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Shared goals and priorities for biodiversity indicators in Biodiversa+

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Shared goals and priorities for biodiversity indicators in Biodiversa+



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What is Biodiversa+

Biodiversa+ is the new European co-funded biodiversity partnership supporting excellent research on biodiversity with an impact for policy and society. It was jointly developed by BiodivERsA and the European Commission (DG Research & Innovation and DG Environment) and was officially launched on 1 October 2021.

Biodiversa+ is part of the European Biodiversity Strategy for 2030 that aims to put Europe's biodiversity on a path to recovery by 2030.

The Partnership aims to connect science, policy and practise for transformative change. It currently gathers 80 research programmers and funders and environmental policy actors from 40 European and associated countries to work on 5 main objectives:

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

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

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Main acronyms

BISE	Biodiversity Information System for Europe
CBD	Convention on Biological Diversity
eBMS	European Butterfly Monitoring Scheme
EBVs	Essential Biodiversity variables
EEA	European Environmental Agency
EESVs	Essential Ecosystem Service Variables
Eionet	European Environment Information and Observation Network
EU	European Union
EuropaBON	Europa Biodiversity Observation Network
FISE	Forest Information System for Europe
GEO BON	Group on Earth Observation Biodiversity Observation Network
HELCOM	Helsinki Commission. Convention on the Protection of the Marine Environment of the Baltic Sea Area.
GBF	Global Biodiversity Framework
IAS	Invasive Alien Species
IUCN	International Union for Conservation of Nature
KCBD	Knowledge Centre on Biodiversity
MSFD	Marine Strategy Framework Directive
OSPAR	Oslo and Paris Convention. Convention on the protection of the marine environment of the North-East Atlantic.
PECBMS	Pan European Common Bird Monitoring Scheme
SEEA EA	System of Environmental Economic Accounting, Ecosystem Accounting
SDGs	Sustainable Development Goals and targets
UN-WCMC	United Nations World Conservation Monitoring Centre
WFD	Water Framework Directive
WISE	Water information systems for Europe (WISE freshwater and WISE marine)

Executive Summary

[Biodiversa+](#), the European Biodiversity Partnership, aims to establish a transnational network of national biodiversity monitoring schemes. To reach this aim, collecting data that can be used to create indicators to efficiently inform policymakers and the public is of key importance. In this report, we present an overview of indicators used and the needs to develop indicators for the major European and global biodiversity goals and policies. Based on this overview and a survey to the Biodiversa+ partners, we propose the shared goals and priorities for indicator work within Biodiversa+. We suggest that Biodiversa+ focus the biodiversity indicator work on questions related to habitats and ecosystems, as well as Invasive Alien Species (IAS). Indicator work on species should also be explored, especially species within the EU Habitats and Birds Directives. Indicator work related to global goals and targets in the Convention on Biological Diversity (CBD) are also highly prioritised. The work should focus on development of guidelines and sharing of good practices. This includes continuous close contacts and collaboration with the European Environmental Agency (EEA), projects and groups as EuropaBON, EU Expert group on monitoring and assessment, and groups within CBD. The governance, including funding for the indicator work, is important to assure the continued development of indicators and exchange of good practices.

Introduction

One of the aims of Biodiversa+, the European Biodiversity Partnership, is to establish a transnational network of national biodiversity monitoring schemes. To reach this aim, the Biodiversa+ biodiversity monitoring activities are split into six main tasks (see Fig. 1). Of particular interest here is the task that defines shared goals and priority topics as well as indicators, fitting to policy, society and research needs. These priorities guide the work in the other tasks including when it comes to defining common indicators to communicate to users and deducing variables/methods/data or information flows that are needed.

A major objective for the Biodiversa+ work to improve monitoring of biodiversity and ecosystem services across Europe is thus to supply data for policy-relevant sets of indicators. Without discussing and defining priorities regarding indicators to be developed, the work will lack proper direction.

However, the policy needs for information packaged as indicators may sometimes shift fast and even unpredictably, while the development of monitoring schemes ideally needs a more stable demand structure, due to the long-term nature of monitoring. For that reason, Biodiversa+ tries to use, as a kind of bridging operation, the Essential Biodiversity Variables (EBVs) as aggregated data products between raw data and indicators (e.g., Kissling et al. 2018a, 2018b).

The aims of this report are threefold: i) to give an overview of the use of indicators in European and global contexts, ii) to review the current situation, as well as future expectations of Biodiversa+ partners, regarding how indicators could help harmonise biodiversity monitoring and assessments and iii) to recommend how to work with biodiversity monitoring indicators in the coming years within Biodiversa+.

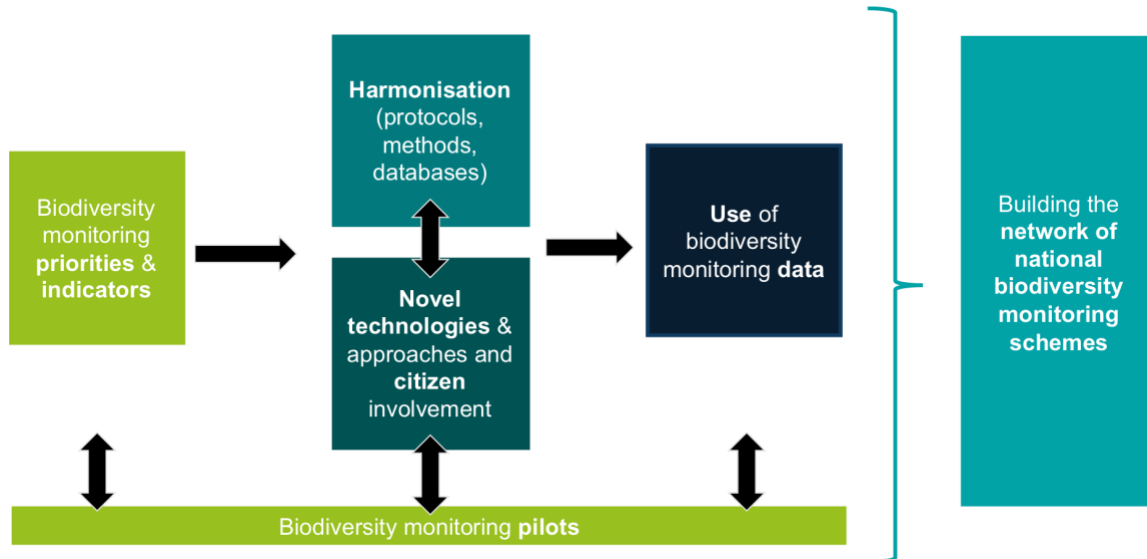


Figure 1: Organisation and workflows in Biodiversa+ that aim to create a network of biodiversity monitoring schemes. The goals and priorities set the framework for the work on harmonisation as well as promotion of new methods/technologies, protocols and databases, so that monitoring data can be efficiently used. The biodiversity monitoring pilots aim to test selected parts of the monitoring schemes and share knowledge among partners.

1. What are indicators and why do we need biodiversity indicators?

A) What are indicators?

In an earlier Biodiversa+ report (Silva del Pozo et al. 2023) the following definition of an indicator was given:

A number or qualitative descriptor generated with a well-defined method which reflects a phenomenon of interest (the indicandum). Indicators are frequently used by policy-makers to set environmental goals and evaluate their fulfilment. An indicator in policy is a metric of a policy-relevant phenomenon used to set environmental goals and evaluate their fulfilment. An indicator in science is a quantifiable metric which reflects a phenomenon of interest (the indicandum).

We will follow this definition in the present report, noting that the *indicandum* in the present context represents different aspects of biodiversity. Within this general frame, biodiversity indicators (or biodiversity relevant indicators) can take on a variety of forms and serve different purposes.

One important consideration is the need for indicators not only for biodiversity *per se*, but also for the anthropogenic factors influencing it. This need is perhaps most clearly expressed in the DPSIR model, developed (for all kinds of environmental indicanda) by the EEA (Smeets & Weterings 1999, Fig. 2).

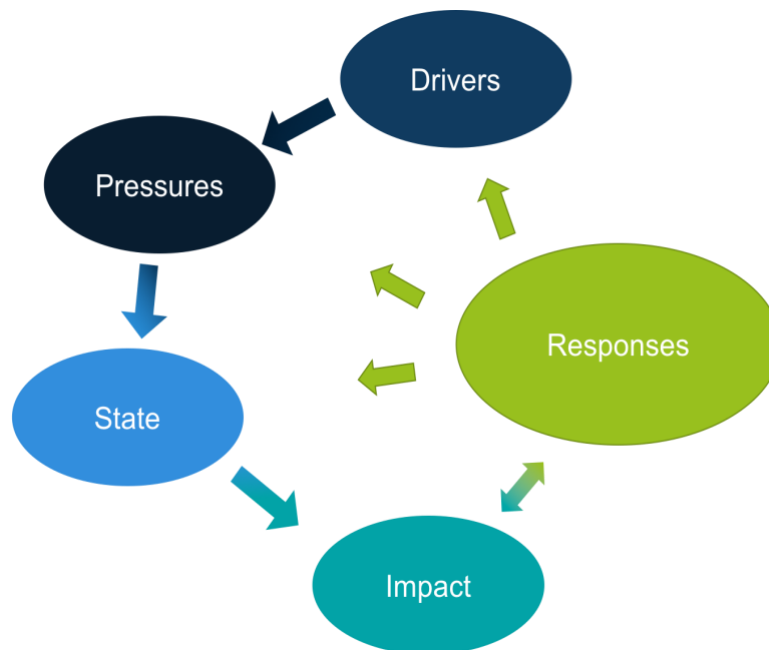


Figure 2: The DPSIR Framework (Drivers, Pressures, State, Impact, Responses). According to this view, based on systems analysis, social and economic developments (the drivers) exert pressures on the environment and, as a consequence, the state of the environment changes.



Shared goals and priorities for biodiversity indicators in Biodiversa+

Obviously, the real world is far more complex than can be expressed in a simple conceptual model¹ (Cooper 2012). Nevertheless, from the policy point of view, there is a need for clear and specific information on (i) driving forces and (ii) the resulting environmental pressures, on (iii) the state of the environment and (iv) impacts on environmental targets and values resulting from changes in environmental quality, and on (v) the societal responses to these changes in the environment. In order to meet this information need, environmental indicators, including biodiversity indicators, should reflect all elements of the causal chain that links human activities to their ultimate environmental impacts and the societal responses to these impacts. Of course, not all indicator sets are developed to cover the whole causal chain in this way, e.g. a state of the environment report may focus on presenting indicators for the state and impact parts.

Often chemical status (e.g. pH or O₂ level in soil or water), microhabitat-creating structures (like deadwood in forests) or indication of processes (e.g. grass height in grasslands as indicator of grazing pressure) are used to indicate ecosystem quality or the presence of suitable habitats for a single species or species group. However, species that are expected to thrive given certain levels of such status indicators may be absent for other reasons, e.g. the presence of toxic pollutants, or the outbreak of virulent disease within that species. The problem remains if measures of the presence (or abundance or reproductive success) of species are used as indicators for ecosystem quality or for a larger group of (non-measured) species, as these indicator species may become victims of diseases, for instance due to narrow-spectrum toxins, not affecting most of the species whose state they were intended to indicate. Often a balanced approach is recommended, with several measures for ecosystem structure, ecosystem functions, and species populations and traits combined as indicators.

Both for economic reasons and to facilitate efficient decision-making, as few indicators as possible should be estimated to cover the area of interest (i.e. the indicandum). This is preferable even for communicative purposes to the general public. However, reality is often too complex to be adequately reflected in a few simple figures. This is especially the case for assessing the state and impact for biodiversity, be it the vast multitude of species or the complex processes and interactions within an ecosystem. In many cases, indicator sets have been created for the few species groups and ecosystem structures and functions that have been available. Thus, easily observed, “charismatic” species groups, like birds and butterflies, have pioneered the development of biodiversity indicators. Even to compile and present this small fragment of the full species-level biodiversity, it has been necessary to create aggregated indicators — also named index indicators or indices — like the Common Bird Index² and the European grassland butterfly indicator³. The advent of advanced DNA- (and RNA-)based methods and AI-based methods (such as image recognition from camera traps images) may change this taxonomic bias in the near future, and even make some inroads into mapping and monitoring ecosystem processes, such as food webs

¹ Critique raised about conceptual vagueness in the DPSIR framework, especially regarding the State/Impact distinction, has triggered the development of the alternative DPSWR framework, W accounting for “Welfare”; it appears to have gained some use within the MSFD. See Cooper 2012. (<https://www.msfd.eu/knowseas/library/PB3.pdf>).

² Common Bird Index. Available at: <https://www.eea.europa.eu/ims/common-bird-index-in-europe>

³ European grassland butterfly indicator. Available at: <https://www.eea.europa.eu/data-and-maps/figures/european-grassland-butterfly-indicator>

(e.g. by analysing DNA in gut content, predator-prey relationships may be mapped, as well as biodiversity of gut microbes).

With much more data available due to the application of new technologies in the near future, the problem may partially shift from data scarcity and a taxonomically biased data availability to the task of interpreting a superabundance of data. To create meaningful indices, taxonomic (“butterfly”) and ecosystem (“grassland”) aggregation should be complemented by other aggregation criteria, e.g. by ecological guild, reproductive strategy, dispersal ability, tolerance to different climate parameters, oxygen levels, toxic substances, etc. A systematic mapping and classification of species has been done only within a few taxonomic groups and for a few sets of characters, as for the Ellenberg indices for vascular plants (Ellenberg et. al. 2001, Tyler et. al. 2021). Much more ought to be done in this field.

Even if a serious ambition to reflect reality is essential for all indicator systems, the communicative aspects of indicators cannot be overlooked. Both the degree of aggregation and simplification and the mode of presentation (e.g. as numerical tables, quantitative graphs, maps or classes of symbols such as “traffic lights”) must be tailored to different target groups and different communicative contexts, from printed publications to digital social media platforms.

B) Biodiversa+ contribution to indicator harmonisation and development

Biodiversa+ has set up a joint working group for indicator harmonisation and development involving seventeen actively contributing Biodiversa+ partners during the first 2022–2023 cycle of Biodiversa+. The working group had six meetings during that period. Knowledge sharing of indicator work within the partner organisations of Biodiversa+ and countries has been a major part of the work. Presentations of ongoing and planned work were given by the Vlaams gewest/Flemish region (VL O, Belgium), the Ministry of Environment Finland (MoE_FI, Finland), the French biodiversity agency (Office français de la biodiversité, OFB, France), the Swedish Environmental Protection Agency (SEPA, Sweden), and the Nature protection agency in Germany (Bfn Bundesamt für Naturschutz, a third party of Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU), Germany) together with VDI/VDE INNOVATION + TECHNIK GMBH Germany.

To include all the ongoing work on biodiversity monitoring indicators, and priority indicator needs, carried out by the Biodiversa+ ministries of environment, environmental protection agencies and other relevant partners of the network (for example at sub-national scale) a survey was sent to all these organisations. The outcome of the survey is described further below in the section *National and sub-national current work and biodiversity indicator priorities*, and suggested further indicator work within Biodiversa+ are described in the section *Proposed biodiversity indicator work within Biodiversa+* below.

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The discussions and knowledge sharing within the working group were complemented with:

- Regular exchanges with partners within Biodiversa+ through the transversal working group with the aim to establish a transnational network of national biodiversity monitoring schemes, see Fig. 1.
- Biodiversa+ reports: “Biodiversity monitoring knowledge gaps and research & innovation priorities” (Hoye et. al 2022), and “Guidance note presenting shared goals/priorities for biodiversity monitoring within Biodiversa+ (Basille et. al 2023).
- Discussions within the Biodiversa+ pilot program⁴.
- Ad-hoc documentation and collaboration with EuropaBON such as the “Europa Biodiversity Observation Network: User and Policy Needs Assessment” report (Moersberger et al. 2022), “List and specifications of EBVs and EESVs for a European wide biodiversity observation network” (Junker et al. 2023), as well as joint meetings and workshops such as the 2022 EuropaBON conference in collaboration with Biodiversa+ on Shaping the future European biodiversity monitoring framework, workshops on methods and Essential Biodiversity variables (EBVs) and the 2023 EuropaBON workshop on showcases and co-design.

⁴ Biodiversa+ monitoring pilot program. Available at: <https://www.biodiversa.eu/biodiversity-monitoring/pilot/>

2. European and global biodiversity indicators

A) Overview of European indicators for biodiversity

Many of the European biodiversity indicators are developed to follow the progress in major policies and legislations within the European Union as well as European and regional conventions, that aim to protect, preserve, and restore biodiversity. Most notably the EU Birds- and Habitats Directives, Marine Strategy Framework Directive (MSFD)⁵, Water Framework Directive (WFD)⁶, Regulation on Invasive Alien Species⁷, Regulation on European Environmental Economic Accounts⁸ including ecosystem extent and condition, the EU Biodiversity Strategy for 2030⁹ including the proposed EU Nature Restoration Law¹⁰, EU Forest Strategy¹¹, EU Soil Strategy¹², the Pollinators Initiative¹³, Bern Convention on the conservation of European wildlife and natural habitats¹⁴, Barcelona Convention for the Protection of the Mediterranean Sea¹⁵, Bucharest Convention¹⁶, Helsinki Convention (HELCOM)¹⁷, and OSPAR Convention¹⁸. Information of European biodiversity indicators related to specific policy areas can be found via the respective Directive, convention, regulation, strategy or initiative (Table 1).

There are also some widely used indicators that have been developed from voluntary initiatives such as the Pan European Common Bird Monitoring Scheme (PECBMS), and the European Butterfly Monitoring Scheme (eBMS), see Table 2. These indicators are also included as indicators

⁵ The Marine environment EU policies to protect Europe's ocean, seas and coasts. European Commission. Available at: https://environment.ec.europa.eu/topics/marine-environment_en

⁶ Water Framework Directive. European Commission. Available at: https://environment.ec.europa.eu/topics/water/water-framework-directive_en

⁷ Invasive Alien Species. European Commission. Available at: https://environment.ec.europa.eu/topics/nature-and-biodiversity/invasive-alien-species_en

⁸ Regulation (EU) No 691/2011 of the European Parliament and of the Council of 6 July 2011 on European environmental economic accounts Text with EEA relevance. European commission. Available at: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32011R0691>

⁹ Biodiversity strategy for 2030. European Commission Available at: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

¹⁰ Nature restoration law. European Commission. Available at: https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en

¹¹ New EU forest strategy for 2030. European Commission. Available at: https://environment.ec.europa.eu/strategy/forest-strategy_en

¹² Soil strategy for 2030. European Commission. Available at: https://environment.ec.europa.eu/topics/soil-and-land/soil-strategy_en

¹³ 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. European Commission. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1528213737113&uri=CELEX:52018DC0395>

¹⁴ Bern Convention. Convention on the Conservation of European Wildlife and Natural Habitats. Council of Europe. Available at: <https://coe.int/en/web/bern-convention>

¹⁵ Barcelona Convention and Amendments. UN Environment Programme. Mediterranean Action Plan. Barcelona Convention. Available at: <https://www.unep.org/unepmap/who-we-are/contracting-parties/barcelona-convention-and-amendments>

¹⁶ The Commission on the Protection of the Black Sea Against Pollution. Available at: <http://www.blacksea-commission.org/>

¹⁷ HELCOM. Helsinki Convention. Baltic Marine Environment Protection Commission. Available at: <https://helcom.fi/>

¹⁸ OSPAR commission. Available at: <https://www.ospar.org/>



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of targets in various policies and strategies, for example the EU Biodiversity Strategy for 2030 (Table 1).

However, considering the vast area and sheer number of policy areas, it is a major task to get an overview of European indicators for biodiversity in all ecosystems and policy areas. Table 2 lists major organisations, networks and initiatives where information and data on indicators are shared. A set of indicators are compiled by the European Environmental Agency (EEA) and the associated European Environment Information and Observation Network (Eionet) and European Topic Centres. Europa Biodiversity Observation Network (EuropaBON), is the European partner of the global Group on Earth Observations Biodiversity Observation Network (GEO BON) that allows the sharing of datasets and indicators. Also, in 2020, the European Commission in close cooperation with the EEA established the Knowledge Centre for Biodiversity (KCBBD) with the aim of facilitating the sharing of knowledge and fostering cross-sectorial policy dialogue for EU policy-making in biodiversity and related fields. KCBBD has established a dashboard with indicators that show progress for the EU Biodiversity Strategy for 2030.

Detailed information on the indicators and statistics can be found in descriptions of the monitoring programmes, and in various databases such as the Biodiversity Information System for Europe (BISE), the Freshwater and Marine information systems for Europe (WISE freshwater and WISE marine), the Forest Information System for Europe (FISE), PECBMS, eBMS, and the Europa Biodiversity Observation Network (EuropaBON) (Table 2).

Table 1: European biodiversity policies, types and source of information for biodiversity indicators.

EU Biodiversity policies	Types of indicators	Source
Birds Directive	Per taxonomic group: Share of species with good, poor, bad or unknown population status. Share of species with increasing, stable, fluctuating, decreasing or uncertain/unknown short- and long-term trend, respectively, for breeding populations and winter populations, respectively.	https://www.eea.europa.eu/en/topics/at-a-glance/nature/state-of-nature-in-europe-a-health-check/explore-nature-reporting-data?activeAccordion=9efcbfbe-66bb-4c3d-ae16-fe4264c17d4c
Habitats Directive	For the listed habitats and species: Conservation status as favourable, unfavourable inadequate, unfavourable bad or unknown. Conservation status includes four separate evaluations: Area, range, quality and future prospects for habitats including trends; population, range, habitat quality and future prospects for species including trends.	https://www.eea.europa.eu/en/topics/at-a-glance/nature/state-of-nature-in-europe-a-health-check/explore-nature-reporting-data?activeAccordion=9efcbfbe-66bb-4c3d-ae16-fe4264c17d4c
Marine Strategy Framework Directive	Good environmental status, contains 11 descriptors that include pressures and state indicators for birds, mammals, reptiles, fish, habitats and ecosystems.	https://water.europa.eu/marine/data-maps-and-tools/msfd-reporting-information-products/ges-assessment-dashboards
Water Framework Directive	Good status consists of four assessments: ecological and chemical status of surface waters, and chemical and quantitative status of groundwater. Priority substances cannot exceed Quality Standards for good chemical status. Ecological status estimates the quality and pressures on quality elements. Groundwater quantitative status measures long-term annual rate of abstraction.	https://water.europa.eu/freshwater/europe-freshwater/water-framework-Directive
Regulation on Invasive Alien Species	Distributions of invasive alien species of Union Concern.	https://environment.ec.europa.eu/topics/nature-and-biodiversity/invasive-alien-species_en
Regulation on European Environmental accounts	Measures ecosystem extent and condition, ecosystem services and monetary ecosystem assets. Ongoing indicator development; with alignment with UN's SEEA EA as a major goal.	https://biodiversity.europa.eu/europes-biodiversity/ecosystems/ecosystem-accounting
Biodiversity strategy for 2030	Indicators for 16 targets under 4 actions on: protected areas on land and sea, EU nature restoration plan, enable transformative change, and global biodiversity.	https://dopa.jrc.ec.europa.eu/kcbd/dashboard/
Proposed Nature Restoration law	Proposed measures and indicators for coastal-, freshwater-, marine-, urban-, agricultural-, and forest ecosystems, connectivity of rivers and floodplains, and pollinators.	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0304



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EU Biodiversity policies	Types of indicators	Source
Ministerial Conference on the Protection of Forests in Europe (Forest Europe)	Forest Europe has developed a set of indicators for sustainable forest management. The latest version, from 2015, includes 10 quantitative indicators on biodiversity.	https://foresteurope.org/wp-content/uploads/2022/02/7MC_MadridMinisterialDeclaration.pdf
Forest strategy	Guidelines for defining, mapping, monitoring and strictly protecting EU primary and old-growth forests are under development and implementation. As a part of this strategy, a COM proposal for a Regulation on a <i>monitoring framework for resilient European forests</i> , including some indicators of relevance for biodiversity, was released 22 nd November 2023.	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0572 https://eur-lex.europa.eu/legal-content/SV/TXT/?uri=COM:2023:728:FIN
Soil strategy	Under development. As a part of the strategy, a COM proposal on Soil Monitoring and Resilience (Soil Monitoring Law) was released on 5 th July 2023, and is presently under negotiation. However, only a few of the so-called descriptors (roughly corresponding to sub-indicators for soil health) concern biodiversity, and all but one of them are voluntary.	https://environment.ec.europa.eu/topics/soil-and-land/soil-strategy_en https://www.eea.europa.eu/publications/soil-monitoring-in-europe https://environment.ec.europa.eu/publications/proposal-Directive-soil-monitoring-and-resilience_en
Pollinator initiative	Proposed monitoring and indicators in the EU Pollinator Monitoring Scheme (EU-PoMS): Measures status and trend wild bees, butterflies, hoverflies, moths, and rare pollinator species. Specific indicators to evaluate the impacts of the Common Agricultural Policy.	https://wikis.ec.europa.eu/pages/viewpage.action?pageId=23462107
Bern Convention	Conservation of European wildlife and natural habitats. Indicators for conservation status of species and habitats and protected sites under the convention in non-EU countries.	https://www.coe.int/en/web/bern-convention/reporting
Barcelona Convention	Protection of the Mediterranean Sea. Indicators for 11 objectives: biodiversity, non-indigenous species, fish and shellfish, marine food webs, eutrophication, sea-floor integrity, hydrography, coastal ecosystems and landscapes, pollution, marine litter, energy.	https://www.unep.org/unepmap/what-we-do/monitoring-and-assessments http://www.info-rac.org/en/infomap-system/imap-pilot-platform
Bucharest Convention	Protection of the Black Sea. Black Sea integrated monitoring and assessment programme. Methods for integration of national indicators and criteria to regional assessments of overall status at the level of descriptors for the Marine Strategy Framework Directive. .	http://www.blacksea-commission.org/Downloads/ANEMONE/Deliverable%201_3.pdf
HELCOM	Protection of the Baltic Sea. Status, pressures and drivers of the Baltic Sea marine environment, including plankton, fish, mammals and water birds.	https://indicators.helcom.fi/
OSPAR	Protection of the north-east Atlantic. OSPAR common indicators include indicators for: marine mammals, seabirds, fish, benthic and pelagic habitats, food webs, non-indigenous species, marine litter, underwater noise, eutrophication, hazardous substances. OSPAR also produces quality status assessments.	https://www.ospar.org/work-areas/cross-cutting-issues/ospar-common-indicators https://oap.ospar.org/en/ospar-assessments/quality-status-reports/

Table 2: Information and databases of European biodiversity data and indicators.

Databases/source of information	Reference
European Environmental Agency on indicators	https://www.eea.europa.eu/ims
European Environment Information and Observation Network	https://www.eionet.europa.eu/
European Topic Centre Biodiversity and Ecosystems dashboards	https://www.eionet.europa.eu/etcs/index https://www.eionet.europa.eu/etcs/etc-be/activities/dashboards
Biodiversity Information System for Europe	https://biodiversity.europa.eu/
Knowledge Centre for Biodiversity	https://knowledge4policy.ec.europa.eu/biodiversity_en
Freshwater Information System for Europe	https://water.europa.eu/freshwater
Marine Information System for Europe	https://water.europa.eu/marine/about/wise-marine
Forest Information System for Europe	https://forest.eea.europa.eu/ https://forest.eea.europa.eu/topics/forest-biodiversity-and-ecosystems/forest-ecosystems
Pan-European Common Bird Monitoring Scheme	https://pecbms.info/trends-and-indicators/indicators/
European Butterfly Monitoring Scheme – eBMS	https://butterfly-monitoring.net/
Europa Biodiversity Observation Network	https://europabon.org/?page_id=2513

B) Overview of global indicators for biodiversity

The Monitoring Framework for the Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework (GBF) was adopted as decision 15/5¹⁹. The monitoring framework contains a limited set of headline indicators that all parties shall report on, and which cover the main elements of the goals and targets of the GBF, but some of them still need development. In addition, there are optional component indicators, to cover remaining components of the goals and targets, and optional complementary indicators for in-depth analysis. For some goals and targets, in particular those yet lacking any headline indicators, a different category called ‘Binary indicators’ has been proposed to track implementation (for example, answering yes or no if a certain regulation has been introduced). The United Nations World Conservation Monitoring Centre (UN-WCMC) is maintaining a repository of the CBD indicators and their associated metadata (Table 3). An Ad-hoc Technical Expert Group is tasked to further develop the indicator system for the monitoring framework.

A number of global indicators were developed to track progress towards the Sustainable Development Goals and targets (SDGs) of the 2030 Agenda for Sustainable Development (Table 3). Of the total 231 indicators, only a small subset cover biodiversity and ecosystem services, and several of these were also included in the CBD monitoring framework.

¹⁹ Monitoring Framework for the Convention on Biological Diversity (CBD) Kunming-Montreal Global Biodiversity Framework (KMGBF). Available at: <https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-05-en.pdf>



Shared goals and priorities for biodiversity indicators in Biodiversa+

Several global and regional agreements and organisations also use indicators for biodiversity in their reporting and assessment activities. The Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) produce regular assessments, and most notably their comprehensive Global Assessment from 2019 (IPBES 2019) used a multidimensional system of indicators from a variety of sources to measure progress towards international goals such as CBD's Aichi biodiversity targets and the SDGs, evaluate policy instruments and consider plausible future scenarios. More information on the indicators can be found in the Chapters 1 and 2.2 supplementary material (Table 3). A second Global Assessment will be done for 2024–2028. Several other published and forthcoming assessments of IPBES use a variety of indicators, and there is continuing work on developing indicators, such as in the task forces on knowledge and data and on scenarios and models. A methodological assessment on monitoring of biodiversity and nature's contribution to people will be carried out in 2024–2025, with the objectives to support national and global efforts to (a) monitor biodiversity, nature's contributions to people and the direct and underlying causes of the observed changes; and (b) specifically monitor progress towards the goals and targets of the GBF by implementing the monitoring framework for the GBF. The assessment will also contribute to monitoring the 2030 Agenda for Sustainable Development and its Sustainable Development Goals as well as other relevant multilateral environmental agreements, processes and efforts.

Table 3: Major information of global biodiversity indicators.

Databases/source of information	Reference
Convention on Biological Diversity (CBD) indicators at UN-WCMC	https://www.post-2020indicators.org/
Group on Earth Observations Biodiversity Observation Network (GEO BON)	https://geobon.org/ebvs/indicators/
Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES)	https://www.ipbes.net/resource-file/102073 , https://www.ipbes.net/resource-file/102075
Sustainable Development Goals and targets	https://unstats.un.org/sdgs/indicators/indicators-list/
The Biodiversity Indicators Partnership	https://www.bipindicators.net/

C) European and global further needs for harmonisation and developments of biodiversity indicators

Despite harmonisation efforts, different methods are often permitted and used for both European and global biodiversity indicators which introduce uncertainty in the evaluation of the indicandum. Methods and efforts to collect the underlying data also vary. Thus, harmonisation and development of indicators are still needed. Below we address these needs for the major European and global indicators for biodiversity that are listed above (Table 1-3).

a) European biodiversity indicators

Habitats Directive

Conservation status for habitats and species listed in the Habitats Directive is evaluated with an index composed of four separate indicators (i.e. parameters equivalent to EBVs) of range, population size for species and area for habitats, habitat quality and future prospects.

The guidelines (DG Environment 2023) provided for the member states reporting conservation status, allow the use of different methods. For instance, status of the habitat's area and range is evaluated by comparing the current area and range against a reference area and range that can sustain the long-term survival of the habitat's species. Here different methods to measure reference area and range are allowed. Evaluation of a habitat's quality also allows for different methods that both affect the outcome of the evaluation of quality status and the calculation of the habitat's area. The methods for evaluating the importance of areas with good quality in the landscape, i.e. distribution patterns within the range, are described in general terms with no clear methodology.

Thus, harmonisation of methods used by member states for the indicators of conservation status would give a better understanding of the area and quality needs, as well as needs for distribution and connectivity patterns for the long-term existence of habitats and species.

Ecosystem assessments and Ecosystem accounting

There are efforts to map and assess European ecosystems (Maes et al. 2020) and, as a further step, to create an EU-wide methodology that is consistent with the global standard for Ecosystem accounting (SEEA EA)²⁰. These are great steps forward and can partly serve as a good example for the work on harmonising the Habitats Directive reporting. Conversely, much work remains to be done to properly integrate data for habitats in Annex 1 of the Habitats Directive as an important component of broader ecosystem assessments and accounts. A major problem is that the SEEA EA envision a system of normalised ecosystem status indicators, going from a reference level (=1) corresponding to an optimal (or desirable) state, all the way down to a level of outright ecosystem collapse (=0), while the Annex 1 habitats of the Habitat Directive are normally considered to reach a point of maximum decay long before that, and areas with worse conditions are not classified as Annex 1 habitats at all.

Thus, there is still a need to develop indicators that further consider how information on the state of high-quality areas (e.g. Annex 1 habitats) shall be represented within broader (wall-to-wall) ecosystem assessments, including ecosystem accounts. It should include assessing the relationships between high-quality areas (e.g. Annex 1 habitats) and the surrounding landscape, i.e. analysing connectivity, patch size needs, and total aerial needs.

Proposed Nature Restoration Law

²⁰ Ecosystem Accounting. UN SYSTEM OF ENVIRONMENTAL ECONOMIC ACCOUNTING. Available at: <https://seea.un.org/ecosystem-accounting>

Shared goals and priorities for biodiversity indicators in Biodiversa+

The proposed Nature Restoration Law²¹ describes and suggests indicators to follow the effects of restoration measures for biodiversity. The proposal aims to complement existing environmental policies for wider ecosystems thereby encompassing all scales of biodiversity. Existing indicators are suggested when appropriate. However, there are also suggestions of further developments of indicators, for example for agricultural and forest ecosystems. It is also suggested to adopt the EU-wide methodology described above (Maes et al. 2020) and baselines for assessing the condition of ecosystems. Therefore, there will be a need to develop more indicators in EU member states to properly follow the effects of restoration measures as well as to harmonise already existing national indicators.

Proposed Directive on Soil Monitoring and Resilience

A proposal for a Directive on Soil Monitoring and Resilience by the European Commission was made public on 5 July 2023²². The monitoring approach is focused on state indicators (called descriptors) corresponding to different pressures, like salinization, erosion, loss of soil organic carbon, subsoil compaction, acidification, soil sealing, etc. Impact on biodiversity is proposed to be measured by a single obligatory descriptor: soil basal respiration in dry soil. However, member states may also select other optional soil descriptors for biodiversity such as:

- metabarcoding of bacteria, fungi, protists and animals.
- abundance and diversity of nematodes.
- microbial biomass.
- abundance and diversity of earthworms (in cropland).
- invasive alien species and plant pests.

A soil basal respiration descriptor may partly reflect some provisioning ecosystem services from biodiversity components within a healthy soil. However, development of the type of (for now) optional biodiversity descriptors, exemplified in the proposed directive text cited above, should be a focus for indicator development on soil biodiversity.

Other indicators for species: Birds Directive, Pollinators, Invasive Alien Species

The reporting cycles for the Birds Directive and Habitats Directive are coordinated and used to evaluate the state of nature in Europe. However, the composed indicator of conservation status that is used for species in the Habitats Directive is not used for birds. Also, methods to evaluate population status differ. Good status of the species populations in the Habitats Directive requires a population that does not go below a set reference value for the population. Status for birds in the Birds Directive use the International Union for Conservation of Nature's (IUCN) red list criteria instead, that are based on trends and risk of extinction. Pressures are reported for species in both the Habitats and Birds Directives. However, the indicator of future prospects that evaluate trends against pressures and measures that are conducted for habitats and species in the Habitats

²¹ Proposal for a Regulation of the European parliament and of the council on nature restoration. Annexes to the proposal for Regulation of the European Parliament and of the Council on nature restoration. European Commission. Available at: [EUR-Lex - 52022PC0304 - EN - EUR-Lex \(europa.eu\)](https://eur-lex.europa.eu/lexUri.do?uri=CELEX:52022PC0304-EN)

²² Proposal for a Directive on Soil Monitoring and Resilience. European Commission. Available at: https://environment.ec.europa.eu/publications/proposal-directive-soil-monitoring-and-resilience_en

Directive are not conducted for birds. Instead, the trends are given as increasing, stable, fluctuating, decreasing or uncertain/unknown. The introduction of assessments of conservation status for birds has been discussed, but it has not been implemented. A major factor being that the Birds Directive covers all breeding and wintering birds, and that would demand major additional resources from the member states. Thus, there is a larger need for harmonisation and development of monitoring methods and efforts than that of the indicators.

The discovery of a drastic decrease in insects, including pollinator species, has resulted in the pollinator initiative²³. Methods for both monitoring and indicators are proposed and under development. The results from the ongoing STING project²⁴ will show further needs of indicator development.

Member states are obliged to report on the distribution of Invasive Alien Species (IAS) of Union concern under the regulation of IAS. Also, an indicator of the effects of IAS on species assessed as threatened with the IUCN Red List are developed within the Red Pulse project. This indicator is suggested to follow the target of a 50% reduction of the number of Red List species threatened by IAS in the Biodiversity strategy for 2030. However, there is still room to develop indicators that explore the effects of IAS on biodiversity. Especially in relation to other policy goals for habitats and species (i.e. the Habitats Directive, and restoration) and in relation to climate change.

Marine Strategy Framework Directive and regional seas conventions

The description of good environmental status (GES) in the Marine Strategy Framework Directive (MSFD), contains 11 descriptors, i.e. indicators, describing both pressures and state. The descriptors are divided into different criteria through Commission Decision on good environmental status (EU) 848/2017. Threshold values for different characteristics are to be established for at least all mandatory criteria. On biodiversity the MSFD covers species of birds, mammals, reptiles, fish and cephalopods. It also covers all benthic habitats and all pelagic habitats within the exclusive economic zone together with food webs and ecosystems.

The developments of indicators (methods and threshold values) are to a large extent done within union or regional cooperation in the four regional sea conventions for the Baltic Sea (Helsinki Commission HELCOM), the North-East Atlantic (Oslo Paris Convention OSPAR), the Mediterranean (Barcelona Convention) and the Black Sea (Bucharest Convention). This cooperation is also required under the MSFD.

Development of indicators and/or methods (including data collection) are still needed. It is important that it is done in close collaboration with the Common Implementation Strategy (CIS) and the regional sea conventions. There are also several connections to both the Habitats Directive and Water Framework Directive.

²³ Food security and ecosystem resilience: Commission boosts action on pollinators. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/ip_23_281

²⁴ Science and Technology for Pollinating Insects: https://knowledge4policy.ec.europa.eu/participatory-democracy/science-technology-pollinating-insects-sting_en

Shared goals and priorities for biodiversity indicators in Biodiversa+

Water Framework Directive

Good ecological status for the Water Framework Directive (WFD) consists of four assessments: ecological and chemical status of surface waters, and chemical and quantitative status of groundwater. Ecological status of surface waters assesses overall ecosystem health as expressed by the biological quality elements phytoplankton, macrophytes, phytobenthos, benthic invertebrate fauna and fish. The biological quality elements are supported by status assessments of hydromorphological, such as hydrological regime, and physico-chemical quality elements, such as nutrients. Each quality element includes assessments of a number of different parameters. Achieving good ecological status implies that all quality elements must be in at least good status. No deterioration of status is allowed at the level of quality elements. Within this framework, cross-member states technical working groups operate directly under the European Commission (Common Implementation Strategy, CIS²⁵). These working groups provide guidance documents on technical and/or thematic aspects of the WFD, ensure intercalibration, and arrange key events.

The biological quality elements need to be chosen to detect several kinds of anthropogenic pressures. To date, the primary focus in the EU has been on pressures from eutrophication. Less attention has been paid, for example, on biological indexes sensitive to physical disturbance of water bodies. These include the effects of drainage in urban environments and agriculture on biota, as well as effects on biota in response to hydrological and morphological changes from hydropower. It is therefore important that **specific biological parameters and subindexes still need to be developed**.

EU Biodiversity Strategy for 2030

The knowledge centre for biodiversity has presented a gap analysis for the state of play of indicators following the progress of the goals in the EU Biodiversity Strategy for 2030 (Robuchon et al. 2023). This shows that there are currently 10 indicators to monitor 5 of the 16 targets.

Indicators that follow targets for primary and old-growth forest, protected areas, urban biodiversity, and by-catch of marine species are missing and there is a need to further explore possible indicators for these areas.

There are also several placeholders for indicators that are under development in various projects and policies that may be used to follow the EU Biodiversity Strategy for 2030, but may need further development to capture the specific goals of the strategy. This includes development of indicators to evaluate landscape aspects for effective protection and preservation of biodiversity, such as the representativeness and value of protected areas and high-diversity landscape features, i.e. hotspots of biodiversity, and their connectivity in the landscape. In this area, there are also specific targets with a need to develop indicators to evaluate the connectivity in rivers, as well as biodiversity connected to agricultural land.

²⁵Common Implementation Strategy, CIS: <https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/dd9b4484-2935-4ee8-b3ce-72f844f3644c>

Indicator developments are also needed for targets that aim to reduce pressures and/or restore various habitats, such as contaminants and nutrients in soils and freshwater, and pressure from fishing activities including seabed destruction and extraction.

b) Global biodiversity indicators

The CBD monitoring framework for the GBF currently lacks headline indicators for some of the goals and targets, and the terms of reference for the Ad-hoc Technical Expert group will address those gaps with existing or new indicators. By its nature, indicators to cover progress to global goals and targets need to be harmonised and standardised in order to be applicable and comparable for countries from different regions with different circumstances. The development of harmonised global indicators is facilitated by initiatives such as the Global Indicators Partnership and GEO BON (Table 3). At the European level, work is ongoing in the EU Biodiversity Platform to harmonise indicators for the EU Biodiversity Strategy for 2030 with those in the CBD monitoring Framework (Robuchon et al. 2023).



3. National and sub-national current work and biodiversity indicator priorities

A) Survey of Biodiversa+ partners' ongoing work, and needs for harmonisation and developments of biodiversity indicators

To explore the Biodiversa+ partners major work on biodiversity indicators as well as priority biodiversity indicator needs, a survey was sent to ministries of environment, environmental protection agencies and other relevant partners of Biodiversa+ contributing parties.

The survey aimed to get information on the priority areas for Biodiversa+ partners when it comes to working on biodiversity monitoring indicators in the short-term (years 2023–2025) and long-term (years 2026–2028). The long-term priorities include work on harmonisation and/or development that Biodiversa+ can contribute to, even though it may need further development after 2028.

The survey explored Biodiversa+ priority areas for biodiversity indicator harmonisation and/or development related to global and European policy frameworks, directives, regulations and laws, in relation to national and sub-national needs.

The survey resulted in 26 answers from 24 different countries, and it should be noted that the survey is not exhaustive. However, respondents have a good geographical distribution (Fig. 3), and some of the partners mobilised extra experts to provide specific information. Also, almost 80 % participants answered on a national level.



Figure 3: Countries covered by the Biodiversa+ indicators survey (in turquoise)

B) Overview of national and sub-national indicators

Most Biodiversa+ partners who answered the survey declared that they have ongoing or planned work on biodiversity indicators. There are multiple purposes and use of the indicators, with the main purposes in the short term (2023-2025) being to inform the general public, to support decision making, and to be a reference on the state of biodiversity (Fig. 4). To support EU and global strategies, policies, directives, and/or initiatives are also of major importance.

In the long-term (2026–2028), the respondents foresee a large increase in planned indicator work in general, and especially an increase in indicator work related to global and EU strategies and policies.

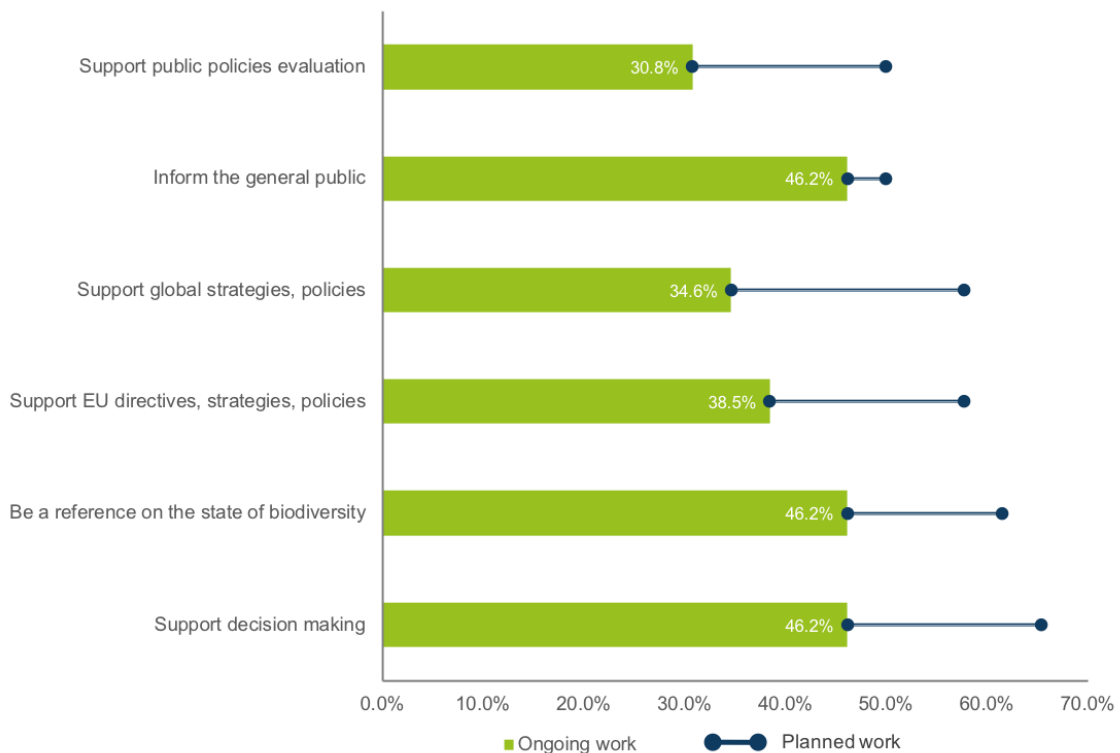


Figure 4: The partners main purposes of their planned (light green) and ongoing (dark green) indicator work.

The main focus of the partners ongoing and/or planned work on biodiversity indicators for ecosystems and habitats are forest and grasslands, followed by coastal, freshwater and marine habitats (Fig. 5). The bogs, mires and fens, rocky, dune, heath and shrub habitats were less represented in current work on indicators.

Shared goals and priorities for biodiversity indicators in Biodiversa+

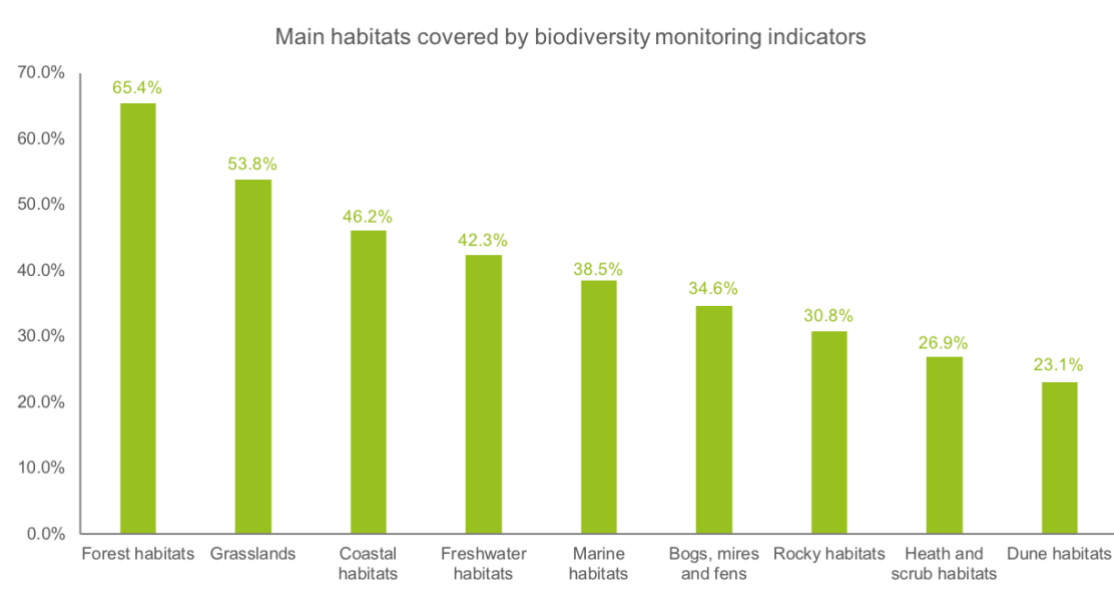


Figure 5: Main focus of the partners ongoing and/or planned work on biodiversity indicators for major habitat groups.

There were almost as many partners working on or planning work on indicators related to species as indicators for habitats. From the suggested species groups in the survey, the main focus of the partners work on biodiversity indicators for species were birds, with almost 60 % of the respondents having ongoing and/or planned indicator work for this group of species. Also, many have ongoing and/or planned work on bats, vascular plants, insects, mammals other than bats, and fish. Amphibians, non-vascular plants, and molluscs are included for around 30 % of the respondents. Indicator work for reptiles and woody plants are uncommon (Fig. 6).

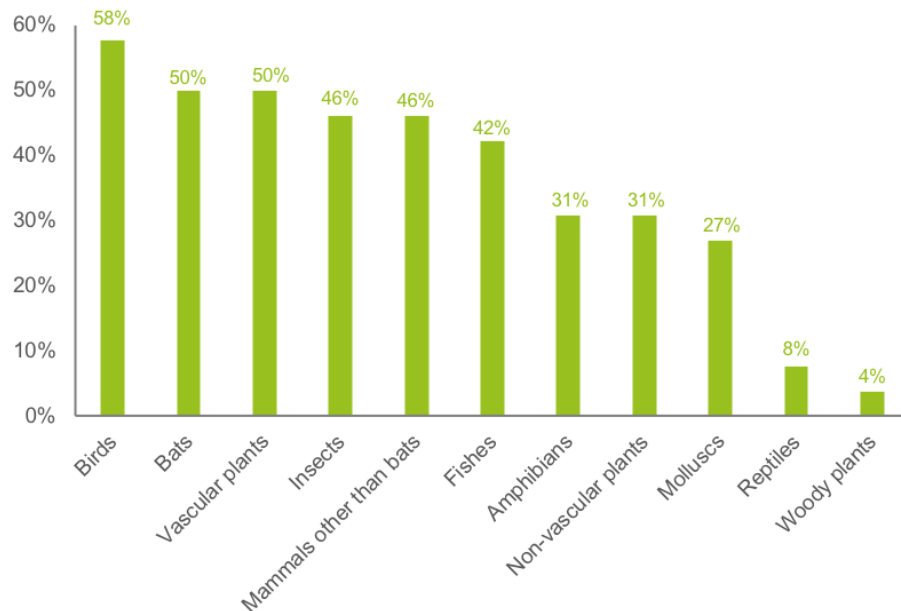


Figure 6: Main species groups for the partners ongoing and/or planned indicator work.

Many partners also have ongoing and/or planned work on biodiversity indicators for invasive alien species and protected areas (Fig. 7), as well as for rare species and pollinator species. There are also around 40% of the respondents that have ongoing and/or planned work on common species and soil biodiversity. Work on urban biodiversity and genetic diversity were unusual, and only one answered that they worked with indicators for wildlife diseases.

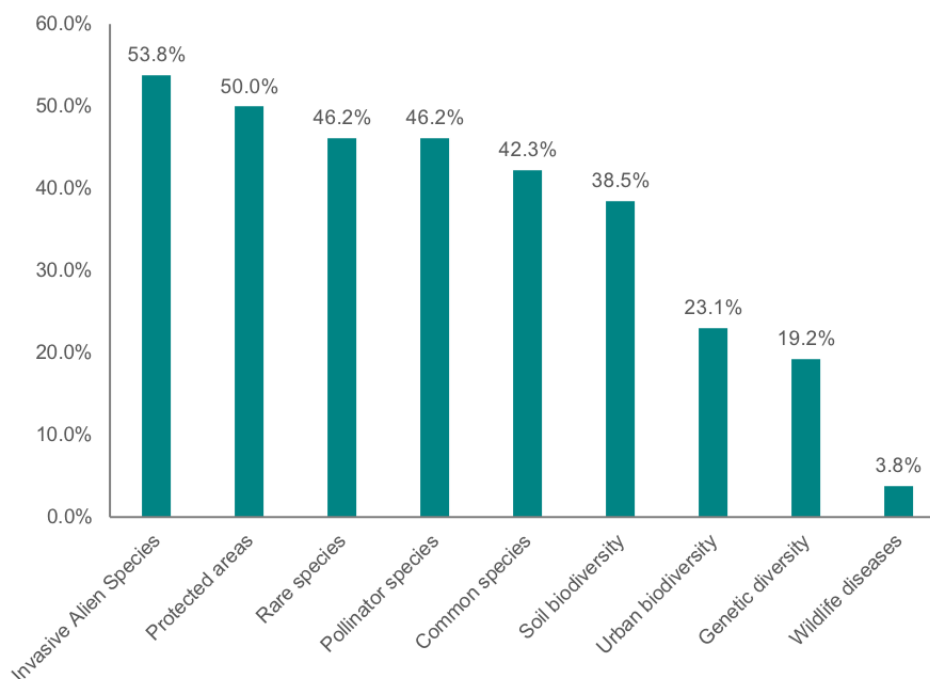


Figure 7: Ongoing and/or planned work on biodiversity indicators related to invasive alien species, rare- common- and pollinator species, genetic diversity, soil biodiversity, wildlife diseases, and biodiversity in urban and protected areas.

C) National and sub-national biodiversity indicator priorities

a) European biodiversity policies

According to the survey, highest priorities for harmonisation and/or indicator development related to European Union policies, namely: the Invasive Alien Species Regulation and the Habitats Directive, both in short- and long term (Year 2023-2025 and 2026-2028 respectively, Fig. 8). Work related to the proposal for a Nature Restoration Law and mapping and assessment of Ecosystems and their services were also highly favoured, especially in the long-term. Work towards the EU Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) had lower priority. However, the MSFD also had the highest numbers of answers where the partners did not know the priority, because they had no marine area, the marine environment was not their responsibility and/or the partner did not have competence in the area.



Shared goals and priorities for biodiversity indicators in Biodiversa+

There were also comments of the wish to coordinate the indicator work for the EU natures Directives and Regulations so that the data collected could be used for several evaluations and reports, as well as for evaluating status and trends for other biodiversity goals as for example pollinators.

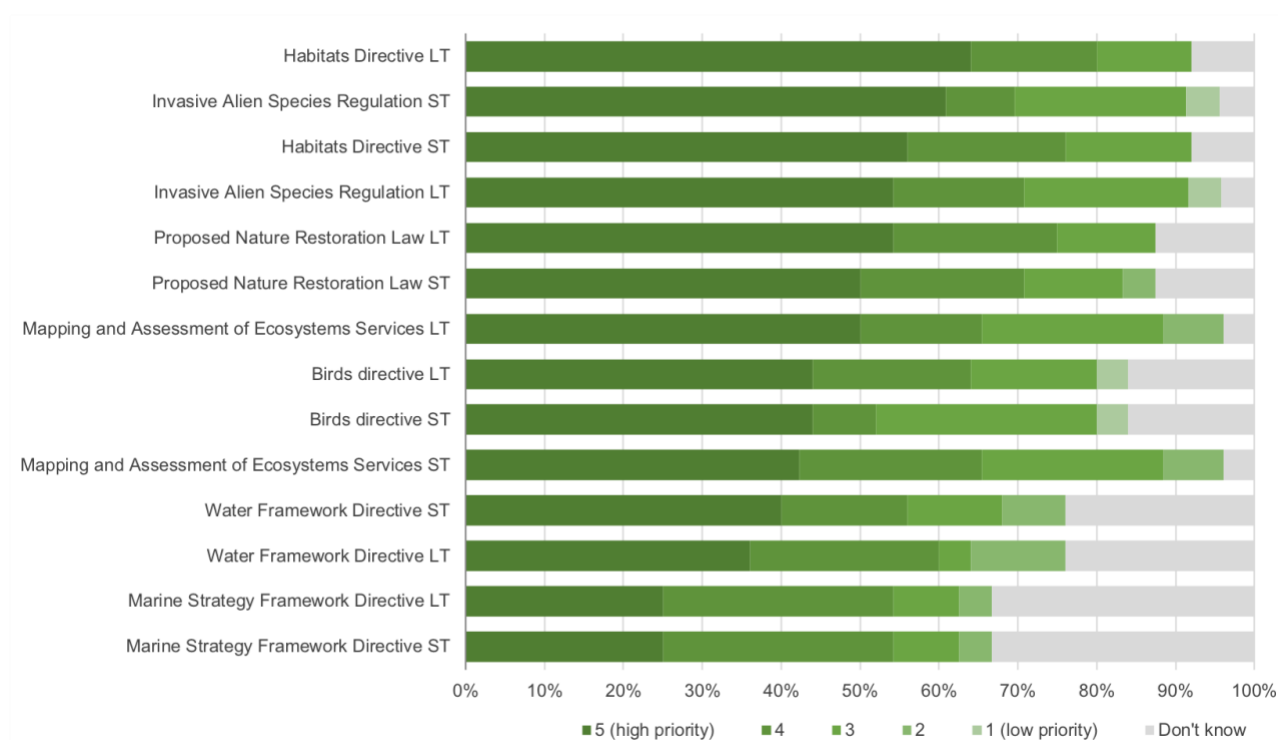


Figure 8: Priority from low (1) to high (5) of indicator harmonisation and/or development related to European policy frameworks directives, regulations, and laws in short-term (ST 2023-2025), and long-term (LT 2026-2028) for the Biodiversa+ survey respondents.

Indicator harmonisation and/or development for the EU Biodiversity Strategy for 2030 goals and targets had high priority for many of the targets (Fig. 9), although a bit lower priority compared to work directed towards directives and laws (Fig. 8). Highest priority was given to indicator work related to assessing a coherent network of protected areas in the long-term. Indicator work directed towards restoration of freshwater, soil, and agricultural ecosystems also had high priority, both in short-and long term. Here, the development of indicators related to restoring freshwater ecosystems had highest priority, while the marine ecosystem still had lower priority. Indicator development and/or harmonisation concerning forest quality, health and resilience was medium ranked together within targets for reducing pollution. Indicator work on greening of urban and peri-urban areas had lowest priority.

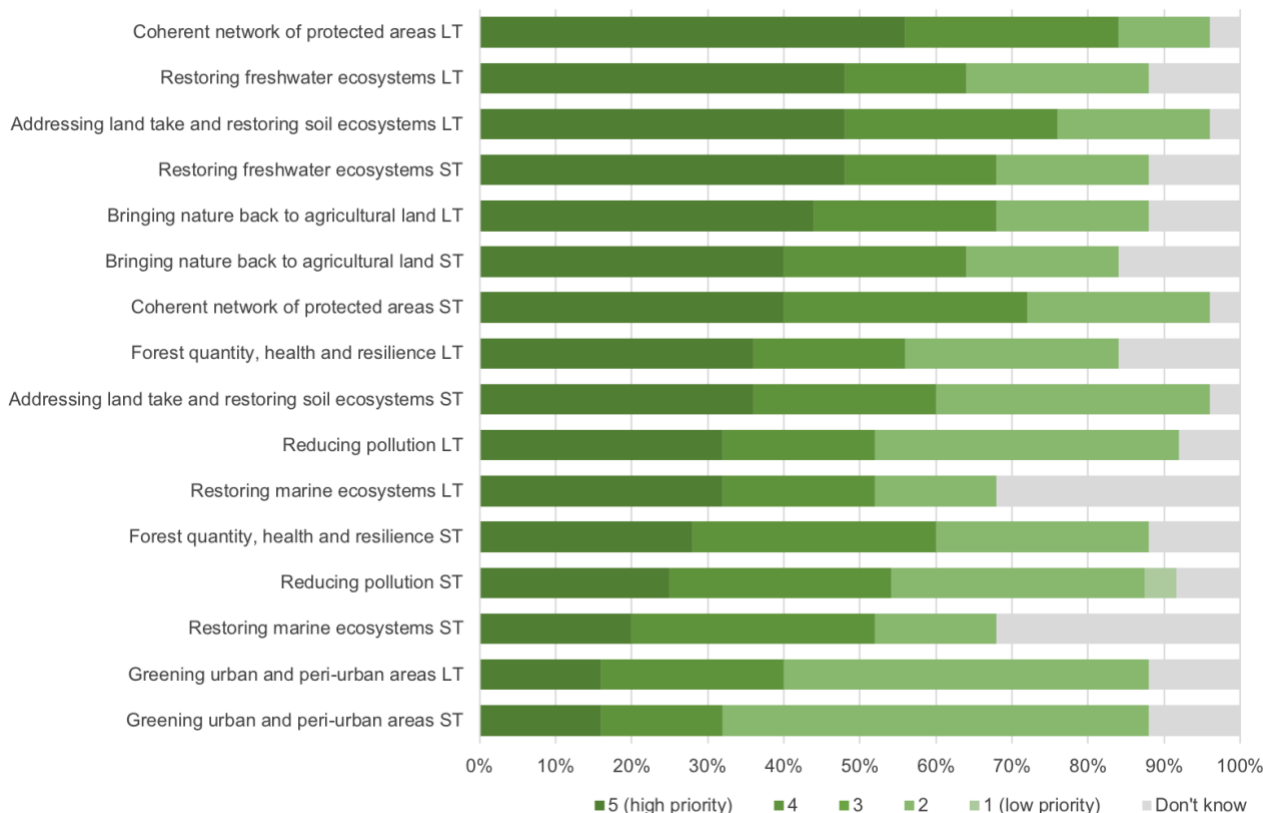


Figure 9: Priority from low (1) to high (5) of indicator harmonisation and/or development related to the EU Biodiversity strategy for 2030 in the short-term (ST 2023-2025) and long-term (LT 2026-2028) for the Biodiversa+ survey respondents.

b) Global policy frameworks

The priority for harmonising and developing indicators for global policy areas (Fig. 10), were more medium ranked compared to European policy areas (Figs 8-9), except for the CBD headline indicators²⁶. It was suggested to focus on headline indicators where the methodology is currently less developed, for example B.1 (services provided by ecosystems), C.1 (indicator on monetary benefits received), C.2 (indicator on non-monetary benefits), 1.1 (percentage of land and sea area covered by biodiversity-inclusive spatial plans), 2.2 (area under restoration), 7.2 (pesticide environment concentration), 9.1 (benefits from the sustainable use of wild species), 9.2 (percentage of the population in traditional occupations) and 15.1 (number of companies reporting on disclosures of risks, dependencies and impacts on biodiversity).

²⁶ Monitoring framework for the Kunming-Montreal Global Biodiversity Framework under the Convention on Biological Diversity, available at: <https://www.cbd.int/doc/c/179e/aecb/592f67904bf07dca7d0971da/cop-15-l-26-en.pdf>

Shared goals and priorities for biodiversity indicators in Biodiversa+

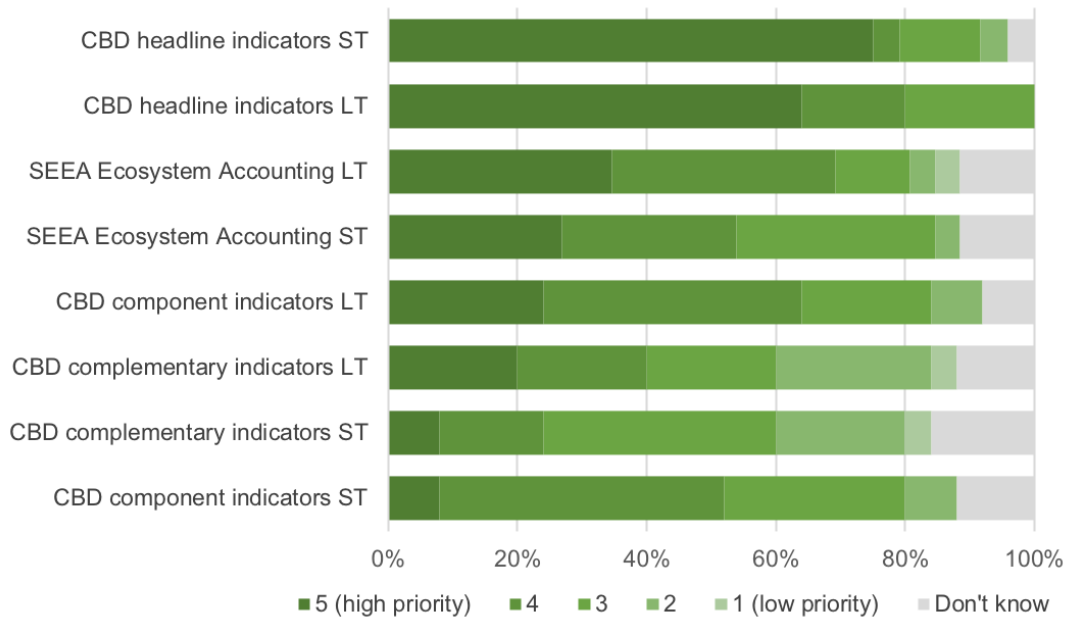


Figure 10: Priority from low (1) to high (5) of indicator harmonisation and/or development related to global indicators in the short-term (ST 2023-2025), and long-term (LT 2026-2028) for the Biodiversa+ survey respondents.

D) How can Biodiversa+ best support national and sub-national biodiversity indicator work?

On the question of how Biodiversa+ best can support the partners in their biodiversity indicator work, the **development of guidelines** was most favoured (Fig 11). Also **sharing of good practices** as well as **funding** were highly favoured.

This fits well with the answers on what challenges that were met in the indicator work, where interpretation/assessment and methodologies/guidelines were mentioned repeatedly. Also **harmonisation and increased cooperation were mentioned, both within and between countries and between different policy areas**. To find the right competence for the desired work is often found challenging.

Funding, both for work on indicators, but also for the collection of data, i.e. monitoring, especially long-term funding were major challenges as well. Other suggestions for the continuous work with indicators within Biodiversa+ were continued and increased cooperation with the European Environment Agency (EEA) and the European Environment Information and Observation Network (Eionet), as well as with EuropaBON and GEO BON. To encourage capacity building for the ecological sector and stakeholders were also suggested.

The survey did not explicitly ask questions related to governance. However, this came up as challenges in the work, where storing and sharing of data was most challenging. Also, to allocate responsibilities for different indicators between institutes/policies, were mentioned.

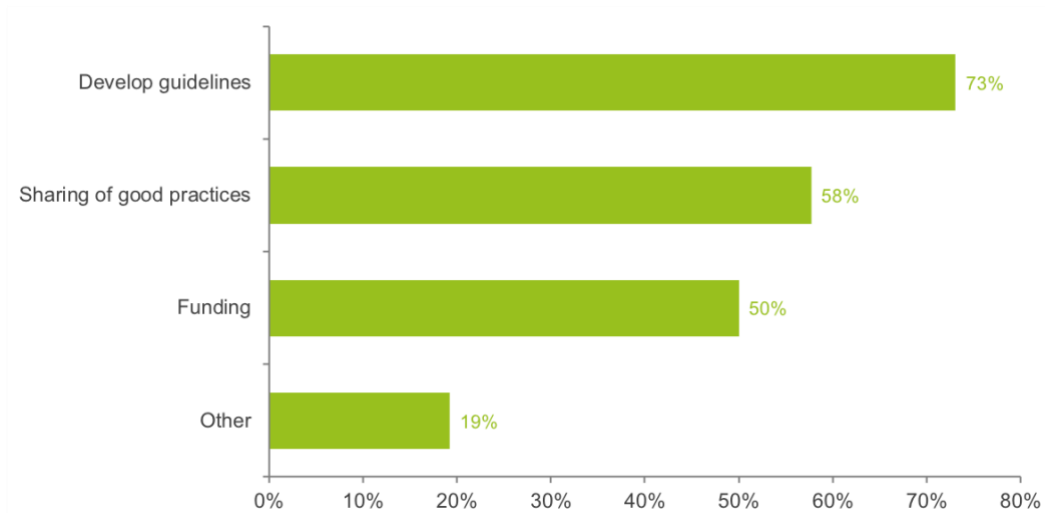


Figure 11: Partners preferred support from Biodiversa+ when it comes to Biodiversity indicator work. The development of guidelines to support harmonisation was most favoured. Sharing of good practices and funding were also highly favoured. Other suggestions were continued and increased cooperation with other organisations and networks (i.e. EEA, Eionet, EuropaBON, GEO BON).



4. Proposed biodiversity indicators work within Biodiversa+

A) Proposed priority biodiversity indicator subjects

The overview of the current state of play for European and global indicators suggests that harmonisation and development of biodiversity indicators is strongly needed. Especially for habitats, where questions of habitat quality, extent and connectivity have got new actuality with the goals in the EU Biodiversity Strategy for 2030 of establishing a functional network of protected areas and launching an EU nature restoration plan. There are also new suggestions for mapping and assessments of European ecosystems and their services and Ecosystem accounting (SEEA EA) that are still not tested on larger scales. The upcoming forest and soil strategies also suggest indicators for habitats and ecosystems. Indicators to follow pressures, and especially pressures from invasive alien species, also need development. Indicators related to habitats, ecosystems and invasive alien species are also priority needs for harmonisation and developments based on the survey to partners. Below, we suggest major questions related to these subjects that Biodiversa+ could focus the indicator work around. The survey to Biodiversa+ partners also suggested exploring indicator work on species within the EU Habitats Directive and Birds Directive, as well as CBD global goals and targets. Below, we suggest major questions related to these subjects that Biodiversa+ could focus the indicator work around.

a) Ecosystems and habitats

Biodiversity indicator work on habitats and ecosystems was highly prioritised in the survey, with a high preference for work related to the EU Habitats Directive and mapping and assessment of ecosystems and their services (Fig. 8). Also, indicator development related to restoration had high priority, especially for soil, freshwater, and agricultural ecosystems (Fig. 9). Focusing on ecosystems and the landscape perspective in the indicator work could also include priorities in the survey for indicator work on networks of protected areas (Fig. 9).

The overview of European and global indicators also suggests that harmonisation and development of biodiversity indicators for habitats and ecosystems are needed. For example, a variety of methods are used for assessing the condition, areal and spatial needs of habitats. There are also suggested new methods for ecosystem assessment, ecosystem services, and assessing the effects of restoration on ecosystems that could be tested and harmonised.

We suggest focusing the biodiversity indicator work on habitats and ecosystems around three major questions:

- Assessment of habitats and ecosystems focusing on quality and restoration needs. Beside indicators based on structure and function variables, where remote sensing and other monitoring methods based on wall-to-wall mapping will be the main data source to explore, much more can be done with data on species. Both as indicators for habitat state *per se* (e.g. the typical species of the Habitat Directive), but also for identifying pressures affecting this state (from climate, eutrophication, toxic pollutants, hunting, too much or too

low grazing pressure, etc.). This also applies to the habitats for the species listed in the annexes of the Habitats Directive.

- Assessment of ecosystems and the relationships between high-quality areas (e.g. protected areas) and the surrounding landscape, i.e. analysing connectivity, patch size needs, and total areal needs.
- How information on the state of high-quality areas shall be represented within broader (wall-to-wall) ecosystem assessments, including ecosystem accounts.

The work should aim for indicator harmonisation and/or development that are relevant for the proposed nature restoration law. Soil and freshwater ecosystems were priority according to the survey and can be used as guidance for choosing case studies.

b) Species, including Invasive Alien Species

To work with biodiversity indicators on Invasive Alien Species has high priority according to the survey to Biodiversa+ partners (Fig. 8). It is also something that is identified as needing further work in assessing progress for targets in the biodiversity strategy for 2030 (Robuchon et al. 2023). Also, indicator work related to the Habitats Directive had high priority and this Directive also includes species. Indicator work on birds in the EU Birds Directive had medium priority. It needs to be further discussed what kind of indicators related Bird Directive and Habitat Directive species to focus on. However, these species habitats could serve as good examples in the suggested indicator work for habitats described above. This is relevant also for the proposed nature restoration law that includes restoration also for these species' habitats.

c) Global CBD headline indicators

Development of indicators for the CBD headline indicators had high priority in the survey (Fig. 10) and it should be further discussed if there are specific goals in the strategy to be addressed. It was for example suggested to focus on goals where the methodology for headline indicators are currently less developed. For example, goals B.1 (services provided by ecosystems), that would align with the priorities to work with indicators for ecosystem services (Fig. 8). That may also contribute to indicator development for CBD C.1 (indicator on monetary benefits received) and C.2 (indicator on non-monetary benefits), 15.1 (number of companies reporting on disclosures of risks, dependencies and impacts on biodiversity), and 9.2 (percentage of the population in traditional occupations). Working on indicators related to restoration as suggested above, could also benefit indicator work needed for CBD 2.2 (area under restoration).

B) Proposed priority biodiversity indicator work

To create reliable indicators, it is crucial to strengthen indicator development that is based on real monitoring data, and filling the gaps in the monitoring schemes where such data is not available yet. Together with the proposed priority topics for Biodiversa+ (Basille et al. 2023)²⁷. The proposed priority indicator work can serve as further guidance for this work within Biodiversa+. The ongoing and planned Biodiversa+ pilots also work as showcases for how to develop harmonised monitoring schemes from which indicators can be developed²⁸.

From answers in the survey, the partners' preferred support from Biodiversa+ when it comes to Biodiversity indicators are development of guidelines to support harmonisation (Fig. 11). Thus, **Biodiversa should explore the possibilities to develop guidelines for indicator development.** Here, Biodiversa+ work on best practices for harmonising protocols can be used as a model (Silva del Pozo et al. 2023).

The partners also wish to share good practices for work on biodiversity indicators and increase the cooperation, both within and between countries and between different policy areas. The sharing and discussion of best practices has already started within the indicator group within Biodiversa+, and is suggested to continue. In addition to this work, listing of national information on indicators, and/or dashboards would be useful for sharing best practices. This work could possibly be part of future plans for a Biodiversa+ dashboard of Essential Biodiversity Variables (EBVs): BioDash.

Biodiversa+ should also investigate the possibility to further coordinate Biodiversa+ indicator work with other ongoing indicator development for the priority indicator themes. This includes continuous close contacts and collaboration with EEA, projects and groups as EuropaBON²⁹, as well as follow the work within the EU Expert group on monitoring and assessment, and groups within CBD. An expert workshop to compare possibilities for development of biodiversity indicators based on monitoring data could be a way to strengthen collaboration and sharing of best-practices across the countries.

The governance of the indicator work should be discussed in the future work on governance within Biodiversa+³⁰ to assure support for a continued exchange of good practices (Vihervaara et al. 2023a & 2023b). Sharing of scripts could for example be done via BON in a Box created by GEO BON. The question of support for funding for biodiversity indicator work also needs to be addressed, since this is a concern for many partners, as shown from the survey. This applied especially for the needs to update and continue development and sharing of good practices also after the Biodiversa+ project period.

According to the survey, most of the indicator work was prioritised in both the short-term period (2023–2025) and the long-term period (2026–2028) of Biodiversa+. However, there is an increase in the partners planned work as well as support for Biodiversa+ indicator work in the long-term period.

²⁷ Biodiversa+ report: <https://www.biodiversa.eu/wp-content/uploads/2023/06/D2.5-Priorities.pdf>

²⁸ Description of Biodiversa+ monitoring pilots: <https://www.biodiversa.eu/biodiversity-monitoring/pilot/>

²⁹ EuropaBON, Europa Biodiversity Observation Network: integrating data streams to support policy, <https://europabon.org/>

³⁰ Biodiversa+ on governance work in collaboration with EuropaBon. <https://www.biodiversa.eu/biodiversity-monitoring/governance/>

Especially work on indicators used for public policies evaluation, and indicator harmonisation and/or development related to EU and global strategies.

In the short-term period of Biodiversa+, indicator work related to Invasive Alien Species and habitats (i.e. the Habitats Directive) had the highest preference and it is suggested to start exploring indicator work within these topics as suggested above. The work could explore the possibility to build on the work on IAS within the Biodiversa+ pilot. The pilot develops methods to identify species along roads with image analysis and deep learning models. It would be valuable to further explore how this kind of data could be used to create indicators related to the effects of IAS on biodiversity. The indicator work on habitats could also build on work in the upcoming pilot on habitats. This pilot aims to work on a landscape scale, and include mapping and evaluating quality in wetlands and grasslands with remote sensing methods. This work is also relevant for planning and creating indicators related to restoration. Indicator work related to restoration was almost equally high in priority for short- and long term, and can therefore be relevant to include also in the short-term period of the indicator work. The preferred ecosystems for indicator work on restoration in the short-term were freshwater and agricultural ecosystems. The habitat pilot partly covers agricultural ecosystems by focusing on grassland habitats. However, it should be further explored how to address indicators related to restoration of freshwaters.

In the long-term period (2026–2028) of Biodiversa+, the indicator work should prioritise continuous work related to restoration including exploring questions addressing land take and restoring of soil ecosystems. It should also be prioritised to explore indicator work on coherent networks of protected areas, mapping and assessment of ecosystems and their services, and global indicators (i.e. CBD headline indicators) (Figs. 8–10). There is ongoing work on soil biodiversity in a Biodiversa+ pilot project³¹. In the pilot, soil data is collected in protected, near natural forests. It would be valuable to explore how this data can be used to create indicators for addressing questions of restoration of soil ecosystems as well as coherent networks of protected areas (i.e. the relationship between valuable areas and the surrounding landscape). It would also be valuable to examine how the approach within this project fits into the proposed optional soil biodiversity descriptors in the Soil Health Directive proposal. It needs to be discussed how to develop indicators related to the CBD headline indicators. These indicators are developed within a group with nominated experts. However, feedback and suggestions can be given directly through a web-based tool³², and the contact and collaboration with experts in this group can be further explored.

Even though the priorities for indicator development fit well with the suggested priority themes and ongoing work within Biodiversa+, some of the proposed priorities for indicator development may also need new, cross-cutting themes. For example, to address questions of assessment of ecosystems and their services and questions related to global indicator development. Future pilots that include major biodiversity indicator harmonisation and/or development within the suggested priority indicator themes should also be considered in the long-term.

³¹ Description of Biodiversa+ monitoring pilots: <https://www.biodiversa.eu/biodiversity-monitoring/pilot/>

³² Web-based tool for feedback on CBD indicators. Available at: <https://www.cbd.int/gbf/related/monitoring/ind/forum/>

Conclusion

A major objective for the Biodiversa+ work to improve monitoring of biodiversity and ecosystem services across Europe, is to supply data for policy-relevant sets of indicators. According to the survey to partners, the priority topics for harmonisation and development of biodiversity indicators are habitats (i.e. those from the Habitats Directive: including both habitats and species), and invasive alien species, especially in the short-term period of Biodiversa+: 2023–2025. There is a planned increase in the partners work as well as support for Biodiversa+ indicator work in the long-term period of Biodiversa+ (2026–2028), especially work on indicators used for public policies evaluation, and indicator harmonisation and/or development related to EU and global strategies such as the EU Biodiversity Strategy for 2030 and CBD's GBF. We therefore recommend focusing the indicator work on the following key issues starting with:

- Further explore the focus of biodiversity indicator work related to Invasive Alien Species. In particular, this should include the possibility to build on the work from Biodiversa+ IAS pilot.
- Further prioritise work on habitats, ecosystems, and restoration in both short- and long-term around the suggested focal questions: a) How to assess quality and restoration needs? b) How to evaluate the relationships between high-quality areas (e.g. habitats in Annex 1 of the Habitats Directive and protected areas) and the surrounding landscape? c) How to represent information on the state of high-quality areas within broader wall-to-wall ecosystem assessments, including ecosystem accounts? This should include the possibility to build on the work on indicators from the upcoming Biodiversa+ habitats pilot.
- Further prioritise work in the long-term for harmonisation and development of indicators related to the CBD headline indicators.

On the question of how Biodiversa+ can best support the partners in their biodiversity indicator work, the development of guidelines was most favoured. Also sharing of good practices as well as funding were highly favoured. The recommended actions for the near future are:

- Continue sharing of good practices and discussion of key subjects in the established group on indicators within Biodiversa+ in close contact with the work on priority topics for Biodiversa+ (Basille et al. 2023). This should also include topics that were outside the scope of the current survey to partners, e.g., discussions on the use of biodiversity monitoring data, priority stakeholders and communication of indicators.
- Explore the possibilities to develop guidelines for indicator development. Here, Biodiversa+ work on best practices for harmonising protocols can be used as a model (Silva del Pozo et al. 2023).
- List national information on indicators, and/or discussion on where to add/link national indicators to dashboards for sharing of best practices. This work could possibly be part of the future Biodiversa+ dashboard of Essential Biodiversity Variables (EBVs): BioDash, which is currently under development. Sharing of scripts could also be done in established databases such as GEO BON's Bon in a Box.
- Further coordinate Biodiversa+ indicator work with other ongoing indicator development for the priority indicator themes. This includes continuous close contact and collaboration with

EEA, projects and groups as EuropaBON, as well as follow the work within the EU Expert group on monitoring and assessment, and groups within CBD.

- Organise an expert workshop to compare possibilities for development of biodiversity indicators based on monitoring data, to strengthen collaboration and sharing of best-practices across the countries.
- Discuss the subject of governance of the indicator work within Biodiversa+ to ensure support for a continued exchange of good practices (Vihervaara et al. 2023a & 2023b). This should include the question of support for funding for biodiversity indicator work, since this is a concern for many partners, as shown from the survey. This applied especially for the needs to update and continue development and sharing of good practices also after the Biodiversa+ project period.



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