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D4.1. List and specifications of EBVs and EESVs for a European wide biodiversity observation network

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EUROPABON

REVISION

D4.1. List and specifications of EBVs and EESVs for a European wide biodiversity observation network

31/01/2023

Lead beneficiary: Martin-Luther-Universität Halle-Wittenberg (MLU)

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Project coordinator:	Prof. Henrique Pereira Martin-Luther Universitaet Halle-Wittenberg (MLU) www.europabon.org
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EC project officer	Laura Palomo-Rios

Deliverable description	EuropaBON harnesses the power of modelling Essential Biodiversity Variables (EBVs) to integrate different reporting streams, data sources, and monitoring schemes, and measure biodiversity change across multiple dimensions in

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	space and time. Therefore, EBVs are at the core of the project and form the basis for several of the tasks feeding into the co-design of a biodiversity monitoring system for Europe. In this document, we describe the stepwise process of identifying and specifying the EBVs that made it to the EBV list presented in this deliverable. We further provide a summary of the characteristics of the EBVs identified for EuropaBON, in terms of their desired spatial- and temporal resolutions, as well as the taxonomic/ ecosystem scope to be measured.
Keywords	Essential Biodiversity Variable (EBV), Essential Ecosystem Services Variable (EESV), GEO BON, policy needs, stakeholder engagement

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Content

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Summary

EuropaBON harnesses the power of modelling Essential Biodiversity Variables (EBVs) to integrate different reporting streams, data sources, and monitoring schemes, and measure biodiversity change across multiple dimensions in space and time. Therefore, EBVs are at the core of the project and form the basis for several of the tasks feeding into the co-design of a biodiversity monitoring system for Europe. In this document, we introduce the EBV framework established by The Group on Earth Observations Biodiversity Observation Network (GEO BON), followed by an in-depth description of the stepwise process of identifying and specifying EBVs for EuropaBON. We further provide a definition for each EBV, and information about the metrics to be measured, the desired spatial- and temporal resolution, and the taxon/ ecosystem to be monitored. Finally, we provide a descriptive analysis of the composition of the EBVs on our list, in terms of EBV class, realm, spatial/ temporal resolution and taxonomic/ ecosystem focus.

Introduction

What are Essential Biodiversity Variables?

Essential Biodiversity Variables (EBVs) are a set of biodiversity measurements that aim to standardise and coordinate the collection and monitoring of biodiversity data. EBVs represent the minimum set of variables, ranging from genes to ecosystems, needed to quantify the magnitude of biodiversity change or ecosystem service delivery. To capture all major dimensions of biodiversity, EBVs are grouped into six major classes according to similarities and differences in the biological *entities* (i.e., the object measured) and *attributes* (i.e., the properties of that object measured) that they measure. EBVs that measure the variability of particular *attributes* of species (*entity*) – i.e., genetic diversity within a species (**Genetic Composition EBVs**), distribution and abundance of species (**Species Populations EBVs**) and trait diversity within species (**Species Traits EBVs**) – are referred to as so-called "species-focused EBVs". EBVs that measure collective *attributes* of the entire ecosystem (*entity*) at a geographically-defined location, such as structural (**Ecosystem Structure EBVs**) and functional attributes of the ecosystem (**Ecosystem Function EBVs**), as well as community-level abundance and various dimensions of the compositional diversity (e.g., taxonomic, phylogenetic, functional) of organisms occurring within the ecosystem (**Community Composition EBVs**), are referred to as "ecosystem-focused EBVs" (Table 1).

The Essential Biodiversity Variables framework

The EBV framework has two components: the identification of priority variables from a set of classes of biodiversity and ecosystem service variables[1]; and the workflow for harmonisation and integration of observations using data infrastructures and models to provide EBV datasets and indicators.

The identification of variables that are essential to monitor, through consultations with different stakeholders and the subsequent mapping of those specific variables to the generic variables defined in the framework, is crucial. Besides matching of those variables with the generic list of existing EBVs (Table 4), this identification needs to include details on the spatial, temporal and taxonomic/biological

[1] Pereira, H. M., Ferrier, S., Walters, M. et al. (2013). Essential Biodiversity Variables. Science, 339, 277–278.

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entity resolution and scope of the variables in order to fully specify them[2]. The prioritisation of the most important variables for monitoring needs to address issues such as the policy and scientific relevance[3], and the feasibility of the monitoring.

Table 1: Biological entities and attributes (also known as generic EBVs) measured by each of six EBV classes (adapted from GEO BON[4]). More detailed descriptions of the attributes measured are provided in Table 4.

***Entity* measured**	**EBV Class**	***Attributes* measured**
Species (Species-focused EBVs)	Genetic composition	Genetic diversity
		Genetic differentiation
		Effective population size
		Inbreeding
	Species populations	Species distributions
		Species abundances
	Species traits	Morphology
		Physiology
		Phenology
		Movement
		Reproduction
Ecosystem	Ecosystem structure	Live cover fraction

[2] Pereira, H. M., Belnap, J., Böhm, M., Brummitt, N., Garcia-Moreno, J., Gregory, R., … Van Swaay, C. (2017). Monitoring Essential Biodiversity Variables at the Species Level. In M. Walters & B. Scholes (Eds.), The GEO Handbook on Biodiversity Observation Networks (pp. 79–105).

[3] Guerra, C. A., Pendleton, L., Drakou, E. G., et al. (2019). Finding the essential: Improving conservation monitoring across scales. Global Ecology and Conservation, 18, e00601

[4] https://geobon.org/

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(Ecosystem-focused EBVs)		Ecosystem distribution
		Ecosystem vertical profile
	Ecosystem function	Primary productivity
		Ecosystem phenology
		Ecosystem disturbances
	Community composition	Community abundance
		Taxonomic/phylogenetic diversity
		Trait diversity
		Interaction diversity

The design of workflows starts with primary earth observations, including those from *in situ* surveys, structured monitoring, citizen science and space or airborne missions, which need to be processed, standardised and mobilised into open-access structures and data centres (Figure 1). Combining the harmonised biodiversity data with biophysical covariates, such as data on habitat structure, and data on weather or climate, can provide seamless spatiotemporal data sets. Data deficiencies or gaps are compensated through biodiversity models integrating *in-situ* with remote-sensing information or with other sources of spatially and temporally continuous data sets, for example from modelling land-use and climate scenarios into the past and the future (so-called "EBV data cubes"; Figure 1). EBV products are used by observation networks (e.g., national, regional, thematic BONs[5]), science applications to develop biodiversity indicators, and policy assessments.

This deliverable covers only the first component of the EBV framework; this is the identification of priority variables and their specification in close consultation with relevant stakeholders. It is also important to highlight that this specification is about the temporal and spatial resolution units of the EBV cube (e.g., the model output) and not of the observations themselves (Figure 1). The identification of EBVs for the new EU biodiversity monitoring system is central to the project and forms the basis for several other tasks in EuropaBON (e.g., identifying monitoring gaps, analysis of workflow bottlenecks, benefits of a European BON). The design of workflows for the EBVs will be the focus of the co-design process in a later task of the project (T4.3).

[5] https://geobon.org/

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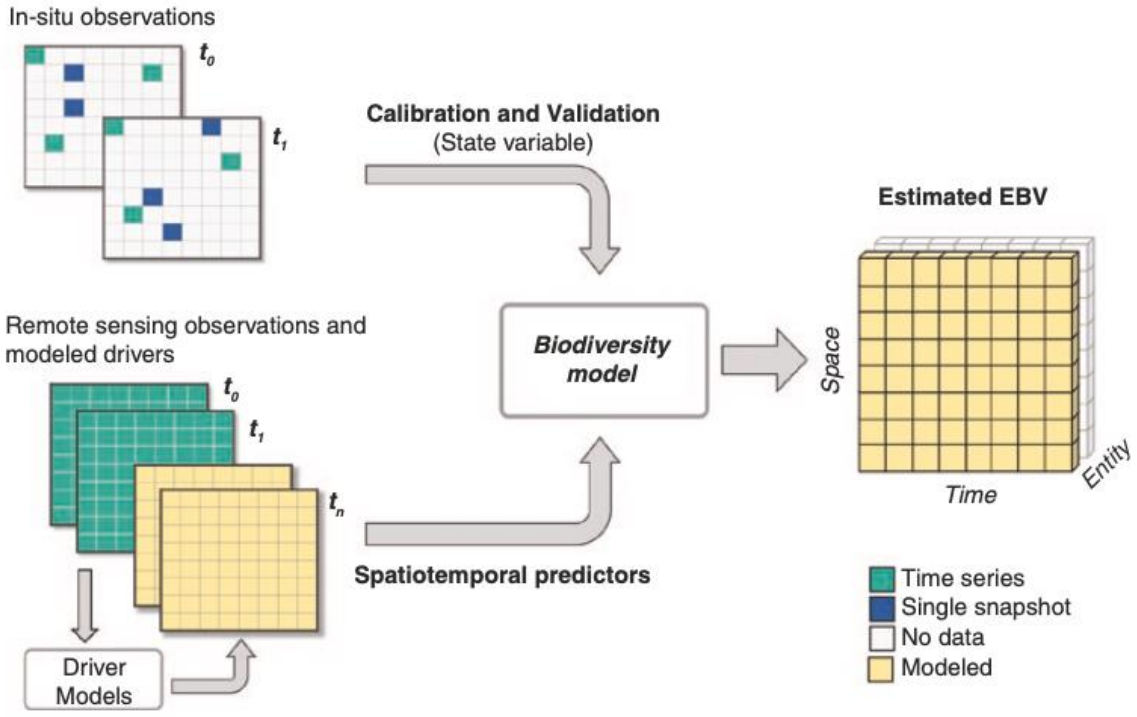

Figure 1: Schematic overview of how models are used in workflows from primary observations to Essential Biodiversity Variables[6]. Note that the spatial and temporal resolution of the observations can be different from the spatial and temporal resolutions of the estimated EBV cube. This report is about the desirable features of the latter.

Ecosystem Services Variables

Ecosystem Services Variables (EESVs) were established by the GEO BON Ecosystem Services Working Group (ESWG) back in 2010 and provide a comprehensive picture of how links between nature and people are changing. Just like EBVs, EESVs are grouped into six classes: 1) Ecological supply, 2) Anthropogenic contribution, 3) Demand, 4) Use, 5) Instrumental value, and 6) Relational value (Table 2). It is important to note that in EuropaBON, we focus only the first class of EESVs, i.e., Ecological supply variables that measure ecosystem structure and functions that underlie the potential capacity of ecosystems to provide ecosystem services. There are numerous essential variables in EuropaBON that could potentially fall into this category and that we collectively refer to as EBVs throughout the text.

[6] Fernández, N., Ferrier, S., Navarro, L. M., & Pereira, H. M. (2020). Essential Biodiversity Variables: Integrating In-Situ Observations and Remote Sensing Through Modeling. In J. Cavender-Bares, J. A. Gamon, & P. A. Townsend (Eds.), *Remote Sensing of Plant Biodiversity* (pp. 485–501). Cham: Springer International Publishing. doi: 10.1007/978-3-030-33157-3_18

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Table 2: Attributes measured by each of six EESV classes (adapted from GEO BON[7]).

EESV Class	*Attributes* measured
Ecological supply	The ecosystem structure and functions that underlie the potential capacity of ecosystems to provide ecosystem services.
Anthropogenic contribution	The efforts that humans invest to enhance ecological supply and to make use of ecosystem services.
Demand	The explicitly or implicitly expressed human desire or need for an ecosystem service, in terms of its quantity or quality, irrespective of whether awareness exists about such need.
Use	The active or passive appropriation of an ecosystem service by people.
Instrumental value	The importance of an ecosystem service to societies or individuals as a means to achieve a specific end (e.g., some dimension of human well-being).
Relational value	The importance ascribed to how ecosystems contribute to desirable and meaningful interactions between humans and nature and between humans in relation to nature.

We identified those EBVs in our list that measure species, ecosystem structure or functions that may influence the provision of specific services and linked them to the broad categories of the EU-endorsed System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) reference list[8] in Figure 2. Almost half (44%; n= 31) of the EBVs in our list qualify as Ecological supply EESVs defined by the GEO BON ESWG and further classified by the SEEA EA. They cover a broad range of 15 different SEEA EA categories (sorted by decreasing number of EBVs that fall into each category): recreation-related services (n= 11), biomass provisioning services (n= 7), global climate regulation services (n= 6), biological control services (n= 4), flood mitigation- and soil quality regulation services (n= 3), air filtration-, pollination-, soil and sediment retention-, and water flow and water purification services (n= 2), and noise attenuation-, storm mitigation-, rainfall pattern regulation-, and water supply services (n= 1). It is important to note that there are some EBVs in our list that provide data to assess change in several SEEA EA categories, such as 'Species distributions of terrestrial plants', 'Species distributions of main trees', 'River continuity/ Free river flow', 'Harmful freshwater algal blooms', and 'Ecosystem distribution of oyster reef habitats'.

[7] https://geobon.org/

[8] Online supplement: Ecosystem Services Reference List Crosswalk to Selected Ecosystem Services Classifications and Typologies; Version 1 July 2021; https://seea.un.org/ecosystem-accounting

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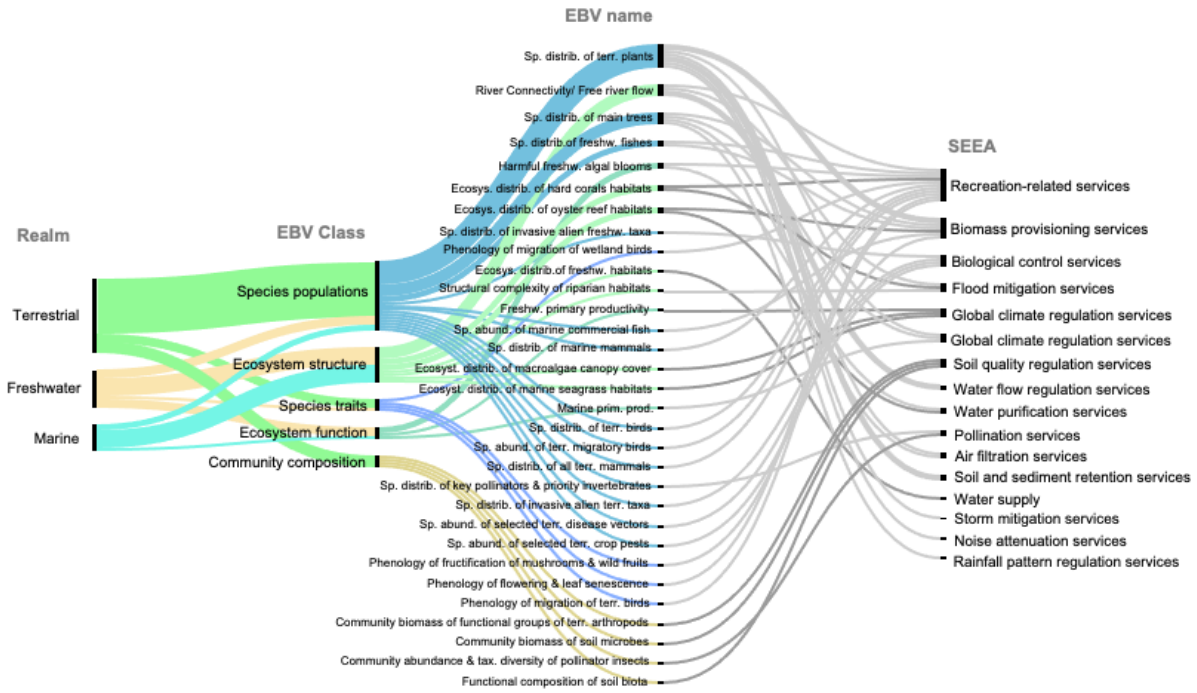

Figure 2: EBVs identified by EuropaBON that measure species, ecosystem structure or functions that may influence the provision of specific services defined by the System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) broad ecosystem services categories. Note that some EBV names were slightly modified for better visualisation.

Methodology for identifying EBVs in EuropaBON

We followed a stepwise process over the course of 18 months to obtain the full list of EBVs delivered for task 4.1 depicted in Figure 4 and described in more detail below.

Stakeholder workshop

As part of the User & Policy Needs Assessment[9], the first open (virtual) stakeholder workshop took place in May 2021. For this workshop, we invited all interested stakeholders to jointly identify and discuss user and policy needs for biodiversity monitoring in Europe. The workshop attracted 362 registrants from 48 countries across the globe and was attended by 246 participants from policy, academia and non-profit organisations. Still, the majority of attendants were from south-western and central Europe and had academic backgrounds.

Rapid survey

[9] Moersberger, H., Martin, J. G. C., Junker, J., et al. (2022). Europa Biodiversity Observation Network: User and Policy Needs Assessment. ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e84517.

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Prior to the workshop, a rapid survey was sent to the participants, asking to list desirable EBVs across the different classes, specifying their spatial and temporal resolution, and taxonomic scope, biome/ ecosystem focus, the rationale for their choice, the importance for each of six policy domains (Birds Directive, Habitat Directive, Freshwater Directive, Marine Directives, Soil and Restoration Policy, Bioeconomy), and what policy question they could address. This rapid survey was answered by 41 participants and resulted in a list of 75 EBVs (Figure 4).

The rapid survey list of EBVs was then used as input for further discussions in the workshop in breakout groups for each policy domain. Participants were free to add further EBVs and to provide ranks of importance (in a scale of 1-low to 5-high) for each of the EBVs to address open policy questions in their country/ agency. This resulted in a list of 243 variables (Figure 4), distributed across the six policy domains (39 for Birds Directive, 56 for Habitats Directive, 33 for Freshwater Directives, 14 for Marine Directives, 49 for Restoration and Soil Policy, and 52 Bioeconomy and Cross-cutting).

First internal review

After the workshop, during the first internal review of the EBV list that included 243 variables, we identified many redundancies, both within each policy domain and across multiple policy domains. In addition, several of the variables had consistently received low rankings at the workshop by participants. We carried out a consolidation of the list and obtained a selection of the variables that had received intermediate to high rankings. This resulted in a list of 45 variables (Figure 4), covering terrestrial (N=35), marine (N=5) and freshwater biomes (N=5), with specified taxonomic/ entity scope, desirable spatial resolution, and desirable temporal resolution[10].

Standardised survey & semi-structured external interviews

We used this list of 45 specified variables in the follow up consultations with national experts. A standardised survey was disseminated in July-September 2021 to all national focal points of the European Environment Information and Observation Network (Eionet) and other relevant experts in 37 European countries. We also sent the survey to nine European Commission Services (comprising Directorate-Generals and agencies) and the European Biodiversity Partnership. The standardised survey asked respondents to rank (on a scale from 1-low to 5-high) the EBVs for national policy-making, evaluate the current monitoring status, provide comments on the proposed spatial, temporal and taxonomic resolution/ scope of the variables, and identify relevant policy/ management questions. We received responses from 21 countries and four Commission Services. Building on the survey responses, we conducted 15 semi-structured interviews with experts from 13 countries and two Commission Services to allow for clarification and in-depth discussion of the respective survey responses. Based on this survey and the interviews, a subset of the highest 15 priority EBVs was selected using the highest average rank scores by respondents, and further analysed in the User and Policy Needs Assessment Report[11] (Figure 4).

[10] Moersberger, H., Martin, J. G. C., Junker, J., et al. (2022). Europa Biodiversity Observation Network: User and Policy Needs Assessment. ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e84517.

[11] Moersberger, H., Martin, J. G. C., Junker, J., et al. (2022). Europa Biodiversity Observation Network: User and Policy Needs Assessment. ARPHA Preprints. https://doi.org/10.3897/arphapreprints.e84517.

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Second internal review

The wide participation of key stakeholders from countries and Commission Services in the User & Policy Needs Assessment varied in the four steps of the stakeholder engagement process (*rapid survey, stakeholder workshop, standardised survey, semi-structured interviews*), which may have thus caused some biases. Furthermore, not all respondents could answer all the questions. Participating stakeholders and policy experts were also mainly working on terrestrial biodiversity, both at national and at EU level, while aquatic biodiversity (freshwater and marine) was less well represented. EuropaBON partners involved in task 4.1 therefore internally reviewed this list for a second time to a) ensure a balanced set of essential variables across realms (terrestrial, freshwater, marine) and EBV classes, b) match and extend essential variables to existing reporting streams (i.e., EU Nature Directives) and c) ensure that they address the three major EU policy missions (1. assessing general biodiversity trends, 2. restore degraded ecosystems, 3. ensure long-term ESS). This resulted in a relatively balanced list of 46 EBVs.

EBV expert workshop and third internal review process

On 29 April 2022, we hosted an online EBV expert workshop to which we invited 135 biodiversity researchers with expertise in monitoring and/or modelling biodiversity variables across the different realms, EBV classes and taxa included on our list. We presented this list of 46 EBVs to 64 biodiversity researchers that attended the EBV expert workshop. During the workshop, experts were given the task to fill thematic gaps in EBVs (across realms and EBV classes) and (re)define spatial-, and temporal resolutions and taxonomic scopes of EBVs where needed. This process again yielded a larger list of > 90 EBVs. In a third internal review process, we refined this list to 72 EBVs (33 terrestrial EBVs, 22 freshwater EBVs, 17 marine EBVs; Table 2) by removing EBVs that 1) were redundant, 2) were added but not specified sufficiently during the EBV expert workshop, 3) could be derived from those already on the list, and 4) were not feasible to map at European scale.

KCBD biodiversity monitoring ad hoc group meeting

On 7 October 2022, our partners from the Joint Research Centre (JRC) organized the second meeting of the European Commission's Knowledge Centre for Biodiversity (KCBD) biodiversity monitoring *ad hoc* group (hereafter referred to as KCBD meeting) in Brussels, Belgium. This in-person meeting was attended by various EU Commission Services and other EU agencies and key stakeholders, including amongst others, representatives from DG ENV, DG MARE, DG AGRI, DG RTD, the EEA, REA, Biodiversa+, SYKE, and GBIF. One aim of this interactive working meeting was to get feedback from the EU Commission Services and other agencies on the policy-relevance and feasibility of each of the 72 EBVs across the three realms. Participants were also asked to give "likes" and "unlikes" to each of the EBVs, where there was no limit to the number of votes they could provide. The information provided by participants of this meeting was processed and summarized and incorporated into the fourth internal review process described below.

Fourth internal review process

From June-December 2022, we conducted the fourth internal review process, during which the core team of T4.3 (co-design of EuropaBON) around M. Lumbierres and D. Kissling (UvA) created so-called fact sheets for each of the 72 EBVs, by adding definitions for each EBV, adding metrics for each EBV,

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revising EBV names, revising the spatial and temporal resolution of each EBV, and providing details on the taxonomic scope (specific species names and taxonomic groups, referencing to taxonomic lists and sources etc.) and ecosystem focus of each EBV (Figure 3). This was done in close coordination with internal and external experts on EBV classes, specific taxa, and/ or realms by one-to-one consultations with them.

This information was presented at the KCBD meeting and served as the blueprint for input by the participants. Based on the information gathered at this meeting and from the EBV fact sheets, we split EBVs by whether the monitoring design for the taxonomic groups differed substantially, merged EBVs if they could be monitored in parallel/ using the same monitoring design, removed EBVs if their monitoring was unfeasible, and added EBVs if they were considered important. This KCBD meeting and the internal review process that followed resulted in a list of 70 unique, feasible, policy-relevant and sufficiently specified EBVs for EuropaBON. The EBVs that resulted from this process are listed in Table 3.

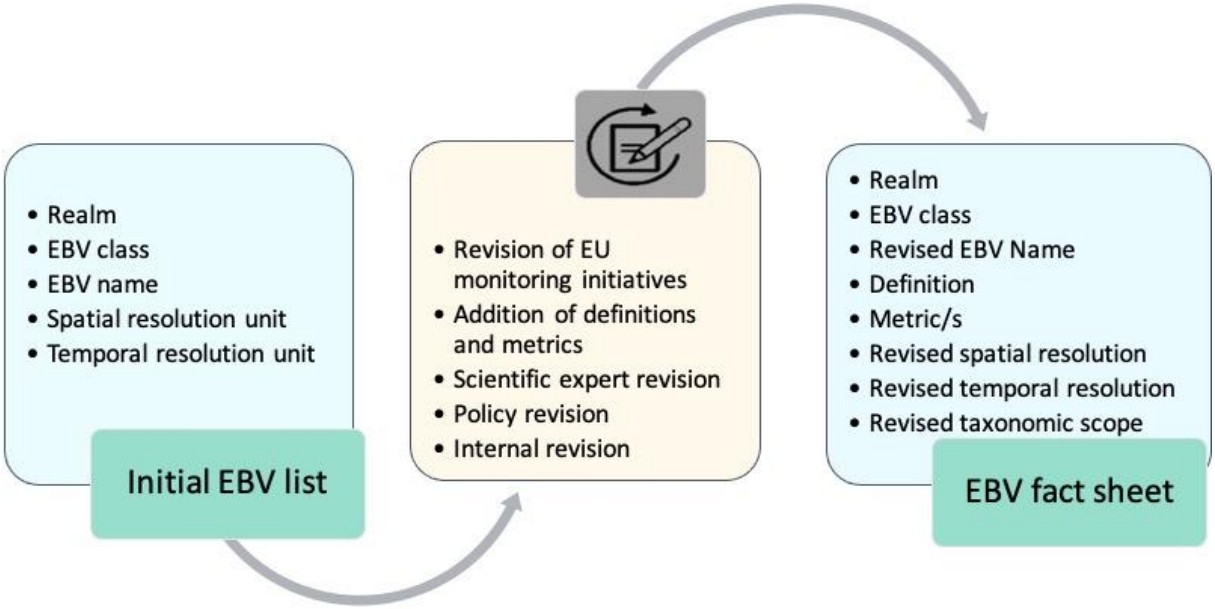

Figure 3: Flowchart of developing EBV fact sheets from the EBV list during the fourth internal review process. Definitions and metrics were added for each EBV and several aspects of the EBV list were further refined.

Webinar on EBVs and final public review process

In the coming weeks, we plan to host a public webinar to briefly recap on the EBV framework, describe the methodology used by EuropaBON to identify and specify EBVs, and explain how to access the current **EBV list in GitHub** (https://github.com/EuropaBON/EBV-Descriptions). After the webinar, we will launch a final public review process that will allow all 1000+ EuropaBON network members and other interested stakeholders to provide one last round of comments on the current list of EBVs.

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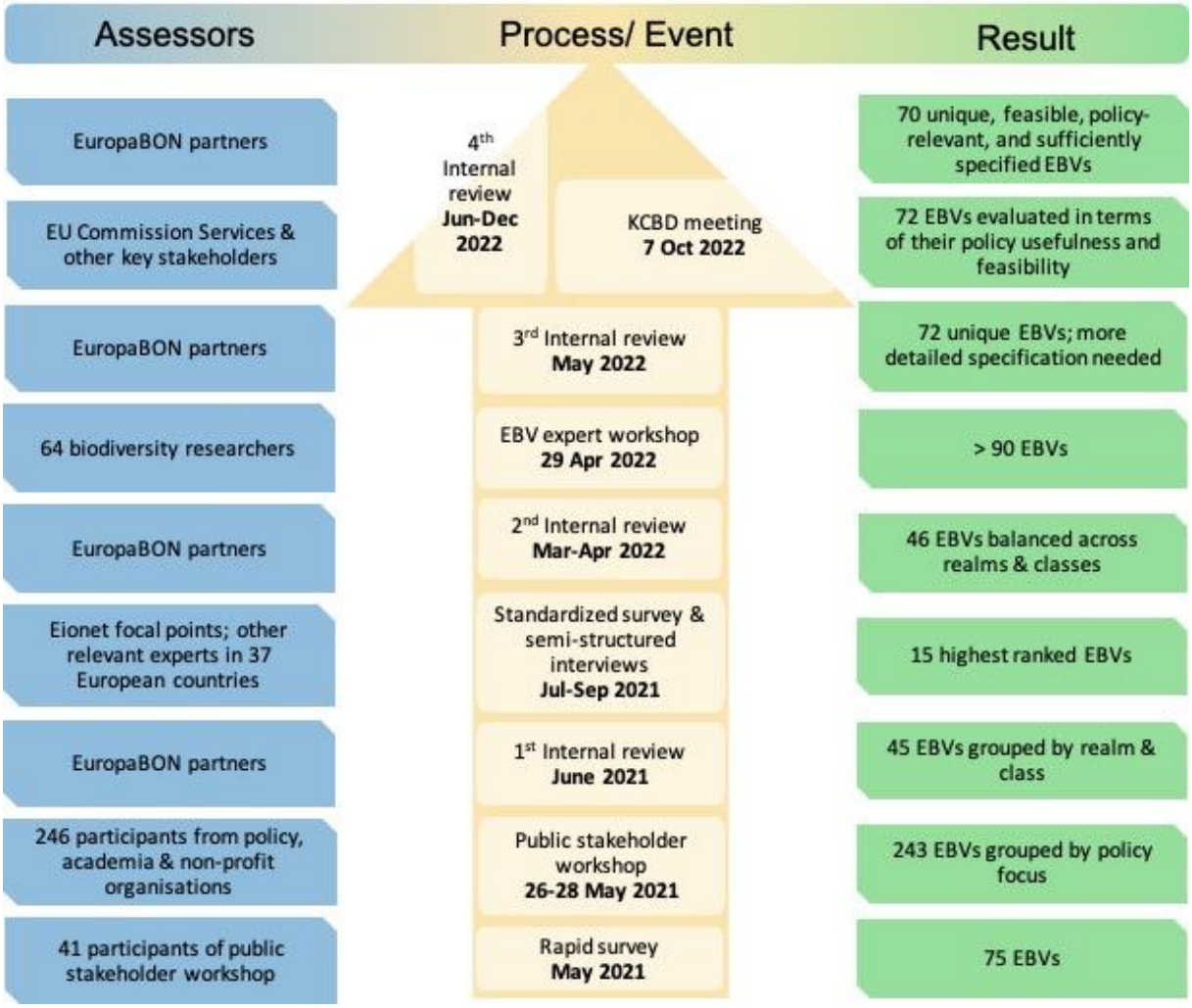

Figure 4: The stepwise methodology of EuropaBON's 18-month EBV identification process.

Characteristics of the EBVs identified by EuropaBON

Our list of EBVs includes 70 variables of which 32 fall into the terrestrial realm, and 20 and 18 variables into the freshwater and marine realms, respectively (Table 3, Figure 5; more detailed definitions of the generic EBVs are provided in Table 4). Of these, 37 (terrestrial= 19; freshwater= 9; marine= 9) are species-focused EBVs and 33 variables (terrestrial= 13; freshwater= 11; marine= 9) are ecosystem-focused EBVs (Figure 5). The identified EBVs cover all classes in each realm. The majority of EBVs were identified during the User and Policy Needs Assessment (n= 39), followed by one of the four internal review processes (n= 16), the EBV expert workshop in April 2022 (n= 14) and the KCBD biodiversity monitoring *ad hoc* group meeting (n= 1). Forty-six percent (n= 32) of the EBVs are expected to be modelled at resolutions of 10 km^2 or less, and of these, just over half (n= 19) have desired spatial resolutions of less than/equal to 1 km^2. Similarly, 54% (n= 38) of the EBVs are expected to be modelled every five years or more frequently and the majority of them (n=31) at yearly intervals or less.

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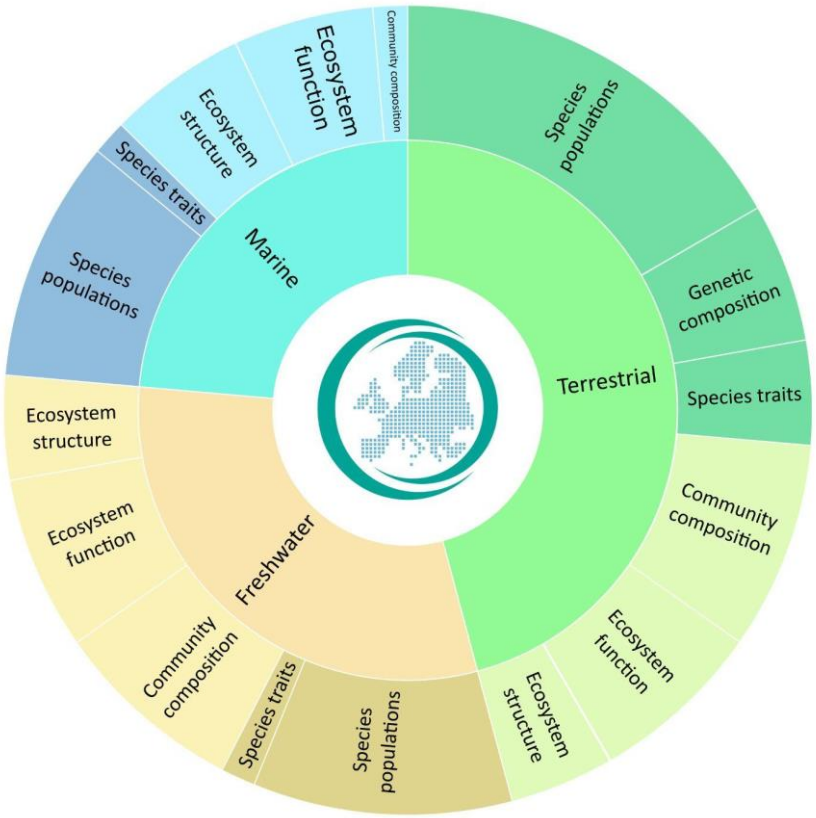

Figure 5: List of species- (darker colours) and ecosystem-focused (lighter colours) EBV classes and their realms.

Twenty-three variables (33%) in our list monitor higher animal taxa, another 12 (17%) and 13 (19%) EBVs monitor invertebrate and plant species, respectively, and 17 EBVs (24%) focus on habitat- rather than species monitoring (Figure 6). The remainder cover fungi (n= 2), bacteria and microorganisms (n= 3), or a combination of taxa (e.g., alien invasive species, disease vectors, crop pests). Birds are the taxonomic group most represented in our list (n= 9), followed by mammals (n= 6), fish (n= 4), reptiles (n= 3), and amphibians (n= 1). Included in the group of "plants" are four EBVs that focus on trees, followed by phytoplankton (n= 3), macrophytes (n= 2), as well as macroalgae, phytobenthos, lichens and shrubs (each n= 1). For more detailed information on the taxonomic focus of invertebrates and the various habitats to be monitored, please refer to Figure 6.

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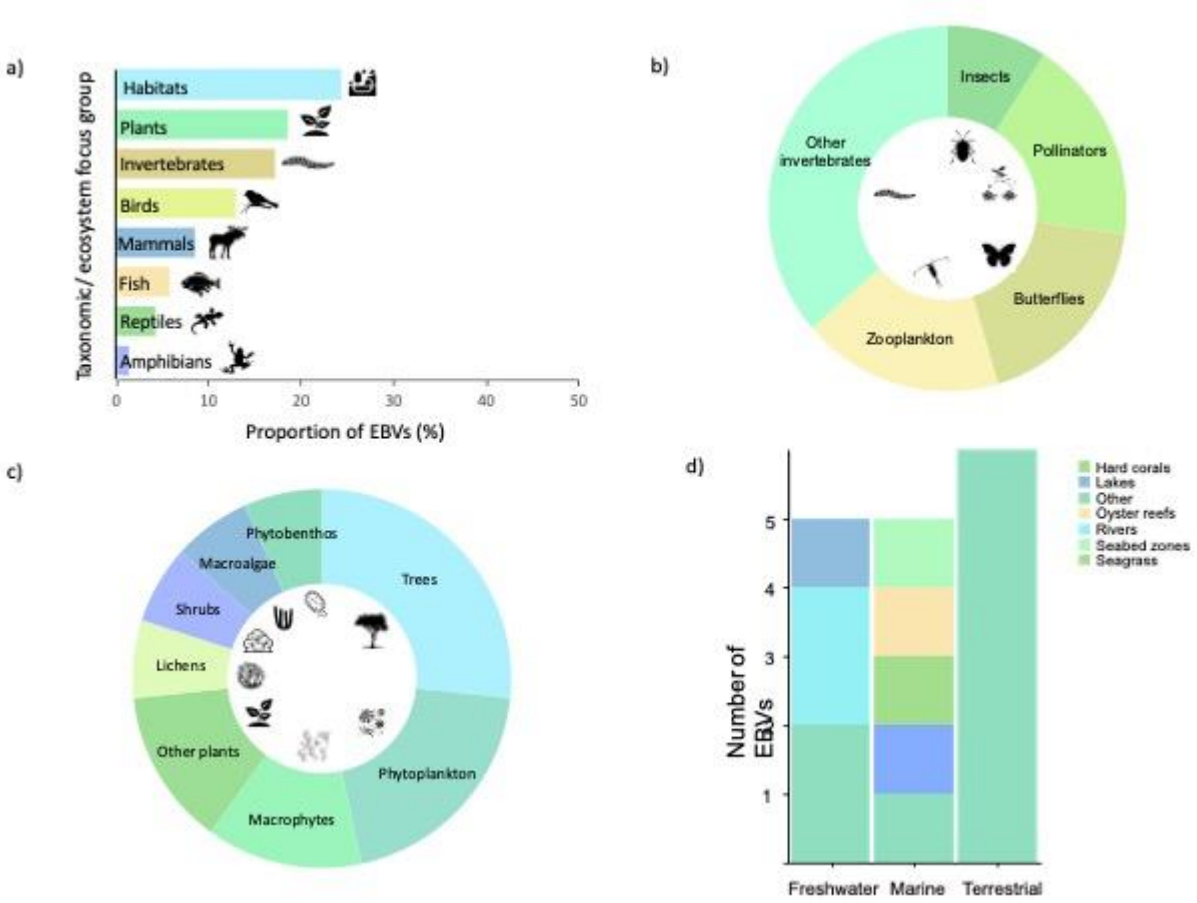

Figure 6: Break-down of taxonomic and ecosystem focus groups into a) vertebrates, invertebrates, plants and habitats) and further broken down into b) different invertebrate groups; c) different plant groups; and d) different habitat types across freshwater, marine and terrestrial ecosystems, covered by EuropaBON's EBVs.

Conclusion and outlook

Monitoring biodiversity is a complex task and identifying the variables that capture biodiversity change across Europe was challenging. To tackle this task, we followed a very comprehensive, multi-step methodology including numerous surveys, workshops, interviews, and public- and internal review processes spanning the past 18 months and interacting and benefitting from the input of literally hundreds of different stakeholders. The resultant list of EBVs provides the building blocks for designing the European Biodiversity Observation Network for which workflows will be established in the following months. Here, we will focus on selecting EBVs that fall into one of three broad categories: 1) EBVs which are already being monitored with strong integrated networks and well-established monitoring protocols, 2) EBVs that are being monitored at much smaller scales or just starting out as pilot studies which contain large gaps and have limited resources, and 3) EBVs with no current monitoring that will require the development of new monitoring schemes or novel monitoring technologies. This process will be undertaken by internal and external experts that will help identify which data are currently available and still needed for each EBV. This co-design process is

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complemented by a cost-effectiveness analysis and an assessment of the full costs and benefits of the schemes developed to monitor these EBVs. This list should not be regarded as a final list, but rather a “work-in-progress” that will continue to serve the needs of the users from all relevant sectors to help design a diverse and user-driven EuropaBON.

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Table 3: List of EBVs and their respective spatial, temporal and taxonomic specifications identified during EuropaBON's stepwise identification and refinement process.

ID	Realm	EBV class	EBV name	Step in identification process	Definition	Metric	Spatial resolution unit	Temporal resolution unit	Taxonomic/ ecosystem focus group
43b	Freshw ater	Genetic composition	Genetic diversity of selected freshwater taxa	Internal review process	Genetic richness (number of alleles in a population) and genetic evenness (expected proportion of heterozygotes in a population at equilibrium) of taxa.	- Allelic richness - Nucleotide diversity (π) - He = expected heterozygosity under Hardy–Weinberg assumptions - HO = observed heterozygosity (probability of randomly drawing two different alleles from the population)	Sample sites (populations) across the geographic range of selected taxa	10 years	Selected species of birds, mammals, reptiles, amphibians or other taxonomic groups which are categorized as threatened by the European Red List.
1	Freshwater	Species populations	Species abundances of wetland birds	Expert workshop	The estimated count of individuals of European wetland bird species within contiguous spatial units (grid cells) over time.	- Estimated count of individuals in winter - Modeled relative abundance in winter	Wetlands as defined by The Critical Site Network (CSN) Tool which is an online resource for the conservation of 312 species of waterbirds and the important sites upon which they depend in Africa and Western Eurasia (http://criticalsites.wetlands.org/en/sites).	1 year	Wetland birds (taxonomy based on the Handbook of the Birds of the World and the BirdLife Taxonomic Checklist, with focus on those bird species that are officially recognized in the List of birds of the European Union, and wetland affiliation defined as the linkages of species and habitat types to MAES [wetland] ecosystems)

2	Freshwater	Species populations	Species distributions of freshwater fishes	User & Policy Needs Assessment	The presence/absence or probability of occurrence of each European freshwater fish species within lakes and river catchments over time.	- Binary presence/absence - Probability of occurrence	1x1km - 10x10km	3-6 years	Freshwater fishes listed in the European Red List of Freshwater Fishes (currently 531 native and described European species)
3	Freshwater	Species populations	Species distributions of amphibians and freshwater reptiles	User & Policy Needs Assessment	The presence/absence or probability of occurrence of each European amphibian and freshwater reptile species within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	10×10km - 50×50km	3-6 years	All European amphibians and freshwater reptiles

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4	Freshwater	Species populations	Species distributions of freshwater mammals	User & Policy Needs Assessment	The presence/absence or probability of occurrence of each European freshwater mammal species within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	10x10 km - 50x50km	3-6 years	Freshwater mammal species listed in the Habitats Directive (*Lutra lutra*, *Galemys pyrenaicus*, *Mustela lutreola*)

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5	Freshwater	Species populations	Species distributions of freshwater invertebrates	Internal review process	The presence/absence or probability of occurrence of invertebrate species within lakes and river catchments over time.	- Binary presence/absence - Probability of occurrence	Lakes and river catchments as delineated in ECRINS (European catchments and Rivers network system)	3-6 years	- Freshwater invertebrate species listed in the Habitats Directive Annex II: Dragonflies: *Coenagrion hylas*, *C. mercuriale, Cordulegaster trinacriae, Gomphus graslinii, Leucorrhina pectoralis, Lindenia tetraphylla, Macromia splendens, Ophiogomphus cecilia, Oxygastra curtisii* Bivalves: *Margaritifera margaritifera* and *Unio crassus* - Freshwater invertebrate species listed in the Habitats Directive Annex IV: Dragonflies: *Aeshna viridis, Cordulegaster trinacriae, Gomphus graslinii, Leucorrhina albifrons, L. caudalis, L. pectoralis, Lindenia tetraphylla, Macromia splendens, Ophiogomphus cecilia, Oxygastra curtisii, Stylurus flavipes* and *Sympecma braueri* Bivalves: *Lithophaga lithophaga, Pinna nobilis, Margaritifera auricularia* and *Unio crassus* - Pollution-sensitive benthic invertebrates that are monitored for the Water Framework Directive: Mayflies (Ephemeroptera), Stoneflies (Plecoptera), Caddisflies (Trichoptera)

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6	Freshwater	Species populations	Species distributions of freshwater macrophytes	Internal review process	The presence/absence or probability of occurrence of European freshwater macrophyte species within lakes over time.	- Binary presence/absence - Probability of occurrence	Lakes as delineated in ECRINS (European catchments and rivers network system)	3-6 years	European macrophytes
7	Freshwater	Species populations	Species distributions of invasive alien freshwater taxa of European concern	User & Policy Needs Assessment	The presence/absence or probability of occurrence of invasive freshwater species within lakes and river catchments over time.	- Binary presence/absence - Probability of occurrence	Lakes and river catchments as delineated in ECRINS (European catchments and rivers network system)	3-6 years	Freshwater species specified in the Consolidated List of Invasive Alien Species of Union Concern

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58c	Freshwater	Species traits	Phenology of migration of wetland birds	Expert workshop	The annual timing of arrival and departure of European wetland migratory bird species at breeding, staging and wintering sites over time.	Migration phenology metrics such as: - Day of arrival - Day of departure - Length of stay	10x10km	1 week (traits derived from weekly distribution data)	Migratory bird species defined as full migrants in the European Red List
9	Freshwater	Community composition	Ecological Quality Ratio (EQR) of phytoplankton in lakes	User & Policy Needs Assessment	Community composition and total biomass of phytoplankton in lakes (Ecological Quality Ratio) based on total abundance (biovolume), taxonomic composition index across all species based on biovolume per indicator species, and bloom intensity, e.g. maximum biomass of cyanobacteria or percentage of cyanobacteria of the total biomass for all taxa	The Ecological Quality Ratio (EQR) of phytoplankton in European lakes, expressed as a numerical value between zero (low) and one (high), quantifying the ecological status of phytoplankton community composition and its deviation from a reference condition. The metric describes the deviation from natural phytoplankton communities.	Lakes as delineated in ECRINS (European catchments and rivers network system)	1 year, weekly-monthly during growing season	Phytoplankton indicator taxa and reference taxa as described in the Water Framework Directive Intercalibration Technical Reports (Part 2, Lakes)

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10	Freshwater	Community composition	Ecological Quality Ratio (EQR) of freshwater macrophytes	User & Policy Needs Assessment	Community composition of macrophytes (Ecological Quality Ratio) based on presence-absence data	The Ecological Quality Ratio (EQR) of macrophytes in European lakes, expressed as a numerical value between zero (bad) and one (very good), quantifying the ecological status of macrophyte community composition and its deviation from a reference condition.	Lakes as delineated in ECRINS (European catchments and rivers network system)	6 years	All macrophytes species with indicator values as defined in the Water Framework Directive Intercalibration Technical Reports (Part 2, Lakes)
11	Freshwater	Community composition	Ecological Quality Ratio (EQR) of freshwater phytobenthos	User & Policy Needs Assessment	The ecological status of phytobenthos in European rivers, measured as Ecological Quality Ratio (EQR).	The Ecological Quality Ratio (EQR) of phytobenthos in European rivers, expressed as a numerical value between zero (bad) and one (very good), quantifying the ecological status of phytobenthos community composition and its deviation from a reference condition.	River catchments as delineated in ECRINS (European catchments and rivers network system)	1-3 years	Phytobenthic species with indicator values as defined in the Water Framework Directive Intercalibration Technical Reports (Part 1, Rivers)

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12	Freshwater	Community composition	Ecological Quality Ratio (EQR) of benthic freshwater invertebrates	User & Policy Needs Assessment	The ecological status of benthic invertebrates in European rivers, measured as Ecological Quality Ratio (EQR).	The Ecological Quality Ratio (EQR) of benthic invertebrates in European rivers, expressed as a numerical value between zero (bad) and one (very good), quantifying the ecological status of benthic invertebrate community composition and its deviation from a reference condition.	River catchments as delineated in ECRINS (European catchments and rivers network system)	2-3 years	Benthic invertebrate species with indicator values as defined in the Water Framework Directive Intercalibration Technical Reports (Part 1, Rivers)
13	Freshwater	Community composition	Ecological Quality Ratio (EQR) of freshwater fish	User & Policy Needs Assessment	The ecological status of fish in European freshwater systems (lakes and rivers), measured as Ecological Quality Ratio (EQR).	The Ecological Quality Ratio (EQR) of fish in European lakes and rivers, expressed as a numerical value between zero (low) and one (high), quantifying the ecological status of fish community composition and abundance and its deviation from a reference condition.	Lakes and river catchments as delineated in ECRINS (European catchments and rivers network system)	3-6 years	Freshwater fish species with indicator values defined in the Water Framework Directive Intercalibration Technical Reports (Part 1, Rivers; Part 2, Lakes)

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14	Freshwater	Community composition	Ecological Quality Ratio (EQR) of freshwater zooplankton	Internal review process	The ecological status of zooplankton in European lakes, measured as Ecological Quality Ratio (EQR).	The Ecological Quality Ratio (EQR) of zooplankton in European lakes, expressed as a numerical value between zero (bad) and one (very good), quantifying the ecological status of zooplankton community composition and its deviation from a reference condition.	Lakes as delineated in ECRINS (European catchments and rivers network system)	1-3 years	Lake zooplankton species with indicator values
15	Freshwater	Ecosystem structure	River Connectivity/ Free river flow	Internal review process	The length of free-flowing rivers (without barriers) and the natural longitudinal and lateral connectivity of rivers and lakes.	- The percentage of free flowing river length per sub-catchment - The presence, number and location of artificial barriers in river segments - The connectivity between rivers, lakes and pond	0.1×0.1km - 1×1km or per river segment	6 years	Broad types of rivers or level 3 EUNIS river habitats
16	Freshwater	Ecosystem structure	Ecosystem distribution of freshwater EUNIS Habitats	User & Policy Needs Assessment	The presence/absence or probability of occurrence of freshwater EUNIS habitats in contiguous spatial units (grid cells) over time .	- Binary presence/absence - Probability of occurrence	100×100m - 1 km×1km	1 year	Freshwater EUNIS Habitats (level 3)

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17	Freshwater	Ecosystem structure	Structural complexity of riparian habitats	Expert workshop	The vegetation structure, width and length, or topographic heterogeneity of riparian habitats over time, representing the density, cover, variability and three-dimensional arrangement of vegetation and other structural features.	- Vegetation height and its horizontal variability (including edge and patch diversity) - Vegetation cover, canopy gaps and penetration ratios - Vertical vegetation variability (including foliage height diversity, vertical density ratios, understory density etc.) - Width and length of riparian zone - Topographic variability and terrain structure	10×10m (if derived from airborne laser scanning data) 100×100m (modeled from in-situ data)	6 years	Riparian habitats (or distance defined from river)
19	Freshwater	Ecosystem function	Harmful freshwater algal blooms	User & Policy Needs Assessment	Distribution, intensity, frequency and position of harmful algal blooms in European lakes which occur when cyanobacteria accumulate in water, with the potential to harm the health of humans, plants, and animals.	- Observed location and intensity of algal blooms as derived from satellite imagery (e.g. Copernicus Sentinel-3) or regulatory monitoring - Modeled cyanobacterial density based on hydrodynamic models and satellite imagery	Lakes as delineated in ECRINS (European catchments and rivers network system)	Real-time, weekly-monthly during the growing season	ECRINS lakes

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20	Freshwater	Ecosystem function	Freshwater primary productivity	Expert workshop	The amount of carbon that is removed by lake habitats (and large rivers) from the atmosphere over time and stored in biomass, roots and sediments.	- Amount of carbon in mass per time unit (e.g. Mg C yr-1)	Lakes and large river catchments as delineated in ECRINS (European catchments and rivers network system)	1 year	EUNIS freshwater habitats (except small rivers)
42c	Marine	Genetic composition	Genetic diversity of selected marine taxa	Internal review process	Genetic richness (number of alleles in a population) and genetic evenness (expected proportion of heterozygotes in a population at equilibrium) of taxa.	- Allelic richness - Nucleotide diversity (π) - He = expected heterozygosity under Hardy–Weinberg assumptions - HO = observed heterozygosity (probability of randomly drawing two different alleles from the population)	Sample sites (populations) across the geographic range of selected taxa	10 years	Selected species of birds, mammals, reptiles, or other taxonomic groups which are categorized as threatened by the European Red List.

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23	Marine	Species populations	Species distributions of marine fishes	User & Policy Needs Assessment	The presence/absence or probability of occurrence of European marine fish species in EU's marine waters within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	50x50km - 200x200km	3 or 6 years	Marine fish species indicated in the Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity
24	Marine	Species populations	Species abundances of marine commercial fish species and long-distance migratory fishes	User & Policy Needs Assessment	The estimated count of individuals of commercially relevant marine fish species and long-distance migratory fishes in EU's marine waters within contiguous spatial units (grid cells) over time.	- Estimated count of individuals - Modeled relative abundance	50x50km - 200x200km	1 year	Commercial marine fish species listed in the Common Fisheries Policy
25	Marine	Species populations	Species distributions of marine birds	User & Policy Needs Assessment	The presence/absence or probability of occurrence of European marine bird species at their	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	Marine bird species indicated in the Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity

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					breeding sites over time.				
26	Marine	Species populations	Species distributions of marine mammals	User & Policy Needs Assessment	The presence/absence (or probability of occurrence) of European marine mammal species within contiguous spatial units (grid cells) in EU's marine waters over time.	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	Marine mammal species indicated in the Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity

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27	Marine	Species populations	Distributions of marine turtle species nesting grounds	User & Policy Needs Assessment	The presence/absence or probability of occurrence of marine turtle species nesting grounds in EU's coastline over time	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	Turtle species indicated in the Habitats Directive and the Review and analysis of Member States' 2018 reports Descriptor 1: Species biological diversity: *Caretta caretta* (Loggerhead turtle), *Chelonia mydas* (Green turtle), *Dermochelys coriacea* (Leatherback turtle), *Eretmochelys imbricata* (Hawksbill turtle), *Lepidochelys kempii* (Kemp's Ridley turtle)
28	Marine	Species populations	Species distributions of benthic marine invertebrates	Internal review process	The presence/absence or probability of occurrence of benthic invertebrate species form the Habitats Directive in EU's benthic habitats within contiguous spatial units (grid cells) over time	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	Seasonal-1 year	Benthic invertebrate species indicated in the Review and analysis of EU Member States' 2018 reports – Descriptor 6: Sea-floor integrity and Descriptor 1: Benthic habitats

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29	Marine	Species populations	Species distributions of invasive alien marine taxa of European concern	User & Policy Needs Assessment	The presence/absence or probability of occurrence of invasive freshwater species (as specified in the Consolidated List of Invasive Alien Species of Union Concern) in EU's marine waters within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	1x1km - 10x10km	3 or 6 years	Coastal marine taxa of invasive concern within 1-5 km from the shore
30	Marine	Species traits	Phenology of migration of marine birds and mammals	Expert workshop	The annual timing of arrival and departure of European marine migratory bird and mammal species at breeding, staging and wintering sites over time.	Migration phenology metrics such as: - Day of arrival - Day of departure - Length of stay	10x10km - 50x50km	1 year	- Marine migratory birds (taxonomy based on the Handbook of the Birds of the World and the BirdLife Taxonomic Checklist), with focus on those bird species that are officially recognized in the List of birds of the European Union, and defined as full migrants in the European Red List. - Migratory mammal species defined as full migrants in the European Red List

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31	Marine	Community composition	Functional composition of marine phyto/zooplankton (based on traits)	User & Policy Needs Assessment	The functional composition and diversity (e.g. based on morphological, physiological or behavioral traits) of marine phyto/zooplankton in EU's marine waters within contiguous spatial units (grid cells) over time	- Presence and dominance of key functional groups or life forms - Diversity of functional groups or life forms - Functional diversity indices	10x10km - 50x50km	Seasonal-1 year	Phytoplankton and zooplankton in EU's marine waters defined in the Marine Strategy Framework Directive - Review and analysis of EU Member States' 2018 reports - Descriptor 1: Pelagic habitats
32	Marine	Ecosystem structure	Ecosystem distribution of hard corals habitats	Internal review process	Presence/absence or probability of occurrence of hard corals habitats in EU's marine waters within contiguous spatial units (grid cells) over time	- Binary presence/absence - Probability of occurrence	10x10m - 300x300m	3 or 6 years	Live hard coral covers defined by EMODnet Seabed Habitats
33	Marine	Ecosystem structure	Ecosystem distribution of marine macroalgae canopy cover	Internal review process	The estimated percentage of macroalgae canopy cover in EU's marine waters within contiguous spatial units (grid cells) over time	- Estimated canopy cover	10x10m - 300x300m	3 or 6 years	Macroalgae canopy covers defined by EMODnet Seabed Habitats

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34	Marine	Ecosystem structure	Ecosystem distribution of marine seagrass habitats	Internal review process	Presence/absence or probability of occurrence of seagrass habitats in EU's marine waters within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	10x10m - 300x300m	3 or 6 years	Seagrass covers defined by EMODnet Seabed Habitats
35	Marine	Ecosystem structure	Ecosystem distribution of oyster reef habitats	Internal review process	Presence/absence or probability of occurrence of oyster reef habitats in EU's marine waters within contiguous spatial units (grid cells) over time.	- Binary presence/absence - Probability of occurrence	10x10m - 300x300m	3 or 6 years	Oyster reefs in the EU's marine waters
36	Marine	Ecosystem function	Degree of seabed disturbance	Expert workshop	The estimated amount of permanent or temporal disturbance of seabed substrate or morphology caused by human activities such as construction, dredging, sand and gravel extraction, deposition of dredged	Estimated amount or intensity of disturbance of seabed disturbance on benthic habitat over time.	1x1km - 10x10km	3 or 6 years	Seabed zones defined at the Marine Strategy Framework Directive – Review and analysis of EU Member States' 2018 reports – Descriptor 6: Sea-floor integrity and Descriptor 1: Benthic habitats

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					material, shipping and bottom trawling.				
37	Marine	Ecosystem function	Harmful marine algal blooms	User & Policy Needs Assessment	Distribution, intensity, frequency and position of harmful algal blooms in European coastal waters which occur when cyanobacteria accumulate in water, with the potential to harm the health of humans, plants, and animals	- Observed location and intensity of algal blooms as derived from satellite imagery (e.g. Copernicus Sentinel-3) or regulatory monitoring - Modeled cyanobacterial density based on hydrodynamic models and satellite imagery	300x300m	Real-time, weekly-monthly during the growing season	EUNIS marine and coastal habitats

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38	Marine	Ecosystem function	Phenology of marine spring phytoplankton bloom	Expert workshop	The annual timing and intensity of spring phytoplankton blooms in EU's marine waters over time.	Phenology metrics of surface chlorophyll-a concentrations such as: - Day of start-of-blooming - Day of end-of-blooming - Blooming amplitude - Slope of the blooming up period - Length of the blooming season	10x10km - 50x50km	1 year	All marine phytoplankton
39	Marine	Ecosystem function	Marine primary productivity	Internal review process	Productivity of organic compounds from atmospheric or dissolved carbon dioxide by cyanobacteria, algae and marine plants in EU's marine waters within contiguous spatial units (grid cells) over time.	Surface chlorophyll-a concentrations or estimates of primary production from satellite observations based on ocean color (proxy of chlorophyll-a)	10x10km - 50x50km	1 year	- Algae cyanobacteria - Other microorganisms

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42a	Terrestrial	Genetic composition	Genetic diversity of selected terrestrial taxa	Expert workshop	Genetic richness (number of alleles in a population) and genetic evenness (expected proportion of heterozygotes in a population at equilibrium) of taxa.	- Allelic richness - Nucleotide diversity (π) - He = expected heterozygosity under Hardy–Weinberg assumptions - HO = observed heterozygosity (probability of randomly drawing two different alleles from the population)	Sample sites (populations) across the geographic range of selected taxa	10 years	Selected species of birds, mammals, reptiles, amphibians or other taxonomic groups which are categorized as threatened by the European Red List.
44	Terrestrial	Species populations	Species distributions of terrestrial birds	User & Policy Needs Assessment	The presence/absence or probability of occurrence of each European terrestrial bird species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence during breeding season - Probability of occurrence during breeding season	1x1km - 10x10km	3 or 6 years	All terrestrial birds of the EU (taxonomy based on the Handbook of the Birds of the World and the BirdLife Taxonomic Checklist, with focus on those bird species that are officially recognized in the List of birds of the European Union.

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45a	Terrestrial	Species populations	Species abundances of terrestrial birds	User & Policy Needs Assessment	The estimated count of individuals of European rare, priority, and common bird species within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals in spring and winter - Modeled relative abundance in spring and winter	1x1km - 10x10km	1 year	- Taxonomy based on the Handbook of the Birds of the World and the BirdLife Taxonomic Checklist - Rare bird species as included in the Annex 1 of the Birds Directive (i.e. species with small populations or restricted local distribution) - Priority bird species as included in Annex 1 of the Birds Directive (i.e. in danger of extinction, vulnerable to specific changes in their habitat or requiring particular attention for reasons of the specific nature of the habitat) - Common bird species as included in the Pan-European Common Bird Monitoring Scheme (PECBMS)
45b	Terrestrial	Species populations	Species abundances of terrestrial migratory birds	User & Policy Needs Assessment	The estimated count of individuals of European migratory bird species within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals - Modeled relative abundance	1x1km - 10x10km	Real-time	- Taxonomy based on the Handbook of the Birds of the World and the BirdLife Taxonomic Checklist - Migratory bird species defined as full migrants in the European Red List

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46	Terrestrial	Species populations	Species abundances of selected terrestrial mammals	User & Policy Needs Assessment	The estimated count of individuals of European terrestrial Carnivora, Artiodactyla and Chiroptera species within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals - Modeled relative abundance - Estimated counts of individuals in key underground sites (hibernation, breeding and transitional roost-sites) as defined by EUROBATS - Estimated counts of individuals in key overground sites (hibernation, breeding and transitional roost-sites) as defined by EUROBATS	1x1km - 10x10km	1 year	Terrestrial Carnivora, Artiodactyla and Chiroptera species included in the European Red List.
47	Terrestrial	Species populations	Species distributions of all terrestrial mammals	User & Policy Needs Assessment	The presence/absence or probability of occurrence of all European terrestrial mammal species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	European terrestrial mammal species included in the European Red List.

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48	Terrestrial	Species populations	Species distributions of terrestrial reptiles	User & Policy Needs Assessment	The presence/absence or probability of occurrence of all European terrestrial reptile species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	1x1km - 10x10km	3 or 6 years	European terrestrial reptile species included in the European Red List.
49	Terrestrial	Species populations	Species abundances of butterflies	User & Policy Needs Assessment	The estimated count of individuals of butterfly species within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals of grassland butterfly species - Modeled relative abundance of grassland butterfly species	10x10km - 50x50km	1 year	Current list of butterfly species underlying the European grassland butterfly indicator, with extension to butterfly species from other habitats.
50	Terrestrial	Species populations	Species distributions of terrestrial priority invertebrates and key pollinators	Internal review process	The presence/absence or probability of occurrence of priority invertebrates and key pollinator species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	- Priority invertebrates as listed in the Annex II and Annex IV of the Habitats Directive - Key pollinator species as specified by the EU Pollinator Monitoring Scheme (EUPoMS)

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51	Terrestrial	Species populations	Species distributions of terrestrial plants	User & Policy Needs Assessment	The presence/absence or probability of occurrence of terrestrial vascular plant species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	- Priority species: 1 × 1 km – 10 × 10 km - All vascular plant species: 10 × 10 km – 50 × 50 km	- Priority species: 1 year - All vascular plant species: 3 or 6 years	- All European terrestrial vascular plants species included in the European Red List - Priority terrestrial vascular plants as listed in Annex II and Annex IV of the Habitats Directive
52	Terrestrial	Species populations	Species distributions of main trees	Expert workshop	The presence/absence or probability of occurrence of European tree species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	Tree species included in the EU-Trees4F dataset (67 species)
53	Terrestrial	Species populations	Species distributions of lichens (as indicators of pollution)	Expert workshop	The presence/absence or probability of occurrence of ecological quality indicator lichen species within contiguous spatial units (grid cells)	- Binary presence/absence - Probability of occurrence	10x10km - 50x50km	3 or 6 years	Ecological quality indicator lichens as defined in POPLAIR and other sources

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					across the EU over time.				
54	Terrestrial	Species populations	Species distributions of invasive alien terrestrial taxa of European concern	User & Policy Needs Assessment	The presence/absence or probability of occurrence of invasive terrestrial species within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	1x1km - 10x10km	3 or 6 years	Species specified in the List of Invasive Alien Species of Union Concern (66 species)
55a	Terrestrial	Species populations	Species abundances of selected terrestrial disease vectors	User & Policy Needs Assessment	The estimated count of individuals of animal vectors within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals - Modeled relative abundance	10x10km - 50x50km	Real-time	The taxonomic scope for disease vectors is defined by the European Centre for Disease Prevention and Control (ECDPC)

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55b	Terrestrial	Species populations	Species abundances of selected terrestrial crop pests	User & Policy Needs Assessment	The estimated count of individuals of crop pests within contiguous spatial units (grid cells) across the EU over time.	- Estimated count of individuals - Modeled relative abundance	100x100m - 1x1km	Strongly species-dependent	The taxonomic scope for crop pests is defined in EU list of priority pests
56	Terrestrial	Species traits	Phenology of fructification of mushrooms and wild fruits	User & Policy Needs Assessment	The annual timing of the fructification of wild mushroom species and wild fruits within contiguous spatial units (grid cells) across the EU over time.	Probability of the start/end date, presence/absence, abundance, seasonal amplitude and duration of fructification.	1x1km - 10x10km	1 week	- Wild mushroom species of commercial and recreational significance - Wild fruits of trees and shrubs
57	Terrestrial	Species traits	Phenology of flowering and leaf senescence	User & Policy Needs Assessment	The annual timing of flowering and leaf senescence of European flowering plants and deciduous trees within contiguous spatial units (grid cells) across the EU over time.	Species-specific phenology metrics such as: - Day of first flowering/senescence - Day of maximum flowering/senescence - Seasonal amplitude - Length of season	10x10km - 50x50km	1 week-1 month	Flowering plants and deciduous trees

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58a	Terrestrial	Species traits	Phenology of migration of terrestrial birds	Expert workshop	The annual timing of arrival and departure of European terrestrial migratory bird species at breeding, staging and wintering sites over time.	Migration phenology metrics such as: - Day of arrival - Day of departure - Length of stay	10x10km	1 week (traits derived from weekly distribution data)	Migratory bird species defined as full migrants in the European Red List
58b	Terrestrial	Species traits	Phenology of the emergence of butterflies	Expert workshop	The annual timing of seasonal emergence of butterflies within contiguous spatial units (grid cells) across the EU over time.	The day after which 5% of individuals have emerged	10x10km	1 week (traits derived from weekly distribution data)	Priority butterfly species listed in the Annex II and Annex IV of the Habitats Directive

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59/60	Terrestrial	Community composition	Community biomass of selected functional groups of terrestrial arthropods (e.g. predator, decomposer)	Expert workshop	Estimated community biomass of arthropod functional groups.	Average or total wet or dry weight of arthropods per ecosystem type	- Ecosystem based - National	1 year	The taxonomical scope should be defined with the help of experts
61	Terrestrial	Community composition	Community biomass of soil microbes	Internal review process	Estimated biomass of the living component of soil organic matter (bacteria, fungi and protozoa) within contiguous spatial units (grid cells) across the EU over time.	- Mass of microbial carbon / mass of dry soil - Mass of microbial carbon / area	1x1km	3 years	Soil microbial species

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62	Terrestrial	Community composition	Community abundance and taxonomic diversity of pollinator insects	User & Policy Needs Assessment	Total amount (abundance) of pollinator insects within spatial units over time	Predicted number of individuals of pollinator insects	Small regions within countries based on nomenclature of territorial units for statistics (NUTS) from Eurostat (1166 regions at NUTS 3 level)	1-5 years (rotation across years)	All pollinator insects as proposed in the species lists of butterflies, wild bees and hoverflies of the EU Pollinator Monitoring Scheme (EUPoMS)
63	Terrestrial	Community composition	Aerial biomass of migrating birds, bats and insects	User & Policy Needs Assessment	Biomass flows of aerial migrants (birds, insects and bats) across Europe within contiguous spatial units (grid cells) over time.	Summary statistics of migration densities of birds, insects and bats derived from vertical profile time series of weather radar data (e.g. hourly averages of bird density and speed)	1x1km - 10x10km	1 day	All migratory bird, bat and insect species (by size class)

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64	Terrestrial	Community composition	Functional composition of soil biota	User & Policy Needs Assessment	The functional composition and diversity of soil biota based on morphological, physiological, phenological and behavioral traits or functional/taxonomic groups.	- Functional group richness - Functional diversity indices	1x1m	1 year	Bacteria, fungi, protozoa, nematodes, collembola, mites, earthworms, larval and adult insects (e.g. Hymenoptera, Coleoptera and Diptera larvae), myriapods, spiders, molluscs and crustaceans
65	Terrestrial	Ecosystem structure	Vertical structure of terrestrial vegetation	Expert workshop	The vertical structure of terrestrial vegetation over time, representing vegetation height, cover, density, structural variability and three-dimensional arrangement of vegetation biomass.	Metrics related to: - Vegetation height - Horizontal height variability (including edge and patch diversity) - Vegetation cover, canopy gaps and penetration ratios - Vertical vegetation variability (including foliage height diversity, vertical density ratios, understory density etc.)	1x1m-10x10m	5 years	European terrestrial land areas

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66	Terrestrial	Ecosystem structure	Ecosystem distribution of terrestrial EUNIS Habitats	User & Policy Needs Assessment	The geographical/spatial distribution of terrestrial EUNIS habitats within contiguous spatial units (grid cells) across the EU over time.	- Binary presence/absence - Probability of occurrence	10x10km	1 year	EUNIS terrestrial habitats (e.g. level 3 or 4)
67	Terrestrial	Ecosystem structure	Connectivity of terrestrial ecosystem habitat types	User & Policy Needs Assessment	The degree of connection of EUNIS habitats within a landscape, in terms of their components, spatial distribution and ecological functions.	Connectivity indices that incorporate connections among habitat patches and their quality, including: - Distance to nearest neighbor patch - Habitat within specific buffer area - Graph-related indices - Other connectivity metrics	10x10km	1 year	EUNIS habitats

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69	Terrestrial	Ecosystem function	Terrestrial primary productivity	User & Policy Needs Assessment	The amount of CO2 fixed by terrestrial plants through the photosynthetic reduction of CO2 into organic compounds minus the CO2 emitted by autotrophic respiration within contiguous spatial units (grid cells) across the EU over time. Geographic distribution of habitats which have been sufficiently affected by wildfires to display significant changes in the vegetation cover (destruction of dry material, reduction or loss of green material) and in the ground surface (temporarily darker because of ash).	Net Primary Production (e.g. gC/m2)	10x10m	10 days	European terrestrial land areas
70	Terrestrial	Ecosystem function	Fire disturbance per habitat type	Internal review process		- Binary presence/absence - Habitat area affected by wildfires	10x10m	10 days	European terrestrial land areas and EUNIS forest habitats (e.g. level 3 or 4)

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71	Terrestrial	Ecosystem function	Ecosystem disturbance as measured by HANPP	Internal review process	Human Appropriation of Net Primary Production (HANPP) is the proportion of terrestrial NPP consumed directly and indirectly through human land.	- HANPP = HANPPluc + HANPPharv - HANPPluc is the change in NPP as a result of human-induced land use change - HANPPharv is the quantity of carbon in biomass harvested or otherwise consumed by people, including crops, timber, harvested crop residues, forest slash, forages consumed by livestock, and biomass lost to human-induced fires	10x10m	10 days	European terrestrial land areas
72	Terrestrial	Ecosystem function	Terrestrial ecosystem phenology	User & Policy Needs Assessment	The seasonal pattern of land surface vegetation variation observed from remote sensing within contiguous spatial units (grid cells) across the EU over time.	Phenology metrics such as: - Day of start-of-season - Day of end-of-season - Day of maximum-of-season - Season amplitude - Length of season - Slope of the greening up/senescent period	10x10m	1 year	European terrestrial land areas

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73	Terrestrial	Ecosystem function	Standing and lying deadwood	KCBD ad hoc monitoring group meeting	Amount of non-living standing and on the ground woody biomass within contiguous spatial units (grid cells) across the EU forest and other wooded lands over time.	Biomass per area (e.g. m3/ha)	100x100m	3 years	EUNIS forest habitats (e.g. level 3 or 4)

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Table 4: Detailed definitions of generic EBVs grouped into 6 classes (Genetic composition, Species populations, Species traits, Ecosystem structure, Ecosystem functioning, Community composition).

Generic EBV	Definition
Genetic composition	This EBV class captures metrics of within-species genetic variation across space and time[12]. It Includes four generic EBVs (Infraspecific genetic diversity, Genetic differentiation, Effective population size, Inbreeding).[13]
Infraspecific genetic diversity	The level of genetic variability within species populations. It is typically captured by two complementary metrics: the number of alleles in a population (richness) and the expected and observed proportion of heterozygotes in a population at equilibrium (evenness). Adapted from Hoban et al. (2022).[11]
Genetic differentiation	The divergence in the frequencies of alleles between populations of the same species[11].
Effective population size	The size of an ideal population that loses genetic variation at the same rate as the focal population[11].
Inbreeding	Degree of relatedness between individuals of a population[11].
Species populations	EBV class that accesses the spatial and temporal variability in the species populations. This includes two generic EBVs (Species distribution, Species abundance).[12]
Species distribution	The probability of occurrence of a species or group of species, measured (or modeled) along contiguous spatial and temporal units. In some cases it may be just a binary variable corresponding to the presence/absence of the species, in others it may refer to the probability that the cell is occupied by the species of interest in a given time period. After Jetz et al. (2019).[14]
Species abundance	The estimated count of individuals or relative abundance of a species or group of species, measured (or modeled) over contiguous spatial and temporal units.[13]
Species traits	EBV class that captures the spatial and temporal variation in trait measurements within species. This includes five generic EBVs (Morphology, Physiology, Reproduction, Phenology, Movement).[12]
Morphology	The volume, mass, height or other traits defining the form of organisms grouped by species, measured (or modeled) over contiguous over contiguous spatial and temporal units. Adapted from Kissling et al. (2018).[15]
Physiology	Values of biochemical or physical quantities (e.g., thermal tolerance, disease resistance) describing functions of organisms grouped by species, measured (or modeled) over contiguous spatial and temporal units. Adapted from Kissling et al. (2018).[14]
Reproduction	Age at maturity, number of offspring and other reproduction traits of organisms grouped by species, measured (or modeled) over contiguous spatial and temporal units.
Phenology	The timing of cyclical biological phenomena, such as the presence, absence, abundance, or duration of seasonal activities of organisms (Kissling et al. 2018), measured (or modeled) for each species over contiguous spatial and temporal units. This can include the date of emergence of leaves and flowers, the first

[12] Hoban et al. 2022. Global genetic diversity status and trends: towards a suite of Essential Biodiversity Variables (EBV) for composition. Biological Reviews, 97, 1511-1538.

[13] https://geobon.org/ebvs

[14] Jetz et al. 2019. Essential biodiversity variables for mapping and monitoring species populations. Nature Ecology & Evolution, 3, 539-551.

[15] Kissling et al. 2018. Towards global data products of Essential Biodiversity Variables on species traits. Nature Ecology & Evolution, 2, 1531-1540.

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	flight of butterflies, the first appearance of migratory birds, the date of leaf coloring and fall in deciduous trees, the dates of egg-laying of birds and amphibia, or the timing of the developmental cycles of honey bee colonies.
Movement	Spatial mobility attributes of species, measured (or modeled) over contiguous spatial and temporal units (e.g. natal dispersal distance, migration routes).
Ecosystem structure	EBV class capturing the spatial and temporal variability of ecosystem units and the organisms defining these units. This includes three generic EBVs (Live cover fraction, Ecosystem distribution, Ecosystem vertical profile).[15]
Live cover fraction	The ratio of the horizontal projection area covered by living organisms, such as vegetation, macroalgae or live hard coral, measured (or modeled) over contiguous spatial and temporal units.
Ecosystem distribution	The area or probability of occurrence of one or more discrete ecosystem types, measured (or modeled) over contiguous spatial and temporal units. In some cases, this could be just a binary variable (presence/absence) or correspond to the output of a probabilistic model for one or more ecosystem types.
Ecosystem vertical profile	Vertical distribution of vegetation volume and biomass in an ecosystem of interest, measured (or modeled) over contiguous spatial and temporal units.
Ecosystem function	EBV class that captures the spatio-temporal variability of the collective performance of organisms that determines the functioning of an ecosystem. This includes three generic EBVs (Primary productivity, Ecosystem phenology, Ecosystem disturbance).[15]
Primary productivity	Estimated rate at which energy is converted to organic matter by photosynthetic producers, measured (or modeled) over contiguous spatial and temporal units.
Ecosystem phenology	The timing of cyclic processes observed at the ecosystem level, such as the start or duration of vegetation activity or phytoplankton blooms, measured (or modeled) over continuous spatial and temporal units.
Ecosystem disturbance	The amount of deviance in the functioning of each ecosystem from its regular dynamics, measured (or modeled) over contiguous spatial and temporal units. Examples include fire, flood, soil erosion.
Community composition	EBV class that assesses inter-specific variability in trait measurements across space and time. This includes four generic EBVs (Community abundance, Taxonomic/phylogenetic diversity, Trait diversity, Interaction diversity).[16]
Community abundance	The number or biomass of all individuals (belonging to one or more species) in a given community, measured (or modeled) over contiguous spatial and temporal units.
Taxonomic/ phylogenetic diversity	The diversity of species and/or phylogenetic distances of organisms in ecological assemblages, measured (or modeled) over contiguous spatial and temporal units. There are several metrics that can be used, such as species richness, different Hill numbers, phylogenetic diversity, etc.
Trait diversity	The diversity of traits of organisms (including those whose species identity is unknown) within ecological assemblages, measured (or modeled) over contiguous spatial and temporal units. Typically this requires a direct measurement of the whole community for each trait of interest, providing a distribution of the trait values in a community, often in a multidimensional trait space. This trait distribution is often summarized in a single metric (e.g. functional divergence or functional richness, Mason et al. 2005[17]). Alternatively, independent measurements of abundance or presence of each of the organisms in a community and a trait matrix describing the trait values for each species can be used to reconstruct the trait distribution in trait space.

[16] https://geobon.org/ebvs

[17] Mason et al. 2005. Functional richness, functional evenness and functional divergence: the primary components of functional diversity. OIKOS, 111, 112-118.

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Interaction diversity	The diversity and structure of multi-trophic interactions between organisms within ecological assemblages, measured (or modeled) over contiguous spatial and temporal units (Pug et al. 2022[18]). Measurements of interaction diversity could include those derived from ecological networks and food web analyses.

[18] Pug et al. 2022. Biodiversity: The role of interaction diversity. Current Biology, 32, R423-R426.

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