![biodiversa+ logo](European Biodiversity Partnership)

SHARED BIODIVERSA+ GOALS AND PRIORITIES FOR BIODIVERSITY MONITORING

For the 3rd instalment of Biodiversa+

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What is Biodiversa+

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

1. Plan and support research and innovation on biodiversity through a shared strategy, annual joint calls for research projects and capacity building activities

2. Set up a network of harmonised schemes to improve monitoring of biodiversity and ecosystem services across Europe

3. Contribute to high-end knowledge for deploying Nature-based Solutions and valuation of biodiversity in the private sector

4. Ensure efficient science-based support for policy-making and implementation in Europe

5. Strengthen the relevance and impact of pan-European research on biodiversity in a global context.

6.

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

Executive Summary

This document introduces the revised biodiversity monitoring priorities for the third instalment (2025–2028) of Biodiversa+, the European Biodiversity Partnership. Priorities are biological elements at all scales from genes to ecosystems that are the subjects of biodiversity monitoring, and for which reinforcement of capacity and resources are urgently needed. Biodiversa+ priorities now include "bats", "common species", "genetic composition", "habitats", "insects", "invasive alien species", "marine biodiversity", "protected areas", "soil biodiversity", "urban biodiversity", "wetlands" and "wildlife diseases", together with "transversal activities" as a special topic.

Biodiversity monitoring priorities are selected based on a series of guiding principles, as to contribute to better decision making, focus on actionable priorities, fill in monitoring gaps, manifest a transnational perspective, provide linkages to established initiatives, and emphasise Biodiversa+ added value. All priorities are supported by an increasing number of partners, from 7 partners on average (ranging from 5 to 11) in 2022—2023 to 12.25 partners on average (from 7 to 19) in 2024 (on comparable priorities), showing both the progress made in recent action, as well as the remaining potential to reach full development.

Biodiversity monitoring priorities guide Biodiversa+ activities related to promotion and support of transnational actions, pilots and support to national biodiversity monitoring. In this report, we detail the rationale, existing initiatives and policy relevance for each priority as to guide further action, and also reflect on Biodiversa+ past and ongoing activities.

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Table of acronyms

Bern Convention	Bern Convention on the Conservation of European Wildlife and Natural Habitats
BIOcean5D	Marine Biodiversity Assessment and Prediction across Spatial, Temporal and Human Scales
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals
CBD	Convention on Biological Diversity
CWI	Carpathian Wetland Initiative
DiverSea	Integrated Observation, Mapping, Monitoring and Prediction for Functional Biodiversity of Coastal Seas
DNA	Deoxyribonucleic acid
DPSIR	Driver-Pressure-State-Impact-Response
EASIN	European Alien Species Information Network
EBOCC	European Biodiversity Observation Coordination Centre
EBV	Essential biodiversity variable
EC	European Commission
EEA	European Environment Agency
eDNA	Environmental DNA (see DNA)
EFSA	European Food Safety Authority
Eionet	European Environment Information and Observation Network
eLTER	European Long-Term Ecosystem Research
EMBRC	European Marine Biological Resource Centre
EMO BON	European Marine Omics Biodiversity Observation Network
ETC BE	European Topic Centre Biodiversity and Ecosystems
EU	European Union
EU-PoMS	EU Pollinator Monitoring Scheme
EUNIS	European Nature Information System
EUP AH&W	European Partnership on Animal Health and Welfare
EUROBATS	UNEP/EUROBATS Agreement on Conservation of European Bat Populations
G-BiKE	Genomic Biodiversity Knowledge for Resilient Ecosystems

GBF	Kunming-Montreal Global Biodiversity Framework
GBIF	Global Biodiversity Information Facility
GBiOS	Global Biodiversity Observing System
GENOA	Genetic Nature Observation and Action
GEO BON	Group on Earth Observations Biodiversity Observation Network
GINAMO	Genetic Indicators for Nature Monitoring
GRIIS	Global Register of Introduced and Invasive Species
HELCOM	Baltic Marine Environment Protection Commission (Helsinki Commission)
IAS	Invasive alien species
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
LUCAS	Land Use/Land Cover Area Frame Survey
MARCO-BOLO	Marine Coastal Biodiversity Long-term Observations
MBON	Marine Biodiversity Observation Network
MedWet	Mediterranean Initiative on the Ramsar Convention on Wetlands
Mhéo	Milieux humides, évaluation, observation—Wetlands, evaluation, observation
MSFD	Marine Strategy Framework Directive
NGO	Non-governmental organisation
NIS	Non-indigenous species
NRR	Nature Restoration Regulation
OBAMA-NEXT	Observing and Mapping Marine Ecosystems—Next Generation Tools
OBIS	Ocean Biodiversity Information System
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
RS	Remote sensing
SoilBON	Soil Biodiversity Observation Network
SPRING	Strengthening Pollinator Recovery through Indicators and Monitoring
WFD	Water Framework Directive

Context and overview

Biodiversa+, the European Biodiversity Partnership, carries out a number of activities, including transnational actions, pilots and support to national biodiversity monitoring. Biodiversity monitoring priorities are thus established as a frame of reference to carry out the partnership activities. In this framework, we refer to **the two facets of biodiversity monitoring**[1], as 1) the repeated standardised collection of primary biodiversity data in order to perceive change in certain quality or quantity; 2) the use of these data to estimate and report on the value of the indicators describing the change. Biodiversity monitoring has three defining characteristics:

- **Biodiversity monitoring operates on the long-term**: Biodiversity monitoring becomes meaningful over extensive periods of time. As such, there is no set term to biodiversity monitoring, as it is supposed to last for as long as it is relevant;

- **Biodiversity monitoring focuses on status and trends**: A single point in time can only define the status, while repeated observations are necessary for evaluating trends and the determining factors for change;

- **Biodiversity monitoring is level, realm and scale agnostic**: it addresses all components of biodiversity from genes to ecosystems, through species and habitats, from terrestrial, marine and freshwater realms, at all geographic and temporal scales.

In this framework, Biodiversa+ defines biodiversity monitoring priorities as **biological elements at all scales from genes to ecosystems that are the subjects of biodiversity monitoring**, and for which transnational collaboration, capacity building and resource reinforcement are urgently needed. At the inception of Biodiversa+, 8 biodiversity monitoring priorities have been defined, including Transversal activities. For the second instalment of the partnership (2023–2025)[2], this was increased to 12 priorities and Transversal activities were specified as a special topic. The same priorities have been kept for the third instalment (2025–2028) and are the focus of this report. The full list of Biodiversa+ priorities for the third instalment, together with their descriptions, can be found in Table 1. The rest of this report describes the guiding principles used to define these priorities, and expand on each priority as a guide for the partnership.

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

[2] Basille M., Body G., Eggermont H., Mandon C. & Vihervaara P. (2023) Guidance note presenting shared goals/priorities for biodiversity monitoring within Biodiversa+. Biodiversa+ report. 21 p. URL: https://www.biodiversa.eu/wp-content/uploads/2023/06/D2.5-Priorities.pdf

Table 1: Biodiversity monitoring priorities for Biodiversa+ (2025–2028), in alphabetic order, presented in the form of a short name and an associated description. Note that "*Transversal activities*" is considered a special topic, instead of a thematic priority *per se*.

Topic	Description
Bats	Monitoring all species of bats and their habitats
Common Species	Monitoring common biodiversity using standardised multi-taxa approaches
Genetic Composition	Monitoring intraspecific genetic diversity, genetic differentiation, inbreeding and effective population size
Habitats	Monitoring habitats and ecosystems in terrestrial, freshwater and marine realms
Insects	Monitoring insect biodiversity, including pollinators
Invasive Alien Species	Detecting and monitoring Invasive Alien Species in terrestrial, freshwater and marine realms, including Non-Indigenous Species in marine realm
Marine Biodiversity	Monitoring coastal and offshore marine biodiversity and habitats, from plankton to marine megafauna and seabirds
Protected Areas	Monitoring biodiversity within protected areas in terrestrial, freshwater and marine realms, including Natura 2000 sites
Soil Biodiversity	Monitoring micro-organisms, micro-, meso- and macrofauna of topsoil and litter, from bacteria to earthworms, including fungi
Urban Biodiversity	Monitoring biodiversity in urban, peri-urban and urban-fluvial environments
Wetlands	Monitoring biodiversity of wetlands, including mires and peatlands
Wildlife Diseases	Monitoring biodiversity facets linked to health issues, from animal, livestock and human perspectives
Transversal Activities	Supporting and valorising biodiversity monitoring: governance, administration, information systems, metrics, novel technologies, social sciences

Guiding principles

The decision to include a topic as a biodiversity monitoring priority for the partnership is based on a few guiding principles:

1. **Contribute to better decision making:** The ultimate goal of biodiversity monitoring is to contribute to improved evaluation and management of biodiversity in a general sense. In other words, biodiversity monitoring priorities should effectively provide evidence for better decision making, and relate to actual reporting needs at national, European (e.g. Directives and Regulations from the European Union [EU]), and global (e.g. Kunming-Montreal Global Biodiversity Framework [GBF] and its monitoring framework agreed under the Convention on Biological Diversity [CBD]) levels. In effect, priorities should be linked with specific public policies relevant at the European scale.

2. **Focus on actionable priorities:** Following on from the previous principle, it is essential to consider topics in which a path forward can be identified, with effective and impactful actions that can be implemented. It has been therefore suggested that the identification of critical topics for biodiversity is a necessary prerequisite, but that it is equally important to link these topics to clear activities of biodiversity monitoring.

3. **Fill in monitoring gaps:** The recently approved EU Nature Restoration Regulation [NRR] recognises that large monitoring gaps exist for both habitat and species[3]. One of the goals of Biodiversa+ monitoring activities is to help fill in gaps in terms of biodiversity monitoring to support science-based conservation and restoration actions. It has been therefore suggested to identify primary and secondary monitoring gaps[4], in order to frame activities–primary gaps being knowledge gaps in space and time for certain taxa and ecosystems, while secondary gaps are roadblocks related to harmonisation, capacity, policy support and coordination.

4. **Manifest a transnational perspective:** The Partnership is transnational at its core, and should reflect the general principle of EU law, i.e. subsidiarity. Applied to biodiversity monitoring, subsidiarity means that the scope of action of the Partnership shall be delineated by areas where individual activities from partners at the national or subnational level are not sufficient without transnational coordination or action. It has been therefore suggested to ensure that priorities show a clear transnational perspective to implement decisive action; in addition, Biodiversa+ monitoring priorities should also be supported by more than only a few countries.

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[3] E.g. in Recital 73: "a substantial share of the information reported by Member States […], in particular on the conservation status and trends of the habitats and species they protect, comes from partial surveys or is based only on expert judgment. […] Filling in those knowledge gaps and investing in monitoring and surveillance are necessary in order to underpin robust and science-based national restoration plans."

[4] Santana, J., Porto, M., Brotons, L., Junker, J., Kissling, W.D., Lumbierres, M., Moe, J., Morán-Ordóñez, A., Pereira, H., Lyche Solheim, A., Villero, D., Moreira, F. & Beja, P. (2023) Report on gaps and important new areas for monitoring in Europe. EuropaBON report. 194 pp. DOI: 10.3897/arphapreprints.e103657

5. **Provide linkages to established initiatives:** The European biodiversity monitoring landscape is already diverse and constantly evolving[5,6], with many initiatives acting at various levels, from transnational to local scale, on broad or specific topics. Extensively coordinated actions are mandatory for the success of the Partnership. It has been therefore suggested to identify, and link to, existing initiatives related to each priority, in order to reduce duplicated efforts, waste of resources and possibly conflicting or contradictory actions. In particular, it is critical that Biodiversa+ efforts support biodiversity monitoring activities at the national (or subnational) level, when results at one level can contribute to activities at the other level, and vice-versa.

6. **Emphasise Biodiversa+ added value:** The strength of Biodiversa+ comes from the diversity of its partners, and, with respect to biodiversity monitoring, its composition is mostly based on ministries of environment and environmental protection agencies. However, there are limits to both the scope and field of action of both individual partners and the Partnership, which restrict Biodiversa+'s capacity for action. It has been therefore suggested to focus on topics that are the responsibility of Biodiversa+ partners (both realm and specific topic).

In addition, a few practical considerations also need to be accounted for. Twelve priorities together with *Transversal activities* have been used during the second Biodiversa+ instalment (2023–2025). For each priority, the number of partners investing in national biodiversity monitoring activities can be used as a metric of success. During the first instalment (October 2021–September 2023), 7 partners invested in biodiversity monitoring activities for each priority, on average (from 5 to 11, Fig. 1). While participation increased across the board during the first half of the second instalment (October 2023–September 2024) to reach 12.25 partners on average for the same priorities (from 7 to 19, Fig. 1), there is still room for further improvement to reach global participation. For comparison, the new priorities for the 2nd instalment, which were purposely targeted at a finer grain, attracted the participation of 4 partners on average (from 3 to 6, Fig. 1), a figure that is, similarly, expected to rise in the next few years. As a result, all priorities are still considered as relevant, and it was collectively decided to keep the same list of priorities for the third instalment, while refining or clarifying their description to provide better guidance for Biodiversa+ partners.

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[5] Morán-Ordóñez, A., Martí Pino, D. & Brotons, L. (2023) Inventory of current European network for monitoring. Web-based database. EuropaBON report. 37 pp. DOI: 10.3897/arphapreprints.e109168

[6] Vihervaara, P., Basille, M., Mandon, C., Suni, T. & Lipsanen, A. (2023) Report on the mapping of ministries, agencies and organisations that fund and steer national/sub-national biodiversity monitoring schemes. Biodiversa+ report. 60 pp. URL:

https://www.biodiversa.eu/wp-content/uploads/2023/03/D2.3-Report-on-the-mapping-of-organisations-that-fund-and-steer-biodiversity-monitoring-schemes.pdf

Number of partners investing in national biodiversity monitoring activities in Biodiversa+

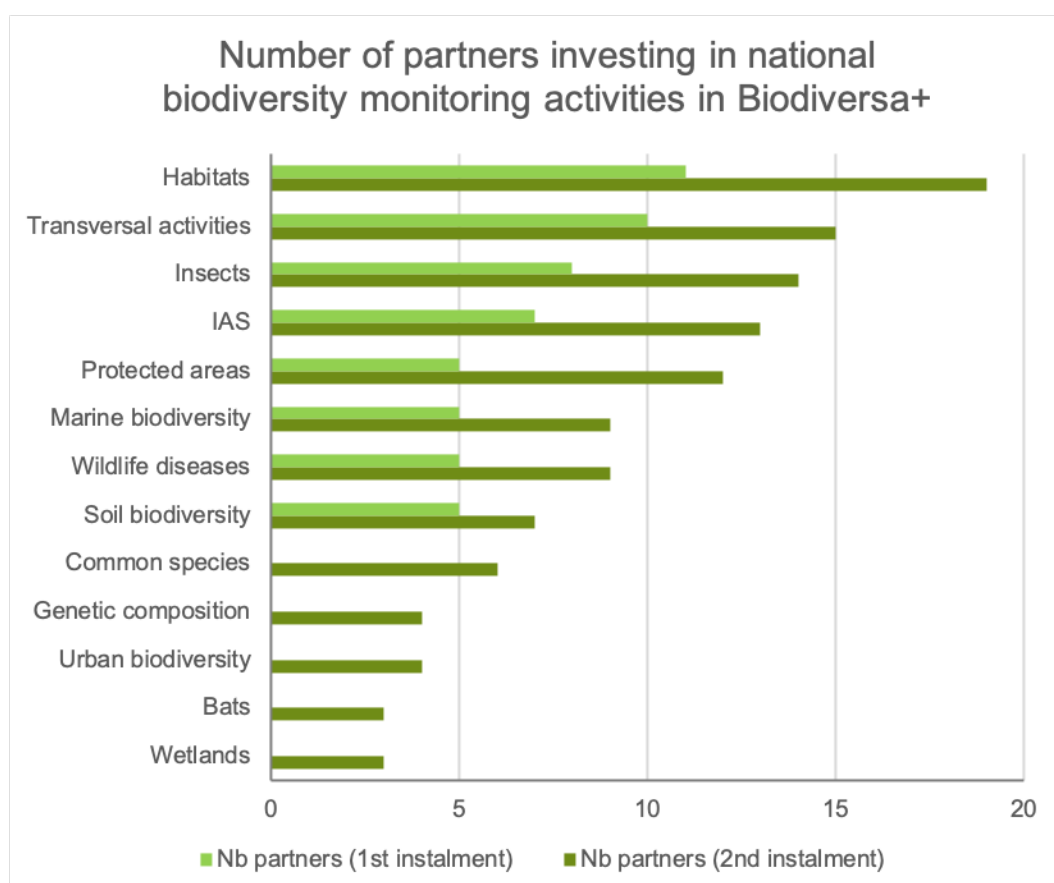Legend: Nb partners (1st instalment), Nb partners (2nd instalment)

Fig. 1: Number of partners investing in national biodiversity monitoring activities in Biodiversa+ for the 12 priorities and Transversal activities, during the 1st instalment (October 2021–September 2023, light green) and the first half of the 2nd instalment (October 2023–September 2024, dark green), by decreasing order.

On a side note, we pay particular attention to the linkages between Biodiversa+ efforts through direct monitoring activities of the partnership, and scientific advances through Biodiversa+-funded research projects. For each priority, we evaluated the relevance of projects launched under the 2021–2022 BiodivProtect joint call[7] ("Supporting the protection of biodiversity and ecosystems across land and sea", 36 projects funded for 3 years between April 2023 and March 2026) and most importantly the 2022–2023 BiodivMon joint call[8] ("Improved transnational monitoring of biodiversity and ecosystem change for science and society", 33 projects funded for 3 years between March 2024 and February 2027), which needs to be further investigated so that monitoring activities can benefit from the most up-to-date science. Beyond Biodiversa+-funded projects, biodiversity monitoring activities run within the partnership should also consider establishing links to the most prominent

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[7] 2021-2022 Biodiversa+ BiodivProtect call for research funded projects
https://www.biodiversa.eu/2022/10/07/2021-2022-joint-call/

[8] 2022-2023 Biodiversa+ BiodivMon call for research funded projects:
https://www.biodiversa.eu/2022/10/07/2022-2023-joint-call/

LIFE projects, when relevant. Finally, in order to present a consistent format, we use a short title and a description for each priority. It has been suggested to use short names as titles (2 to 5 words with no parentheses), together with a short description (up to 15–20 words) that more precisely delineates their scope.

Biodiversity monitoring priorities for 2025–2028
1. Bats

Monitoring all species of bats and their habitats

Rationale: Bats are long-living, slowly reproducing animals that are sensitive indicators for environmental change and pressures, such as habitat fragmentation, ecosystem stress or changing habitat use, resulting from human activities. They also play an essential role in pest control. After a historical massive decline throughout the 20th century, some bat populations seem to partially recover, but many species remain endangered and are in unfavourable conservation status in most of European biogeographical regions. Pressures and threats include habitat loss (size and quality), collisions with wind turbines, light pollution, agriculture, road infrastructure, water management and pollution, inappropriate forest management, and diseases. Collecting harmonised data on status and trends of bats across Europe is a necessary step towards informed conservation actions and regulatory requirements in order to improve their conservation status and/or conservation trend.

Existing initiatives and policy relevance: The UNEP/EUROBATS Agreement on Conservation of European Bat Populations (EUROBATS) is an established network of key bat research and conservation actors in Europe, consisting of universities, range states, national and international non-governmental organisations (NGOs). It focuses on bat conservation, their migratory status, development of guidelines to mitigate recognized key threats, and working towards the production of population trends, through harmonisation of monitoring protocols. The Bat Monitoring Programme (mostly implemented in Spain but currently expanding to other European countries) currently tries to use citizen science in order to complement bat monitoring. At the European level, all 45 species of bats are listed under the Habitat Directive to receive strict protection (Annex IV) and 14 species require the designation of Special Areas of Conservation (Annex II). At the international level, all the species are protected under the Bern Convention (Bern Convention on the Conservation of European Wildlife and Natural Habitats) and Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals).

Biodiversa+ activities: An ongoing Biodiversa+ pilot is focusing on the deployment of multi-taxa monitoring stations (targeting nocturnal insects, bats, and birds): "ABMS: Automated monitoring of birds, bats and nocturnal insects through sound and image recognition" (2024–2025). In addition, during the 2nd instalment, 3 Biodiversa+ partners: BOZEN, DACC and OFB are investing in national biodiversity monitoring activities on this priority (Fig. 1).

2. Common Species

Monitoring common biodiversity using standardised multi-taxa approaches

Rationale: Species abundance and persistence are key components of biodiversity, especially from a functional perspective. A lot of effort has been devoted to rare, threatened and endangered, or emblematic species. However, common species play a critical role as they are likely to contribute disproportionately more than rare ones to ecosystem structure, function, and services. Yet, little attention has been given to common species, and no harmonised approach is currently in place to monitor biodiversity of common species as a whole across Europe. A transnational multi-taxa approach is necessary to overcome national and subnational differences, and provide comparable data on ecosystems' health at the continental scale. There is also a good methodological opportunity to monitor those species that are, by definition, common across Europe, and can adequately be monitored using a broad, cost-efficient, harmonizable, sampling scheme. The focus of this priority should specifically be the harmonisation of approaches to monitor common species, particularly understudied taxa, at the European scale in order to provide more comprehensive information (e.g. based on species list and presence/absence data) for models and scenarios.

Existing initiatives and policy relevance: Existing indicators at the European scale include common farmland and forest birds, common grassland butterflies, and common fishes in the European North-East Atlantic waters. Specifically, on birds, the EuroBirdPortal[9] gathers existing data from online bird recording portals from across Europe to describe the temporal and spatial distribution of birds across large geographical areas and their change over time. Other common taxa are vastly understudied, and would benefit from a multi-taxa approach.

Biodiversa+ activities: Three Biodiversa+-funded projects (under the BiodivMon call) relate to this priority: BIG_PICTURE ("Developing data management and analytical tools to integrate and advance professional and citizen science camera-trapping initiatives across Europe") will facilitate the sharing, integration and joint analysis of multi-species data collected through wildlife camera traps; TABMON ("Towards a Transnational Acoustic Biodiversity Monitoring Network") will develop a transnational biodiversity monitoring with autonomous acoustic sensors targeting a wide range of birds; WildINTEL ("Building a scalable WILDlife monitoring system by integrating remote camera sampling and artificial INTELligence with Essential Biodiversity Variables") will develop a wildlife monitoring system combining a multi-species camera trapping, citizen science, artificial intelligence, and hierarchical models for the automated production of species population and community structure data. In addition, an ongoing Biodiversa+ pilot is focusing on the deployment of multi-taxa monitoring stations (targeting nocturnal insects, bats, and birds): "ABMS: Automated monitoring of birds, bats and nocturnal insects through sound and image recognition" (2024–2025). In addition, during the 2nd instalment, 6 Biodiversa+ partners: DACC, EAA, MEPA, NPWS, OFB and SAS are investing in national biodiversity monitoring activities on this priority (Fig. 1).

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[9] EuroBirdPortal: https://eurobirdportal.org/

3. Genetic composition

Monitoring intraspecific genetic diversity, genetic differentiation, inbreeding and effective population size

Rationale: Intraspecific genetic variation is a crucial component of biodiversity, yet is very poorly covered in biodiversity monitoring initiatives, even across the EU. This includes estimation of intraspecific parameters such as effective population size, genetic diversity, inbreeding, population structure, and gene flow at large spatio-temporal scales. Recently, the CBD has adopted two genetic diversity indicators. These indicators can be reported using non-genetic monitoring data, which allows for fast adoption and a wide representation of species. This information is required for reporting to the CBD, but also benefits the Habitats and Bird Directives to assess the favourable reference population, i.e. the minimum population necessary to ensure the long-term viability of the species. The downsides of non-genetic proxies are that they lack precision and risk missing certain types of species, which may not be well targeted without true genetic data. Efforts are thus required to identify blind spots in proxy-based assessments of genetic indicators across the EU, and suggest solutions to solve this issue, especially for species with populations occurring across country borders.

Existing initiatives and policy relevance: Relevant working groups include the Conservation Genetics Specialist Group from the International Union for Conservation of Nature, and the Conservation Genetics Working Group from the Society for Conservation Biology. In Europe, in addition to national initiatives, it is worth mentioning the G-BiKE project ("Genomic Biodiversity Knowledge for Resilient Ecosystems", EU Cost Action 18134, 2019–2023), a scientific network from 39 European countries with the aim of establishing the use of genomic data as a standard tool for monitoring and managing wild and ex situ populations of plants and animals. Also noteworthy is the Genetic Nature Observation and Action (GENOA, EU Cost Action 23121, 2024–2028), a European network across 34 European countries (and counting), focusing on the integration of genetic indicators across Europe in species management and conservation planning. GENOA is a knowledge hub for national stakeholders, and is tightly linked to G-BiKE and the GINAMO project ("Genetic Indicators for Nature Monitoring", see below). In the marine realm, the European Marine Omics Biodiversity Observation Network (EMO BON), launched in 2021 by the European Marine Biological Resource Centre (EMBRC), will fill current gaps in the genetic composition of marine biodiversity through a network of 16 sites from Northern Norway to the tropical Red Sea in Israel. The GBF recognises the importance of genetic diversity and requires its signatories to use two genetic diversity indicators: the percentage of a species' populations that are large enough (~5,000 individuals, on average) to maintain their genetic diversity; and the percentage of a species' populations that have been maintained.

Biodiversa+ activities: The Biodiversa+-funded project GINAMO ("Genetic Indicators for NAture MOnitoring"), under the BiodivMon call, will further test, improve and deploy the GBF genetic indicators across several EU partner countries, at the national level. In addition, a pilot candidate focusing specifically on genetic diversity of transboundary populations will be developed in 2025 for the 3rd wave of Biodiversa+ pilots. Finally, during the 2nd instalment, 6 Biodiversa+ partners: NPWS,

OFB, SAS SEPA, SPW_DGO3 and SwAM are investing in national biodiversity monitoring activities on this priority (Fig. 1).

4. Habitats

Monitoring habitats and ecosystems in terrestrial, freshwater and marine realms

Rationale: Habitats and associated ecosystem services remain an area requiring important monitoring efforts. An essential part of habitat monitoring is mapping — for instance, the new NRR requests to comprehensively map habitats in terrestrial, freshwater and marine realms, as well as to assess habitat quality to find suitable restoration areas and/or monitor changes in large-scale quality and pressure parameters. Habitat mapping quality and methods vary largely from country to country and should be developed further in a harmonised way. A relevant avenue for development is the use of remote sensing (RS) methods, which are under-utilised for monitoring of high nature-value land, such as habitat types listed in Annex I of the Habitats Directive, despite efforts within the Copernicus programme. While RS methods will not be able to cover all needs in this respect, they have a huge unexplored potential to contribute to an efficient and harmonised mapping and monitoring system of European habitats.

Existing initiatives and policy relevance: The Ad-hoc expert group on habitat quality under the EU Expert group on reporting (Contract nr. 09.0201/2022/883379/SER/ENV.D.3) is currently reviewing the EU member states methods and data used for assessing habitat quality for Annex 1 habitats in the Habitats Directive. The group will also propose methods for evaluating habitat quality for use in EU reporting according to Article 17 in the Habitats Directive. This takes place in the EU Biodiversity Strategy for 2030, and specifically the NRR, which aims to reverse the degradation of ecosystems and habitats with actions for restoration. The Habitats Directive, while in place since 1992, is also acutely relevant as a strong regulation to monitor habitats and their condition.

Biodiversa+ activities: Five Biodiversa+-funded projects (under the BiodivMon call) relate to this priority: ForBioMon ("Boosting FORest BIOdiversity MONitoring in Europe through smart combination of existing data") will enhance forest biodiversity monitoring in Europe; GRASS4FUN ("Monitoring the contribution of European grasslands to the conservation of soil biodiversity and ecosystem function under multiple global change stressors") will monitor soil biodiversity, microbial diversity and multiple ecosystem services in European natural grasslands; HiRAD ("Harmonising and integrating Radar-based approaches for monitoring Aerial bioDiversity") will use automated radar systems to continuously monitor the airspace as habitat for the movements of birds and insects; MOTIVATE ("Monitoring of Terrestrial habitats by Integrating Vegetation Archive Time series in Europe") will improve monitoring of European terrestrial habitats and plant biodiversity; Sub-BioMon ("Developing and testing approaches to monitor subterranean biodiversity in karst") will monitor biodiversity in European caves. In addition, Biodiversa+ has launched a Habitat pilot in January 2024, focusing on monitoring and mapping of grassland and wetland habitats (see also below for the specific priority on Wetlands), with the aim to build a harmonised monitoring and mapping system for these two terrestrial habitats, and assess how remote sensing can effectively

contribute to this goal. In addition, two pilot candidates related to Habitats will be developed in 2025. The first one will focus on monitoring and mapping the condition of forest habitats, with similar aims as the current Habitat pilot. The second one will focus specifically on ponds, which are often biodiversity hotspots in local and regional contexts. Finally, 11 Biodiversa+ partners invested in national biodiversity monitoring activities on habitats through Biodiversa+ during the 1st instalment (Fig. 1). This figure increased to 19 during the Biodiversa+ 2nd instalment (Fig. 1)[10].

5. Insects

Monitoring insect biodiversity, including pollinators

Rationale: Insects are a crucial compartment of biodiversity, making up roughly half of currently described extant species (across all groups). Insect populations are undergoing a fast decline in Europe in response to major pressures such as pesticide use, landscape homogenisation and connectivity disruption. This is of great concern since they are key functional components of ecosystems, acting as pollinators and decomposers, a major food source in the food chain, and powerful regulators of plants and animals. Despite their clear importance, their monitoring is hindered by the diversity of species and identification challenges for many taxa. This calls for novel solutions, based on recent technological developments, to complement traditional monitoring methods. Citizen science in particular has seen a rising interest in recent years, and volunteer contributions can become an essential part of insect monitoring in Europe.

Existing initiatives and policy relevance: The revised EU Pollinators Initiative ("New Deal for Pollinators") refers to the binding commitments to the recovery of pollinators by 2030, contained in the recent NRR, and to the need to finalise the EU Pollinator Monitoring Scheme (EU-PoMS) and carry out pollinator monitoring, as trialled in several countries through the EU SPRING project ("Strengthening Pollinator Recovery through Indicators and Monitoring"). The European Long-Term Ecosystem Research (eLTER) could provide the infrastructure to monitor insects over a network of sites throughout Europe.

Biodiversa+ activities: Three Biodiversa+-funded projects (under the BiodivMon call) relate to this priority: ANTENNA ("Making technology work for monitoring pollinators") will fill key pollinator monitoring gaps through advancing innovative technologies to complement EU-PoMS; MonitAnt ("Developing a European-level Monitoring strategy for mound-building Formica Ants and symbiont communities residing in nest mounds") will develop and validate a harmonised monitoring strategy for mound-building ant species; SEPPI ("Standardised European monitoring of plant-pollinator

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[10] Biodiversa+ partners implementing national activities on habitats under the 1st instalment: BOZEN, ExEA, MESD, MoC_EE, MoE_DK, MoE_FI, NCA_CZ, OFB, SAS, SEPA, SPW_DGO3 and VL O. Biodiversa+ partners implementing national activities on habitats under the 2nd instalment: BOZEN, DACC, EAA, EPA_M, ExEA, MEPA, MESD, MoC_EE, MoE_DK, MoE_FI, MoEP, NCA_CZ, NPWS, OFB, SAS, SEPA, SPW_DGO3, VL O and SwAM.

interactions") will monitor simultaneously plants, pollinators, and their interactions. In addition, insects are an important part of 3 ongoing Biodiversa+ pilots: The IAS pilot, launched in 2023, with a module focusing on nocturnal invasive insects; the ABMS pilot, launched in 2024, with a module focusing on nocturnal insects in general; and the Soil biodiversity pilot, launched in 2023, in which insects are part of the macro-fauna target group. In addition, a pilot candidate focusing on insect monitoring will be developed in 2025, which aims to harmonize methods and establish best practices for EU-wide monitoring using DNA methods, Malaise traps and volunteer engagement. Finally, 8 Biodiversa+ partners invested in national biodiversity monitoring activities on insects through Biodiversa+ during the 1st instalment (Fig. 1). This figure increased to 14 during the Biodiversa+ 2nd instalment (Fig. 1)[11].

6. Invasive Alien Species

Detecting and monitoring Invasive Alien Species in terrestrial, freshwater and marine realms, including Non-Indigenous Species in marine realm

Rationale: The severe global threat posed by invasive alien species (IAS) is underappreciated, underestimated, and often even unacknowledged. The recent assessment report on invasive alien species from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) found that more than 37,000 alien species have been introduced by many human activities to regions and biomes around the world, across all three realms of biodiversity. More than 3,500 of these IAS are harmful, i.e. seriously threatening nature, nature's contributions to people and good quality of life. Repeatable and efficient sampling methods that can expand the extent and resolution of monitoring invasive alien species and speed up the process of updating regional and global overviews on changes in the occurrence of IAS are critically needed. Note that this priority includes the near-synonymous term of non-indigenous species (NIS) in the marine realm, as the adverse effects of alien species necessary to qualify invasiveness are rather difficult to assess in marine environments.

Existing initiatives and policy relevance: Monitoring of IAS is a key element of the EU Invasive alien species Regulation (1143/2014) on the prevention and management of the introduction and spread of invasive alien species. The core of the Regulation is the list of Invasive Alien Species of Union concern (Union List). As a key element of the implementation of this regulation, the European Alien Species Information Network (EASIN) facilitates the exploration and sharing of existing information on alien species across Europe. In the marine realm, regional coordination for the development and application of appropriate monitoring methods for early detection of NIS exist within the Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM) and the OSPAR Commission (Convention for the Protection of the Marine Environment of the North-East

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[11] Biodiversa+ partners implementing national activities on insects under the 1st instalment: BOZEN, ExEA, MESD, NCA_CZ, NEA, OFB, SPW_DGO3 and VL O. Biodiversa+ partners implementing national activities on insects under the 2nd instalment: BOZEN, DACC, EEA, EPA_M, ExEA, MoE_DK, MoE_FI, NCA_CZ, NPWS, OFB, SAS, SEPA, SPW_DGO3 and VL O.

Atlantic). At a broader scale, the Target 6 of the GBF is highly relevant ("Reduce the Introduction of Invasive Alien Species by 50% and Minimize Their Impact"), and supported by the Global Register of Introduced and Invasive Species (GRIIS) to maximise the data utility for biodiversity monitoring and IAS management.

Biodiversa+ activities: The Biodiversa+-funded project CLIMATE INVASIVES ("Minimizing the negative effects of climate change-induced spread of invasive alien species to marine protected areas"), under the BiodivProtect call, will notably detect and monitor IAS in marine protected areas. In addition, Biodiversa+ has launched an IAS pilot in January 2023, which aims to establish the foundation for the implementation of transnational monitoring of invasive alien plant and insect species, using innovative imaging methods. In addition, two pilot candidates related to IAS will be developed in 2025. The first one will focus on the monitoring of marine NIS through introduction sites, while the second will focus on the harmonization of IAS early detection and rapid response systems in freshwater. Both candidates suggest the use of standardised protocol based on metabarcoding, i.e. the simultaneous identification of multiple taxa through environmental DNA (eDNA). Finally, 7 Biodiversa+ partners invested in national biodiversity monitoring activities on invasive alien species through Biodiversa+ during the 1st instalment (Fig. 1): ExEA, MESD, MoC_EE, NEA, OFB, SAS and SPW_DGO3. This figure increased to 13 during the Biodiversa+ 2nd instalment (Fig. 1): DACC, EPA_M, MEPA, MoE_DK, MoC_EE, MoEP, NEA, NPWS, OFB, SAS, SPW_DGO3, SwAM and VL O.

7. Marine Biodiversity

Monitoring coastal and offshore marine biodiversity and habitats, from plankton to marine megafauna and seabirds

Rationale: Marine biodiversity is in decline, whether it is large mammals, sharks or corals. Threats range from extensive land use to climate change, through eutrophication, pollution and invasive alien species. This priority includes a broad spectrum of marine biodiversity, from plankton which forms the basis of the marine food web, to the largest marine megafauna and seabirds, which play crucial roles in ecosystem functioning. An integrated approach considering both coastal and offshore ecosystems is required: Coastal ecosystems (including shallow waters, estuaries, salt marshes etc.) are highly impacted by anthropogenic activities like ports, aquaculture and tourism, and thus require specific attention on their vulnerability and ecological impact assessment. Offshore areas characterized by deeper water face distinct challenges such as deep-sea mining, pollution (litter, oil spills), and overfishing that necessitate dedicated monitoring efforts.

Existing initiatives and policy relevance: Several European and global initiatives address some aspect of marine biodiversity monitoring: OBAMA-NEXT ("Observing and Mapping Marine Ecosystems—Next Generation Tools", Horizon Europe Programme) will provide a toolbox to map and assess marine habitats and biodiversity; MARCO-BOLO ("Marine Coastal Biodiversity Long-term Observations") focuses on observation methods; DiverSea ("Integrated Observation, Mapping,

Monitoring and Prediction for Functional Biodiversity of Coastal Seas", Horizon Europe Programme) develops and refines new DNA-based monitoring technologies; BIOcean5D ("Marine Biodiversity Assessment and Prediction across Spatial, Temporal and Human Scales) is a collaborative effort among European institutions to explore marine biodiversity comprehensively; the Marine Biodiversity Observation Network (MBON) connects actors around the globe to share knowledge and know-how on data, products, protocols and methods, data systems and software. Monitoring marine habitats aligns with the objectives of the EU Marine Strategy Framework Directive (MSFD), which requires Member States to assess the Good Environmental Status of their marine waters with a particular focus on biodiversity components. Furthermore, it contributes to the implementation of the Habitats Directive, aimed at the conservation of marine habitats and species, and supports the goals of the GBF, particularly those related to marine and coastal ecosystems. The recent NRR also includes specific restoration targets on marine habitats such as seagrass beds or sediment bottoms, and the habitats of iconic marine species such as dolphins and porpoises, sharks and seabirds.

Biodiversa+ activities: Eleven Biodiversa+-funded projects (3 under the BiodivProtect call and 8 projects under the BiodivMon call) relate to this priority: eWHALE ("Combining environmental DNA sampling, whale watching and citizen science for stakeholder-driven marine biodiversity protection in the North-East Atlantic and the Mediterranean") will monitor marine megafauna and their prey through eDNA and whale watching; PETRI-MED ("Plankton biodivErsity Through Remote sensing and omIcs in the MEDiterranean Sea") will use novel satellite-based indicators to monitor the microbial plankton community in the entire Mediterranean Sea; SponBIODIV ("Marine sponge biodiversity, from genes to ecosystems: delivering knowledge and tools for sustainable management and conservation") will monitor sponge biodiversity; BioBoost+ ("Boosting the frequency and scale of marine Biodiversity monitoring using digital imagery and artificial intelligence") will use artificial intelligence technology with digital imagery to sample and identify marine biota; CAMBioMed ("Coordinated and Adaptive Monitoring of Biodiversity change across Mediterranean rocky ecosystems") will monitor rocky reefs across the Mediterranean Sea; DNASense ("From gene to landscapes: development of environmental impact assessment tools for marine biodiversity monitoring using eDNA and remote sensing techniques") will harmonise the use of eDNA, community DNA, and remote sensing techniques to monitor multiple dimensions of benthic biodiversity; EMPHATIC ("E-DNA, Microbiomes, Photogrammetry and Hormones – Assessment Techniques In Cetaceans") will provide innovative monitoring tools to monitor cetaceans and their health; MOOBYF ("Monitoring the Open-Ocean BiodiversitY with Fishers") will develop monitoring platforms to observe the open ocean and its biodiversity; NorTrack ("The Northeast Atlantic Marine Tracking Network") will monitor marine fishes through acoustic telemetry; SEAGHOSTS ("Winged ghosts wandering the oceans: the global spatial ecology and conservation of the world's smallest and elusive seabirds, the storm petrel (Hydrobatidae & Oceanitidae), across the Mediterranean and the NE Atlantic Ocean") will monitor storm petrels that breed along Europe; WOBEC ("Weddell Sea Observatory for Biodiversity and Ecosystem Change") will develop a systematic ecosystem monitoring framework in the Eastern Weddell Sea. In addition, the Biodiversa+ pilot program will provide inputs on the effective utilization of data, methodologies and contribute to comprehensive marine biodiversity monitoring activities: The EuRockFish pilot, started in 2024, develops and tests standard protocols to monitor and assess the ecological status of European reef fish. In addition, a pilot candidate focusing specifically on marine non-indigenous species will be developed in 2025 for

the 3rd wave of Biodiversa+ pilots. In addition, ongoing collaboration with the MARCO-BOLO project, that focuses on long-term monitoring of marine biodiversity within coastal zones, will facilitate the effective utilization of existing data, methodologies, and expertise, maximizing the impact and efficiency of collective efforts. Finally, 5 Biodiversa+ partners invested in national biodiversity monitoring activities on marine biodiversity through Biodiversa+ during the 1st instalment (Fig. 1): MESD, MoC_EE, MoE_FI, MoEP and OFB. This figure increased to 9 during the Biodiversa+ 2nd instalment (Fig. 1): EPA_M, MESD, MoE_DK, MoC_EE, MoE_FI, MoEP, NPWS, OFB and SwAM.

8. Protected Areas

Monitoring biodiversity within protected areas in terrestrial, freshwater and marine realms, including Natura 2000 sites

Rationale: Protected areas play a critical role in safeguarding Europe's biodiversity, where effective area-based conservation measures can maximise the ability to conserve biodiversity and prevent extinctions. The EU Biodiversity Strategy for 2030 has set the goal to protect at least 30 % of the land and sea (which has been reinforced by the same target in the GBF). With the Natura 2000 network, Europe has the largest coordinated network of protected areas in the world. Natura 2000 is made up of Special Areas of Conservation and Special Protection Areas designated under the Habitats and Birds Directive, respectively, and includes both terrestrial and marine protected areas. As of 2022, Natura 2000 covers more than 18 % of the EU's land area and more than 7 % of its marine area, and is completed by regulatory protected areas at national and subnational levels in European countries. The unique position of protected areas in the conservation landscape together with their connections at the European level calls for the intensification and harmonisation of biodiversity monitoring within protected areas, which is the focus of this priority. Note that this priority focuses on monitoring aspects of Protected Areas, aiming at standardisation and harmonisation of practices, as well as the collection and analysis of necessary data to evaluate the effectiveness of protected areas (including comparisons inside and outside of protected areas).

Existing initiatives and policy relevance: While regulatory targets in terms of area have particularly driven the landscape in recent years, few initiatives focus on standardisation and harmonisation of biodiversity monitoring in protected areas itself. Of noteworthy importance is the IUCN's framework for monitoring biodiversity in protected areas[12], which aims to help managers and site planners to develop effective biodiversity monitoring programmes for improved management outcomes. In addition, the Copernicus programme provides dedicated services for protected areas on land (through the Copernicus Land Monitoring Service) and at sea (through the Copernicus Marine Service) that monitor environmental variables relevant for both realms. Several protected areas

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[12] Dalton, D., Berger, V., Kirchmeir, H., Adams, V., Botha, J., Halloy, S., Hart, R., Švara, V., Torres Ribeiro, K., Chaudhary, S. & Jungmeier, M. (2024). A framework for monitoring biodiversity in protected areas and other effective area-based conservation measures: Concepts, methods and technologies. IUCN WCPA Technical Report Series No. 7, Gland, Switzerland: IUCN. DOI: 10.2305/HRAP7908

throughout Europe are also eLTER sites, making them relevant targets for the development of standard practices.

Biodiversa+ activities: In January 2023, Biodiversa+ has launched a Soil biodiversity pilot, focusing on near-natural forests, preferably Natura 2000 sites (see below Priority on "Soil biodiversity" for more details). In addition, in 2024, the third Biodiversa+ desk study started, which will produce a review on Protected Area's effectiveness ("How is the effectiveness of terrestrial protected areas to conserve biodiversity measured?"), with an outcome expected in 2025. Finally, 5 Biodiversa+ partners invested in national biodiversity monitoring activities on protected areas through Biodiversa+ during the 1st instalment (Fig. 1): BOZEN, ExEA, MoC_EE, OFB and SAS. This figure increased to 12 during the Biodiversa+ 2nd instalment (Fig. 1): BOZEN, DACC, EAA, MEPA, MoE_DK, MoC_EE, NPWS, OFB, SAS, SPW_DGO3, SwAM and VL O.

9. Soil Biodiversity

Monitoring micro-organisms, micro-, meso- and macrofauna of topsoil and litter, from bacteria to earthworms, including fungi
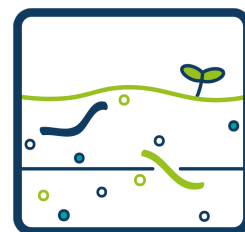
Rationale: Soils are home to almost 60 % of the known species, and many more, particularly from the microbial species pool, are still unknown. Soil organisms are involved in a wide range of soil and ecosystem processes such as litter decomposition, nutrient cycling, water filtration and pest control and are thus essential for ecosystem functioning. Little is known about how soil organisms will be affected by global change and how changes in community composition will affect ecosystem processes, mainly because long-term data on soil biodiversity are largely lacking. In addition, species identification has been difficult due to the wide range of taxa that make up soil communities, and taxa have mostly only been identified at the level of the order or family (for invertebrates) or operational taxonomic unit (for microorganisms). Thus, there is immense need for more soil biodiversity data, especially comprising all taxons, ranging from microbes (including fungi) to invertebrates, an assessment which is currently largely missing. Novel technologies, such as eDNA, are now mature enough to help bridge this gap.

Existing initiatives and policy relevance: Several initiatives have been launched recently to monitor soil biodiversity, such as the Land Use/Land Cover Area Frame Survey (LUCAS) Soil module in Europe and the global Soil Biodiversity Observation Network (SoilBON). While LUCAS aims at agricultural sites, SoilBON uses a paired approach with a protected and an unprotected site, but with only few sites in Europe. The EU has a list of policies in which soil biodiversity plays a key role, such as the EU Biodiversity Strategy 2030, which includes the EU Soil Strategy 2030, the Habitats Directive, the NRR, and the upcoming Soil Monitoring Law (proposal for a Directive on Soil Monitoring and Resilience), which aims, among other things, at healthy soils to ensure food security. In addition, the EU Mission "A Soil Deal for Europe" aims to establish 100 living labs and lighthouses to lead the transition towards healthy soils by 2030. Notable projects funded through the Mission include: BENCHMARKS ("Building a European Network for the Characterisation and Harmonisation of Monitoring Approaches for Research and Knowledge on Soils"), which will guide the selection of

soil health indicators and assessment; AI4SoilHealth ("Accelerating collection and use of soil health information using AI technology to support the Soil Deal for Europe and EU Soil Observatory"), which will develop tools to assess and monitor soil health metric; BIOservicES ("Linking soil biodiversity and ecosystem functions and services in different land uses: From the identification of drivers, pressures and climate change resilience to their economic valuation"), which aims to identify the pressures and drivers influencing soil organisms; SOB4ES ("Integrating SOil Biodiversity to Ecosystem Services: testing cost-effectiveness of Soil Biodiversity indicators and the provision of soil biodiversity-based Ecosystem Services to build better land management solutions that effectively implement the EU Soil Strategy"), which will monitor ecosystem condition and enhance soil biodiversity and its contribution to ecosystem services; and ECHO ("Engaging Citizens in soil science: the road to Healthier sOils"), which will notably involve citizens in data collection on soil-related matters.

Biodiversa+ activities: Three Biodiversa+-funded projects (1 under the BiodivProtect call and 2 under the BiodivMon call) relate to this priority: MicroEco ("Microbial Diversity, Ecosystem Services of the Soil Microbiome and Ecosystem Conservation") will monitor rare and endangered species from soil DNA and several ecosystem services provided by the soil biome; FunDive ("Monitoring and mapping fungal diversity for nature conservation") will bridge the gap for fungi monitoring; SoilRise ("Raising awareness for soil biodiversity and multiplying monitoring by student-based Citizen Science") will monitor earthworms through Citizen Science. In addition, Biodiversa+ has launched a Soil biodiversity pilot in January 2023, which aims to advance a possible large-scale soil biodiversity monitoring scheme by developing a feasible experimental design, defining and optimising a common protocol for field and laboratory work, as well as testing the use of EBVs and other indicators of soil diversity and functionality in soil biodiversity monitoring (in particular those that have been proposed by the Soil Monitoring Law). In addition, 5 Biodiversa+ partners invested in national biodiversity monitoring activities on soil biodiversity through Biodiversa+ during the 1st instalment (Fig. 1): BMUV, BOZEN, SAS, SEPA and VL O. This figure increased to 7 during the Biodiversa+ 2nd instalment (Fig. 1): BOZEN, DACC, EAA, MEPA, SAS, SEPA and VL O.

10. Urban Biodiversity

Monitoring biodiversity in urban, peri-urban and urban-fluvial environments

Rationale: Urban biodiversity is often overlooked, despite the demonstrated social and health benefits associated with green spaces in a broad sense, from ecosystem services to well-being and mental health. There is increasing evidence that healthy urban ecosystems are more resistant to climate change and are one of the key measures for adapting and mitigating climate change impacts in cities. Pressures on urban biodiversity, which includes strictly protected taxa, range from light, noise, air, water and soil pollution to urban management that does not take into account ecological needs of taxa and urban ecosystems in order to be sustainable. In addition, there is limited harmonisation of methods and indicators for measuring urban biodiversity at the European scale. In line with the EU Biodiversity Strategy for 2030, as well as the new NRR, it is now critical to monitor the status and trends of urban

biodiversity, in order to develop informed conservation measures and guidelines for sustainable management of green infrastructure, as well as other urban areas that are important for biodiversity, roosts in buildings, river banks, etc. Since 75 % of the European population lives in cities, that makes city dwellers a key target group to raise awareness about biodiversity and mobilise citizen science.

Existing initiatives and policy relevance: This work should be conducted hand in hand with the Green City Accord, a movement of European cities (with over 100 signatories) committed to making cities cleaner and healthier, and build on the outcome of BiodiverCities, a pilot project nearing completion with the aim to enhance the biodiversity and green infrastructure of European cities. Potential links with the Driving Urban Transitions Partnership will also need to be explored, such as common approaches to evaluate the degree of biodiversity in European urban areas. Several national or local initiatives also exist, such as the French Capitals of Biodiversity and the newly established centre for research of urban biodiversity "Sciurus" in Zagreb (Croatia), and would also benefit from the monitoring dimension of this priority.

Biodiversa+ activities: A pilot candidate focusing on monitoring urban biodiversity has been developed for the second wave of Biodiversa+'s pilots (2024–2025), but was eventually withdrawn before evaluation. In addition, 4 Biodiversa+ partners invested in national biodiversity monitoring activities on urban biodiversity through Biodiversa+ during the 2nd instalment (Fig. 1): BOZEN, MoEP, SAS and SPW_DGO3.

11. Wetlands

Monitoring biodiversity of wetlands, including mires and peatlands

Rationale: Wetlands have undergone a strong decline globally in the past century, and are currently under threat from urbanisation, pollution and agricultural intensification. Despite being a small portion of Europe, they are increasingly recognized as critical ecosystems as they play a crucial role in biodiversity conservation, ecosystem services, water regulation and carbon sequestration. With sites present in all European countries from Scandinavia to the Mediterranean Sea, wetlands host a high biodiversity (e.g. up to 40 % of plant species), but existing policy frameworks at the European scale are not enforced or comprehensive. There is, therefore, a need for harmonised monitoring of wetland biodiversity across taxa over Europe. It is worth noting that identifying and delineating every wetland across Europe would require massive effort and multidimensional resources. This priority should instead focus on established wetlands across Europe (e.g. according to the European Nature Information System [EUNIS]) in order to provide data on their ecological status in a manageable way. Having multi-taxa biodiversity monitoring (plants, invertebrates, birds, mammals, etc.) provides more comprehensive information on habitat conservation.

Existing initiatives and policy relevance: Several initiatives of importance dealing with wetlands should be mentioned. On a global scale, the Convention on Wetlands (Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat) contributes to the conservation and sustainable use of wetlands. GEO-Wetlands is a partnership created for the

development of a global wetland observation system initiated by the Convention on Wetlands and supported by Group on Earth Observations Biodiversity Observation Network (GEO BON). In Europe, work in this priority should also coordinate with the Mediterranean Initiative on the Ramsar Convention on Wetlands (MedWet, 25 countries) and the Carpathian Wetland Initiative (CWI, 7 countries), as well as Wetlands International Europe (11 NGOs from 8 countries). Two Horizon 2020 projects are also relevant for this priority: WaterLANDS ("Water-based solutions for carbon storage, people and wilderness"), which launched large-scale wetland restoration initiatives in Europe; and MERLIN ("Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: INnovation, upscaling and transformation"), which will demonstrate best practices for freshwater restoration, including 7 case studies in wetlands and peatlands. Local or national initiatives also exist, such as the project Mhéo (*Milieux humides, évaluation, observation*—Wetlands, evaluation, observation) in France, which aims at harmonising biodiversity monitoring protocols in wetlands at a national scale.

Biodiversa+ activities: Two Biodiversa+-funded projects (under the BiodivMon call) relate to this priority: MiDiPeat ("Monitoring of peat microbial diversity through vegetation properties and its implication for carbon dynamics across European peatlands") will monitor microbial diversity and plant traits in peatlands; TRANSPONDER ("Transnational biodiversity and ecosystem assessment approaches for pondscapes in Europe") will monitor pond biodiversity. In addition, Biodiversa+ has launched a Habitat pilot in January 2024, focusing on monitoring and mapping of grassland and wetland habitats, with the aim to build a harmonised monitoring and mapping system for these two terrestrial habitats, and assess how remote sensing can effectively contribute to this goal. In addition, during the 2nd instalment, 3 Biodiversa+ partners are investing in national biodiversity monitoring activities on this priority: NPWS, OFB and SAS.

12. Wildlife Diseases

Monitoring biodiversity facets linked to health issues, from animal, livestock and human perspectives

Rationale: The interactions between wildlife, livestock and humans increase the risk of pathogen transmission and biodiversity erosion, which in turn increase the risk of emerging infectious diseases, both of terrestrial (e.g. white nose disease in bats or the African swine fever) and aquatic animals (e.g. amphibian Herpesvirus skin disease), and zoonotic risks (such as the avian influenza). This is the core concept of the One Health approach, at the intersection of human health, animal health, and environmental health. It is therefore critical to detect new infectious diseases early, and identify pathogens that can be transmitted to humans, such as mosquitoes and ticks, or shared between wildlife and livestock. Ultimately, this calls for the monitoring in space and time of diseases of species of strategic importance for the health of both wild and domesticated populations or for humans.

Existing initiatives and policy relevance: The European Green Deal, with the Farm to Fork Strategy, aims to make food systems fair, healthy and environmentally-friendly. In practice, the

European Food Safety Authority (EFSA) is an agency that provides scientific advice to risk managers and communicates on risks associated with the food chain. Specifically, on the African swine fever, each Member States has to develop a National action plan for wild porcine animals in order to avoid the spread of the disease. Recently, the European commission launched the European Partnership on Animal Health and Welfare (EUP AH&W, Horizon Europe Programme) to control infectious diseases of animals, and to promote animal welfare.

Biodiversa+ activities: The Biodiversa+-funded project IMPACT ("Integrated Monitoring of Parasites in Changing Environments"), under the BiodivMon call, will monitor freshwater fish parasite biodiversity. In addition, 5 Biodiversa+ partners invested in national biodiversity monitoring activities on wildlife diseases through Biodiversa+ during the 1st instalment (Fig. 1): MESD, MoC_EE, MoEP, OFB and VL O. This figure increased to 9 during the Biodiversa+ 2nd instalment (Fig. 1): MEPA, MESD, MoC_EE, MoEP, OFB, SAS, SPW_DGO3, SwAM and VL O.

Special topic: Transversal Activities

Supporting and valorising biodiversity monitoring: governance, administration, information systems, metrics, novel technologies, social sciences

Rationale: This special topic covers all aspects of biodiversity monitoring that are not related to specific biodiversity monitoring activities per se, but are nevertheless crucial for the advancement of biodiversity monitoring across scales. This includes fundamental aspects like governance, information systems (data systems), biodiversity metrics (e.g. essential biodiversity variables [EBVs], aggregative or composite indicators), supporting the uptake of novel technologies to monitor biodiversity, and the role of social sciences in biodiversity monitoring. Several aspects need to be considered, from filling in gaps and missing pieces in the biodiversity monitoring landscape, to coordination of existing schemes in order to leverage at a higher level the effort of national and subnational programmes.

Existing initiatives and policy relevance: The EU Biodiversity Strategy for 2030 is central for the Biodiversa+ partnership, with direct links to European regulations: the Habitats and Birds Directives, the Nature Restoration Regulation, the MSFD, the Water Framework Directive (WFD), the upcoming Soil Directive, and the Natura 2000 network. In relation to the piloting of a European Biodiversity Observation Coordination Centre (EBOCC), Biodiversa+ aims to help build national biodiversity monitoring coordination centres. Key transnational actors in this area include the European Environment Agency (EEA), European Environment Information and Observation Network (Eionet), and the European Topic Centre Biodiversity and Ecosystems (ETC BE). Global initiatives such as the Global Biodiversity Information Facility (GBIF), the Ocean Biodiversity Information System (OBIS), and the Global Biodiversity Observing System (GBiOS, a global observatory to monitor Earth's biodiversity developed by GEO BON) aim to streamline data sharing and collaboration by combining technology, data, and knowledge from around the world. At the European scale, several research infrastructures are relevant actors for transversal activities: LifeWatch ERIC is a research

infrastructure aims to provide online access to the world's biodiversity content, services and communities for scientists; EMBRC facilitates access to services, facilities, and technology platforms for marine biodiversity and ecosystems research; the eLTER Research Infrastructure provides services for users (from data management to analysis and synthesis) and in-situ facilities for long-term ecosystem research. Finally, the GBF calls for integrating biodiversity in decision making, strengthening capacity building and technology transfer, and data and knowledge sharing through several targets.

Biodiversa+ activities: Four Biodiversa+-funded projects (1 under the BiodivProtect call and 3 under the BiodivMon call) relate to this priority: TRANSNATURE ("TRANSboundary governance models of biodiversity protection: case studies for an enhanced protection of NATURal resources in Europe") focuses on transboundary biodiversity conservation governance; DNAquaIMG ("Innovative transnational aquatic biodiversity monitoring using high-throughput DNA tools and automated image recognition") focuses on the use of DNA-based and automated image-based biodiversity monitoring in freshwater; ENABLElocal ("Enabling use of biodiversity monitoring data in local conservation management") will bridging gaps between biodiversity monitoring efforts and data infrastructures at the national or transnational levels, and practical decision-making at local scales; Forest-Web-3.0 ("Mobilising, harmonising and incentivising forest biodiversity and environmental monitoring data through Web 3.0 technology") will increase forest data accessibility to stakeholders, from conservation to resource extraction; METAPLANTCODE ("Harmonising plant metabarcoding pipelines in Europe to support monitoring activities in the field of plants and their functional organismic networks") will harmonise and recommend best practices for plant metabarcoding. Altogether, transversal activities are a core focus of Biodiversa+, notably through the governance pilot (2023) and all the Biodiversa+ biodiversity monitoring activities at transnational level to support, in the long-term, the establishment of a transnational network of (sub-)national biodiversity monitoring schemes, well linked with Research & Innovation and policy, leading to improved monitoring of biodiversity. Biodiversa+ is committed to promote collaboration (notably through data sharing) across levels, all the way from transnational to local — while adhering to the principle of subsidiarity. Many ongoing and planned activities within the partnership essentially reinforce this approach, from the support to national biodiversity monitoring activities and national coordination centres to the better interoperability enabled by the use of EBVs and the development of BioDash (the European EBV-based dashboard of biodiversity monitoring programmes) and pilots. In addition, 10 Biodiversa+ partners invested in national biodiversity monitoring activities on transversal activities through Biodiversa+ during the 1st instalment (Fig. 1): BOZEN, BMUV, MESD, MoC_EE, MoE_FI, MoEP, NCA_CZ, OFB, SPW_DGO3 and VL O. This figure increased to 15 during the Biodiversa+ 2nd instalment (Fig. 1): BOZEN, DACC, EEA, ExEA, FB, MEPA, MESD, MoC_EE, MoEP, NCA_CZ, NPWS, OFB, SAS, SPW_DGO3 and SwAM.

Conclusions

This report, and the revised biodiversity monitoring priorities listed therein, provide guidelines for current and future activities of Biodiversa+ until 2028. As described above, the different topics addressed vary in their maturity level, from action-ready fields to less-defined and structured subjects. Some topics are already tackled within the Partnership's pilot programme or are covered by pilot candidates, while others have merely identified critical areas. However, these priorities are expected to be promoted with the co-funded budget dedicated to biodiversity monitoring activities to improve harmonised transnational biodiversity monitoring across Europe, and partners started investing in national biodiversity monitoring activities for all of them. It is thus essential to invest time and resources for a proper assessment of urgent actions needed for each priority, as well as the establishment of specific road maps for the third instalment of Biodiversa+. The agreed priorities identify where the partnership should help to urgently reinforce or increase monitoring efforts; some areas, like birds and mammals in general, are good examples of extensive biodiversity monitoring programmes already in place, and as such, are not part of the priorities for the partnership. Although they are very important parts of European biodiversity monitoring efforts, they are currently addressed by other ongoing initiatives. Most importantly, work and activities at the crossroads of priorities have to be encouraged. Priorities are considered perspectives to approach a particular issue, but are certainly not mutually exclusive. Rather, several perspectives—hence several priorities—on the same issue provide multiple benefits, including the possible rallying of different expert communities, as well as pooling of resources and knowledge as a path towards harmonisation.

On a different note, our priorities are defined as objects of biodiversity monitoring, focusing on the state of species or ecosystems in order to monitor, study, manage and report biodiversity changes. EBVs provide a relevant framework for biodiversity monitoring and are defined as basic information about the state of biodiversity, measured or estimated at a given biological level, and within spatial and temporal ranges and resolutions. EBVs are modular pieces of knowledge that foster harmonisation of monitoring products and provide a standardised information system for informed policy-making about biodiversity. Our biodiversity monitoring priorities thus rely on and promote EBVs as a common interoperable language across the Partnership.

Other dimensions of biodiversity notably cover pressures and impacts on biodiversity. The Driver-Pressure-State-Impact-Response (DPSIR) framework provides a complementary tool for a comprehensive management of social-ecological systems. While EBVs only focus on state variables, DPSIR conceptualises a chain of causal links from drivers (driving forces of environmental change, either natural or human), to pressures (stresses that drivers place on the environment), to states (as described by EBVs), to impacts (i.e. biological, economic and social effects of environmental change), to responses (actions by society, targeting all elements of the chain). While not embedded in the design of priorities, which, as explained above, relies on EBVs, DPSIR is a relevant tool to further analyse the products of biodiversity monitoring, and could be considered and used in a comprehensive approach to solving biodiversity problems. Climate change in particular is not a biodiversity issue *per se*, although it is one of the main pressures affecting biodiversity. Monitoring climate change *per se* would thus not fit into our framework for biodiversity monitoring, while the latter should indeed allow the assessment of climate change effects on biodiversity.

To conclude, this list of revised biodiversity monitoring priorities provides guidelines for action during the third instalment. While further work is required to fully implement all priorities, it is however essential that activities are actually carried out in the context of each priority—in other words, the current list of revised priorities encourages active contributions from Biodiversa+ partners, and highlights some directly actionable items.