stands as a pivotal European co-funded partnership to bridge the gap between science, policy, and societal actions in the realm of biodiversity conservation. Officially launched on 1 October 2021, it embodies a collaborative effort between BiodivERsA, the European Commission (DG Research & Innovation and DG Environment), and a network comprising 81 research programmers, funders, and environmental policy actors from 40 European and associated countries. Positioned within the ambit of the European Biodiversity Strategy for 2030, Biodiversa+ is instrumental in steering Europe's biodiversity towards a path of recovery by the end of this decade[23]. It underpins the standardisation of monitoring methods, facilitates data interoperability (Basset et al. 2021), and pilots initiatives for the efficient mapping and monitoring of critical habitats such as grasslands and wetlands. By fostering the co-design of national biodiversity monitoring coordination centres and emphasising IT solutions, Biodiversa+ enhances the comprehensive network of ministries of environment and environmental protection agencies responsible for the EU's environmental policy implementation and reporting (Silva del Pozo and Body 2022, Vihervaara et al. 2023a). Through its commitment to connecting science, policy, and practice, Biodiversa+ aims to catalyse transformative change, supporting research and innovation, improving biodiversity and ecosystem services monitoring, contributing knowledge for nature-based solutions, and ensuring that science-based support fortifies policy-making and implementation across Europe, thereby amplifying the global relevance and impact of European research on biodiversity (Vihervaara et al. 2023b).

#### 2.3.2.4. BioAgora

BioAgora is a five-year EU-Horizon funded project running from July 2022 to June 2027, involving a consortium of 22 partners from 13 European countries. The project aims to support sustainable transformation for biodiversity across Europe by bridging the gap between biodiversity research outcomes and policy requirements. Through collaborative efforts, BioAgora seeks to facilitate a targeted dialogue among scientists, knowledge stakeholders, and policymakers to address the pressing challenges facing biodiversity conservation and management[24].

A pivotal role of BioAgora is the establishment of the SSBD[25], which will support scientific KCBD tasks. Importantly, the SSBD aims to catalyse the impact of outcomes from Horizon Europe projects by offering research-based assessments and facilitating their application in national, EU, and international levels (European Commission 2021, Viti et al. 2024 *pre-print*). To achieve

[23] https://www.biodiversa.eu/
[24] https://bioagora.eu/
[25] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/new-science-service-biodiversity-2021-09-07_en

this goal, BioAgora is conducting pilot tests to evaluate various functions and mechanisms of the SSBD, ensuring its dynamic, inclusive, and functional operation. Additionally, BioAgora will take the lead in establishing governance structures, decision-making processes, and an ethical framework for the SSBD. Lastly, the project aims to deploy a web platform, facilitating access for all relevant stakeholders to leverage the benefits of the SSBD (BioAgora 2024).

## Takeaway messages

| EU-Policy institutions and policy cycle |
|---|
| • The EC together with DG ENV are responsible for formulating EU biodiversity policies, which are shaped, adopted or rejected in the European Parliament.<br>• Once the policies are adopted, the EEA, with the scientific support of the ETC-BE, monitors the reporting obligations of the Member States.<br>• EU environmental policy has placed the "Knowledge for Policy" framework at the heart of its continued development and implementation.<br>• The KCBD, and the forthcoming SSBD, play pivotal roles in translating scientific evidence into policy decisions, facilitating two-way communication between EU research projects and policymakers.<br>• It is essential to foster an effective exchange between science and policy in order to make the best decisions on biodiversity management and conservation. |
| **Research projects and Infrastructure** |
| • Establishing a communication channel to explore and identify synergies between B3 and Lifewatch would be advantageous for enhancing B3's long-term impact.<br>• Active participation in projects and initiatives such as BioAgora, SSBD and the EU Biodiversity Observation Coordination Center would increase understanding of the upcoming challenges for an evidence-based policy.. |

# 3. EU Policy for Biodiversity

The following section outlines the EU Green Deal and the EU Biodiversity Strategy for 2030, provides an overview of key species-oriented policies, and explores a taxonomic analysis of species under EU policies.

## 3.1. The European Green Deal and EU Biodiversity Strategy for 2030

The European Green Deal “provides a roadmap for making the EU's economy sustainable by turning climate and environmental challenges into opportunities across all policy areas” (European Commission 2019). The EU Biodiversity Strategy for 2030 is a cornerstone of the Green Deal, setting forth a plan to protect nature and reverse ecosystem degradation. It aims to establish legally binding nature restoration targets and measures to address the key drivers of biodiversity loss (European Commission 2020). Below we highlight core legislative instruments that underpin the EU Green Deal and the EU Biodiversity Strategy for 2030, and present a chronology of more than four decades of biodiversity legislation in Europe (Figure 2):

- **Birds and Habitats Directives:** The Birds (2009/147/EC) and Habitats (92/43/EEC) Directives form the bedrock of the EU’s nature conservation efforts, focusing on the protection of species and habitats. They mandate the creation of the Natura 2000

network, a vast network of protected areas that safeguard endangered species and habitats.

- **Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD):** The WFD (2000/60/EC) aims for 'good status' of all European waters, promoting sustainable water use and protecting aquatic ecosystems. The MSFD (2008/56/EC) complements the WFD by striving for good environmental status of marine waters, applying an ecosystem-based approach to marine conservation.
- **Invasive Alien Species Regulation:** The Invasive Alien Species (IAS) Regulation (1143/2014) addresses the issue of invasive species, which are a major threat to biodiversity. It establishes a framework for the prevention, early detection, and management of invasive species, integrating with broader biodiversity goals.
- **Pollinators Initiative:** Launched in 2018, the Pollinators Initiative seeks to address the decline of wild pollinating insects. It outlines actions to improve knowledge, tackle the causes of decline, and raise awareness. Pollinators are crucial for biodiversity and agriculture, making this initiative a key component of the EU's ecological network.
- **Nature Restoration Law:** Proposed as part of the Biodiversity Strategy for 2030, the Nature Restoration Law aims to set legally binding targets for restoring degraded ecosystems across the EU. It represents a significant step forward in the EU's commitment to reversing biodiversity loss and ensuring ecosystem resilience.
- **Farm to Fork Strategy:** The Farm to Fork Strategy is at the heart of the European Green Deal, aiming to make food systems fair, healthy, and environmentally-friendly. It links agricultural practices with biodiversity objectives, emphasising sustainable production methods and the reduction of chemical pesticides, which directly benefit biodiversity.

These legislative tools are complemented by the EU Soil Strategy, the Common Agricultural Policy, and the forthcoming One Health Action, which is a cross-agency task force in response to the COVID-19 pandemic that advocates for an integrated approach to human, environmental, animal, and planetary health (European Union Agencies 2023).

Furthermore, effective implementation of the EU's biodiversity policies requires robust reporting and monitoring mechanisms. Member States are obligated to report every six years on the status of habitats and species (under the Birds and Habitats Directives), the quality of water bodies (under the WFD), and the status of marine environments (under the MSFD). These reporting mechanisms ensure accountability, facilitate adaptive management, and inform policy revisions and are explained in more detail in the next section.

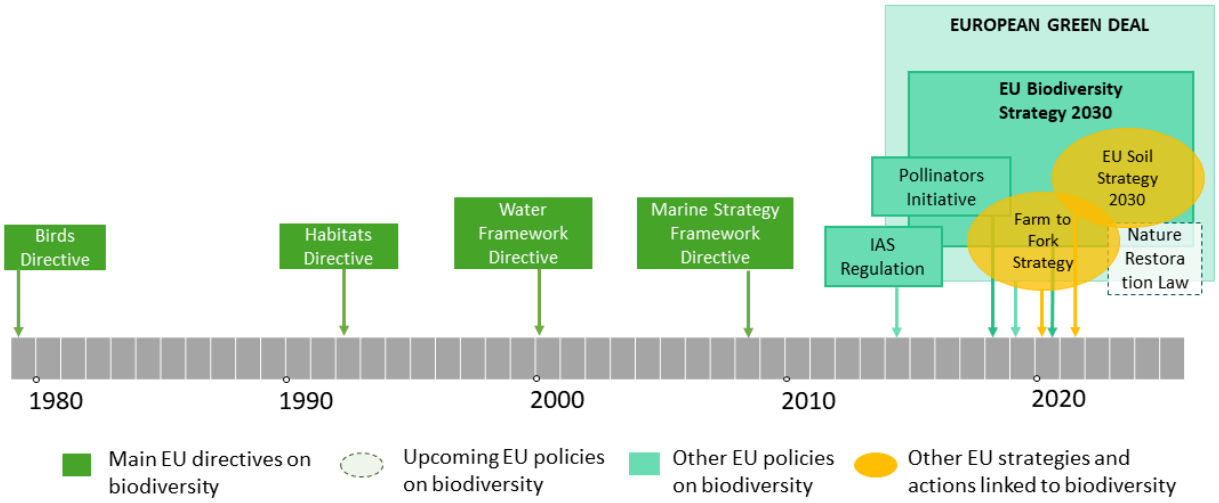



**Figure 2: Main EU legislative tools on or closely related to biodiversity from 1979 to 2023.**

## 3.2. EU policies focused on species conservation and management

Our aim in this section is to dig deep into the main legislations in Europe that are centred around species assessment. We emphasised here the species listed in the policy and therefore those that the EU Member States are obliged to monitor, assess and/or report to the Commission. To do so, we have focused on the list of species covered by the Birds and Habitats Directives, the MSFD, the list of IAS of Union Concern as regulated in the IAS Regulation, the European Red List of Species as part of the EU Biodiversity Strategy for 2030, and the Pollinator Initiative.

As part of our analysis, we checked the taxonomy of the different species lists contained in the legislation using the GBIF backbone taxonomy and the World Register of Marine Species (WoRMS) taxonomy for marine species. The only legislations that reported taxonomic information were the European Red List and the latest list of the Pollinator Initiative. We consider this analysis as a first step in understanding the magnitude of the tasks of Member States in species conservation and management, and how bioinformatics could contribute to it.

An initial challenge in analysing EU biodiversity legislation is that information is not centralised, but distributed across various web portals from the EEA, EUNIS and others. Retrieving key information, such as the list of species in the nature directives, becomes a titanic and time-consuming task. Such data are hardly identified by browsers and are not always available in tabular formats. All lists used in the following analyses and their taxonomy are available in tabular format in the following GitHub repository:
https://github.com/linamaes/sps_taxonomy_plots_Task1d5.git

### 3.2.1. Birds Directive

The Birds Directive[26] was adopted in 1979 and amended in 2009, and was one of the first nature conservation-related directives in Europe. In general, the directive protects the habitats of bird species and regulates activities such as hunting and trade (European Parliament 2009). Article 12 specifies the reporting of population status and trends by Member States. So far there have been three reporting periods to the Commission: 2005-2007, 2008-2012 and 2013-2018.

Bird species are listed in three annexes according to their conservation measurements:

- Annex I: Species listed are subject to special conservation measures (concerning their habitat in order to ensure their survival and reproduction in their area of distribution).
- Annex II: Species mentioned may be hunted under national legislation if their population level, geographical distribution and reproductive rate throughout the community do not interfere with conservation efforts.
- Annex III: list of species that Member States shall allow trading considering if they have been legally killed, captured or acquired (part A) or not (part B).

We checked the taxonomy of species with special conservation measures and listed in Annex I against the GBIF backbone taxonomy. In general, scientific names have a very high match (97% exact match). Two subspecies (2%) were identified to species level by GBIF which were *Cygnus bewickii* (*Cygnus columbianus bewickii*) and *Pyrrhula murina* (*Pyrrhula pyrrhula murina*) and *Xenus cinereus* (*Tringa cinerea*). After investigating both cases, the subspecies names (indicated in brackets) were considered synonyms of the respective species. The remaining 1% were classified as a fuzzy match due to missing author names and dates (i.e. *Chlidonias hybridus, Turnix sylvatica)*. As is well known, birds are a well studied group, their taxonomy has been extensively researched and, consequently, the species list is well determined and has not undergone significant changes. Figure 3 shows key aspects of the taxonomy of Annex I species. In summary, there are a total of 193 species in 47 families and 22 orders.

[26] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009L0147-20190626

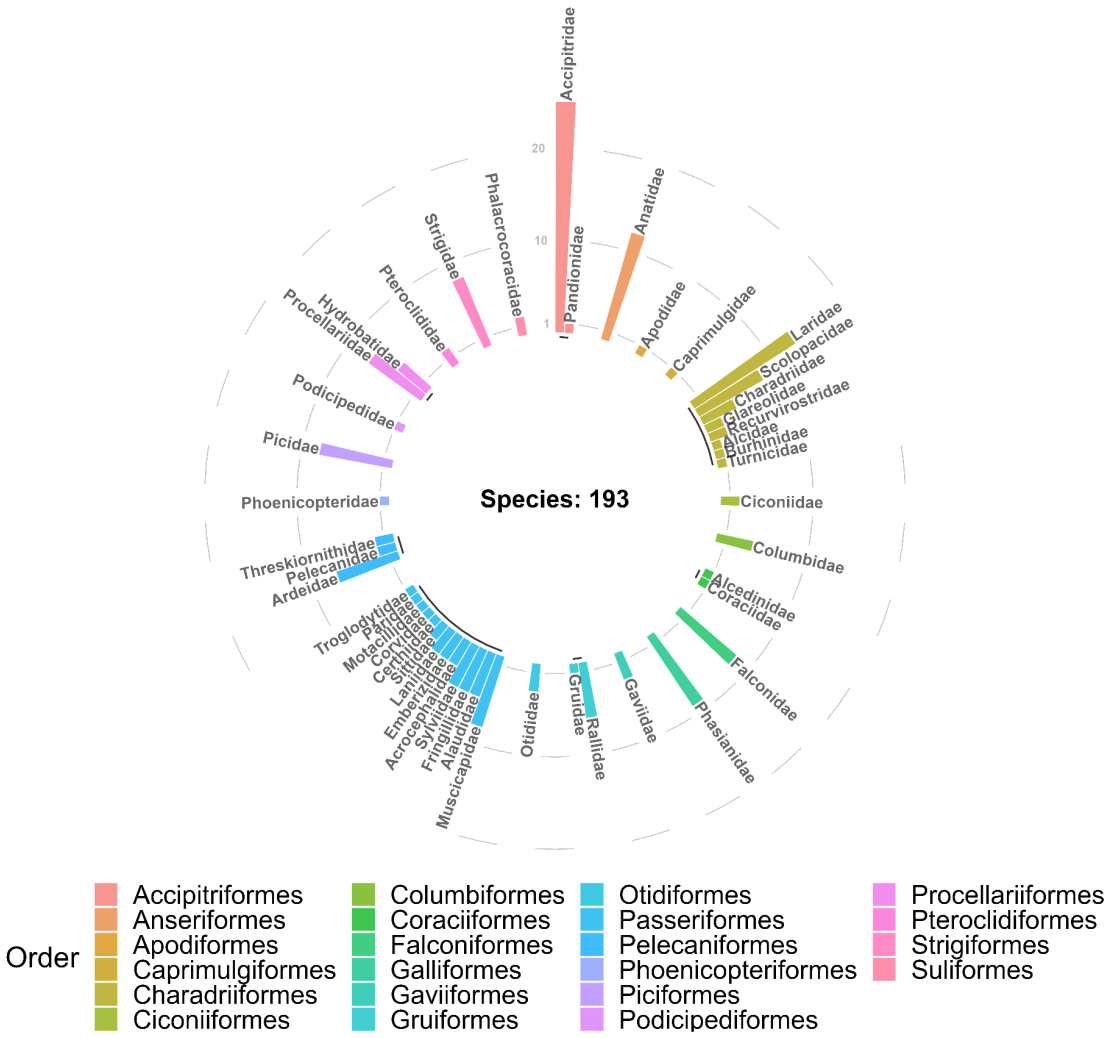



**Figure 3: Higher taxonomy of species included in Annex I of the Birds Directive. The rank Order is indicated by the coloured bar and the rank Family by the text next to the bars. (Data source: Birds Directive[27])**

### 3.2.2. Habitats Directive

The Habitats Directive was adopted in 1991. The overarching goal is to protect, maintain or improve the conservation status of EU key habitats and species. This requires the designation of special areas, strict protection of certain species, among others, as specified in the following annexes (Council Directive 1992):

- Annex I: natural habitat types of community interest whose conservation requires the designation of special areas of conservation[28].

[27] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0147
[28] https://eunis.eea.europa.eu/references/2324

- Annex II: animal and plant species of community interest whose conservation requires the designation of special areas of conservation[29].
- Annex IV: animal and plant species of community interest in need of strict protection[30].
- Annex V: animal and plant species of community interest whose taking in the wild and exploitation may be subject to management measures[31].

Under Article 17, Member States are required to report on the conservation status of species and habitats in their territory. The reports must be submitted every six years to the Commission. As a short introduction, the national reports are structured in three sections: a) general information on the implementation of the Directive, b) assessment of the conservation and status of species, c) and habitats. The conservation status of each habitat and species is assessed individually and within the relevant biogeographical or marine region covered by the Member State. The conservation status can be categorised as "favourable", "unfavourable-inadequate", "unfavourable-bad" and “unknown”, which is estimated using the parameters set out in Article 1. In particular, the parameters for assessing the conservation status of the habitats are: range, area, structure and functions and future prospects. Similarly, for species, the parameters are range, population, species habitat and future prospects[32].

The EEA has developed the Article 17 web tool[33] to visualise the result from all previous assessments which can be sorted by reporting period, taxonomic group, bio-region and name (i.e., species or habitat names). Also, the methodology of assessment under Article 17 of the EU habitats directive is available at the Eionet website[34]. This methodology explains the evaluation matrix for assessing the conservation status and trends, and also specifies the need of justifying the reasons when any species or habitat had changed its status at aiming to identify whether the change is genuine or not.

In our analysis for this section, we have focused on the Article 17 species check-list[35] updated in 2020. There are a total of 1510 species listed with a couple of remarks; some scientific names are accompanied by "all others" (i.e. *Barbus meridionalis* all others, *Cottus gobio* all others) or "Complex" (i.e. *Bufotes viridis* Complex, *Coregonus lavaretus* Complex, *Cobitis taenia* Complex, *Osmoderma eremita* Complex) respectively. In this context, "all others" refers to all subspecies with one exception, while "Complex" refers to species that can only be identified by DNA and therefore countries have suggested listing them in the rank of Genus.

We retrieved the taxonomy of species listed in Article 17 using GBIF. Two species did not have any match with the GBIF backbone: *Liparis loeselii*, the ‘fen orchid’, and *Coronella austriaca*, the ‘smooth snake’. Figure 4 shows the higher taxonomy of a total of 766 species belonging to the phylum Plantae (756) and Fungi (10). Due to taxonomic issues, both *Sphagnum spp.* and *Sphagnum auriculatum* (not found in GBIF) are only counted once (as *Sphagnum spp.)* and so 765 species were plotted instead.

[29] https://eunis.eea.europa.eu/references/2325
[30] https://eunis.eea.europa.eu/references/2326
[31] https://eunis.eea.europa.eu/references/2327
[32] https://www.eionet.europa.eu/etcs/etc-be/activities/reporting/article-17
[33] https://nature-art17.eionet.europa.eu/article17/
[34] https://nature-art17.eionet.europa.eu/article17/static/documents/Article%2017%20Assessment%20tool%20methodology.pdf
[35] https://cdr.eionet.europa.eu/help/habitats_art17

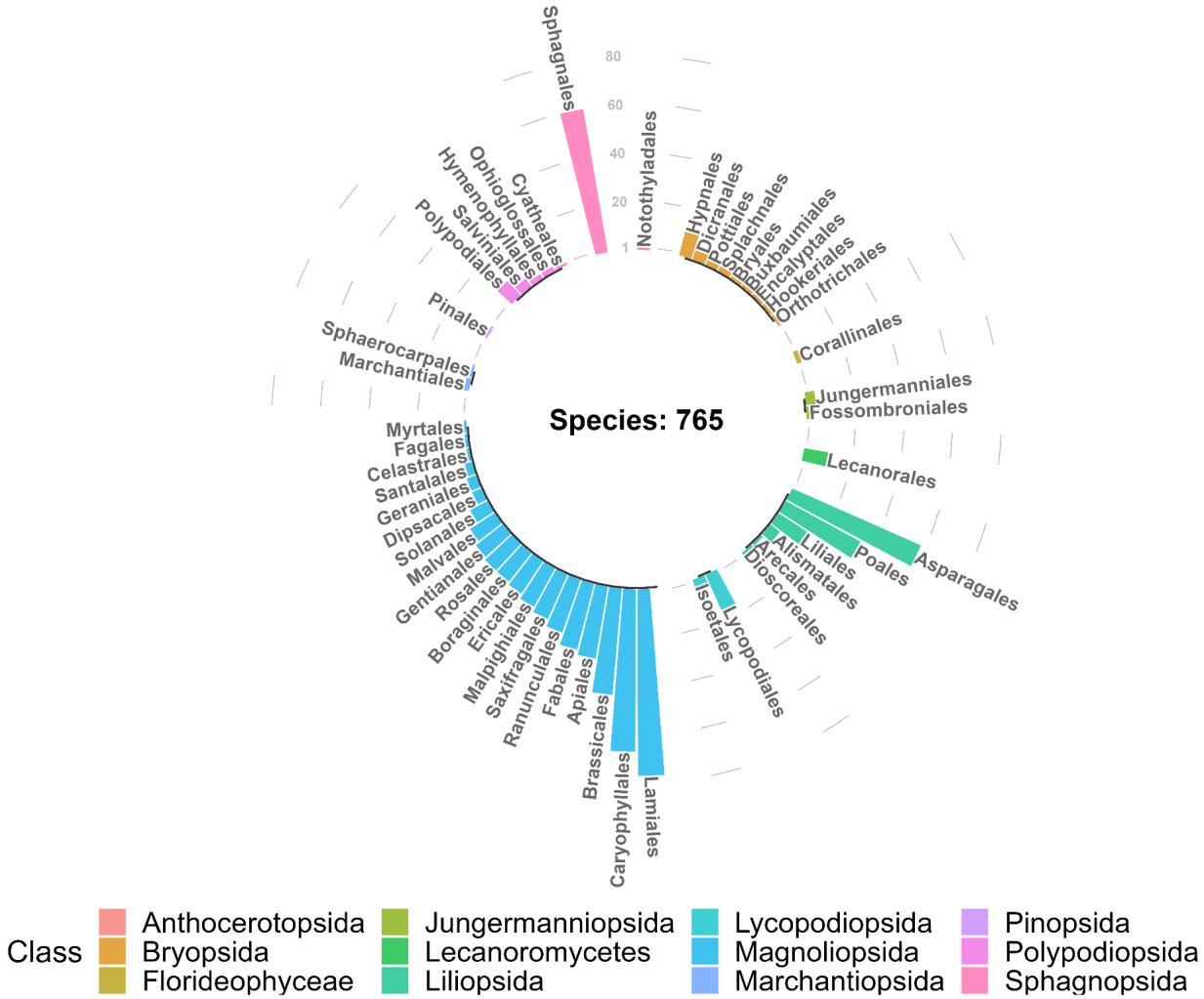



**Figure 4: Higher Taxonomy of the species related to the Article 17 of the Habitats Directive for the Plantae and the Fungi phylums. Note that the class "Lecanoromycetes" refers to the Fungi Kingdom. All other classes correspond to the Plantae Kingdom. (Data source: Eionet i.e., Art. 17 species check-list).**

Figure 5 shows the higher taxonomy of species belonging to the Kingdom Animalia. In total there are 742 records, however the taxonomy of the "*Bufotes viridis* Complex", "*Coregonus lavaretus* Complex", "*Cobitis taenia* Complex" was not included because the scientific names are duplicates of other records. Therefore, the figure only shows 739 species. It is important to mention that from this subset, we excluded Testudines and Squamata; both belonged to the former Class Reptilia now considered Superclass. The challenge we faced is that not all Testudines and Squamata are available in WoRMS. Specifically, the turtles not included in WoRMS are *Testudo hermanni*, *Testudo marginata, Mauremys rivulata*, and *Emys trinacris*. Therefore, we used the GBIF backbone taxonomy for Testudines and Squamata. For the sake of simplicity and consistency in Figure 5, we indicate Testudines and Squamata as Orders (rank) and use the Superclass Reptilia as shown in the legend.

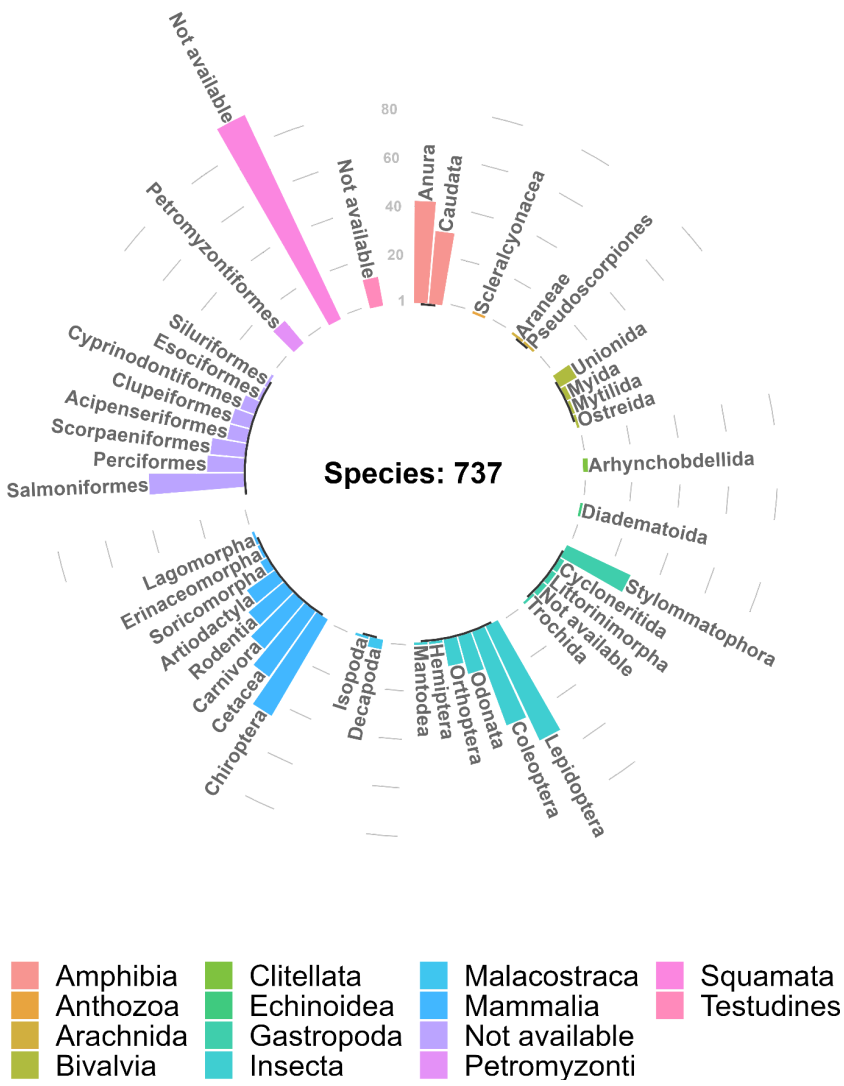



**Figure 5: Higher taxonomy of species related to Article 17 of the Habitats Directive for the Kingdom Animalia. Note that Testudines and Squamata are considered as Order rank and that the taxonomic rank Class is not available and therefore it was replaced by the Class Reptilia. (Data source: Eionet i.e., Art. 17 species check-list).**

### 3.2.3. Marine Strategy Framework Directive

In 2008, the European Commission adopted the Marine Environmental Strategy Directive 2008/56/EC, which aims to "prevent, protect and conserve the marine environment". In particular, this strategy aims to achieve "good environmental status (GES)" through 11 environmental descriptors (European Parliament 2008). GES is partly covered by Article 8 (assessment), Article 9 (determination of GES) and Article 10 (setting of objectives). The latest report from Member States dates back to 2018. We focused on "Descriptor 1: Marine Biodiversity", which is linked to Articles 8, 9 and 10. The Joint Research Center (JRC) has published a comprehensive review of these national reports and compiled a list of species

reported by Member States (Palialexis and Boschetti 2021), which we have used for our analysis.

The species groups reported by Member States under Article 8 (assessment) are: mammals, turtles, birds, fish and cephalopods. Items describing communities/groups (i.e. coastal fish community, demersal fish community, sensitive fish species, benthic birds, grassland birds, pelagic birds, surface birds, wading birds) and incomplete scientific names have been excluded from our analysis (i.e., *Alloteuthis spp., Ammodytes spp., Apristurus spp., Argentina, Beryx spp., Chimaera spp., Deania spp., Gavia sp., Lepidotrigla spp., Melanitta spp., Mustelus*). We checked the taxonomy of the scientific names using the WoRMS taxon match tool. Only three scientific names out of 379 species are not included in the WoRMS database, i.e. *Hydrobates castro*, *Hydrobates monteiroi* and *Lagerorhynchus albirostri*. One species was found to be misspelt, i.e., *Notocanthus chemnitzii* and replaced by *Notacanthus chemnitzii* Bloch, 1788 (correct spelling). In addition, the environment for 17 birds and 8 fish species were referred to as non-marine. Figure 6 shows the higher taxonomy of species listed in MSDF Descriptor 1.

### 3.2.4. Invasive Alien Species Regulation

The IAS Regulation (EU) 1143/2014 specifies the measurements Member States should take to control IAS (European Parliament 2014). In 2016 the list of IAS of Union concern was adopted. Since then the list has been updated in 2017, 2019 and 2022 by the respective Commission implementing regulations. Currently there are 88 IAS under strict environmental restrictions for trading, maintaining, breeding, growing and releasing into the environment[36].

We compiled the list of IAS of Union concern from all regulations implemented by the Commission[37] (PDF format). Our final list is in a tabular format (CSV) and has been used to match the scientific names with the GBIF backbone taxonomy. For all species, the match is over 95%. The only gaps we found are very few blanks in some taxonomic fields. Firstly, for the orders Testunides and Squamata there is no information about their respective class as explained in previous sections. This is also the case in WoRMS and Catalogue of Life, and is due to taxonomic changes in the former class Reptilia. For plotting purposes, in Figure 7, we used the corresponding superclass rank i.e. Reptilia. Secondly, information on the class rank was missing for ten species in GBIF. In all ten cases, the blanks were filled with information from WoRMS and all corresponded to the class Teleostei (i.e. fish).

[36] https://environment.ec.europa.eu/topics/nature-and-biodiversity/invasive-alien-species_en
[37] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02016R1141-20220802&from=EN

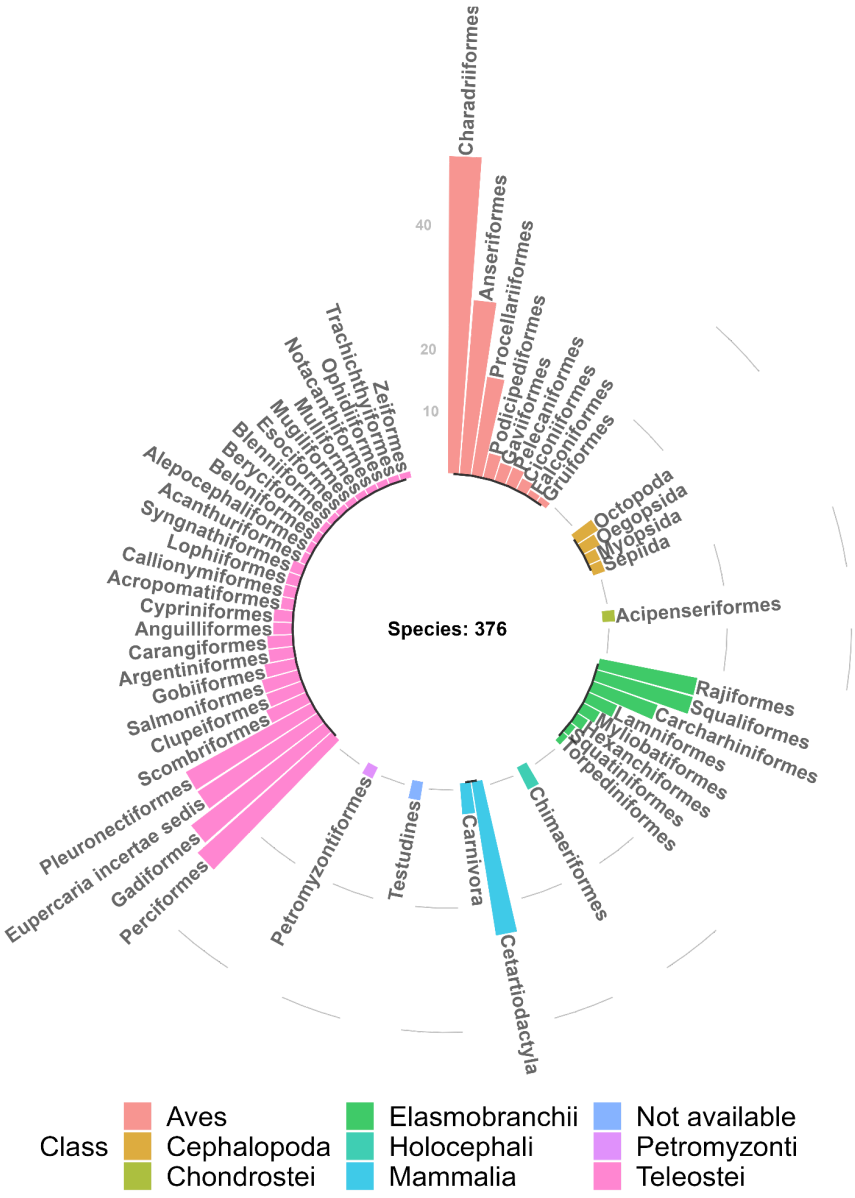
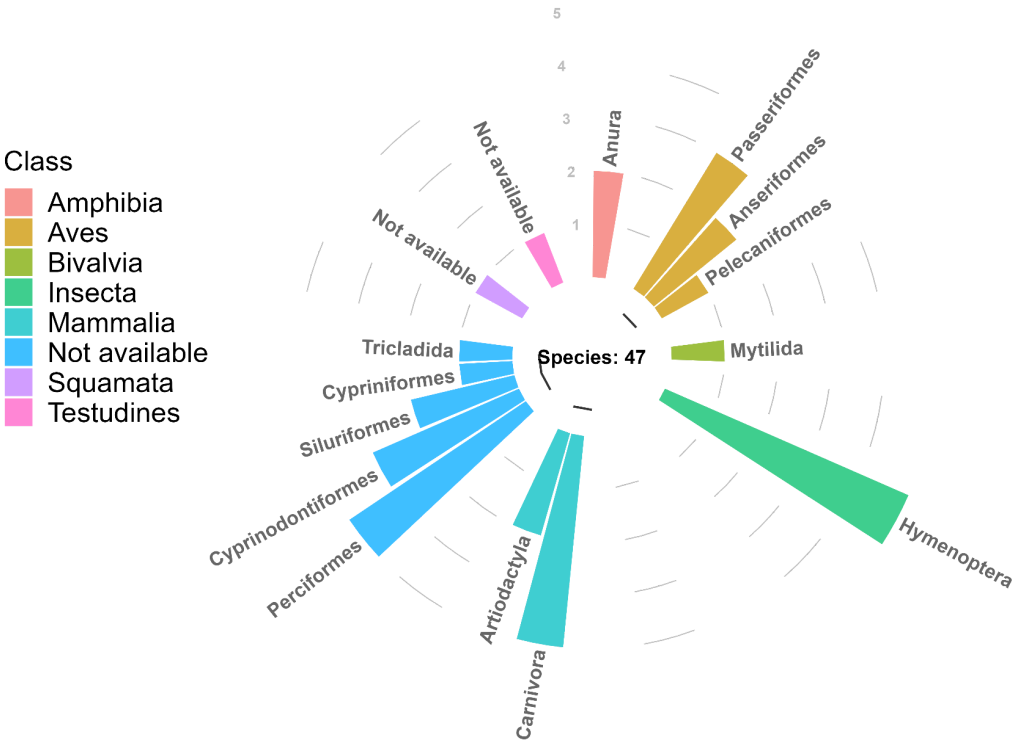
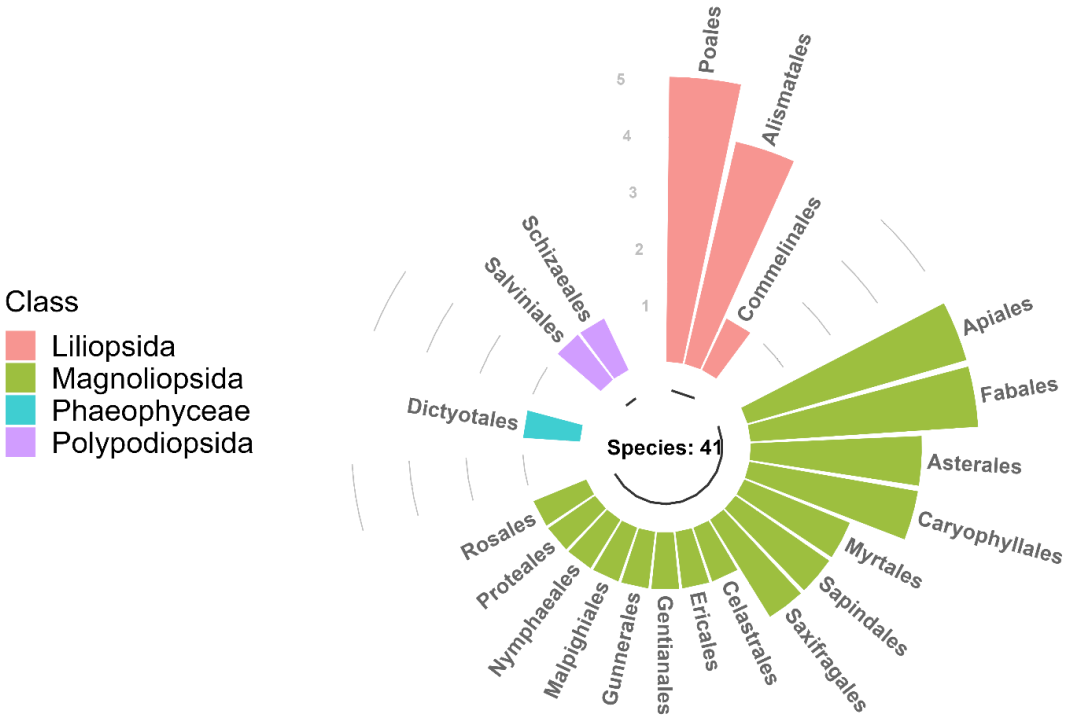



**Figure 6: Higher taxonomy of the species in the Descriptor 1 (related to Articles 8, 9 and 10) of the Marine Strategy Framework Directive. The class rank is indicated by the colours bar and the order rank is written next to the bars. Note that the Testudines taxonomic rank class is 'Not available' and it belonged to the former superclass Reptilia. (Data source: Palialexis and Boschetti 2021).**




**a.**




**b.**

**Figure 7: Higher taxonomy of the IAS list of Union Concern in the EU. The rank class is indicated by the colours bar and the order rank is written next to the bars. a. Animalia kingdom. b. Plantae kingdom. Note that missing taxonomic information is indicated as 'Not available'. (Data source: European Parliament 2014, European Commission DG ENV 2017, 2019, 2022).**

### 3.2.5. EU Pollinators Initiative

The Pollinators Initiative Communication was published in 2018 and revised in 2023. Its objectives are: "(priority I) improving knowledge of pollinator decline, its causes and consequences, (priority II) tackling the causes of pollinator decline, and (priority iii) raising awareness, engaging society-at-large and promoting collaboration". It is the heart of the 2030 biodiversity strategy and is closely linked to the farm-to-fork strategy, to the sustainable use of pesticides and thus to agricultural policies. It will also be a key component of the Nature Restoration Law (European Commission 2018).

The ongoing Safeguarding European Wild Pollinators Project[38] brings together stakeholders from multiple sectors, starting with scientific to private organisations. Currently, it provides information on wild pollinating insects. A list of 3051 species of bees and hoverflies, including their taxonomy, has recently been published and is available as an annex to the scientific paper by Reverté et al. 2023. We have used this species list to show the higher taxonomy of this subgroup of wild pollinating insects in Figure 8.

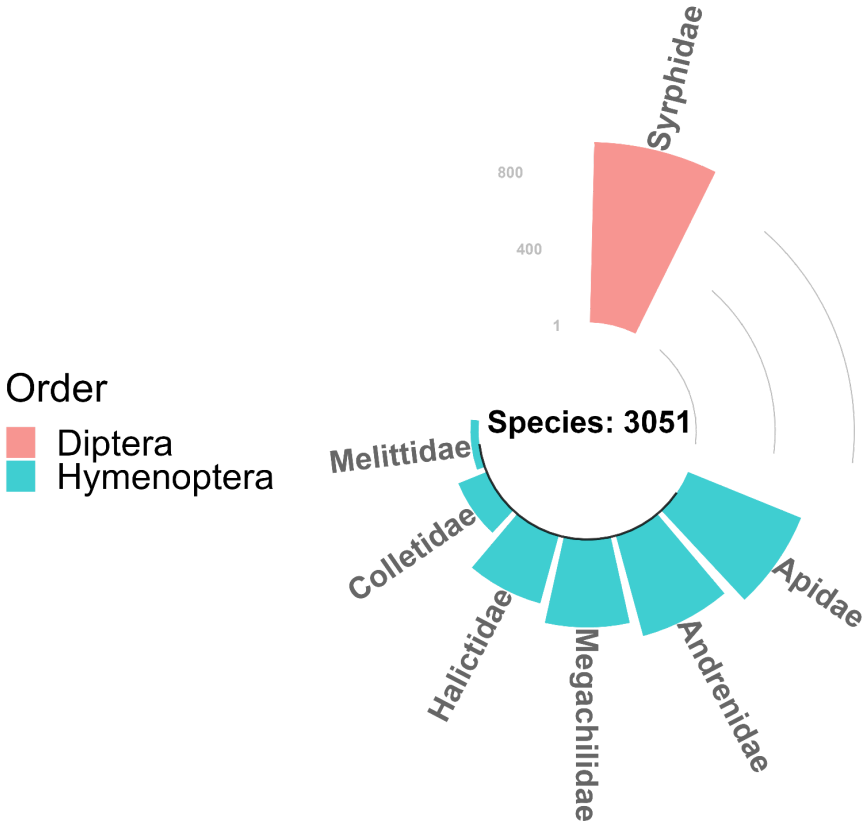



**Figure 8: Higher taxonomy of a subset of European wild pollinators from the Pollinators Safeguard Project. The order is indicated by the coloured bar and the family rank is written next to the bars. Note that this species list is specific to bees and hoverflies. (Data source: Reverté et al. 2023).**

[38] https://www.safeguard.biozentrum.uni-wuerzburg.de/

### 3.2.6. European Red List of Species

One objective of the EU Biodiversity Strategy for 2030 is to halve the number of threatened species by 2030. One basis for this is the European Red List of Species[39], published in 2019 and covering the period from 2006 to 2017. This list includes more than 10,000 European species of the following groups: mammals, birds, reptiles, amphibians, freshwater and marine fish, butterflies, dragonflies, freshwater molluscs, selected groups of beetles, terrestrial molluscs, vascular plants including medicinal plants, bees, grasshoppers, locusts and crickets, lycopods and ferns. In addition, the list provides information on taxonomy and habitat.

We selected the species declared as being in the vulnerable threat category (VU) or in a higher risk category. These species belong to 17 different classes of the Phylum Plantae (8 classes - 514 species) and Animalia (9 classes - 1350 species). The VU category holds the highest number of species (815), followed by Endangered (EN)(619) and Critically Endangered (CR)(385). The categories Extinct (EX)(22), Extinct in the Wild (EW)(3) and CR probably extinct (20) are the highest threat categories and show how some species are at very high risk or even extinct. Detailed information by the taxonomic rank Class against the risk category is given in Figure 9.

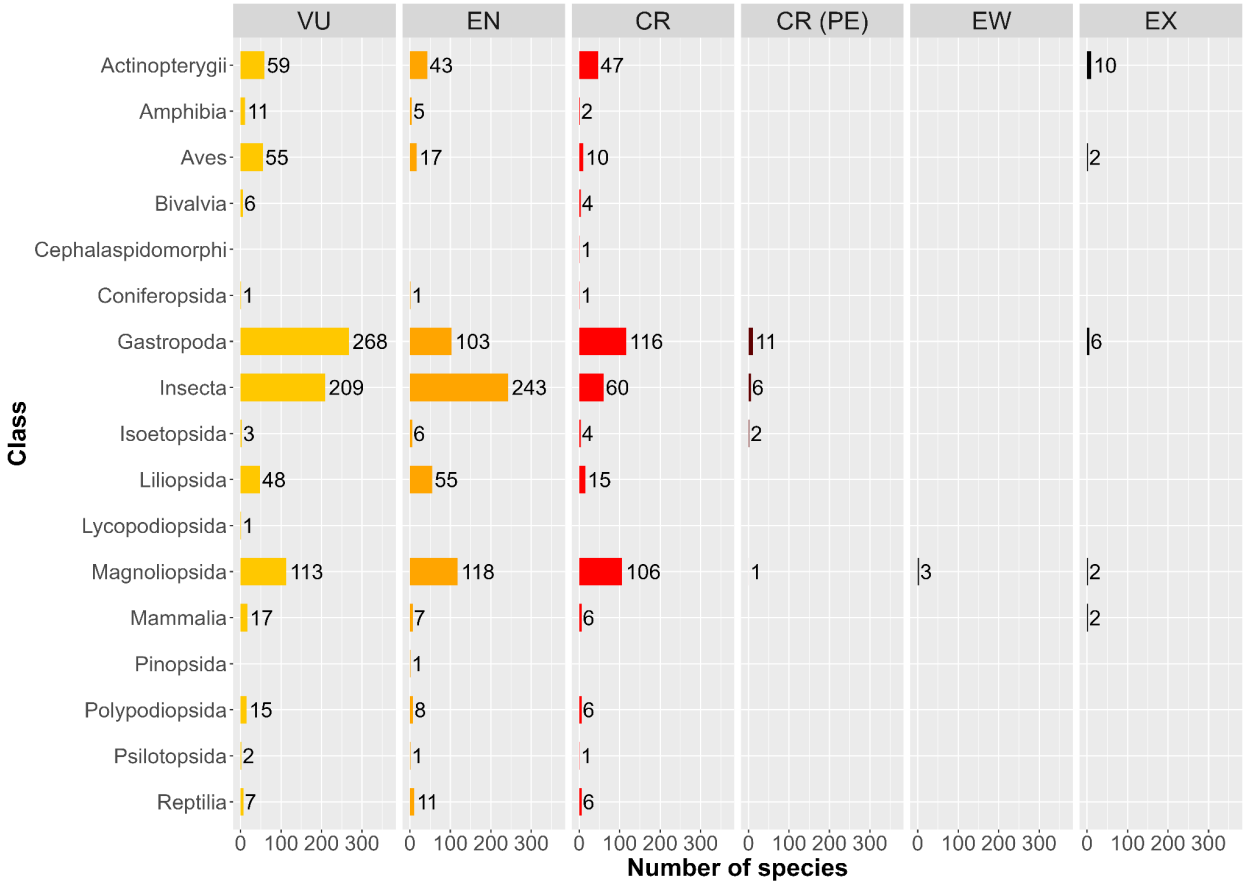



**Figure 9: Taxonomy of the European Red List of Species 2017 (at the rank Class) using the 'EU Regional Red List Category' field. VU: Vulnerable. EN: Endangered. CR: Critically**

[39] https://sdi.eea.europa.eu/data/9c785326-8859-4abd-aad6-c8d35b619ff9

**endangered. CR(PE): Critically endangered (possibly extinct). EW: Extinct in the wild. EX: Extinct. Note that the category CR (PE) is not an official category of the IUCN Red List, but a tag applied by BirdLife (and under review by the IUCN Red List) to identify those critically endangered species that are likely to be extinct. (Source: European Red List 2017)**.

## Takeaway messages

| EU Legislation |
|---|
| • EU mandates require member states to engage in systematic reporting on the status of habitats and species, water quality, and marine environments, fostering accountability and facilitating adaptive management strategies.<br>• Effective environmental policy application hinges on robust mechanisms for reporting, managing, and tracking progress toward policy objectives.<br>• A critical bridge between biodiversity science and high-level environmental policy is the realm of regulatory compliance. |
| **Species lists** |
| • The species lists, from the EU legislations, provide extensive information in terms of what species are subject to protection or regulation (section 3.2.1 to 3.2.6). However, the lack of data centralisation and harmonisation, in addition to changes in taxonomy, pose major challenges with these lists regarding data integration and up-to-date information.<br>• A recurrent issue is the changes in the species taxonomy which implies keeping the scientific names and their respective status updated, while preserving links and efficient access to the previous documents and legislations. Another drawback is the incomplete taxonomy of marine species in GBIF and discrepancies between GBIF and WORMS taxonomy.<br>• A centralised database that combines different policies and provides a more holistic view is still lacking.<br>• Some species lists are hardly findable in tabular formats, which poses extra work for automating data analysis.<br>• Our assessment revealed the presence of over 7,000 species across all evaluated legislations including species at high risk of threat (Table 2), acknowledging that a portion of these may be duplicates (e.g., species shared in the Bird, Habitats and Marine Directives). |

**Table 2: Number of species and other taxonomic ranks by EU legislation. "~" Indicates approximate values due to missing information on some species or other taxonomic issues. Detailed explanations can be found in the main text. Note that some species can be listed in more than one legislation.**

| Legislation | Issue | N. of species | N. of families | N. of orders | N. of classes | Kingdom | Notes |
|---|---|---|---|---|---|---|---|
| Birds directive | Annex I | 193 | 47 | 19 | 1 | Animalia | Species list retrieved from the policy document (.PDF). |
| Habitats Directive | Article 17 checklist (2020) | ~1510 | 257 | 98 | 28 | Animalia Fungi Plantae | This species list is used for the county member reports (.XLS). |
| Marine Water Framework Directive | Descriptor 1 | 368 | 112 | ~54 | 9 | Animalia | Species list retrieved from JRC report (.XLS). |

| Legislation | Issue | N. of species | N. of families | N. of orders | N. of classes | Kingdom | Notes |
|---|---|---|---|---|---|---|---|
| IAS list of union concern | IAS updated at 2020 | 88 | 57 | 37 | ~13 | Animalia Chromista Plantae | Species list retrieved from the policy document (.PDF). |
| Pollinators initiative | National records of 3000 European bee and hoverfly specie | 3051 | 7 | 2 | 1 | Animalia | This list solely covers bees and hoverflies (.XLS) |
| EU Biodiversity Strategy for 2030 European Red List of Species | Species VU or in a higher risk category | 1864 | 231 | 101 | 17 | Animalia Plantae | Data available in the EEA server (.XLS) |

# 4. Mainstreaming Essential Biodiversity Variables in Europe

The Essential Biodiversity Variables (EBV) framework, proposed by GEO BON, acts as an intermediary between biodiversity observations (raw information) and derived information to inform policy. It has been widely accepted as a framework to support evidence-based policies in the EU and will serve as a foundation for the European biodiversity monitoring pilot. EBVs cover all three realms: terrestrial, freshwater and marine, and they cover biodiversity at multiple scales (e.g. genetics, species, communities, ecosystems) and dimensions (e.g. function, structure and composition) (Pereira et al. 2013, Navarro et al. 2017, Kissling et al. 2018, Junker et al. 2023). GEO BON has worked intensively in recent years on the development of the EBV Data Portal that acts as a geospatial repository of biodiversity data to facilitate data sharing.

In the next sections we reviewed recent reports by EuropaBON and Biodiversa+ that have identified user and policy needs, gaps and bottlenecks in mainstreaming EBVs, raw data and indicators. Similar to the previous sections we emphasise in the Species Population EBV class.

## 4.1.1. Identified gaps and bottlenecks on EU biodiversity monitoring

Estimation of EBVs is limited by taxonomic biases, uneven national and regional coverage, insufficient data sampling and few time series. This limits the estimation of EBVs with the spatial and temporal resolution desired by policy and users (Santana et al. 2023). Importantly, among the EBVs, populations and communities have the most information available, which facilitates the modelling of present and future species scenarios and indicators (Santana et al. 2023). However, critical issues for assessing species distribution are data integration and standardisation, and accounting for the uncertainties derived from the observation process into downstream models and indicators. These key aspects are fundamental for a better understanding of the biodiversity state and dynamics relationships, and ultimately drivers and pressures (Hoye et al. 2022).

In terms of bottlenecks, Moran-Ornodez et al. (2023) investigated the main bottlenecks for EBVs in Europe. Here we summarised their results for the species population EBV class and the Data Integration category for being the ones with links to B3. For the Species Population EBV class, different monitoring programs were assessed, most of them are in charge of estimating species distribution and a few estimate species abundances. The identified bottlenecks are similar across the terrestrial, marine and freshwater realm and different monitoring programs (Figure 10). They are mostly related to:

- Limited statistical models used routinely for data integration and processing.
- Dissimilar level of coordination between the initiatives and networks at the European level especially those that do not have a sharing policy.
- Low level of matching between products already generated/integrated by the monitoring network and the EBV specifications.
- Lack of resources for data integration initiatives running in the mid- to long- term.
- Lack of software in place that facilitates data flows at various levels (e.g., from data collection to data integration) and embraces entire workflows.
- User-friendly software that is easy to operate and updated for non-technical people.
- Gaps in open data: Raw data is frequently not findable and accessible from monitoring networks.

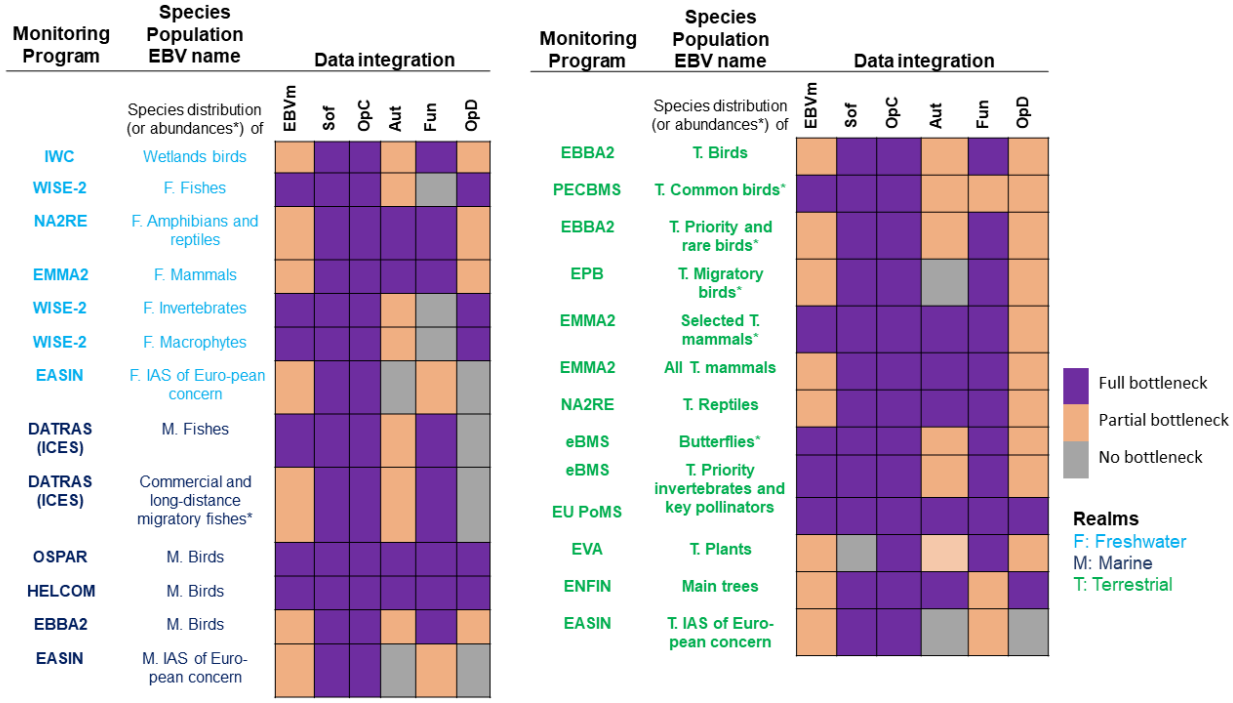



**Figure 10: Identification of current monitoring workflows and bottlenecks for different biodiversity monitoring programs. The figure shows information for the Species Population EBV class within the Data integration category. Note that in the second column * indicates species abundances, if nothing is indicated it refers to species distribution. EBV match (EBVm), Software (Sof), Open reproducible code (OpC), Automated data streams (Aut), Funding (Fun), Open Data (OpD). Monitoring programs: International Waterbird Census (IWC), Water Information System for Europe - Biology data (WISE-2), The New Atlas of Amphibians and Reptiles of Europe (NA2RE), Second**

**Atlas of European Mammals (EMMA2), European Alien Species Information Network (EASIN), North-east Atlantic and Baltic seas (DATRAS (ICES)), Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR), The Baltic Marine Environment Protection Commission Helsinki Commission (HELCOM), Second European Breeding Bird Atlas (EBBA2), Common Bird Monitoring Scheme (PECBMS), EuroBirdPortal (EBP), European Butterfly Monitoring Scheme(eBMS), European Pollinator Monitoring scheme (EU PoMS), European Vegetation Archive(EVA), European National Forest Inventory Network (ENFIN). IAS: Invasive Alien Species. (Modified from Morán-Ordóñez et al. 2023).**

Most of the bottlenecks are in the category of data integration. B3 contributes to solving them by providing new software, documented workflows and open source code as the core of the project and its FAIR foundations.

### 4.1.2. Analysis of the EBVs priority list in the light of the legislation for species

In 2023, a EBVs priority list has been proposed for Europe by the EuropaBON community and is available on GitHub[40] (Junker et al. 2013). In this report, we analysed the EBV priority list in the light of the information collected for the species lists of the EU policies (section 3). Our analysis focused on the species population EBV class and the corresponding policies mentioned in the specification section of the EBV priority list (i.e., 'Entity' field). Note that some species lists, from the EBVs specifications, are out of the scope of this analysis. Examples of these excluded lists are "Species listed in the Common Fisheries Policy", "Current list of butterfly species underlying the European grassland butterfly indicator", "Common bird species as included in the Pan-European Common Bird Monitoring Scheme ", among others.

Table 3 shows the number of species per taxonomic group related to specific policies on biodiversity. It illustrates the extensive tasks according to each policy and group that needs to be undertaken by Member States and other stakeholders. We believe that with the current technology and development of data cubes, analysis for these large numbers of species can be carried out more efficiently and bring timely information to stakeholders. Here, the scalability attribute of data cubes becomes crucial as well as its cloud computing features. The development of workflows for solving these tasks could turn into supporting activities of scientific projects that aim to inform policy.

**Table 3: Main EU legislations cited in the EBVs priority list and the respective number of associated species. The column "Search criteria (' ') and number of species" indicates the criteria used for filtering and matching the species list from the EU legislation with the corresponding EBVs specifications.**

[40] https://github.com/EuropaBON/EBV-Descriptions

| Policy | Specifications from the EBVs | | | | Search criteria (' ') and number of species (n) |
|---|---|---|---|---|---|
| | EBV name | Spatial resolution | Temporal resolution | Species specification for policy | |
| Birds directive | Spp_ SP_abn_bird_FW<br>Spp_ SP_abn_bird_MA<br>Spp_ SP_abn_bird_TER | 1 x 1 km<br>10 x 10 km (and flyways for migratory) | Wetland birds: 3 to 6 years<br>Migratory birds: weekly | Annex 1: Rare and priority birds species | 'Birds' (194) |
| Habitats directive[41] | Spp_ SP_dis_rept_MA | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Turtle species | 'Reptiles' AND 'Testudines' (9) |
| | Spp_ SP_dis_fish_FW | Catchment unit | 3 to 6 years | All freshwater fish | All 'Fish' (2017) in Article 17 |
| | Spp_ SP_dis_inve_FW | 1 x 1 km | 1 year | All freshwater invertebrates | All 'Invertebrates' (181) in Article 17 |
| | Spp_ SP_dis_mamm_FW<br>Spp_ SP_dis_mamm_MA | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Native freshwater, marine, and terrestrial mammals | All 'Mammals' (141) in Article 17 |
| | Spp_ SP_dis_inve_TER | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Priority invertebrates as listed in the Annex II and Annex IV | Annex II: 'Arthropods' OR 'Molluscs' OR 'Other invertebrates' (181) Annex IV: 'Invertebrates' (128) |
| | Spp_ SP_dis_plan_TER | 1 x 1 km<br>10 x 10 km | 3 or 6 years | Priority terrestrial vascular plants as listed in Annex II, IV and V | Annex II: 'Vascular plants' (662)<br>Annex IV: 'Ferns' OR 'Flowering plants' OR 'Conifers' (625)<br>Annex V: 'Vascular plants' (644) |
| Marine Strategy Framework Directive | Spp_ SP_dis_fish_MA | 50 x 50 km<br>200 x 200 km | 3 to 6 years | Descriptor 1: Marine fish species | 'Chondrostei' (92) |
| | | | | | 'Elasmobranchii' (50) |
| | | | | | 'Holocephali' (3) |
| | | | | | 'Petromyzonti' (2) |
| | | | | | 'Teleostei' (147) |
| | Spp_ SP_dis_bird_MA | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Descriptor 1: Marine bird species | 'Marine' AND 'Birds' (88) |
| | Spp_ SP_dis_mamm_MA | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Descriptor 1: Marine mammal species | 'Marine' AND 'Mammalia' (33) |

[41] When the policy annexes are not specified we based the data selection in the Article 17 species checklist.

| Policy | Specifications from the EBVs | | | | Search criteria (' ') and number of species (n) |
|---|---|---|---|---|---|
| | EBV name | Spatial resolution | Temporal resolution | Species specification for policy | |
| | Spp_ SP_dis_inve_MA | 10 x 10 km<br>50 x 50 km | 1 year | Descriptor 6: Sea-floor integrity | Species list not available. Information at community level. |
| | Spp_ SP_dis_inve_MA | 10 x 10 km<br>50 x 50 km | 1 year | Descriptor 1: Benthic habitats | Species list not available. Information at community level. |
| EU Red List 2017 | Spp_ SP_dis_fish_FW | Catchment unit | 3 to 6 years | Freshwater fish VU and above | 'Freshwater_fishes' (160) |
| | Spp_ SP_dis_inve_TER | 1 x 1 km | 1 year | Invertebrates VU and above | 'Coleoptera' (113) |
| | | | | | 'Hymenoptera' (76) |
| | | | | | 'Lepidoptera' (30) |
| | | | | | 'Odonata' (22) |
| | | | | | 'Orthoptera' (277) |
| | Spp_ SP_abn_inse_FW<br>Spp_ SP_dis_inse_FW | 10 x 10 km | 1 year | All dragonfly species | All 'Odonata' families except 'Lestidae' (133) |
| | Spp_ SP_abn_bird_FW<br>Spp_ SP_abn_bird_MA<br>Spp_ SP_abn_bird_TER | 1 x 1 km<br>10 x 10 km (and flyways for migratory) | Migratory birds: weekly | Full migrant birds[42] | 'Full Migrant'(423) |
| | Spp_ SP_abn_mamm_TER | 1 x 1 km<br>10 x 10 km | 1 year | Terrestrial Carnivora, Artiodactyla and Chiroptera species | 'Cetartiodactyla' (49)<br>'Carinivora'(34)<br>'Chiroptera' (42) |
| | Spp_ SP_dis_mamm_TER | 10 x 10 km<br>50 x 50 km | 3 to 6 years | Terrestrial mammals included in this list | 'Carinivora' (34) |
| | | | | | 'Eulipotyphla' (36) |
| | | | | | 'Lagomorpha' (8) |
| | | | | | 'Primates' (1) |
| | | | | | 'Rodentia' (91) |
| | Spp_ SP_dis_rept_TER<br>Spp_ SP_dis_rept_FW | 1 x 1 km<br>10 x 10 km | 3 to 6 years | Freshwater and terrestrial reptiles included in this list | 'Reptilia' (148) |
| | Spp_ SP_dis_plan_TER | 1 x 1 km<br>10 x 10 km | 3 or 6 years | Threatened (VU and above) species in this list | 'Plantae' (514) |

[42] The Red List does not include any filter option for full migrant birds. This Information was retrieved from https://www.birdlife.org/wp-content/uploads/2022/05/BirdLife-European-Red-List-of-Birds-2021.pdf.pdf

| Policy | Specifications from the EBVs | | | | Search criteria (' ') and number of species (n) |
|---|---|---|---|---|---|
| | EBV name | Spatial resolution | Temporal resolution | Species specification for policy | |
| List of IAS of Union Concern[43] | Spp_ SP_dis_alie_FW | ECRINS units between fundamental catchment units and sub-basins (Level 2), and ECRINS lakes | 3 to 6 years | Freshwater species of concern | 'Freshwater' (21)<br>'Freshwater' AND 'Brackish' (6) |
| | Spp_ SP_dis_alie_MA | 1 x 1km<br>10 x 10 km | 3 to 6 years | Coastal marine taxa of concern within 1-5 km from the shore | 'Marine' (1)<br>'Marine' AND 'Brackish' AND/OR 'Freshwater' (4) |
| | Spp_ SP_dis_alie_TER | 1 x 1km<br>10 x 10 km | 3 to 6 years | Terrestrial species specified | 'Terrestrial' (48)<br>'Terrestrial' AND 'Brackish' AND/OR 'Freshwater' (8) |

## Takeaway messages

| Species Population EBV |
|---|
| • Significant progress has been made identifying EBV gaps and bottlenecks on biodiversity monitoring which is key for streamlining EBVs<br>• The large number of species specified in the EBV priority list, and linked to the policy, reinforce the complexity and challenges of assessing the state and trends of biodiversity.<br>• Conducting analyses for large numbers of species needs to be efficient to bring timely information to stakeholders. This issue can be tackled through the scalability of data cubes and is cloud computing performance. |

# 5. EU Biodiversity stakeholders engagement

In this initial phase of the project, we concentrated on the early stages of stakeholder engagement, primarily employing 'informing' and 'consultation' approaches (Durham et al. 2014, Chakarova and Barov 2021). In the next project phases, we plan to transition into the 'involvement' and 'collaboration' phases with key organisations to carry out the

[43] Note that the habitat information was retrieved from EASIN

stakeholder-driven case study. In the following sections, we provide detailed descriptions of the activities conducted in the last year. Specifically, in Section 5.1, we build on the extensive stakeholder identification and mapping efforts undertaken by Biodiversa+ and EuropaBON over the years. In section 5.2, we present the result of the stakeholder consultations to identify their needs and gather information on key challenges, gaps, and bottlenecks, and the selection of the stakeholder-driven case study. The dissemination activities by the Task 1.5 partners are summarised in section 5.3. Stakeholder engagement will remain a continuous and dynamic process throughout the duration of B3.

## 5.1. Stakeholders landscape

Over the last few years, Biodiversa+ and EuropaBON have made significant progress in identifying and mapping biodiversity stakeholders in the EU. These initiatives have collaborated to establish a more robust biodiversity network across various organisational levels and sectors. Here, we analysed the primary outcomes of Biodiversa+'s mapping of national and sub-national organisations steering monitoring schemes (Vihervaara et al., 2023a), along with the EuropaBON network analysis (Junker et al., 2024, in prep.).

### 5.1.1. National and sub-national mapping of EU institutions

Governmental institutions and organisations responsible for steering and funding biodiversity programs vary among Member States. To understand the diversity of these institutions, including ministries, environmental agencies, and other organisations, Vihervaara et al. (2023a) conducted surveys and interviews across 20 European countries involving 40 institutions. They found that the most frequent task is reporting on EU directives, followed by networking activities among monitoring actors and centralising the results of monitoring programmes. Additionally, they mapped the number of participating institutions per country, with one or two being the most common (Figure 12a). Most of these institutions coordinate activities at the national level (Figure 12b) and typically cover all realms (Figure 12c). This stakeholder identification by Biodiversa+ is key for our stakeholder-driven case study because it provides key information of the institutions in charge or leading the EU nature directives reporting.

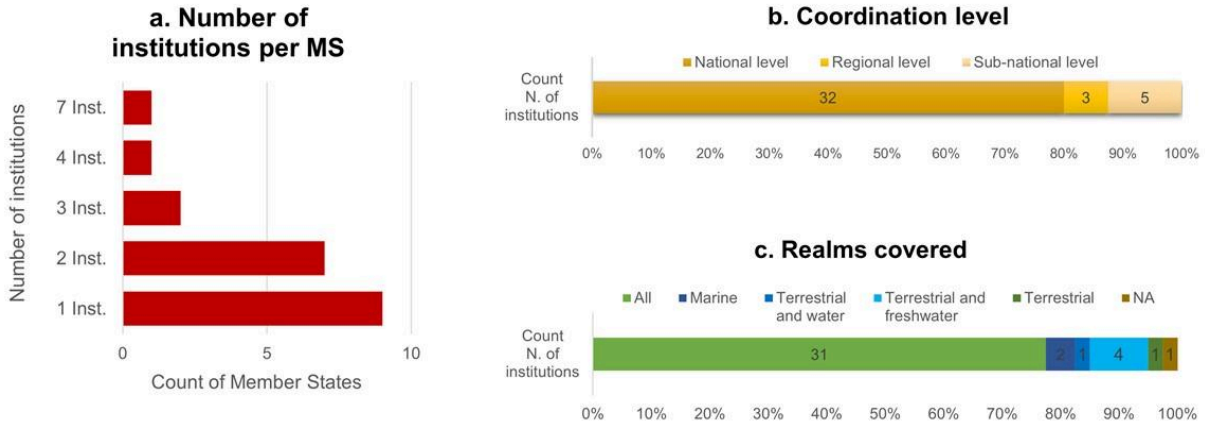


**Figure 12: National and sub-national institutions identified by Biodiversa+ for 20 Member States (MS). a. Number of institutes participating by MS. b. Number of institutions at different coordination levels. c. Realms covered by institutions. NA. Not available (Data source: Vihervaara et al. (2023)).**

### 5.1.2. Network analysis of the EU biodiversity community

In this section we present the main outcomes of a network analysis conducted by EuropaBON on all member institutions (nodes) registered by the time the analysis was carried out (956 nodes) (Junker et al. 2024, in-prep). A comprehensive list of the nodes is available at EuropaBON Network Dashboard[44] with attributes such as name, data user/provider role, sector and the resulting metrics of the network analysis. Figure 13 shows all members that have information for all attributes (530 nodes). The results show that the EU biodiversity community sector is dominated by academia followed by governmental and non-governmental organisations. The number of institutions is equal between Southern and Western Europe, and with less institutions in Northern and Eastern Europe. Furthermore, the majority of institutions serve as both data users and providers, in contrast to the minority that are exclusively data providers. While most institutions cover all realms, the distribution among thematic domains is uneven, with terrestrial institutions dominating, followed by marine, and freshwater ranking last. This analysis reinforced the role of academia to provide evidence based information to decision-makers for biodiversity conservation and management. Still, the effective flow of information is a further step that might be facilitated by the Knowledge for Policy framework implementation.

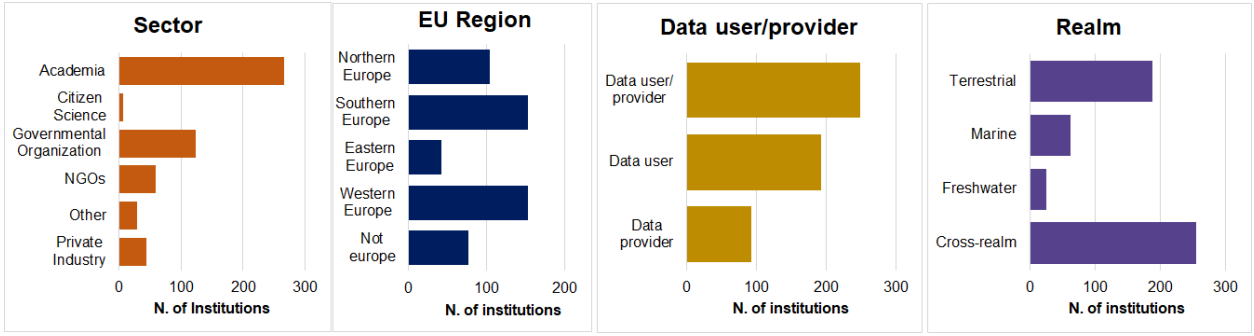



**Figure 13: Summary of the EU biodiversity community identified by EuropaBON (Data source: EuropaBON Network Dashboard).**

In addition, the network analysis revealed that the five most connected nodes were GBIF, European Commission, EEA, JRC and IUCN. A similar analysis but focusing only on projects and infrastructures identified EuropaBON (82 connections), Biodiversa+ (80 connections), IPBES (79 connections), eLTER (56 connections) and LifeWatch ERIC (53 connections) as the most connected projects (Junker et al., 2024, in prep.). An interactive visualisation of these connections can be accessed on the EuropaBON Network Dashboard[45].

[44] https://europabon.org/members/network-analysis/src/
[45] https://europabon.org/members/network-analysis/src/

## 5.2. Stakeholders consultation and engagement

Our work included a strong component of stakeholder engagement through semi-structured interviews with multiple stakeholders (section 5.2.1), a survey for identifying data analytics needs conducted in collaboration with the BISE (section 5.2.3), and various dissemination activities (section 5.2.2).

### 5.2.1. Semi-structured interviews

We conducted the semi-structured interviews in parallel to the workshop on “Co-designing the European Biodiversity Observatory” organised by EuropaBON from November 13th to 17th 2023, which gave us the opportunity to reach out to a broad and diverse community of stakeholders. In light of our project's objectives, we have opted to transition from organising a workshop to conducting semi-structured, in-person and online interviews with a selected group of stakeholders. This decision was supported by the project coordination and motivated by our realisation that one-on-one interactions, guided by carefully crafted questions, are inherently more effective for delving into the nuanced contexts of each participating institution. Such a format allows us to uncover specific scientific and policy gaps, as well as to explore the intricacies of stakeholder interactions in greater depth. The key consideration underpinning this strategic shift is that the tailored nature of bilateral interviews enables us to engage in deeper, more meaningful dialogues, where stakeholders can freely express their unique perspectives and insights without the constraints often present in group settings (Gubrium et al., 2012).

We prepared a set of 10 questions starting with questions on professional experience, type of organisation and 8 specific questions on challenges and opportunities in the convergence of science and policy in Europe (Annex 1). The first two questions helped us identify which were the main biodiversity fields covered by the interviewees, while the last 10 questions focused on biodiversity data gaps, bottlenecks, data flows, data sources, citizen science, open data policy, the science-policy interface, and, importantly, the selection of B3's stakeholder-driven case study.

Out of 30 people invited, 17 interviewees responded positively. Each interview was conducted in accordance with GDPR policy, and lasted between 45 minutes and 1 hour. The interviews were recorded with the consent of the interviewee. Approximately two days were spent transcribing each interview, and then the answers were aggregated and generalised to secure participants anonymity. The main results are in the following sections.

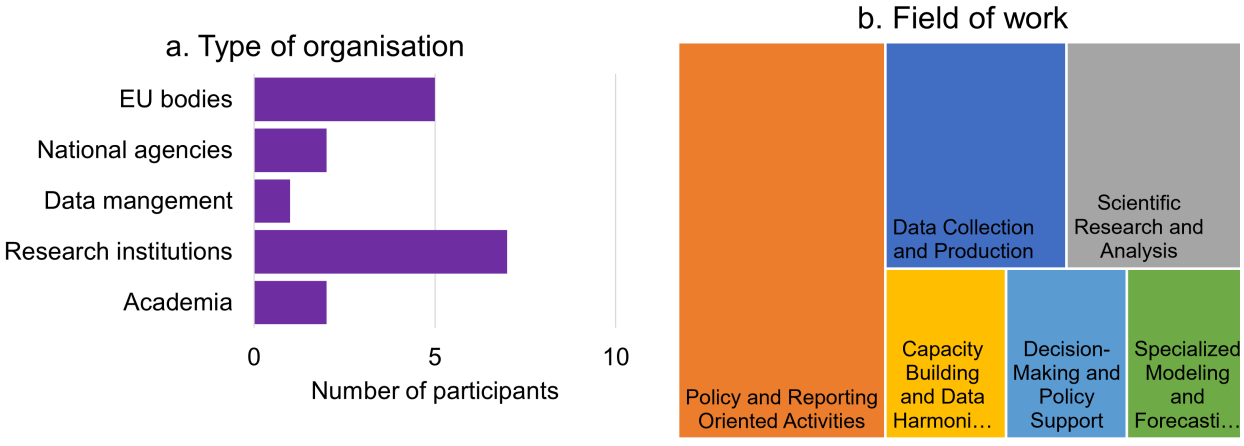
#### 5.2.1.1. Professional background and field of work

The 17 participants of the interviews were from different sectors including stakeholders from academia to policy institutions (Figure 14a).The work experience of the interviewees was very diverse which allowed us to cover multiple fields. They described their professional background in the following areas:

- Botany, ecology, zoology, edaphology, marine biology, limnology, agriculture.
- Biodiversity indicators, biodiversity monitoring (schemes), biodiversity change, biodiversity health and resources, biodiversity conservation.
- Ecological modelling and forecast, ecosystem accounting, ecosystem assessment.
- Environmental quality, sustainable land use.
- Fire, climate change, zoonotic diseases.
- Remote sensing, geospatial data and modelling.
- Data and infrastructure development.
- Economic social science knowledge exchange, community engagement, policy and decision support.

To gain insight into the interviewees' current field of work, we asked them how they relate to biodiversity data. Most of them work in policy and report-oriented activities, data collection and production, or scientific research and analysis. A few work on capacity building and data harmonisation among others (Figure 14b). As noted, nature-oriented reporting was the most shared category, which highlights the required working group and the number of institutions involved.

We also investigated the data sources most frequently used by interviewees, as shown in Figure 14c, with ‘ground monitoring and field data’ and ‘official and governmental databases’ being the most frequently used. Several participants mentioned collaborations and networks as important sources of data. This includes international exchanges, thematic groups, and collaborations with research institutions and NGOs.



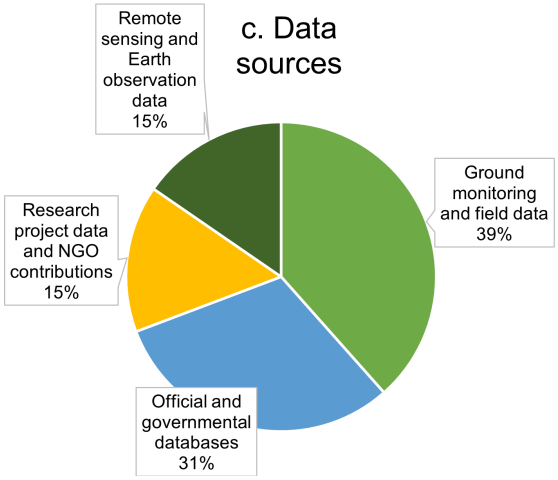



**Figure 14: a. Number of participants by sectors from the semi-structured interviews. b. Main field of work. Note that an interviewee may be involved in more than one field. c. Main used data sources. Note that 15 of 17 participants answer this question**

### 5.2.1.2. EU Horizon projects: Sustainability, impact and continuity

The interviewees shared their views on EU Horizon projects. We classified them into four categories.

Impact

- Understanding policy needs is crucial. The scope of projects that address policy demands has the greatest impact.
- Aim for a balance between innovative research methods and practical applications.
- Alignment between policy and societal needs and researchers' interests. Advocate for more applied research that directly addresses real-world problems.
- Develop effective communication strategies to make research results accessible and impactful.

Continuity

- Use standardised data formats and ensure that results are accessible and useful beyond the life of the project.
- Emphasise the creation of workflows that remain relevant after the end of the project.
- Collaborate with end-users, policy makers and the wider community to ensure that research results are communicated and used effectively.

Sustainability

- Improved coordination and clustering of projects to fill gaps and avoid overlaps or duplication.
- Engagement with policy and practical applications should score as highly as academic publications in job applications.
- Explore various sources of funding, including the private sector, to ensure the long-term sustainability of projects and their social impact, while guaranteeing FAIR principles.

Main challenges

- Research and innovation are often decoupled from direct policy implementation due to the inherent characteristics and time-consuming nature of the policy cycle.
- Curiosity-driven research projects are at the heart of scientific breakthroughs and should continue as independent research even if they are not perceived as a political priority.
- Stable, long-term funding structures are needed, in contrast to the current trend of short-term, project-based funding.

### 5.2.1.3. Data gaps, bottlenecks and unlocking workflows

Data gaps and bottlenecks

The answers surrounding biodiversity data gaps and bottlenecks reveal multiple perspectives that underscore the complexity of the biodiversity community. Firstly, there is a controversy between the push for standardised data against the desire to retain the richness of diverse data sources. Challenges arise in standardising data, as it can result in a loss of detail and richness, particularly when dealing with varied sources e.g. survey observations, citizen observations and advanced technologies like eDNA and remote sensing. Therefore there is a dilemma of finding a balance between the benefits of standardisation for comparability and the need to preserve the detailed insights provided by more complex and varied data sets.

Opposite opinions emerge regarding the centralization versus decentralisation of data management. While some advocate for more centralised and standardised data, others are concerned about losing data richness to respond to local needs and capture biodiversity trends. Different perceptions also arose between technological advancements and traditional/accepted methods. Challenges exist in transitioning from old to new technologies, with some emphasising the reliability of traditional methods while others advocate for the adoption of modern technologies and innovative methods. This conflict reflects a broader debate on the balance between leveraging new technologies and maintaining tried-and-tested traditional methods.

Unlocking workflows

In addressing the unlocking of biodiversity data flows, interviewees highlighted several key issues. These include developing and implementing centralised directories, facilitating data integration through standard data formats and protocols, and harnessing advanced technologies. This requires building technical infrastructure, fostering capacity building, enhancing local and global collaboration, and projects directly involving stakeholders.

Main challenges

- Comparability and standardisation of data remains one of the main challenges. This includes problems of taxonomic resolution, standardisation of indicators, gaps in time series and differences in data coding between countries. There is also a need for standard methodologies and agreed baselines in biodiversity policy.
- Some members are reluctant to share data for free, due to the cost and effort of fieldwork campaigns and data collection. This issue is reinforced by restricted datasets stored in national repositories, thematic networks and the absence of a systematic

approach to data sharing.

- Existing disparities in resource allocation and capacity building widen scientific gaps, particularly between developed and developing regions. This could affect the ability of scientists in developing regions to contribute to global datasets and use them effectively.
- There is a lack of a centralised data infrastructure at European level.
- The need for continued funding and political will to maintain and update monitoring infrastructures was emphasised.
- There is a lack of sustainable and comparable reporting mechanisms.
- More experts are needed who can interpret remote sensing data in the context of specific habitats and vegetation.
- An unresolved issue is the need to make data more accessible, centralised and standardised, while preserving high levels of detail and accuracy, as well as their ability to respond to local issues.
- There is a discrepancy between data availability and its practical use. Although data is continuously increasing, this does not necessarily mean that it is used. This highlights the challenges of effective access to and use of available data.

#### 5.2.1.4. Benefits and constraints of using GBIF data

There was no consensus among the participants on the usefulness of GBIF data. While some participants view GBIF as a viable solution for global biodiversity data storage, others raise concerns about its limitations for detailed trend analysis and close-scale observations. There were concerns about data quality and validation, with emphasis on the need for rigorous review processes, especially for citizen science data. Another critical point was the gap between indicators required for policy and the available information in databases like GBIF, necessitating improvements in data updates, harmonisation, and long-term trend estimation.

In general, while GBIF presents opportunities for enhancing data use and processing, and there are ongoing efforts to optimise the utility of biodiversity data for both policy and research purposes, some participants see notable challenges regarding data scale, detail, and completeness. Overall, the discussions encompassed considerations of data accessibility, quality, integration, and utilisation.

#### 5.2.1.5. Guiding the selection of the stakeholder driven case-study

To present B3 and the stakeholder-driven case study consultation, Martin-Luther-University Halle-Wittenberg (MLU), in collaboration with PENSOFT, designed a poster to navigate through with the interviewees (Annex 2). The configuration of the poster is based on different panels. Panel 1 represents the EBVs framework (Pereira et al. 2013, Kissling et al. 2018) and classes. Founded on this framework, EuropaBON proposed the EBVs priority list for Europe as shown in Panel 2. In parallel, there are technological developments, such as the development of species occurrence cubes by B3 (Panel 3) that has a direct link to the species occurrence EBV class. Numerous outcomes of B3 can contribute to the species population EBV class as shown in Panel 4, and particularly the stakeholder driven case study that will be focused on facilitating workflows and analysis for actionable policy (Panel 5).

We collected different suggestions for stakeholder-driven case study topics and summarised them in Table 5. We present the main characteristics of the case studies in terms of connection to policy, spatial scale, data source, data resolution and overlaps with other initiatives. Later, we organised a series of meetings among the participants of Task 1.5 to carry out the case study selection. The first meeting aimed to present the main results of the interviews. In the second meeting we made a first screening based on the appropriateness of the topic taking into account resources, timing, expertise and scope of the project. We shortlisted the topics of the habitats directive and pollinators as the most viable case studies for B3. For the third meeting, we further investigated the gaps that could be filled by B3 for (i) the habitats and birds reports, and (ii) the pollinator initiative. We also assessed overlaps with other initiatives. The results show that Member States' reporting on habitats and birds is extensive and overwhelming. There are significant differences between reports, partly due to the resources and infrastructures of each country. We found that data cube workflows could facilitate data collection and analysis for reporting. In addition, a complementary analysis using GBIF data could provide an updated picture of the geographic distribution of species and likely fill gaps in specific regions. The Pollinator Initiative requires detailed information on species occurrence and land cover. Open databases are only available for a few countries and data of wild pollinators is very scarce. In addition, there are various projects such as the pollinator safeguard project[46] and the European Pilot Project ABLE[47] that actively support the pollinator initiative with consolidated national and European networks and strongly involving citizen science. As a result, we have selected as a case study the development of workflows for supporting the Habitats Directive and implementing methodologies using GBIF data that could help improve the biological range of species listed in the Nature Directives.

**Table 5: Summary of the stakeholder's driven case study.**

| Case study | Connection to policy | Study areas | Data | Notes |
|---|---|---|---|---|
| Freshwater:<br>- Benthic communities<br>- Algae blooming | Water framework directive | Lakes in the EU | Available for some lakes | Link to human and ecosystems health |
| Improving species distribution for regions with lack of data and workflows for habitats reporting | Habitats directive | EU Biogeo-graphic regions | EEA and GBIF | Unbalanced information between countries |
| Indices for pollinators | Pollinators initiative | Europe | Projects database | Cross-cutting topic between EEA policies |
| Soil data analysis | EU soil strategy | Europe | Eudophobase | Strong taxonomic expertise but lack of data infrastructure |

[46] https://www.safeguard.biozentrum.uni-wuerzburg.de/Default.aspx
[47] https://butterfly-monitoring.net/able-results

| | | | | |
|---|---|---|---|---|
| Zoonotic diseases | One health action | Regional | Vectors data from GBIF | Cross-cutting topic between EU offices |

### 5.2.2. Survey on biodiversity priorities for data analytics

In collaboration with BISE, we conducted a survey to identify the priorities on data analysis for biodiversity, e.g services, tools, etc. The survey used the EUSurvey platform and was distributed through EuropaBON and other project networks. The final questionnaire resulted from internal interactions and feedback from close collaborators that helped us to determine the scope, level of detail and clarity of each question. It was organised into seven sections with multiple-selection answers and an optional textbox for additional details. Respondents were expected to spend approximately 15 minutes completing the survey. We collected responses over a two-week period, starting on 27.11.2023, with periodic reminders. Our target audience included participants from EU and national environmental agencies, European Commission Directorates, research and academic institutions, observation networks, and the private sector, spanning diverse European regions.

In total, 2,346 individuals and organisations were contacted, of which we obtained responses from 9%. A total of 204 stakeholders from multiple sectors involved in the flow and application of biodiversity data participated in the survey. The results revealed a strong demand for core functionalities such as data access, quality assurance, visualisations and alignment with key EU biodiversity frameworks such as the Habitats Directive and the Nature Restoration Law. The survey revealed different priorities among the various stakeholders, which are summarised in Table 6 below. In general, stakeholders highlighted the importance of user-friendly platforms, need for interoperability between platforms with multiple sources and formats, and importantly, to tackle data quality and standardisation issues.

**Table 6. Takeaways from the survey on priority needs for biodiversity data analysis.**

| Sector and number of participants | Organisations | Identified priorities and takeaways |
|---|---|---|
| Research (108 participants) | Research infrastructures or institutions, Think Tanks, universities and academia. | • Warranty data sharing (uploading and downloading rights).<br>• Interoperability between biodiversity infrastructures and data standards.<br>• Need for immediate data availability for computational research and analysis. |
| Public (29 participants) | National government, EU Institutions/ Agencies, Regional or Local Government | • Compatibility with national biodiversity databases.<br>• Support for compliance with environmental regulations and conservation efforts. |
| Private (26 participants) | Consultants, CEOs, presidents. | • Ensure data downloading rights.<br>• Implement user-friendly interfaces and data visualisations.<br>• Integrate with existing platforms via API, with a strong focus on agro-business. |

## Takeaway messages

| Stakeholder consultation |
| --- |
| • Projects addressing policy demands achieve a greater impact, underscoring the importance of understanding policy needs.<br>• Research and innovation often diverge from direct policy implementation due to the rapid pace of technological advances versus the slower pace of the policy cycle, prompting a wider debate on the balance between new technologies and traditional methods.<br>• Improved coordination and clustering of projects are necessary to fill gaps and avoid duplication.<br>• Data availability and quality present significant obstacles to data mobilisation in Europe, with issues such as national-level delays, access difficulties, and the lack of standardised methods leading to inconsistent data across different regions.<br>• Contrasting views arise from the need to improve data accessibility, centralisation and standardisation, versus the need to preserve high levels of detail and accuracy to respond to local questions. This is reinforced by the challenge of serving local interests and data sovereignty while fostering global collaboration.<br>• Developing workflows that remain relevant beyond the project's conclusion contributes to a long-term impact.<br>• Adequate communication and dissemination of both methods and results, following FAIR principles, is key to engaging users.<br>• The reporting on habitats and birds directives is extensive and varied due to differing resources and infrastructures. Data cube workflows could streamline data collection and analysis for these reports.<br>• The alignment of B3 with other biodiversity initiatives and stakeholder engagement at European level is an ongoing and adaptive process that will mature with the implementation of data cube software and open workflows. |

# 6. Limitations, challenges, opportunities, and perspectives

The main results from all sections are summarised and categorised into one or more of the following categories: Limitations **(L)**, challenges **(C)**, opportunities **(O)**, and perspectives **(P)**. Each bullet point is tagged according to the category to which it best corresponds.

Policy

- Repeatability of analysis for policy-making **(C)**: Balancing technological advancements with the need for consistent and reliable data for policy decisions remains a critical challenge.
- Dependency on official and non-official data sources **(C)**: Biodiversity data analysis based on open data platforms such as GBIF, combined with strict regulatory reporting formalities, limits the use of multiple datasets.

- Enhanced data infrastructure **(O)**: Establishing a single point of access for both official data and contributions from platforms like GBIF could streamline data utilisation.
- Continuity for long-term impact **(P)**: Ensuring that data sources and infrastructures are maintained over the long term is essential for sustained biodiversity management.
- Enhancing local data relevance **(P)**: Efforts to scale down data aggregation to local levels could improve the applicability and effectiveness of global biodiversity indicators.

Data and IT infrastructure

- Time lag for mobilising biodiversity data **(L, C, P)**: Needs to be shortened to enhance responsiveness to biodiversity changes, which often occur at local scales.
- Data standardisation and quality issues **(L, C)**: Standardisation of biodiversity data is an ongoing challenge. While large studies require harmonised datasets, local studies call for singularities of data that correspond to more specific problems and solutions.
- Lack of clarity in available species lists with clear taxonomy **(L, C)**: This challenge significantly complicates efforts to accurately identify, categorise, and model species, a fundamental step for effective biodiversity research and policy enforcement.
- Complexity in data analysis and accessibility **(C)**: Supporting the biodiversity community to utilise big data analysis using cloud computing is hindered by the steep learning curve and limited access.
- Single point of access **(C, O)**: Lack of a centralised access point for biodiversity data hampers efficient data management and analysis.
- Increasing the use of GBIF data **(C, O)**: Further analysis is needed to understand and address the bias of multiple GBIF data sources. This will facilitate greater use of GBIF data for indicator estimation.

Stakeholders

- Stakeholders engagement as an ongoing process **(P)**: Continuous engagement with stakeholders is crucial for maintaining support and receiving timely feedback for biodiversity initiatives.
- Effective communication **(P)**: The public must be reached with clear and effective messages as they are vital for the continued involvement and supporting stakeholders.
- Fatigue of stakeholders due to multiple consultations by different projects **(L, C)**: Reducing the frequency and increasing the efficiency of consultations are necessary to maintain stakeholder engagement without overwhelming them.
- Data protection constraints **(L, C)**: GDPR complicates stakeholders' mapping and analysis, often classifying these as sensitive documents, restricting data sharing.
- Stakeholder mapping **(O)**: Establishing a common EU projects strategy to map the stakeholder landscape could alleviate stakeholder fatigue and improve efficiency of data collection. On one hand, conducting common surveys would help to identify general needs. Alternatively, project-specific requirements could be addressed through an already identified and smaller stakeholder group.
- Inclusion of the private sector **(O)**: Although currently outside the scope of analysis, recognising private sector roles in biodiversity conservation could open new avenues for collaboration and support.

## 7. Data availability

The code to produce the figures and the compiled and harmonised list of species, including their taxonomy according to the GBIF backbone taxonomy or the WoRMS match tool, is available at: https://github.com/linamaes/sps_taxonomy_plots_Task1d5/tree/main

## 8. Acknowledgements

We would like to express our gratitude to all participants of the interviews for their valuable insights. We also acknowledge the support provided by ETC-BE during the interviews. Special thanks to E. Oceguera for providing the initial R code which greatly facilitated the plotting process. We thank two internal reviewers for their valuable comments and insights.

# 9. References


BirdLife International. 2021. “European Red List of Birds.” Luxembourg.

Chakarova, R., and B. Barov. 2022. “NICHES Stakeholder Engagement Strategy. Deliverable D5.1.”

Council Directive. 1992. “Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (OJ L 206, 22.7.1992, p. 7).”

Dornelas, Maria, Cher Chow, Robert Patchett, Tom Breeze, Lluís Brotons, Pedro Beja, Laurence Carvalho, et al. 2023. “Deliverable 4.2 Novel Technologies for Biodiversity Monitoring - Final Report.” *ARPHA Preprints*, February, ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e105600.

Durham E., Baker H., Smith M., Moore E., and Morgan V. 2014. *The BiodivERsA Stakeholder Engagement Handbook. BiodivERsA.* Paris.

EU BON. 2017. “European Biodiversity Observation Network: Selected Outcomes.” Booklet. 2017.

European Commission. 2020. “EU Biodiversity Strategy For 2030 Bringing Nature Back Into Our Lives. European Commission Communication From the Commission to the European Parliament, the Council, the European Economic And Social Committee And the Committee of the Regions. Com/2020/380 Final, 2020.” Brussels.

———. 2021. “Directorate-General for Research and Innovation, Science at the Service of Biodiversity.” *Publications Office of the European Union*, September 1, 2021.

———. 2023. “Third Report on the Application of Council Regulation (EC) No 723/2009 of 25 June 2009 on the Community Legal Framework for a European Research Infrastructure Consortium (ERIC). Report from the Commission to the Council and the European Parliament.” Brussels.

European Commission DG ENV. 2018. “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. EU Pollinators Initiative.” Brussels.

European Commission DG RTD. 2021. “Science at the Service of Biodiversity.” *European Commission Directorate-General for Research and Innovation. Publications Office.*, 2021. https://doi.org/doi/10.2777/425134.

European Parliament, and Council of the European Union. 2008. “Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 Establishing a Framework for Community Action in the Field of Marine Environmental Policy (Marine Strategy Framework Directive).”

———. 2009. “Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the Conservation of Wild Birds (Codified Version).” *Official Journal of the European Union*.

European Union Agencies. 2023. “Cross-Agency Knowledge for One Health Action.” *Joint Statement by European Union Agencies: European Centre for Disease Prevention and Control (ECDC), European Chemicals Agency (ECHA), European Environment Agency (EEA), European Food Safety Authority (EFSA), European Medicines Agency (EMA)*.

Groom, Q., S. Vanderhoeven, L. Reyserhove, D. Oldoni, T Adriaens, and P Desmet. 2018. “TrIAS : Publishing and Analysing Biodiversity Data Rapidly, Repeatably and FAIR-Ly for

Agile Policy Relevant Results." In *10th International Conference on Ecological Informatics-Translating Ecological Data into Knowledge and Decisions in a Rapidly Changing World*.

Groom, Quentin, Diederik Strubbe, Tim Adriaens, Amy J S Davis, Peter Desmet, Damiano Oldoni, Lien Reyserhove, Helen E Roy, and Sonia Vanderhoeven. 2019. "Empowering Citizens to Inform Decision-Making as a Way Forward to Support Invasive Alien Species Policy." *Citizen Science: Theory and Practice* 4 (1).

Gubrium, Jaber F., Holstein James A., Amir B. Marvasti, and Karyn D. McKinney, eds. 2012. *The SAGE Handbook of Interview Research: The Complexity of the Craft*. Sage Publications.

Hardisty, Alex R, Lee Belbin, Donald Hobern, Melodie A McGeoch, Rebecca Pirzl, Kristen J Williams, and W Daniel Kissling. 2019. "Research Infrastructure Challenges in Preparing Essential Biodiversity Variables Data Products for Alien Invasive Species." *Environmental Research Letters* 14 (2): 025005.

Hardisty, Alex R, William K Michener, Donat Agosti, Enrique Alonso García, Lucy Bastin, Lee Belbin, Anne Bowser, Pier Luigi Buttigieg, Dora A L Canhos, and Willi Egloff. 2019. "The Bari Manifesto: An Interoperability Framework for Essential Biodiversity Variables." *Ecological Informatics* 49: 22–31.

Henle, Klaus, Simon Potts, William Kunin, Yiannis Matsinos, Jukka Simila, John Pantis, Vesna Grobelnik, Lyubomir Penev, and Josef Settele, eds. 2014. *Scaling in Ecology and Biodiversity Conservation*. Pensoft Publishers. https://doi.org/10.3897/ab.e1169.

Hoffmann, Anke, Johannes Penner, Katrin Vohland, Wolfgang Cramer, Robert Doubleday, Klaus Henle, Urmas Kõljalg, Ingolf Kühn, William E Kunin, and Juan José Negro. 2014. "Improved Access to Integrated Biodiversity Data for Science, Practice, and Policy-the European Biodiversity Observation Network (EU BON)." *Nature Conservation*, no. 6: 49–66.

Hoye, T. T., Q. Groom, A. Juslén, C. Mandon, L. Dinesen, A. Rosenberg, R.J.J. Hendriks, H. Eggermont, and P. Vihervaara. 2022. "D2.1 Report on the Knowledge Gaps and Research & Innovation Priorities Related to Biodiversity Monitoring."

IPBES. 2019. "Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services." Zenodo. https://doi.org/10.5281/zenodo.3553579.

Jetz, Walter, Melodie A McGeoch, Robert Guralnick, Simon Ferrier, Jan Beck, Mark J Costello, Miguel Fernandez, Gary N Geller, Petr Keil, and Cory Merow. 2019. "Essential Biodiversity Variables for Mapping and Monitoring Species Populations." *Nature Ecology & Evolution* 3 (4): 539–51.

Junker, J., H., Pereira, C., Langer, and et al. 2024. "EuropaBON Network Analysis: Mapping Europe's Biodiversity Community."

Junker, Jessi, Pedro Beja, Lluís Brotons, Miguel Fernandez, Néstor Fernández, W Daniel Kissling, Maria Lumbierres, et al. 2023. "D4.1. List and Specifications of EBVs and EESVs for a European Wide Biodiversity Observation Network." *ARPHA Preprints*, February, ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e102530.

Kissling, W Daniel, Jorge A Ahumada, Anne Bowser, Miguel Fernandez, Néstor Fernández, Enrique Alonso García, Robert P Guralnick, Nick J B Isaac, Steve Kelling, and Wouter Los. 2018. "Building Essential Biodiversity Variables (EBV s) of Species Distribution and Abundance at a Global Scale." *Biological Reviews* 93 (1): 600–625.

Langer, Christian, Jessica Junker, and Henrique Miguel Pereira. 2023. "EuropaBON Network Dashboard." Zenodo. https://doi.org/10.5281/zenodo.10047342.

Lumbierres, Maria, and W Daniel Kissling. 2023. "Important First Steps towards Designing the Freshwater, Marine and Terrestrial Essential Biodiversity Variable (EBV) Workflows for the

European Biodiversity Observation Network." *Research Ideas and Outcomes*, July, e109120. https://doi.org/10.3897/rio.9.e109120.

Moe, S Jannicke, Sophie Mentzel, Samuel A Welch, and Anne Lyche Solheim. 2023. "From National Monitoring to Transnational Indicators: Reporting and Processing of Aquatic Biology Data under the European Environment Agency's State of the Environment Data Flow." *Frontiers in Environmental Science* 11: 1057742.

Morán-Ordóñez, Alejandra, Pedro Beja, Sara Fraixedas, Sergi Herrando, Jessi Junker, W Daniel Kissling, Maria Lumbierres, et al. 2023. "D3.3 Identification of Current Monitoring Workflows and Bottlenecks." *ARPHA Preprints*, July, ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e103765.

Oldoni, Damiano, Quentin Groom, Tim Adriaens, Jasmijn Hillaert, Lien Reyserhove, Diederik Strubbe, Sonia Vanderhoeven, and Peter Desmet. 2024. "Occurrence Cubes at Species Level for European Countries." Zenodo. https://doi.org/10.5281/zenodo.10528506.

Palialexis, A, and S. T. Boschetti. 2021. *Review and Analysis of Member States' 2018 Reports – Descriptor 1 – Species Biological Diversity*. EUR 30664 EN. Luxembourg: Publications Office of the European Union. https://doi.org/doi/10.2760/27700.

Pereira, Henrique Miguel, Simon Ferrier, Michele Walters, Gary N Geller, Rob H G Jongman, Robert J Scholes, Michael William Bruford, Neil Brummitt, Stuart H M Butchart, and A C Cardoso. 2013. "Essential Biodiversity Variables." *Science* 339 (6117): 277–78.

Potts, Simon G, Vera Imperatriz Fonseca, Hien T Ngo, Jacobus C Biesmeijer, Thomas D Breeze, Lynn Dicks, Lucas Alejandro Garibaldi, Rosemary Hill, Josef Settele, and Adam J Vanbergen. 2016. "Summary for Policymakers of the Assessment Report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on Pollinators, Pollination and Food Production."

Reverté, Sara, Marija Miličić, Jelena Ačanski, Andrijana Andrić, Andrea Aracil, Matthieu Aubert, Mario Victor Balzan, Ignasi Bartomeus, Petr Bogusch, and Jordi Bosch. 2023. "National Records of 3000 European Bee and Hoverfly Species: A Contribution to Pollinator Conservation." *Insect Conservation and Diversity* 16 (6): 758–75.

Santana, Joana, Miguel Porto, Lluís Brotons, Jessi Junker, W Daniel Kissling, Maria Lumbierres, Jannicke Moe, et al. 2023. "D3.2 Report on Gaps and Important New Areas for Monitoring in Europe." *ARPHA Preprints*, March, ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e103657.

Seebens, Hanno, David A Clarke, Quentin Groom, John R U Wilson, Emili García-Berthou, Ingolf Kühn, Mariona Roigé, Shyama Pagad, Franz Essl, and Joana Vicente. 2020a. "A Workflow for Standardising and Integrating Alien Species Distribution Data." *NeoBiota* 59: 39–59.

———. 2020b. "A Workflow for Standardising and Integrating Alien Species Distribution Data." *NeoBiota* 59: 39–59.

Silva del Pozo, Michelle, and Guillaume Body. 2022. "Literature Survey on Biodiversity Monitoring Protocols Used across Countries." https://www.biodiversa.eu/wp-content/uploads/2022/12/MS55-Literature-survey-biodiversity-monitoring-protocols.pdf.

UC3 - University of California Curation Center. 2012. "A Brief Thought: What Is E-Science?" Https://Uc3.Cdlib.Org/2012/12/04/a-Brief-Thought-What-Is-e-Science/. December 4, 2012.

Vihervaara, P., M. Basille, C. Mandon, T. Suni, and A. Lipsanen. 2023. "D2.3 Report on the Mapping of Ministries, Agencies and Organisations That Fund and Steer National/Sub-National Biodiversity Monitoring Schemes. Biodiversa+. Deliverables & Reports."

Vihervaara, P., A. Lipsanen, T. Suni, C. Mandon, H. Eggermont, G. Body, M. Basille, et al. 2023. "Biodiversa+ Strategic Biodiversity Monitoring Governance Document (Phase 1)."

Viti, Martina Marei, Georgios Gkimtsas, Camino Liquete, Grégoire Dubois, Janica Borg, Silvia Dalla Costa, Anne Teller, Rayka Hauser, and Marine Robuchon. 2024. “Introducing the Progress Monitoring Tools of the EU Biodiversity Strategy for 2030.” *Social Science Research Network* submitted.

# 10. Annex

## Annex 1: Interview Questions

1. Basic introductory questions (organisation, geographic context, etc.,)
2. How are you involved with biodiversity data? Follow up: user, producer, data hub, data analyst, policy maker…
3. In what context do you or your organisation use biodiversity data and data infrastructures in your work? Which sources do you use for this data?
4. Where do you see a gap in biodiversity data availability?
5. What is the main bottleneck along the process of mobilising biodiversity data to policy making in the EU? Do you think it's more related to data availability, data integration, data analysis, data visualisation, data communication, or decision support?
    a. How to improve the flow of biodiversity information for decision-making?
6. How confident do you feel about using data from infrastructures such as GBIF? How would you increase that confidence?
7. How can we increase the impact of EU projects that produce biodiversity data on policy and decision making?

**B3 Impact**

8. Where/how can B3 have its largest impact? Should we partner with others to increase our impact?
9. How can we ensure B3 products uptake? Which products would be more useful in your daily work? How can we ensure B3 products are useful for policy?
10. What are the urgent biodiversity topics that need to be addressed, from your field, using the occurrence data cubes? What would be your suggestion for a stakeholder-driven case-study?

## Annex 2: Poster

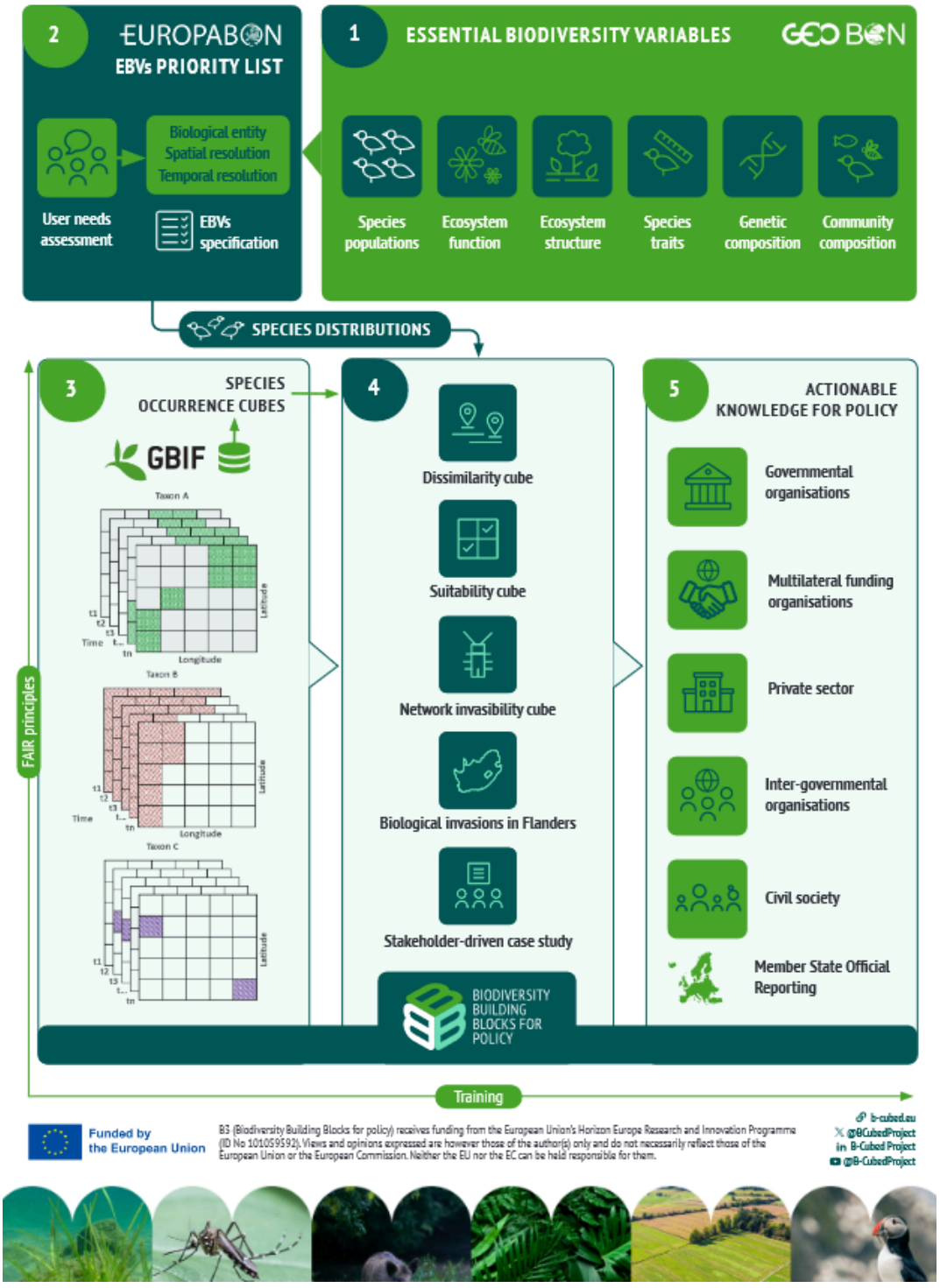



**Figure 16: Poster designed for introducing the B3 project and the stakeholders' case study in the semi-structured interviews.**