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Deliverable D1.1 – Policy Landscape and Needs

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OBSGESSION

Observation of Ecosystem Changes for Action

Deliverable D1.1 – Policy Landscape and Needs

Lead Beneficiary: UNEP-WCMC

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List of Acronyms and Abbreviations

CBD	Convention on Biological Diversity
EBV	Essential Biodiversity Variable
EO	Earth Observation
EU	European Union
EU BDS 2030	European Union's Biodiversity Strategy for 2030
EuropaBON	Europa Biodiversity Observation Network
GBF	Kunming-Montreal Global Biodiversity Framework
GEO BON	Group on Earth Observations Biodiversity Observation Network
KCBD	Knowledge Centre for Biodiversity
RS	Remote Sensing
UNEP-WCMC	UN Environment Programme World Conservation Monitoring Centre

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Summary

This report provides a review of the biodiversity policy landscape at the European Union (EU) level and identifies a set of priority Essential Biodiversity Variables (EBVs) to support policy needs. Policy needs were determined based on the European 'Union's Biodiversity Strategy for 2030 (EU BDS 2030), which serves as the overarching framework for biodiversity-related policies and legislation at the EU level in response to the requirement for countries to have a National Biodiversity Strategy and Action Plan (NBSAP) as Parties to the Convention on Biological Diversity (CBD). The analysis focuses on the actions from the EU BDS 2030 as the key articulation of policy needs, and indicators to evaluate monitoring requirements. Actions were categorized based on their relevance to different stages of the policy process (e.g., planning, implementation, reporting or review), while indicators were categorized as relevant to policy reporting. Actions and indicators were also tagged by ecosystem realm (i.e., terrestrial, freshwater, marine) or as cross-cutting. The potential applicability of EBVs for broadly supporting the implementation of each of the 102 actions and sub-actions. Also, the monitoring of the 16 available indicators from the 'Strategy's dashboard, was assessed. The review found that EBVs could broadly be used to support the implementation of 37 actions and the monitoring of five indicators. These selected actions and indicators were then mapped to EBV classes and candidates based on the EBV framework by the Group on Earth Observations Biodiversity Observation Network (GEO BON). EBV candidates were ranked from high to low priority based on the total number of actions and indicators they were mapped to, both overall and within different ecosystem realms and stages of the policy process. Candidates linked to the greatest number of actions and indicators were considered the highest policy priority. Overall, the *species abundance* candidate ranked 1st in terms of policy priority, followed by *species distributions* (2nd), *ecosystem distribution* (3rd) and *ecosystem vertical profile* (4th), with markedly higher total scores than other candidates. These candidates were also consistently ranked among the top four candidates across different ecosystem realms and stages of the policy process. Taking into consideration the findings from the Europa Biodiversity Observation 'Network's (EuropaBON) User and Policy Needs Assessment, this review identified species abundances, species distributions and ecosystem distribution as priority EBVs for the development of remote sensing (RS) biodiversity products in the OBSGESSION project. The ecosystem vertical profile also ranked highly, but further assessment is recommended to determine its policy importance. While this review provides a priority set of EBV candidates based on policy needs, further prioritisation considering scientific gaps and technical feasibility for monitoring EBVs via RS will be continued under Task 1.2 as part of the Science Policy Traceability Matrix (SPTM), taking into consideration work already undertaken on RS-enabled EBVS.

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1. Introduction

1.1 Policy Landscape

At the global level, the Convention on Biological Diversity (CBD) serves as the primary instrument for biodiversity governance. Signatory parties, including European Union (EU) Member States, are committed to implementing its articles, strategies and frameworks at the national level. At the regional level, the EU Biodiversity Strategy for 2030 (EU BDS 2030) sets out the EU's approach to protecting nature and reversing the degradation of ecosystems (European Commission, 2020). At the regional level it is the key instrument for implementing the Kunming-Montreal Global Biodiversity Framework, the current strategic framework for 2030 under the CBD (CBD, 2022a). As the overarching instrument guiding biodiversity policy in the EU, the EU BDS 2030 provides a framework for the coordination and alignment of other biodiversity-related policies and legislation to achieve EU and global biodiversity goals. Table A1 in the Annex provides an overview of links between the actions of the EU BDS 2030 and relevant EU policy and legal frameworks, where applicable, based on mapping carried out under this task. These include, but are not limited to, the Habitats Directive, Birds Directive, Water Framework Directive, Nitrates Directive and EU Nature Restoration Law. Therefore, under Task 1.1, the needs of biodiversity policy at the EU level are identified through the framework provided by the EU BDS 2030.

The overarching objective of the EU BDS 2030 is to put Europe's biodiversity on the path to recovery by 2030 for the benefit of people, climate and the planet (European Commission, 2020). To achieve this objective, the EU and its Member States committed to implementing a set of 102 actions and sub-actions to meet 16 targets and six sub-targets by 2030. These actions are grouped under four pillars: (i) protecting nature, (ii) restoring ecosystems, (iii) enabling transformative change, and (iv) adopting an ambitious global biodiversity agenda (European Commission, 2020). Each EU BDS 2030 action represents a concrete policy need and, therefore, provides an entry point where EBVs could be used to support the implementation of the strategy. Given this context, the policy landscape review focuses on the actions from the EU BDS 2030, as the key articulation of policy needs to evaluate how EBVs can be used to address these needs.

Furthermore, to support the implementation of the EU BDS 2030 the European Commission's Knowledge Centre for Biodiversity (KCBD) has developed two progress monitoring tools: the *EU Biodiversity Strategy for 2030 Actions Tracker*[1] that displays progress towards implementation of each action in the Strategy, and the *EU Biodiversity Strategy for 2030 Dashboard*[2] to track

[1] European Commission Knowledge Centre for Biodiversity. (n.d.). EU BDS 2030 Actions Tracker. European Commission. Retrieved January 20, 2025, from https://dopa.jrc.ec.europa.eu/kcbd/actions-tracker/

[2] European Commission Knowledge Centre for Biodiversity. (n.d.). EU BDS 2030 Dashboard. European Commission. Retrieved January 20, 2025, from https://dopa.jrc.ec.europa.eu/kcbd/EUBDS2030-dashboard/?version=1

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progress towards the 16 targets and six sub-targets using a set of indicators (Viti et al. 2024). Data for these indicators are obtained from various EU reporting schemes and independent sources. The dashboard currently includes 16 indicators covering 8 of the 16 targets, with some indicators still under development (Viti et al. 2024). The available indicators from the Strategy's dashboard were reviewed to assess key biodiversity policy monitoring requirements at the EU level.

1.2 Defining EBVs in the OBSGESSION Project

EBVs are defined as "a minimum set of common, observable values across the various dimensions of biodiversity that can be used to create indicators of system-level biodiversity trends" (Brummitt et al., 2017) encompassing genetic composition, species populations, species traits, community composition, ecosystem functioning, and ecosystem structure. They provide a standardized framework for monitoring, studying, managing, and reporting biodiversity changes across spatial and temporal scales. GEO BON (2022) has identified 21 detailed EBVs (referred to as "EBV names" or more generally just "EBVs") falling into these six classes. Expanding on this framework, EuropaBON has proposed additional EBVs (currently consisting of 70), to better address biodiversity monitoring needs in Europe.

The development of EBVs relies on diverse data sources, including *in-situ* observations and RS data. "*EBV data products*" are standardized datasets created by harmonizing and integrating raw observations, allowing for direct comparison and analysis of biodiversity trends on a global scale (Kissling et al., 2018). To enhance accessibility and interoperability, EBV data products can be structured into databases and integrated into multidimensional data cubes ("*EBV data cubes*") - spatiotemporal frameworks that allow for efficient storage, retrieval and analysis of biodiversity information (EuropaBON, 2022).

RS plays a crucial role in the development of these "*EBV data products*" with many EBVs relying on RS data. Recent research, including work by Skidmore et al. (2021), has emphasized the potential of RS for monitoring EBVs. Skidmore et al. (2021) introduced the concept of ""*RS Biodiversity Products*"" as the outputs derived from the processing of remotely sensed images that closely inform EBVs. In their work, they also used the term "*EBV candidates*" to describe the 21 EBVs proposed by GEO BON, highlighting their significance for global biodiversity assessments.

For the OBSGESSION project, we will align with this naming convention and the GEO BON proposed 21 ""*EBV candidates*"" (Table 1) to ensure consistency with established EBV frameworks and facilitate integration with global biodiversity monitoring efforts.

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Table 1. GEO BON's proposed EBV candidates for each EBV Class.

EBV Class	EBV Candidate
Genetic composition	Genetic diversity (richness and heterozygosity) Genetic differentiation (number of genetic units and genetic distance) Effective population size Inbreeding
Species populations	Species distributions Species abundances
Species traits	Morphology Physiology Phenology Movement Reproduction
Community composition	Community abundance Trait diversity Interaction diversity
Ecosystem functioning	Primary productivity Ecosystem phenology Ecosystem disturbances
Ecosystem structure	Live cover fraction Ecosystem distribution Ecosystem vertical profile

1.3 Use of EBVs in Policy Processes

The EBV framework provides a standardized set of variables that capture key aspects of biodiversity change, making it a powerful tool for supporting evidence-based decision-making across the policy cycle. By integrating biodiversity data from diverse sources into a common spatial, temporal, and taxonomic framework, EBVs enable the generation of high-level biodiversity change summaries, such as indicators (Boyd et al., 2023). Policymakers can use these high-level summaries of biodiversity change to identify priority areas for the development and implementation of targeted conservation interventions, make resource allocation decisions and set evidence-based targets (Skidmore et al., 2021). Throughout policy implementation, EBVs can be used to monitor and assess the effectiveness of interventions to meet reporting requirements under various EU Directives and enable adaptive management (Lock et al., 2021). Furthermore, EBVs can provide the underlying data for carrying out policy reviews and contribute to policy revision processes. Beyond tracking current biodiversity trends, EBVs can be used to develop future biodiversity scenarios under different policy and management conditions to identify appropriate interventions that are more likely to lead to desired conservation outcomes (Pereira et al., 2024).

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EBVs are relevant for meeting policy needs at the global, regional, national and sub-national level. At the global level, the development of the EBV framework by GEO BON was first endorsed by the CBD (Decision XI/3), for its potential to underpin a global, harmonised biodiversity observation system for tracking changes in biodiversity (Pereira et al., 2013). Most recently, as part of a package of decisions at COP-15, Parties to the CBD adopted a monitoring framework (Decision 15/5) for monitoring the implementation of the Kunming-Montreal Global Biodiversity Framework (GBF) at the national, regional and global level. A revised decision on the monitoring framework was adopted at COP-16 (CBD, 2025). The monitoring framework is composed of a set of indicators for measuring progress towards the goals and targets of GBF (CBD, 2022b). A set of EBVs that are aligned with the monitoring framework could be used to support planning, monitoring, reporting and review activities in line with the GBF's goals and targets (Timmermans and Kissling, 2023).

At the national level, EBVs can be utilized to address policy needs, including providing information for policy planning, implementation, reporting and review processes. For example, in New Zealand, the Department of Conservation systematically monitors multiple EBVs through its national biodiversity monitoring program (Bellingham et al, 2020). This program collects long-term systematic data on two EBV classes, species populations (i.e., species abundances and distributions) and community composition (i.e., taxonomic diversity), across the country. This provides a strong evidence-base for setting policies, evaluating their effectiveness and meeting global and national reporting obligations (Bellingham et al, 2020). In Finland, Vihervaara et al. (2017) highlighted the potential for using EBVs and RS applications to improve data production for national indicators to strengthen Finland's national biodiversity monitoring system. In the UK, Boyd et al. (2023) developed a workflow for generating national biodiversity indicators using species occupancy estimates derived from raw occurrence data to generate policy-relevant indicators to support policy-making. Additionally, Turak et al. (2017) outlined a structured process for prioritizing EBVs to support country-specific policy needs and showcased its application at the sub-national level by identifying 11 candidate EBVs to assess biodiversity conditions across ecological features and ecoregions in New South Wales, Australia.

At the EU level, a standardised set of EBVs could provide a consistent approach to monitoring and reporting under various biodiversity-related EU Directives. As part of efforts to design an EU-wide monitoring framework for biodiversity and ecosystem services variables, the EuropaBON identified priority EBVs and Essential Ecosystem Service Variables (EESVs) for monitoring EU policies in their User and Policy Needs Assessment (Moersberger et al., 2022). The assessment was based on expert stakeholder workshops where participants identified EBVs/EESVs required to answer key policy questions for EU policy and legal frameworks, such as the Birds Directive, Habitats Directive and restoration law (Moersberger et al., 2022). EBVs/EESVs were then ranked by the degree of importance to national policy-making (see Table A2 in Annex). The top one-third of EBVs/EESVs included species abundance, species distribution, community abundance and ecosystem distribution variables linked to specific taxa, ecosystems or other entities. The assessment found that many EBVs map to existing indicators for reporting on the assessment of

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conservation status of habitat and species in the Habitats Directive under Article 17 (e.g., species abundances, distributions, ecosystem distribution and ecosystem function variables) and have the potential for use in the assessment of "good" condition of habitats and species under several EU Directives such as the Marine Strategy Framework Directive and the Water Framework Directive (Moersberger et al., 2022).

While the assessment highlighted key opportunities for the use of EBVs at the EU level, it also identified several challenges at the Member State level that represent barriers to the use of EBVs. The barriers included: insufficient financial resources, short-term monitoring policies, inadequate spatial and temporal coverage, taxonomic biases, lack of capacity (e.g., human and technical), insufficient data integration across multiple geographical scales and bias towards certain ecosystem types (Moersberger et al., 2022). The assessment highlighted several biases in current monitoring schemes under EU Directives. For example, they found a strong bias towards monitoring protected areas and species, particularly birds and mammals, with over two-thirds of datasets being used to report to the Habitats and Birds Directives (Moersberger et al., 2022). Conversely, less than one-third of datasets were being used to report to other EU Directives and policies. The EuropaBON analysis further highlighted significant gaps in habitat and ecosystem monitoring at the EU level, as well as limited monitoring of genetic diversity (Moersberger et al., 2022). This suggests that existing EU monitoring schemes may not support the full range of biodiversity policy needs and may, limit progress towards implementing biodiversity policies and legislation. These technical challenges and biases should be considered in the context of the OBSGESSION project to inform the development of RS biodiversity products. OBSGESSION may want to consider how the project can support policy needs, such as meeting needs of diverse EU Directives and policies, incorporating insufficiently monitored EBVs, or underrepresented taxa and ecosystems.

2. Methods

The policy landscape review aims to identify priority EBV candidates based on policy needs, as articulated in the EU Biodiversity Strategy for 2030. Its findings will inform the Science Policy Traceability Matrix (SPTM) under Task 1.2, ensuring the effective prioritization and design of RS biodiversity products.

To identify policy needs, the actions and indicators from the EU BDS 2030 were reviewed. Actions were filtered based on whether EBVs could broadly support their implementation, and indicators were filtered based on whether EBVs could be used to meet their data requirements. This resulted in a dataset of EBV-applicable EU BDS 2030 actions and indicators (see Table A3 in the Annex). These actions and indicators were subsequently tagged according to the policy process and ecosystem realm and mapped to specific EBV classes and candidates (see Table A4 in the Annex). EBV candidates were ranked from high to low policy priority based on the number of actions and indicators they were mapped to, both overall and within specific policy processes and

ecosystem realms. Candidates linked to the greatest number of actions and indicators were considered the highest policy priority. Figure 1 provides an overview of the workflow for Task 1.1.

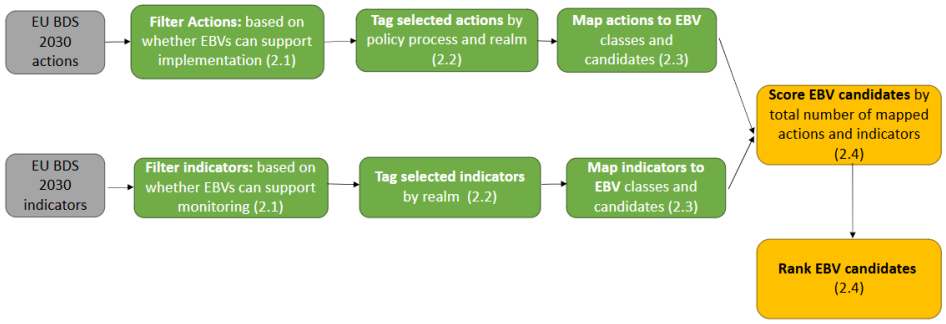

Figure 1. Workflow diagram for the policy landscape review (Task 1.1)

2.1 Filtering Actions and Indicators by EBV-applicability

Each individual action of the EU BDS 2030 was systematically reviewed by experts at UNEP-WCMC to assess the applicability of EBVs based on whether there is potential for the use of EBVs to support the implementation of the action. The actions were considered EBV-'applicable' where EBV data could support the implementation by providing evidence for policy planning and decision-making on implementation. For example, for "action 54: implement measures to reduce or maintain fishing mortality at or under maximum sustainable yield", EBVs can be used to guide decision-making on which measures are most effective or appropriate for reducing fishing mortality. Actions related to reporting or review processes where EBVs could directly track progress or inform evaluations of effectiveness, such as action 102 on assessment of progress in implementing the strategy, were also selected for inclusion in this analysis. This is an exploratory approach to expand the use of the EBV framework, specifically exploring the role of EBVs in supporting implementation while still acknowledging the primary role of EBVs for monitoring progress.

The indicators from the EU BDS 2030 Dashboard were also reviewed to determine whether EBVs could be used to monitor them. This assessment was based on available documentation and methodologies for each indicator from the Strategy's dashboard, to identify data requirements.

2.2 Tagging Actions and Indicators

The selected actions and indicators with EBV-applicability were then tagged by policy process and ecosystem realm.

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1. Policy Process: actions were tagged based on which stage of the policy process they were most relevant too from the following options:
    - Planning: actions focused on developing policies and legislation, setting objectives and determining resource allocation.
    - Implementation: actions that execute policies and legislation to achieve policy objectives.
    - Reporting: actions that focus on documenting and communicating progress on achieving policy objectives or completing implementation activities to fulfil reporting requirements.
    - Review: actions which involve evaluating the effectiveness, efficiency, and alignment of policies and legislation.

It is important to note that many actions could be relevant to multiple stages of the policy process. However, for the purposes of this tagging, the most relevant process was selected. This means that while some actions may contribute to multiple stages, the tagging reflects their primary role in the policy lifecycle. All selected indicators were tagged as 'reporting'.

2. Ecosystem realm: actions and indicators were also classified according to their ecosystem realm using the IUCN Global Ecosystem Typology (Keith et al., 2020):
    - Marine: includes all connected saline ocean waters characterized by waves, tides and currents.
    - Freshwater: includes all permanent and temporary freshwater bodies as well as saline water bodies that are not directly connected to the oceans.
    - Terrestrial realm: includes all dry land, its vegetation cover, proximate atmosphere and substrate (soils, rocks) to the rooting depth of plants, and associated animals and microbes.

Where actions or indicators applied to multiple realms, they were classified as "cross-cutting". No actions or indicators were relevant to "subterranean" or "atmospheric" realms, so these were not considered in this review.

2.3 Mapping to EBV Classes and Candidates

The selected actions and indicators were then mapped to specific EBV classes and candidates following the EBV framework developed by GEO BON with 6 EBV classes and 21 candidates, as outlined in Table 1. The mapping of the selected actions was carried out based on information for

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each action from the EU BDs 2030's actions tracker[3]. Similarly, the indicators from the 'Strategy's target dashboard[4] were mapped to the relevant EBV classes and candidates that could provide the necessary data for tracking the indicator. Actions and indicators were mapped to multiple EBV classes and candidates where applicable. The supplementary table from Skidmore et al. 2021 listing RS biodiversity products and their relationship with the candidate EBVs was used to support this mapping.

It should be noted that this mapping aimed to identify the EBV classes and candidates relevant to the implementation of each action and the monitoring of each indicator rather than serving as an exhaustive list. The selected actions and indicators and their mapping to EBV classes and candidates were reviewed by RS experts from Universiteit Twente (UT-ITC) and refined based on their feedback. Given the broad and high-level nature of many of the actions, different interpretations and approaches to mapping are possible. This mapping provides an initial assessment and could be further refined over the course of the project in consultation with relevant policy and EBV experts.

2.4 Ranking EBV Candidates Overall

The total number of actions and indicators mapped to each EBV candidate was calculated, and the candidates were ranked in descending order based on their total score. This ranking allowed for the identification of priority EBV candidates, with those mapped to the highest number of actions and indicators having the greatest potential to address a broad range of biodiversity policy needs at the EU level.

2.5 Ranking EBV candidates across policy dimensions

To assess the contribution of each EBV candidate to different policy dimensions and determine which EBVs should be prioritized for specific thematic policy goals, the mapped actions and indicators were grouped based on two different categorization approaches:

(1) Policy process (i.e., planning, implementation, reporting, review)
(2) Ecosystem realm (i.e., marine, freshwater, terrestrial) or cross-cutting

For each EBV candidate, the frequency of mapping to actions and indicators was calculated within each of these groupings. For example, actions and indicators were grouped by policy process, and the total frequency of each candidate mapped to these actions and indicators under the

[3] [3] European Commission Knowledge Centre for Biodiversity. (n.d.). EU BDS 2030 Actions Tracker. European Commission. Retrieved January 20, 2025, from https://dopa.jrc.ec.europa.eu/kcbd/actions-tracker/
[4] [4] European Commission Knowledge Centre for Biodiversity. (n.d.). EU BDS 2030 Dashboard. European Commission. Retrieved January 20, 2025, from https://dopa.jrc.ec.europa.eu/kcbd/EUBDS2030-dashboard/?version=1

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different policy processes (planning, implementation, reporting, review) was calculated. EBV candidates were then ranked within each policy process. The same approach was used to assess policy priorities across ecosystem realms.

3. Results and Discussion

From the 102 actions and sub-actions outlined in the EU BDS 2030, EBVs were identified as broadly applicable to 37 actions. Additionally, out of 16 indicators from the Strategy's dashboard, only five were determined to be EBV-applicable, bringing the total number of EBV-applicable actions and indicators to 42. For the complete list of selected actions and indicators, see Table A3 in the Annex.

3.1 EBV Candidates Overall Ranking

EBV classes and candidates were mapped to each of the 37 selected actions from the EU BDS for 2030 and five selected indicators from its dashboard. All six EBV classes and 21 candidates were mapped to at least one action or indicator. For the full set of EBV class and candidate mappings, refer to Table A4 in the Annex.

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Table 2 EBV candidates are ranked by policy priority based on the total number of mapped actions and indicators from the EU BDS 2030. Colors represent the EBV class as presented in the legend.

EBV Candidate	Number of actions	Number of indicators	Total score	Rank
Species abundances	31	4	35	1st
Species distributions	33	1	34	2nd
Ecosystem distribution	30	2	32	3rd
Ecosystem Vertical Profile	28	1	29	4th
Primary productivity	20	1	21	5th
Ecosystem disturbances	17	0	17	6th
Live cover fraction	12	0	12	7th
Movement	11	0	11	8th
Reproduction	7	1	8	9th
Taxonomic diversity	8	0	8	9th
Community abundance	8	0	8	9th
Interaction diversity	7	0	7	10th
Phenology	6	1	6	11th
Ecosystem Phenology	5	0	5	12th
Physiology	5	0	5	12th
Morphology	4	1	5	12th
Effective population size	5	0	5	12th
Trait diversity	3	0	3	13th
Genetic differentiation	3	0	3	13th
Genetic diversity	3	0	3	13th
Inbreeding	3	0	3	13th

EBV class
Genetic composition
Species populations
Species traits
Community composition
Ecosystem functioning
Ecosystem structure

Species abundances emerged as the highest-ranked EBV candidate, with a total score of 35 out of 42 (Table 2), comprising 31 actions and four indicators. Species distributions followed closely in second place with a total score of 34, linked to more actions (33) but only one indicator.

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Ecosystem distribution ranked third with a total score of 32, due to its relevance for the implementation of 30 actions and two indicators (Table 2) and the ecosystem vertical profile candidate was the fourth-ranked candidate due to its relevance for implementing 28 actions and one indicator (Table 2). A considerable gap was observed between these top four candidates and the next candidates. Primary productivity followed in fifth place with a lower total score of 21 (20 actions and one indicator) (Table 2). The ecosystem disturbance candidate trailed further behind, with a total score of 17, all of which were actions (Table 2).

At the broader class level, the ecosystem structure class was mapped to the highest number of actions and indicators (Figure.2), with all three candidates - ecosystem vertical profile, ecosystem distribution, and live cover fraction - ranking in the top one-third of the candidate ranking list (Table 3). The species population class followed with a total score of 69 (Figure.2), driven by the high rankings of species abundances (1st) and species distributions (2nd) in Table 2. However, it received a lower overall score compared to the ecosystem structure class, because it only includes two candidates. The ecosystem functioning class ranked third overall (Figure.2), primarily due to primary productivity (5th) and ecosystem disturbances (6th) candidates, while ecosystem phenology received a low score and ranked only 12th (Table 2).

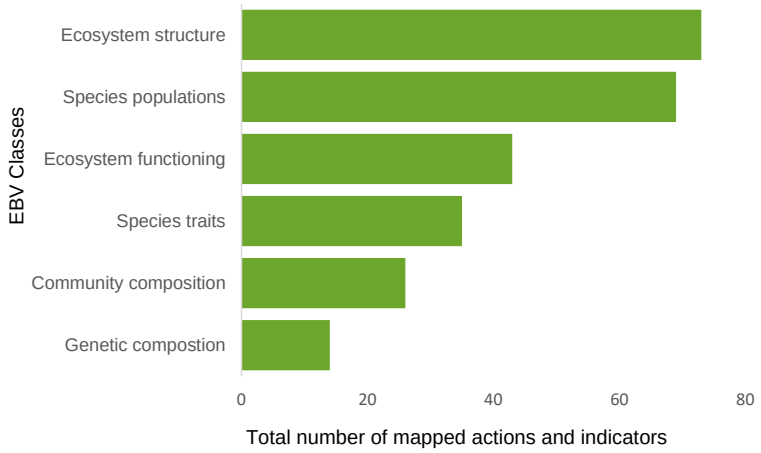

Figure 2. Total number of actions and indicators mapped to EBV classes.

The species traits class ranked 4th overall (Figure.2). Within this class, movement and reproduction candidates ranked 8th and 9th (Table 2), respectively, likely due to their broad relevance for spatial conservation planning, including the design of protected areas, ecological corridors, and the selection of priority habitats (Actions 1, 2, 5 and 11). In contrast, phenology was ranked 11th and physiology and morphology in 12th place (Table 2). The community composition class was ranked 5th overall (Figure.2). Within this class, taxonomic diversity and community abundance ranked highest (9th), closely followed by interaction diversity (10th), while trait diversity

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was mapped to relatively fewer actions and indicators, resulting in a much lower ranking (Table 2).

The genetic composition class had the lowest overall ranking (Figure.2), being mapped to only 14 actions/indicators in total. Three of its four candidates - genetic differentiation, genetic diversity, and inbreeding – occupied the bottom rank (13th) (Table 2). These candidates were mapped only to broadly defined actions with a variety of potential implementation approaches and data needs, which where therefore mapped to all candidates (e.g., Actions 9, 76 and 102). Effective population size ranked slightly higher (12th), potentially due to its broader applicability for assessing conservation status and managing populations (e.g., Actions 1 and 11) (Table 2).

These rankings may reflect biases in current EU biodiversity policies towards the ecosystem and species level, strongly emphasizing ecosystem conservation and restoration, and species protection and limited policies addressing genetic diversity. Furthermore, the outcomes of the rankings could also reflect differences in technical feasibility for monitoring different EBV candidates and classes. Higher-ranked EBVs, such as ecosystem distribution, species abundances and species distributions, have a much longer history of monitoring, with more established monitoring schemes and a wealth of data compared to genetic composition candidates (Moersberger et al., 2020). The technical feasibility of monitoring different biodiversity variables influenced which candidates were mapped to actions and indicators. For example, ecosystem distribution is easily monitored through RS and often used for assessing other biodiversity variables indirectly (Barkmann et al, 2025). However, recent advances in using RS technologies for monitoring the genetic composition EBVs could help bridge this gap (Skidmore et al., 2022; Mergeay & Galbusera, 2024).

The role of RS in monitoring broadly is recognized both within the scientific and policy-making communities, especially as RS has the ability to provide long term data coverage and quickly detect changes, thus supporting rapid action (Skidmore et al., 2015). RS-enabled EBVs have the potential to support policy-making in a number of ways: i) providing information around not just ecosystem structure but also ecosystem function, which is often not addressed in policies (Lock et al., 2021); ii) support the harmonization of monitoring efforts across countries (Lock et al., 2022); and, iii) compliment field observations to provide a comprehensive state and changes in biodiversity (Skidmore et al., 2021). For RS-enabled EBVs to be properly utilized in policy-making more effectively, agreement must be reached between scientists and the end users of the information. Lock et al., 2021 sets out the two areas where agreement must be reached: i) the spatial extent and ii) the attributes to be monitored. Once agreement has been reached, a list of already prioritized RS products has been identified by scientists for further advancement (Skidmore et al., 2021).

EuropaBON conducted a similar review and ranking of EBV candidates in their User and Policy Needs Assessment to identify priority EBVs for national policy-making, specifically to address key questions arising from EU Nature Directive and EU Birds Directive (Moersberger et al., 2020). This assessment mapped GEO BON's EBV candidates to specific taxa and ecosystems, resulting in a more detailed set of candidates. The full ranking of candidates from the EuropaBON

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assessment can be referred to in Table A2 in the Annex. Overall, the results align with the rankings from this policy landscape review, with the top-ranked EBV candidates including species abundances of rare/priority species (1st), common birds (2nd), grassland butterflies (4th), and species distributions of freshwater fish (4th) and invasive species (4th). Ecosystem distribution of habitats under the Habitats Directive ranked 3rd (Moersberger et al., 2020). Similar to this landscape review, species abundance, ecosystem distribution, and species distribution emerged as the highest-ranked candidates overall, representing 13 out of the top 15 candidates in the upper third of the rankings. Candidates from the genetic composition class were also ranked as low policy priority (32nd and 36th place) out of 44 candidates.

One of the key differences between the prioritization in the EuropaBON assessment and this review is the low ranking of ecosystem vertical profile for vegetation (37th) and primary productivity of plants (41st), compared to 4th and 5th, respectively, in this review. One potential explanation for this difference is that the EuropaBON assessment used more specific candidates, focusing solely on the ecosystem vertical structure of vegetation, while this review considered a broader application, including aquatic realm. For example, the ecosystem vertical profile was mapped to actions 42, 44, and 45, which related to the freshwater realm and actions 55 and 57, which relate to marine realm (Table A4 in the Annex). Additionally, primary productivity was divided into freshwater, marine, and terrestrial categories in the EuropaBON assessment, whereas this review took a more holistic approach to primary productivity. However, these differences are unlikely to fully explain the large discrepancy. Another potential reason could be that due to the broad nature of the actions from the EU BDS for 2030, many actions have a wide range of potential implementation approaches and data needs, which may have led to an overemphasis on broadly applicable ecosystem structure and functioning EBVs. While these EBVs support multiple aspects of biodiversity monitoring, they may not accurately reflect how actions are implemented and monitored in practice.

3.2 EBV Candidate Ranking Across Ecosystem Realms

The analysis of EBV candidate rankings across ecosystem realms aimed to determine whether certain EBVs are more relevant to the policy needs within specific realms. Selected actions and indicators from the EU BDS 2030 were assigned to the freshwater, marine or terrestrial realms or as cross-cutting actions/indicators. This enabled a realm-specific ranking of EBV candidates based on their mapping to selected actions and indicators. For the selected actions and indicators categorized by ecosystem realm, refer to Table A3 in Annex.

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Table 3. Distribution of selected actions and indicators from the EU BDS 2030 across ecosystem realms

Ecosystem realms*	Number of actions	Number of indicators	Total
Cross-cutting	15	1	16
Freshwater	4	0	4
Marine	3	1	4
Terrestrial	15	3	18

*Ecosystem realms are based on the IUCN Global Ecosystem Typology (Keith et al., 2020). Where actions or indicators applied to multiple realms, they were classified as "cross-cutting". No actions or indicators were relevant to subterranean or atmospheric realms.

The majority of selected actions were categorized as either cross-cutting or terrestrial, with 15 actions each, while only four actions were assigned to the freshwater realm and three to the marine realm. Similarly, most of the selected indicators (3 indicators) were assigned to the terrestrial realm, with one assigned to the marine realm and one as a cross-cutting indicator (Table 3).

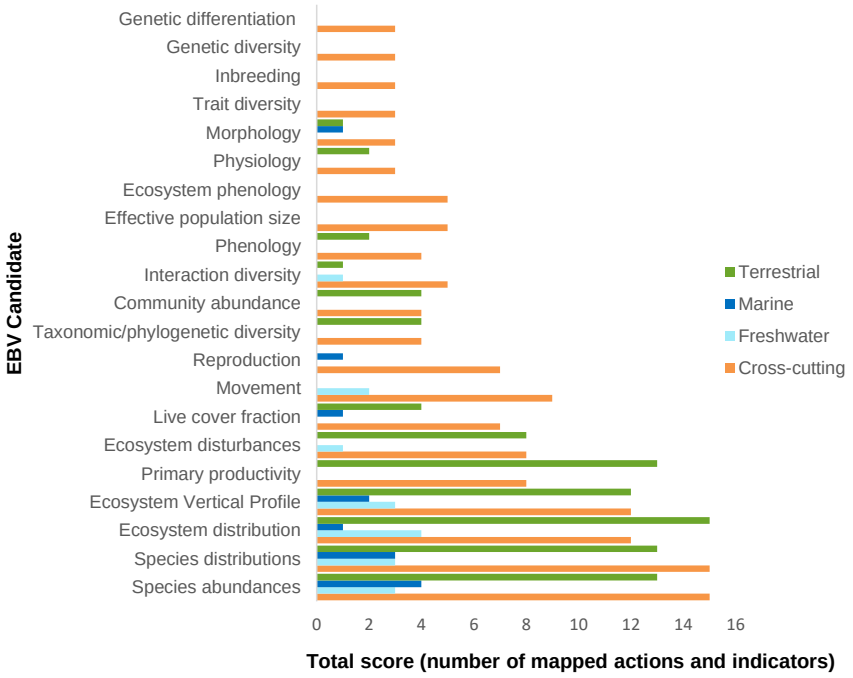

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Figure 3. A total number of actions and indicators mapped to EBV candidates within each ecosystem realm.

The findings largely support the overall EBV ranking, with species abundances, species distributions, ecosystem distribution, and ecosystem vertical profile consistently mapped to the highest number of actions and indicators across all realms (Figure. 3). However, there are some realm-specific variations. Ecosystem distribution is linked to the highest number of actions and indicators for terrestrial and freshwater realms (Figure. 3), even though it is not the highest-ranked EBV overall (Table 3). In marine ecosystems, ecosystem vertical profile ranks slightly higher than ecosystem distribution (Figure.3), likely reflecting the significance of vertical structure in the marine realm. Primary productivity has the second highest score in the terrestrial realm but is of low priority in freshwater and marine realms (Figure.3), suggesting differing policy priorities or monitoring approaches for these realms. Movement is notably highly ranked in cross-cutting and freshwater ecosystems (Figure.3), indicating its relevance for tracking species movement and connectivity in these realms. However, the differences in candidate scores within realms are not large, and a key limitation of this analysis is the low number of selected actions and indicators in the marine and freshwater realms, which may make rankings in these realms less robust.

3.3 EBV Candidate Ranking Across Stages of the Policy Process

The ranking of EBV candidates across policy processes aimed to assess whether different EBVs are more or less important for different stages of the policy cycle (planning, implementation, review, and reporting). Actions were tagged based on which stage they were most relevant to, with all five indicators categorized under "reporting". For the set of selected actions and indicators categorized by policy process, refer to Table A3 in Annex.

Table 4. Distribution of selected actions and indicators from the EU BDS 2030 across different stages of the policy process.

Policy process stage	Number of actions	Number of indicators	Total
Planning	7	0	7
Implementation	23	0	23
Reporting	2	5	7
Review	5	0	5

The distribution of selected actions showed that most actions (25 out of 39 Actions) were relevant to the implementation stage, followed by policy planning (Seven Actions), review (Five Actions), and reporting (Two Actions) (Table 4).

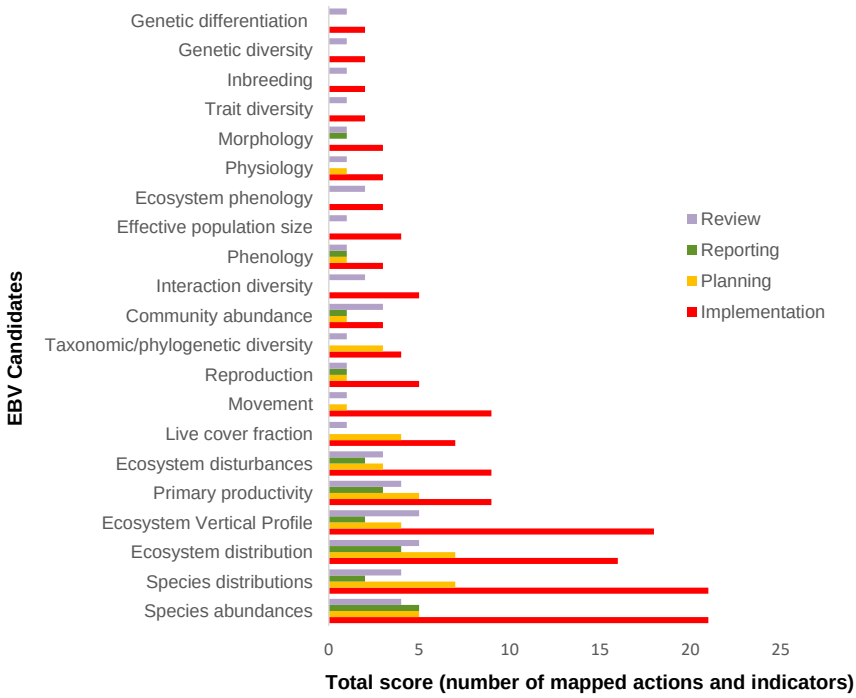

Figure 4. A total number of actions and indicators mapped to EBV candidates within each stage of the policy process.

The results of this analysis again support the overall ranking of EBV candidates, with species abundances, species distributions, ecosystem distribution and ecosystem vertical profile consistently ranking as the highest priority EBVs across all policy stages (Figure.4). Similarly, genetic composition candidates rank low across all stages (Figure.4). Notably, ecosystem-level EBVs ranked higher in the review stage with ecosystem distribution and ecosystem vertical profile ranking first, compared to second and third overall (Table 4) potentially reflecting the need for more ecosystem-scale data for policy review processes. Similarly, species distribution and ecosystem distribution were ranked as joint-top priorities for the planning stage, potentially highlighting the importance of distribution data for policy planning. However, these results are constrained by the relatively small number of actions linked to the planning, reporting, and review stages. As a result, even minor differences in candidate scores within realms can lead to shifts in ranking.

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3.4 Limitations

The approach used in this policy landscape review has several limitations that may affect the priorization of EBV candidates. One key limitation was the broad nature of many of the actions from the EU BDS 2030, which allowed for a range of interpretations of potential implementation approaches and data needs and consequently led to a range of potentially relevant EBVs being mapped. This was particularly evident when mapping actions compared to indicators, as indicators had clearer data needs and were typically associated with only one or two EBVs. The broad applicability of EBV candidates from the ecosystem structure and function classes, which can support multiple aspects of biodiversity monitoring, may have resulted in their frequent mapping. This could have led to an overestimation of their policy priority compared to how actions are implemented in practice. The differences observed in the prioritization of ecosystem vertical profile and primary productivity compared to the EuropaBON User Needs Assessment may be partly explained by this approach.

Another limitation was that the prioritization of EBVs was solely based on the number of actions and indicators they supported rather than the importance of each EBV for specific actions or indicators. The lack of a relevance scoring system meant that all mappings carried equal weight, which could have led to the over or under-ranking of certain candidates. The lack of contextualization may also limit the accuracy of the prioritization exercise, as the approach did not fully consider technical feasibility, knowledge/ data gaps, or capacity to monitor EBVs. Some of these factors may be considered as part of the SPTM under Task 1.2.

To address these limitations, a refinement of the mapping could be achieved through interviews with policy makers and practitioners with experience in knowledge needs at regional, national, and sub-national levels. Engaging policy makers with an understanding of how actions are implemented in practice would help improve the accuracy of the EBV mapping process. Additionally, introducing a relevance scoring system through this process could address the potential overemphasis on ecosystem structure and function variables and provide a more precise prioritization of EBVs. Furthermore, OBSGESSION could now take a global perspective within this task and look at mapping EBV needs to global commitments such as the Kunming-Montreal Global Biodiversity Framework.

4. Conclusions

Overall, the top four ranked EBV candidates in terms of policy priority fall under the species population and ecosystem structure classes. The species abundance candidate ranked 1st, closely followed by species distributions (2nd), ecosystem distribution (3rd) and ecosystem vertical profile (4th). These candidates had markedly higher scores compared to other candidates, highlighting their strong relevance for monitoring, and implementing a wide range of actions and indicators from the EU BDS 2030. They were also consistently ranked among the top four candidates across different ecosystem realms and stages of the policy process, indicating their

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importance to multiple dimensions of biodiversity policy. These rankings are to some extent consistent with the EBV rankings from the EuropaBON User and Policy Needs Assessment, where species abundances and distributions of specific taxa, as well as ecosystem distribution of particular habitats, accounted for 13 out of the top 15 candidates in terms of importance to national policy-making. However, unlike this policy review, the EuropaBON assessment ranked ecosystem vertical profile as a low policy priority (Moersberger et al., 2022). Based on the results of this landscape review and the EuropaBON assessment, species abundance, species distribution, and ecosystem distribution candidates should be prioritized to meet policy needs at the EU level. Further consideration may be required to determine the policy priority of the ecosystem vertical profile candidate, which could be verified through interviews with policy makers as part of efforts to understand national policy priorities for pilots under Work Package 5. In contrast, genetic composition EBV candidates ranked low in terms of policy priority, including across different realms and stages of the policy process. However, effective population size stood out as a potentially more relevant candidate for policy, given its slightly higher ranking. Candidates from the community composition and species traits classes showed more variation in their rankings. Within the species traits class, reproduction and movement candidates stood out as higher policy priorities.

The findings of this review suggest, species abundance, species distribution, and ecosystem distribution candidates should be prioritized for RS-biodiversity product development under OBSGESSION to best address EU policy needs. While the ecosystem vertical profile also ranked highly, further assessment is recommended to determine its importance in biodiversity policy implementation and monitoring.

5. Next Steps

This policy landscape review identified a set of priority EBV candidates based on policy needs as determined through the actions and indicators from the EU BDS 2030, and informed by the findings of the EuropaBON User and Policy Needs Assessment (Moersberger et al., 2022). However, further prioritization, considering scientific knowledge gaps and the technical feasibility of monitoring EBVs via RS, will continue as part of the SPTM under Task 1.2 of the OBSGESSION project to ensure effective prioritization and design of policy-relevant RS biodiversity products. The final selection of EBV candidates should not only consider technical feasibility but also the need to address major data gaps, including taxonomic, habitat/ecosystem, and geographical gaps, and insufficiently monitored EBVs - within current EU monitoring schemes. Other considerations for the development of data products could include whether to target Directives and policies with less well-established monitoring schemes and whether ensuring a balanced selection of variables across different EBV classes is desirable. This policy landscape review presents an initial approach that will be expanded throughout the project life cycle. This expansion could either, take into consideration new information needs with respect to new strategies, policies

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and monitoring requirements or provide an assessment at the global level (e.g. Kunming-Montreal Global Biodiversity Framework).

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7. Annex

Table A1. Mapping of actions from the EU Biodiversity Strategy for 2030 with relevant EU policy and legal frameworks.

This table presents the mapping of actions from the EU Biodiversity Strategy for 2030 to the most relevant EU policy and legal frameworks. While it aims to capture key linkages, it may not be exhaustive. Actions without direct relevance to other EU policy and legal frameworks are not included in this table.

EU BDS 2030 Action	Relevant EU policy and legal frameworks
Action 1	Habitats Directive, Birds Directive
Action 2	Habitats Directive, Birds Directive
Action 3	Habitats Directive, Birds Directive
Action 4	Habitats Directive, Birds Directive
Action 5	Habitats Directive, Birds Directive
Action 7	EU Forest Strategy for 2030, Habitats Directive
Action 8	EU Green Infrastructure Strategy
Action 10	Nature Restoration Law
Action 11	Habitats Directive, Birds Directive
Action 12	Nature Restoration Law
Action 13	Nature Restoration Law
Action 14	EU Pollinators Initiative
Action 15a	EU Pollinators Initiative
Action 15b	EU Pollinators Initiative
Action 16	Farm to Fork Strategy, Sustainable Use of Pesticides Directive, Zero Pollution Action Plan, EU Common Agricultural Policy
Action 17	Sustainable Use of Pesticides Directive
Action 18	EU Common Agricultural Policy
Action 19	EU Common Agricultural Policy
Action 20	EU Action Plan on Organic Farming, Farm to Fork Strategy, EU Common Agricultural Policy
Action 21	EU Common Agricultural Policy, Farm to Fork Strategy
Action 22	EU Action Plan on Organic Farming, Commission Implementing Directive on Derogation for Organic Vegetable Varieties, Commission Implementing Directive on Derogation for Organic Agricultural Plant Varieties
Action 23	Regulation on Plant Reproductive Material, Regulation on Forest Reproductive Material
Action 24	EU Common Agricultural Policy
Action 25	EU Forest Strategy for 2030
Action 26	EU Forest Strategy for 2030
Action 27	EU Forest Strategy for 2030, EU Common Agricultural Policy
Action 28	EU Forest Strategy for 2030
Action 29	EU Forest Strategy for 2030

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EU BDS 2030 Action	Relevant EU policy and legal frameworks
Action 30	EU Common Agricultural Policy, EU Soil Strategy for 2030
Action 31	EU Soil Strategy for 2030
Action 32	EU Soil Strategy, Zero Pollution Action Plan
Action 33	Renovation Wave Strategy and Action Plan, EU Soil Strategy for 2030
Action 34	EU Soil Strategy for 2030
Action 35	Implementing Act on REDII Forest Sustainability Criteria for Forest Biomass, Recast Renewable Energy Directive (RED II)
Action 36	Implementing Act on REDII Forest Sustainability Criteria for Forest Biomass, Recast Renewable Energy Directive (RED II), EU Strategy on Offshore Renewable Energy
Action 37	Implementing Act on REDII Forest Sustainability Criteria for Forest Biomass, Recast Renewable Energy Directive (RED II)
Action 38	Recast Renewable Energy Directive (RED II), Emissions Trading Scheme (ETS) Directive, Land Use, Land Use Change & Forestry Regulation
Action 39	Implementing Act on REDII Forest Sustainability Criteria for Forest Biomass, Recast Renewable Energy Directive (RED II), Emissions Trading Scheme (ETS) Directive, Land Use, Land Use Change & Forestry Regulation
Action 40	Implementing Act on REDII Forest Sustainability Criteria for Forest Biomass, Recast Renewable Energy Directive (RED II)
Action 41	Recast Renewable Energy Directive (RED II), Land Use, Land Use Change & Forestry Regulation, Delegated Regulation on ILUC-risk Feedstock and Low-ILUC biofuels
Action 42	Water Framework Directive, Nature Restoration Law
Action 43	Water Framework Directive, Nature Restoration Law
Action 44	Water Framework Directive
Action 45	Water Framework Directive
Action 46	Invasive Alien Species (IAS) Regulation
Action 47	Farm to Fork Strategy, Zero Pollution Action Plan, EU Common Agricultural Policy, Integrated Nutrient Management Action Plan, Nitrates Directive
Action 48	Integrated Nutrient Management Action Plan
Action 49	Zero Pollution Action Plan
Action 50	EU Chemicals Strategy for Sustainability
Action 54	Common Fisheries Policy
Action 55	EU Action Plan: Protecting and Restoring Marine Ecosystems for Sustainable and Resilient Fisheries
Action 56	Maritime Spatial Planning Directive
Action 57	Habitats Directive, Birds Directive, Marine Strategy Framework Directive, Common Fisheries Policy
Action 58a	Marine Strategy Framework Directive, Decision on Good Environmental Status
Action 58b	Common Fisheries Policy
Action 59	Marine Strategy Framework Directive, Common Fisheries Policy

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EU BDS 2030 Action	Relevant EU policy and legal frameworks
Action 62	Birds Directive, Habitats Directive, Marine Strategy Framework Directive, Water Framework Directive
Action 63	Environmental Crime Directive, Environmental Liability Directive, Action Plan on Environmental Compliance and Governance
Action 64	Aarhus Regulation
Action 65	Environmental Crime Directive
Action 66	Corporate Sustainability Due Diligence Directive
Action 68	Non-Financial Reporting Directive
Action 70	Habitats Directive
Action 71	Circular Economy Action Plan
Action 73	Taxonomy Regulation
Action 74	EU Strategy for Financing the Transition to a Sustainable Economy
Action 77	Amendment to the Natural Capital Accounting Regulation
Action 91	Regulation on Deforestation-free Products
Action 92	Revised EU Action Plan Against Wildlife Trafficking
Action 93	CITES Basic Regulation, CITES Implementing Regulation

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Table A2. EBVs and EESVs as ranked by importance to national policy-making by participating countries and EU services from the EuropaBON User and Policy Needs Assessment (Moersberger et al., 2022).

EBV/ EESV	Taxa, ecosystem, other entities measured	Average of Importance for national policy	Rank
Species abundance	Birds: rare and priority species	4.5	1
	Birds: common	4.26	2
	Butterflies: grassland	4.15	4
	Mammals: Carnivora, Artiodactyla and Bats	4.13	7
	Marine harvested fish species	3.77	14
	Birds: migratory	3.7	17
Community abundance	Pollinator insects	3.95	12
	Completeness of apex predators	2.81	39
Ecosystem distribution	Habitats in Habitats Directive/ EUNIS Habitats	4.25	3
	Land-use/ land cover change	4	10
	Connectivity of vegetation types	3.43	24
Species distributions	Freshwater fish species	4.15	4
	Invasive species	4.15	4
	Plants: priority	4.1	8
	Birds: all	4.09	9
	Plants: all vascular	3.81	13
	Mammals: all	3.76	15
	Marine fish species	3.62	19
	Amphibians	3.59	20
	Reptiles: all	3.43	24
Taxonomic/ functional diversity	Soil biota: invertebrates, fungi and microbiota	3.65	18
	Marine/ transitional plants, diatoms, zooplankton, macro-invertebrates	3.29	26
	Freshwater and transitional phytoplankton, zooplankton, phytobenthos, benthic invertebrates, macroalgae	3.25	28
	Arthropods	3.05	32
Regulating (dis)services	Harmful algal blooms threatening recreation and provisioning services	3.44	23
	Risk of infection by animal vectors	3.07	30
	Crop pest risk in agriculture	3.07	30

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EBV/ EESV	Taxa, ecosystem, other entities measured	Average of Importance for national policy	Rank
Non-material benefits	Public visitation rates to protected areas	3.26	27
	Recreation value from landscapes	3.12	29
Regulating services	Regulation of freshwater quality	4	10
	Belowground carbon content	3.58	21
	Economic value of pollination and seed dispersal	3.47	22
	Level of service based on species diversity or species providing units	2.89	37
	Elimination of carcasses by scavengers	1.87	45
Effective size and/ or inbreeding	Priority taxa in Birds and Habitats directive (e.g., all Annex II species)	3.05	32
Provisioning services	Fish harvest	3.75	16
	Mushrooms and wild fruits production	2.31	43
Morphology	Fishes: harvested species	3	34
Phenology	Selected species: flowering and leaf senescence (plants); migration dates (birds)	3	34
Ecosystem vertical profile (e.g. vegetation height)	Vegetation	2.89	37
Intraspecific genetic diversity	Priority taxa in Birds and Habitats directive (e.g., all Annex II species)	2.9	36
	Trees	2.72	40
Primary productivity	Plants	2.68	41
Ecosystem phenology	Tree phenology	2.68	41
Interaction diversity	Insect predator-prey networks	2.11	44

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Table A3. Complete list of selected actions and indicators from the EU BDS 2030 with EBV-applicability tagged by ecosystem realm and policy process.

Entry type	Action/ Indicator Description	Policy process	Realm
Action	Action 1: Commission guidance for identifying and designating additional protected areas, and appropriate management planning	Implementation	Cross-cutting
Action	Action 2: Complete the designation of Natura 2000 sites, including the necessary designations of marine sites	Implementation	Cross-cutting
Action	Action 5: Progress significantly in legally designing new protected areas and integrating ecological corridors	Implementation	Cross-cutting
Action	Action 6: Commission assessment of progress to the 2030 targets on protected areas, and whether additional action is needed	Review	Cross-cutting
Action	Action 7: Commission guidance on defining, mapping and strictly protecting all primary and old-growth forests	Implementation	Terrestrial
Action	Action 9: Protect and restore ecosystems in the EU's Outermost Regions, and support biodiversity action in the Overseas Countries and Territories	Implementation	Cross-cutting
Action	Action 11: Commission guidance on the selection of species and habitats currently not in favourable conservation status for priority action	Implementation	Cross-cutting
Action	Action 12: Restore 30% of habitats and species currently not in favourable conservation status	Implementation	Cross-cutting
Action	Action 13: Commission guidance on an EU methodology to map, assess and achieve good condition of ecosystems so that they can deliver benefits	Implementation	Cross-cutting
Action	Action 14: Fully implement the EU Pollinators initiative	Implementation	Terrestrial
Action	Action 15a: Commission report on the review of progress in the implementation of the EU Pollinators Initiative	Reporting	Terrestrial
Action	Action 15b: Revise the EU Pollinators Initiative	Review	Terrestrial
Action	Action 18: Implement measures to ensure that at least 10% of agricultural area will be under high diversity landscape features by 2030	Implementation	Terrestrial
Action	Action 19: Constantly review progress on the target of 10% high-biodiversity landscape features and its possible impacts, and adjust if necessary	Review	Terrestrial
Action	Action 21: Take measures to ensure that Member States CAP'Strategic Plans set explicit national values for the relevant targets of the Biodiversity and farm to Fork Strategies	Planning	Cross-cutting
Action	Action 25: EU Forest Strategy	Planning	Terrestrial
Action	Action 26: Further develop the Forest Information System for Europe (FISE)	Implementation	Terrestrial

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Entry type	Action/ Indicator Description	Policy process	Realm
Action	Action 28: Guidance on biodiversity-friendly afforestation and reforestation and closer-to-nature forestry	Implementation	Terrestrial
Action	Action 29: Commission Roadmap for planting at least 3 billion additional trees in the EU by 2030 in full respect of ecological principles	Planning	Terrestrial
Action	Action 36: Prioritise renewable energy solutions favourable to biodiversity	Implementation	Cross-cutting
Action	Action 37: Regularly assess EU and global biomass supply and demand and related sustainability	Reporting	Terrestrial
Action	Action 39: Publish a study on the sustainability of the use of forest biomass for energy production	Review	Terrestrial
Action	Action 40: Commission operational guidance on the new sustainability criteria on forest biomass for energy	Implementation	Terrestrial
Action	Action 41: Review the data on biofuels with high indirect land-use change risk and set-up a strategy for their gradual phase out by 2030	Planning	Terrestrial
Action	Action 42: Commission technical guidance to support Member States for the restoration of 25000 km of free-flowing rivers	Implementation	Freshwater
Action	Action 43: Remove or adjust barriers and restore floodplains	Implementation	Freshwater
Action	Action 44: Provide technical support to Member States on their measures to review water abstraction and impoundment permits to restore ecological flows	Implementation	Freshwater
Action	Action 45: Review water abstraction and impoundment permits to implement ecological flows and achieve good status or potential to all surface waters	Implementation	Freshwater
Action	Action 46: Step up the implementation of the European Invasive Alien Species (IAS) Regulation	Implementation	Cross-cutting
Action	Action 53: Develop Urban Greening Plans	Planning	Terrestrial
Action	Action 54: Implement measures to reduce or maintain fishing mortality at or under maximum sustainable yield	Implementation	Marine
Action	Action 55: New Action Plan to conserve fisheries resources and protect marine ecosystems	Planning	Marine
Action	Action 57: Establish fisheries management measures in marine protected areas	Implementation	Marine
Action	Action 70: Develop an EU-level Prioritised Action Framework	Planning	Cross-cutting
Action	Action 76: Develop methods, criteria and standards to better integrate biodiversity considerations into public and business decision making and to measure environmental footprint	Implementation	Cross-cutting

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Entry type	Action/ Indicator Description	Policy process	Realm
Action	Action 90: Improve the assessment of the impact of trade agreements on biodiversity and strengthen the provisions of existing and new agreements if relevant	Implementation	Cross-cutting
Action	Action 102: Assessment of progress in implementing the strategy	Review	Cross-cutting
Indicator	4.1.1 Common bird index by type of species	Reporting	Cross-cutting
Indicator	5.0.1 Grassland butterfly index	Reporting	Terrestrial
Indicator	8.1.1 Area under organic farming	Reporting	Terrestrial
Indicator	9.0.1 Number of trees planted in the EU as part of the 3 Billion Trees Pledge	Reporting	Terrestrial
Indicator	13.1.2 Change in the concentration of nitrate in rivers	Reporting	Freshwater
Indicator	13.1.3: Change in the concentration of phosphate in rivers	Reporting	Freshwater
Indicator	13.1.4: Change in the concentration of total phosphorus in lakes	Reporting	Freshwater
Indicator	15.1.1 Proportion of fish stocks sustainably exploited	Reporting	Marine

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Table A4. Full set of mappings of selected actions and indicators from the EU BDS 2030 to EBV classes and candidates.

Action/ Indicator Description	EBV Class	EBV Candidate
Action 1: Commission guidance for identifying and designating additional protected areas, and appropriate management planning	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Ecosystem structure	Ecosystem distribution
	Species populations	Species distributions
	Species populations	Species abundances
	Species traits	Movement
	Genetic composition	Effective population size
Action 2: Complete the designation of Natura 2000 sites, including the necessary designations of marine sites	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Species populations	Species distributions
	Species populations	Species abundances
	Species traits	Movement
Action 5: Progress significantly in legally designing new protected areas and integrating ecological corridors	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Live cover fraction
	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species distributions
	Species populations	Species abundances
	Species traits	Movement
	Species traits	Reproduction
Action 6: Commission assessment of progress to the 2030 targets on protected areas, and whether additional action is needed	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Ecosystem phenology
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species abundances
	Species populations	Species distributions
Action 7: Commission guidance on defining, mapping and strictly protecting all primary and old-growth forests	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem structure	Live cover fraction
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Species traits	Morphology
	Species populations	Species distributions
	Species populations	Species abundances

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Action/ Indicator Description	EBV Class	EBV Candidate
Action 9: Protect and restore ecosystems in the EU's Outermost Regions, and support biodiversity action in the Overseas Countries and Territories	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem phenology
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Species populations	Species abundances
	Species populations	Species distributions
	Community composition	Community abundance
	Community composition	Taxonomic/phylogenetic diversity
	Community composition	Trait diversity
	Community composition	Interaction diversity
	Species traits	Reproduction
	Species traits	Morphology
	Species traits	Physiology
	Species traits	Phenology
	Species traits	Movement
	Genetic composition	Genetic diversity
	Genetic composition	Genetic differentiation
	Genetic composition	Effective population size
	Genetic composition	Inbreeding
Action 11: Commission guidance on the selection of species and habitats currently not in favourable conservation status for priority action	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species abundances
	Species populations	Species distributions
	Species traits	Movement
	Species traits	Phenology
	Species traits	Reproduction
	Community composition	Interaction diversity
	Genetic composition	Effective population size
Action 12: Restore 30% of habitats and species currently not in favourable conservation status	Community composition	Interaction diversity
	Species populations	Species distributions
	Species populations	Species abundances
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem phenology

Action/ Indicator Description	EBV Class	EBV Candidate
	Ecosystem functioning	Ecosystem disturbances
	Species traits	Reproduction
Action 13: Commission guidance on an EU methodology to map, assess and achieve good condition of ecosystems so that they can deliver benefits	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem functioning	Primary productivity
	Species populations	Species distributions
	Species populations	Species abundances
Action 14: Fully implement the EU Pollinators initiative	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Primary productivity
	Community composition	Community abundance
	Species populations	Species abundances
	Species populations	Species distributions
Action 15a: Commission report on the review of progress in the implementation of the EU Pollinators Initiative	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Primary productivity
	Community composition	Community abundance
	Species populations	Species abundances
	Species populations	Species distributions
Action 15b: Revise the EU Pollinators Initiative	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Community composition	Community abundance
	Species populations	Species abundances
	Species populations	Species distributions
Action 18: Implement measures to ensure that at least 10% of agricultural area will be under high diversity landscape features by 2030	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species abundances
	Species populations	Species distributions
Action 19: Constantly review progress on the target of 10% high-biodiversity landscape features and its possible impacts, and adjust if necessary	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Species populations	Species abundances
	Species populations	Species distributions
	Community composition	Interaction diversity
	Community composition	Community abundance
	Ecosystem functioning	Primary productivity
Action 21: Take measures to ensure that Member States CAP Strategic Plans set	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Primary productivity

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Action/ Indicator Description	EBV Class	EBV Candidate
explicit national values for the relevant targets of the Biodiversity and farm to Fork Strategies	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species distributions
Action 25: EU Forest Strategy	Species populations	Species abundances
	Species populations	Species distributions
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Community composition	Taxonomic/phylogenetic diversity
	Species traits	Phenology
	Species traits	Physiology
Action 26: Further develop the Forest Information System for Europe (FISE)	Species populations	Species abundances
	Species populations	Species distributions
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Community composition	Taxonomic/phylogenetic diversity
	Species traits	Physiology
Action 28: Guidance on biodiversity-friendly afforestation and reforestation and closer-to-nature forestry	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Species populations	Species abundances
	Species populations	Species distributions
	Community composition	Taxonomic/phylogenetic diversity
Action 29: Commission Roadmap for planting at least 3 billion additional trees in the EU by 2030 in full respect of ecological principles	Species populations	Species distributions
	Ecosystem functioning	Primary productivity
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Live cover fraction
	Community composition	Taxonomic/phylogenetic diversity
Action 36: Prioritise renewable energy solutions favourable to biodiversity	Species traits	Movement
	Species populations	Species abundances

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Action/ Indicator Description	EBV Class	EBV Candidate
	Species populations	Species distributions
Action 37: Regularly assess EU and global biomass supply and demand and related sustainability	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem structure	Ecosystem distribution
Action 39: Publish a study on the sustainability of the use of forest biomass for energy production	Ecosystem functioning	Primary productivity
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Ecosystem functioning	Ecosystem disturbances
Action 40: Commission operational guidance on the new sustainability criteria on forest biomass for energy	Ecosystem functioning	Primary productivity
	Ecosystem structure	Ecosystem Vertical Profile
Action 41: Review the data on biofuels with high indirect land-use change risk and set-up a strategy for their gradual phase out by 2030	Ecosystem functioning	Primary productivity
	Ecosystem structure	Ecosystem distribution
	Species populations	Species distributions
	Species populations	Species abundances
Action 42: Commission technical guidance to support Member States for the restoration of 25000 km of free-flowing rivers	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem functioning	Ecosystem disturbances
	Community composition	Interaction diversity
	Species populations	Species abundances
	Species populations	Species distributions
	Species traits	Movement
Action 43: Remove or adjust barriers and restore floodplains	Ecosystem structure	Ecosystem distribution
	Species populations	Species abundances
	Species populations	Species distributions
	Species traits	Movement
Action 44: Provide technical support to Member States on their measures to review water abstraction and impoundment permits to restore ecological flows	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Species populations	Species abundances
	Species populations	Species distributions
Action 45: Review water abstraction and impoundment permits to implement ecological flows and achieve good status or potential to all surface waters	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
Action 46: Step up the implementation of the European Invasive Alien Species (IAS) Regulation	Species populations	Species abundances
	Species populations	Species distributions
	Ecosystem functioning	Ecosystem disturbances
Action 53: Develop Urban Greening Plans	Species populations	Species abundances
	Species populations	Species distributions

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Action/ Indicator Description	EBV Class	EBV Candidate
	Ecosystem structure	Ecosystem distribution
Action 54: Implement measures to reduce or maintain fishing mortality at or under maximum sustainable yield	Species populations	Species abundances
	Species populations	Species distributions
Action 55: New Action Plan to conserve fisheries resources and protect marine ecosystems	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Live cover fraction
	Species populations	Species abundances
	Species populations	Species distributions
Action 57: Establish fisheries management measures in marine protected areas	Species populations	Species abundances
	Species populations	Species distributions
	Ecosystem structure	Ecosystem Vertical Profile
Action 70: Develop an EU-level Prioritised Action Framework	Ecosystem structure	Live cover fraction
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Species populations	Species abundances
	Species populations	Species distributions
	Species traits	Movement
	Species traits	Reproduction
	Community composition	Community abundance
	Community composition	Taxonomic/phylogenetic diversity
Action 76: Develop methods, criteria and standards to better integrate biodiversity considerations into public and business decision making and to measure environmental footprint	Ecosystem structure	Live cover fraction
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem phenology
	Ecosystem functioning	Ecosystem disturbances
	Species populations	Species abundances
	Species populations	Species distributions
	Community composition	Community abundance
	Community composition	Taxonomic/phylogenetic diversity
	Community composition	Trait diversity
	Community composition	Interaction diversity
	Genetic composition	Genetic diversity
	Genetic composition	Genetic differentiation

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Action/ Indicator Description	EBV Class	EBV Candidate
	Genetic composition	Effective population size
	Species traits	Morphology
	Species traits	Physiology
	Species traits	Phenology
	Species traits	Movement
	Species traits	Reproduction
	Genetic composition	Inbreeding
Action 90: Improve the assessment of the impact of trade agreements on biodiversity and strengthen the provisions of existing and new agreements if relevant	Species populations	Species abundances
	Species populations	Species distributions
Action 102: Assessment of progress in implementing the strategy	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile
	Ecosystem structure	Live cover fraction
	Ecosystem functioning	Primary productivity
	Ecosystem functioning	Ecosystem disturbances
	Ecosystem functioning	Ecosystem phenology
	Species populations	Species abundances
	Species populations	Species distributions
	Community composition	Community abundance
	Community composition	Taxonomic/phylogenetic diversity
	Community composition	Trait diversity
	Community composition	Interaction diversity
	Species traits	Morphology
	Species traits	Physiology
	Species traits	Phenology
	Species traits	Movement
	Species traits	Reproduction
	Genetic composition	Genetic diversity
	Genetic composition	Genetic differentiation
	Genetic composition	Effective population size
	Genetic composition	Inbreeding
Indicator 4.1.1 Common bird index by type of species	Species populations	Species abundances
Indicator 5.0.1 Grassland butterfly index	Species populations	Species abundances
	Species populations	Species distributions
	Ecosystem structure	Ecosystem distribution
	Ecosystem structure	Ecosystem Vertical Profile

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Action/ Indicator Description	EBV Class	EBV Candidate
Indicator 8.1.1 Area under organic farming	Species traits Ecosystem functioning	Phenology Primary productivity
Indicator 9.0.1 Number of trees planted in the EU as part of the 3 Billion Trees Pledge	Species populations Ecosystem structure	Species abundances Ecosystem distribution
Indicator 13.1.2 Change in the concentration of nitrate in rivers	Ecosystem functioning	Phenology Primary productivity
Indicator 13.1.3: Change in the concentration of phosphate in rivers	Ecosystem functioning	Phenology Primary productivity
Indicator 13.1.4: Change in the concentration of total phosphorus in lakes	Ecosystem functioning	Phenology Primary productivity
Indicator 15.1.1 Proportion of fish stocks sustainably exploited	Species populations Species traits Species traits	Species abundances Morphology Reproduction

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