EUROPABON

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

31/07/2022

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

This project receives funding from the European Commission's Horizon 2020 research and innovation programme, under Grant Agreement n.101003553

Prepared under contract from the European Commission

Grant agreement No. 101003553
EU Horizon 2020 Coordination and Support Action

Project acronym:	**EuropaBON**
Project full title:	**EUROPA BIODIVERSITY OBSERVATION NETWORK: INTEGRATING DATA STREAMS TO SUPPORT POLICY**
Start of the project:	01.12.2020
Duration:	36 months
Project coordinator:	Prof. Henrique Pereira Martin-Luther Universitaet Halle-Wittenberg (MLU) www.europabon.org
Type:	Coordination and Support Action
Call:	The Sc5-33-2020 Call: "Monitoring ecosystems through innovation and technology"

Project ref. no.	**101003553**
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Deliverable title	**List and specifications of EBVs and EESVs for a European wide biodiversity observation network**
Deliverable number	**D4.1**
Contractual date of delivery	**31.05.2022**
Actual date of delivery	**31.07.2022**
Type of deliverable	**Report**
Dissemination level	**Public**
Work package number	**WP4**
Institution leading work package	**Universiteit van Amsterdam (UvA)**
Task number	**T4.1**
Institution leading task	**Martin-Luther-Universität Halle-Wittenberg (MLU)**
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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 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**

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	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 scope/ biological entity to be measured. Finally, we present a brief outlook on how we plan to narrow down our EBV list to achieve a set of 20-30 EBVs that can be feasibly included in the co-design process and that serve as the basis for identifying data gaps and workflow bottlenecks, as well as informing the cost-benefit analysis of the new European biodiversity monitoring scheme.
Keywords	**Essential Biodiversity Variable (EBV), Essential Ecosystem Services Variable (EESV), indicators, policy needs, stakeholder engagement**

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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 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 scope/ biological entity to be measured. Finally, we present a brief outlook on how we plan to narrow down our EBV list to achieve a set of 20-30 EBVs that can be feasibly included in the co-design process and that may serve as the basis for identifying data gaps and workflow bottlenecks, as well as informing the cost-benefit analysis of the new European biodiversity monitoring scheme.

Introduction

What are EBVs?

Essential Biodiversity Variables (EBVs) are a set of measurements of biodiversity change 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 change, 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 EBV 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. This identification needs to include details on the spatial, temporal and

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

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taxonomic/biological 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 measured by each of six EBV classes.

***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
Ecosystem (Ecosystem-focused EBVs)	Ecosystem Structure	Live cover fraction
		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 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, 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[4]), 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. It is also important to highlight that this specification is about

[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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the temporal and spatial resolutions of the EBV cube 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).

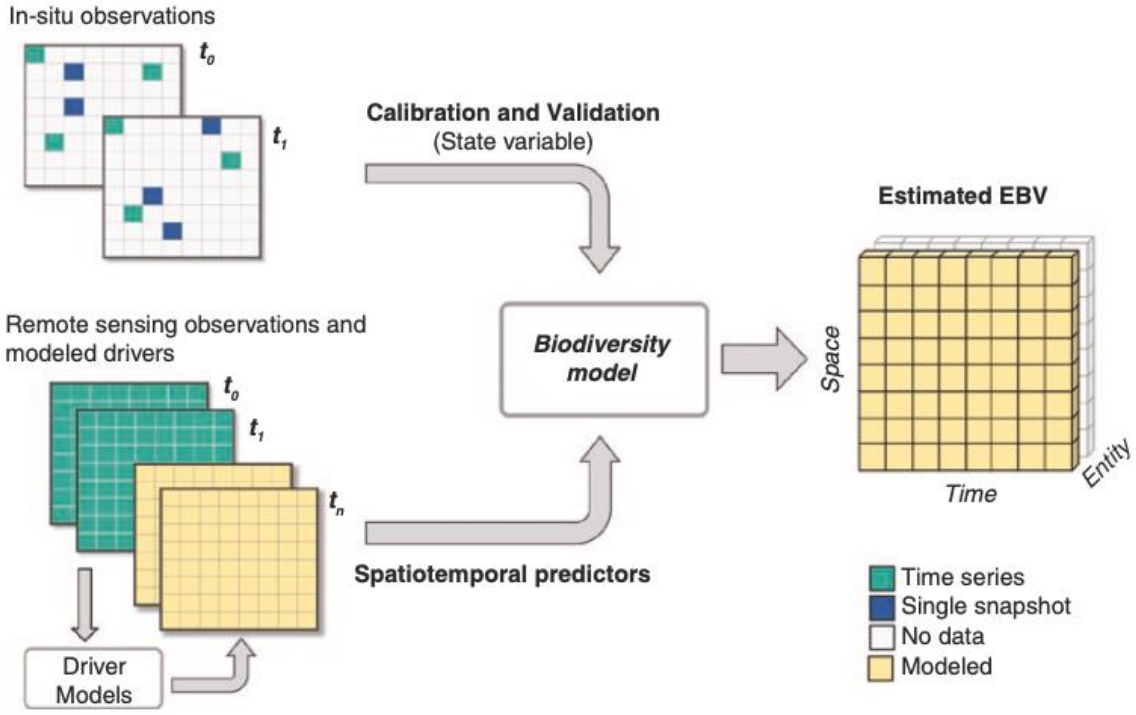

Figure 1: Schematic overview of how models are used in workflows from primary observations to Essential Biodiversity Variables[5]. Note that the spatial and temporal resolution of the observations can be different from the spatial and temporal resolutions of the estimated EBV cube. This report is about the desirable features of the latter.

Methodology for identifying EBVs in EuropaBON

We followed a stepwise process over the course of one year to obtain the full list of EBVs delivered for task 4.1 depicted in Figure 2 and described in more detail below.

Rapid survey, stakeholder workshop, standardised survey, semi-structured interviews

As part of the User & Policy Needs Assessment[6], 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,

[5] 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

[6] 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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academia and non-profit organisations. Still, the majority of attendants were from south-western and central Europe and had academic backgrounds.

Prior to the workshop, a rapid survey was sent to the participants, asking to list desirable EBVs and EESVs across the different classes, specifying their spatial grain, temporal resolution, and taxonomic scope (for EBVs) or type of ecosystem service (for EESVs), 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 and EESVs (Figure 2).

The rapid survey list of EBVs/EESVs 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/EESVs and to provide ranks of importance (in a scale of 1-low to 5-high) for each of the EBVs/EESVs to address open policy questions in their country/agency. This resulted in a list of 243 variables (Figure 2), 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).

After the workshop, during the first internal review of the EBV/ EESV 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 a selection of the variables that had received intermediate to high rankings. This resulted in a list of 45 variables (Figure 2), covering terrestrial (N=35), marine (N=5) and freshwater biomes (N=5), with specified taxonomic/entity scope, desirable spatial resolution, and desirable temporal resolution.

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 (in a scale of 1-low to 5-high) the EBVs and EESVs 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/EESVs was selected using the highest average rank scores by respondents, and further analysed in the User and Policy Needs Assessment Report[7] (Figure 2).

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

[7] 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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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 (for a list of partners involved in the different tasks, please see here) 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 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 into 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.

We aim to prioritise this list even further to obtain a set of 20-30 EBVs that can feasibly be included in the co-design process, guide the identification of gaps and bottlenecks and inform the estimation of monitoring costs.

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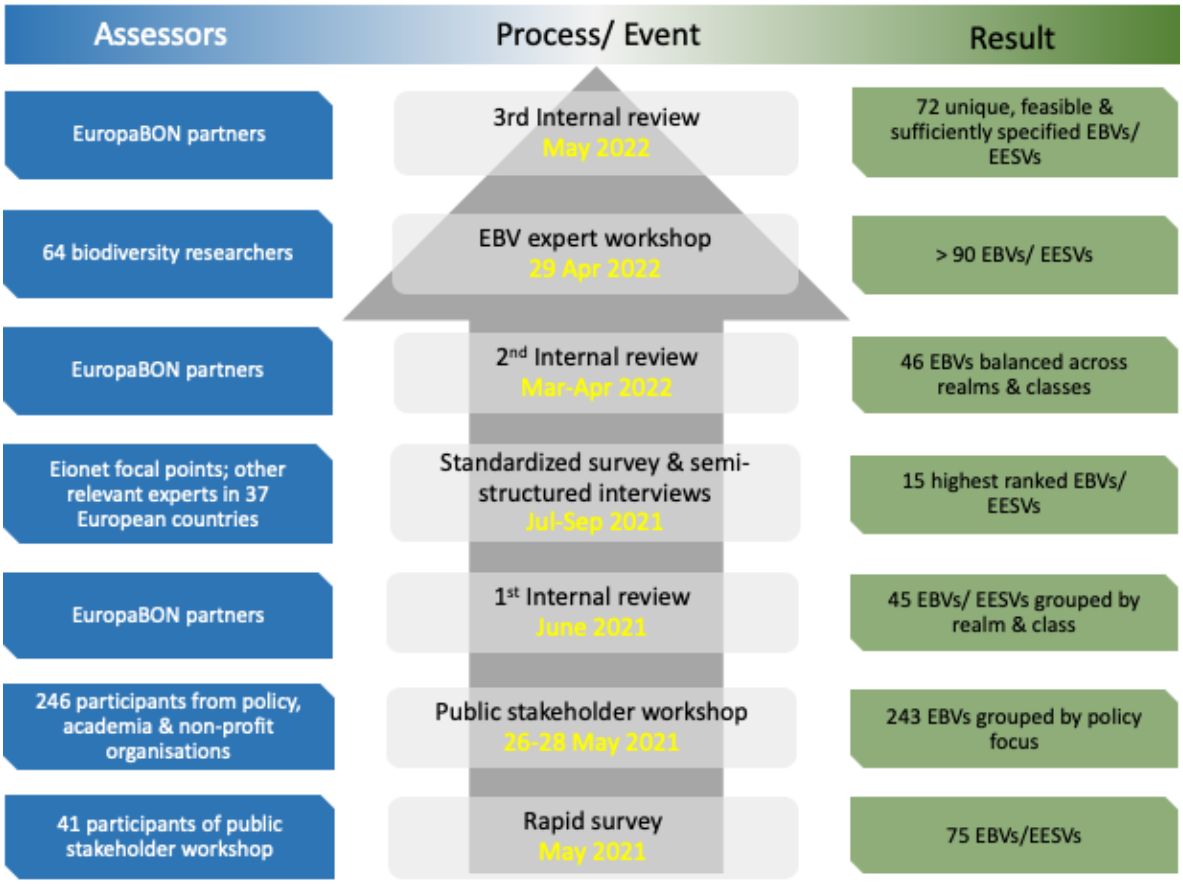

Figure 2: The stepwise methodology of EuropaBON's 12-month EBV identification process.

EBV list

Our list of EBVs includes 72 variables of which 33 could be grouped into the terrestrial realm, and 22 and 17 variables into the freshwater and marine realms, respectively (Table 2, Figure 3; more detailed definitions of the more generic EBVs are provided in Table 3). Of these, 35 are species-focused EBVs and 37 variables are ecosystem-focused EBVs (Figure 3). The identified EBVs cover all classes, albeit not for each realm. For example, the freshwater realm does not include any EBVs that monitor "Species traits" and EBVs on the "Genetic Composition" of organisms are lacking in both the freshwater and marine realms. However, we include the four terrestrial "Genetic Composition" EBVs proposed by Hoban and colleagues[8] to monitor genetic diversity and differentiation, inbreeding and effective population size of terrestrial taxa.

[8]Hoban, S., Archer, F. I., Bertola, L. D., et al. (2022). Global genetic diversity status and trends:towards a suite of Essential Biodiversity Variables (EBVs) for genetic composition. Biological Reviews, doi.org/10.1111/brv.12852.

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Figure 3: List of species- (lighter colours) and ecosystem-focused (darker colours) EBV classes and their realms.

Of these variables, the majority were identified during the User and Policy Needs Assessment (n=40), followed by the EBV expert workshop (n=18) and the internal review processes (n=14). Forty-four 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=17) have desired spatial resolutions of less than 1 km^2. Similarly, 86% (n=62) of the EBVs are expected to be modelled every five years or more frequently and more than half of them (n=34) at yearly intervals or less.

Seventeen variables (24%) in our list monitor higher animal taxa including fish, amphibians, reptiles, birds and mammals. Another 12 (17%) and 11 (15%) EBVs monitor invertebrate and plant species, respectively, and twelve EBVs (17%) focus on habitat- rather than species monitoring. The rest cover microorganisms, a combination of taxa, or their specific taxonomic focus has not yet been defined.

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Outlook

In a next step, we aim to derive a refined list of 20-30 EBVs that will be used as the building blocks to design the European Biodiversity Observation Network for which workflows will be established. This refined list will focus on selecting a sample set of 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 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 the realm of experts within the consortium that will help identify what is currently available and what is still needed for each EBV. More specifically, EBVs will then be scored (low, medium, high) on policy relevance, relevance to private industry and NGOs, as well as monitoring costs, feasibility, and ability to detect biodiversity change within each of these three categories across the realms. The final list will also undergo another public review process, similar to the one used during the User & Policy Needs Assessment, to ensure a balanced set of essential variables that serve the needs of the users from all relevant sectors. This sample of EBVs will be used to help design a diverse and user-driven EuropaBON.

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Table 2: List of EBVs and their respective spatial, temporal and taxonomic specifications identified during EuropaBON's stepwise identification and refinement process.

No.	Realm	EBV class	EBV name	Step in identification process	Spatial resolution	Temporal resolution	Taxonomic focus
1	Freshwater	Species populations	Species abundance of wetland birds	Expert workshop	1x1km - 10x10km	1 year	All wetland birds
2	Freshwater	Species populations	Species distribution of freshwater fishes	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	5 years	All freshwater fishes
3	Freshwater	Species populations	Species distribution of amphibians and freshwater reptiles	User & Policy Needs Assessment	10x10 km - 50x50km	5 years	All amphibians and freshwater reptiles
4	Freshwater	Species populations	Species distribution of freshwater mammals	User & Policy Needs Assessment	10x10 km - 50x50km	5 years	Species in Habitats Directive
5	Freshwater	Species populations	Species distributions of freshwater invertebrates	Internal review process	Catchment Characterisation Model (CCM2)	5 years	Species in the Habitats Directive
6	Freshwater	Species populations	Species distributions of freshwater macrophytes	Internal review process	Location of lakes	5 years	Lake species in the Habitats Directive
7	Freshwater	Species populations	Species distribution of freshwater taxa of invasive concern	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	5 years	Freshwater taxa of invasive concern
8	Freshwater	Species populations	Species distribution of freshwater parasites	Expert workshop	Catchment Characterisation Model (CCM2)	1 year	Freshwater parasites of public health concern
9	Freshwater	Community composition	Community composition of phytoplankton in lakes (Ecological Quality Ratio)	User & Policy Needs Assessment	Location of lakes	1 year, weekly-monthly during growing season	Total abundance (biovolume) and all lake phytoplankton species with indicator values + bloom intensity

10	Freshwater	Community composition	Community composition of macrophytes (Ecological Quality Ratio)	User & Policy Needs Assessment	Location of lakes	3-6 years	All lake macrophytes species with indicator values
11	Freshwater	Community composition	Community composition of phytobenthos (Ecological Quality Ratio)	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	1-3 years	All river phytobenthic species with indicator values
12	Freshwater	Community composition	Community composition of benthic invertebrates (Ecological Quality Ratio)	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	1-3 years	All river benthic invertebrate species with indicator values
13	Freshwater	Community composition	Community composition of fish (Ecological Quality Ratio)	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	3-6 years	Abundance, species distribution and age structure of all fish species
14	Freshwater	Community composition	Community composition of zooplankton (Ecological Quality Ratio)	Internal review process	Location of lakes	1-3 years	All lake zooplankton species with indicator values
15	Freshwater	Ecosystem structure	Free river flow/ River continuity (including lakes and ponds connectivity)	Internal review process	Sub-catchment	3-6 years	% Free flowing river length/sub-catchment
16	Freshwater	Ecosystem structure	Ecosystem distribution of freshwater EUNIS Habitats	User & Policy Needs Assessment	Catchment Characterisation Model (CCM2)	1 year	EUNIS freshwater habitats (including temporary water bodies)
17	Freshwater	Ecosystem structure	Structural complexity of riparian habitats	Expert workshop	Catchment Characterisation Model (CCM2)	1 year	EUNIS riparian habitats
18	Freshwater	Ecosystem function	Nutrient Retention/ Regulation of freshwater quality	User & Policy Needs Assessment	Sub-catchment	6 months-1 year	All water bodies
19	Freshwater	Ecosystem function	Harmful freshwater algal blooms	User & Policy Needs Assessment	Location of lakes	Real-time, weekly-monthly	All lake water bodies

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20	Freshwater	Ecosystem function	Carbon sequestration (based on ecosystem typology) and GHG emissions	Expert workshop	10x10m - 30x30m	1 year	EUNIS freshwater habitats
21	Freshwater	Ecosystem function	Carbon stock (based on ecosystem typology)	Expert workshop	10x10m - 30x30m	1 year	EUNIS freshwater habitats
22	Freshwater	Ecosystem function	Flood resilience	Expert workshop	10x10m - 30x30m	1 year	All floodplains, marshes, estuaries, peatlands
23	Marine	Species populations	Species distribution of marine fishes	User & Policy Needs Assessment	50x50km - 200x200km	5 years	Selected fish species
24	Marine	Species populations	Species abundance of marine commercial fish species and long distance migratory fish	User & Policy Needs Assessment	50x50km - 200x200km	1 year	All commercial marine fishes
25	Marine	Species populations	Species distribution of marine birds	User & Policy Needs Assessment	10x10km - 50x50km	5 years	All marine birds
26	Marine	Species populations	Species distribution (abundance?) of marine mammals	User & Policy Needs Assessment	10x10km - 50x50km	5 years	All marine mammals
27	Marine	Species populations	Species distribution of marine turtles	User & Policy Needs Assessment	10x10km - 50x50km	5 years	2 (or 3) most common marine turtle species
28	Marine	Species populations	Species distribution of benthic invertebrates	Internal review process	10x10km - 50x50km	Seasonal-1 year	Species in the Habitats Directive
29	Marine	Species populations	Species distribution of marine taxa of invasive concern	User & Policy Needs Assessment	1x1km - 10x10km	5 years	Coastal marine taxa of invasive concern within 1-5 km from the shore

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30	Marine	Species traits	Phenology of migration of marine birds and mammals	Expert workshop	10x10km - 50x50km	1 year	All marine bird and mammal migrants
31	Marine	Community composition	Functional diversity of marine phyto/ zooplankton (based on traits)	User & Policy Needs Assessment	10x10km - 50x50km	Seasonal-1 year	Functional groups
32	Marine	Ecosystem structure	Ecosystem distribution of hard corals habitats	Internal review process	10x10m - 300x300m	5 years	Hard corals habitats
33	Marine	Ecosystem structure	Ecosystem distribution of macroalgae canopy cover	Internal review process	10x10m - 300x300m	5 years	Macroalgae
34	Marine	Ecosystem structure	Ecosystem distribution of seagrass habitats	Internal review process	10x10m - 300x300m	5 years	Seagrass habitats
35	Marine	Ecosystem structure	Ecosystem distribution of oyster reef habitats	Internal review process	10x10m - 300x300m	5 years	Oyster reef habitats
36	Marine	Ecosystem function	Degree of seabed disturbance	Expert workshop	1x1km - 10x10km	5 years	Seabed
37	Marine	Ecosystem function	Harmful marine algal blooms	User & Policy Needs Assessment	300x300m	Real-time, weekly or monthly	EUNIS marine habitats
38	Marine	Ecosystem function	Phenology of marine spring phytoplankton bloom	Expert workshop	10x10km - 50x50km	1 year	All phytoplankton
39	Marine	Ecosystem function	Marine primary productivity	Internal review process	10x10km - 50x50km	1 year	Algae cyanobacteria; other microorganisms
40	Terrestrial	Genetic composition	Effective population size of terrestrial priority taxa	User & Policy Needs Assessment	per country or per population	12 years	A subset of priority taxa in the Birds and Habitats Directives

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41	Terrestrial	Genetic composition	Inbreeding (genetic composition) of terrestrial priority taxa	User & Policy Needs Assessment	per country or per population	12 years	A subset of priority taxa in the Birds and Habitats Directives
42	Terrestrial	Genetic composition	Genetic diversity of terrestrial (selected/ priority?) taxa	Expert workshop	50x50km - 200x200km	10 years	Priority taxa in the Birds and Habitats Directives
43	Terrestrial	Genetic composition	Genetic differentiation of terrestrial (selected/ priority?) taxa	Expert workshop	per country or per population	10 years	A subset of priority taxa in the Birds and Habitats Directives
44	Terrestrial	Species populations	Species distributions of terrestrial birds	User & Policy Needs Assessment	1x1km - 10x10km	5 years	Terrestrial birds
45	Terrestrial	Species populations	Species abundances of terrestrial (rare; priority; migratory; common) birds	User & Policy Needs Assessment	1x1km - 10x10km	Rare and priority: 1 year; migratory: real-time; common: 1 year	Rare; priority; migratory; common birds
46	Terrestrial	Species populations	Species abundance of selected terrestrial mammals	User & Policy Needs Assessment	1x1km - 10x10km	1 year	Carnivora, Artiodactyla and bats
47	Terrestrial	Species populations	Species distributions of all terrestrial mammals	User & Policy Needs Assessment	10x10km - 50x50km	5 years	All terrestrial mammals
48	Terrestrial	Species populations	Species distribution of terrestrial reptiles	User & Policy Needs Assessment	1x1km - 10x10km	5 years	All terrestrial reptiles
49	Terrestrial	Species populations	Species abundance of butterflies	User & Policy Needs Assessment	10x10km - 50x50km	1 year	Current/ extended list of species underlying the European grassland butterfly indicator
50	Terrestrial	Species populations	Species distribution of terrestrial priority invertebrates and key pollinators	Internal review process	10x10km - 50x50km	5 years	Terrestrial priority invertebrates and key pollinators (EUPoMS)

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51	Terrestrial	Species populations	Species distribution of terrestrial plants (all vascular; priority)	User & Policy Needs Assessment	priority: 1x1km - 10x10km; vascular: 10x10km - 50x50km	Priority: 1 year; vascular: 5 years	All/priority vascular plant species
52	Terrestrial	Species populations	Species distribution of (all/ main) trees	Expert workshop	10x10km - 50x50km	5 years	All/ main tree species
53	Terrestrial	Species populations	Species distribution (abundance?) of lichens (as indicators of pollution)	Expert workshop	10x10km - 50x50km	5 years	Ecological quality indicator lichens
54	Terrestrial	Species populations	Species distribution of terrestrial taxa of invasive concern	User & Policy Needs Assessment	1x1km - 10x10km	5 years (max)	66 IAS of Union concern
55	Terrestrial	Species populations	Species abundance of selected terrestrial disease vectors and crop pests	User & Policy Needs Assessment	animal vectors: 10x10km - 50x50km; crop pests: 100x100m - 1x1km	Animal vectors: real-time; crop pests: strongly species-dependent	Animal vector: *Aedes albopictus*; crop pests: not yet defined
56	Terrestrial	Species traits	Phenology of fructification of mushrooms and wild fruits	User & Policy Needs Assessment	1x1km - 10x10km	1 week	Wild fruits and mushrooms
57	Terrestrial	Species traits	Phenology of flowering and leaf senescence	User & Policy Needs Assessment	10x10km - 50x50km	1 week-1 month	Flowering plants and deciduous trees
58	Terrestrial	Species traits	Phenology of terrestrial animal traits (e.g., frog spawning, birds start nesting, migrant bird arrival, emergence [mean flight date] of butterflies)	Expert workshop	10x10km	1 week (traits derived from weekly distribution data)	Frogs, birds, butterflies
59	Terrestrial	Community composition	Biomass of terrestrial arthropods; Biomass of terrestrial arthropod functional; terrestrial taxonomic groups	Expert workshop	Ecosystem based; national	1 year	Forest arthropods; beetles

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60	Terrestrial	Community composition	Community abundance of terrestrial predator and decomposer invertebrates	Expert workshop	10x10km - 50x50km	5 years	Predator and decomposer invertebrates
61	Terrestrial	Community composition	Community biomass of soil microbes	Internal review process	1x1km	3 years	Soil microbial species
62	Terrestrial	Community composition	Community abundance and taxonomic diversity of pollinator insects	User & Policy Needs Assessment	National scale to NUTS III; 100x100m UK	1-5 years (rotation across years)	All pollinator insects
63	Terrestrial	Community composition	Biomass of migrating birds and arthropods	User & Policy Needs Assessment	1x1km - 10x10km	Real-time	All bird migrants (by size class); selected migrating arthropod species in agroecosystems
64	Terrestrial	Community composition	Functional or taxonomic diversity of soil biota	User & Policy Needs Assessment	1x1m	1 year	Collembola, Acari, small Coleoptera, fungi
65	Terrestrial	Ecosystem structure	Vertical structure of terrestrial vegetation	Expert workshop	1x1m-10x10m	5 years	Vegetation height (m); vertical complexity; cover and vegetation density of layers
66	Terrestrial	Ecosystem structure	Ecosystem distribution of terrestrial EUNIS Habitats	User & Policy Needs Assessment	10x10km	1 year	EUNIS priority habitats
67	Terrestrial	Ecosystem structure	Connectivity of terrestrial ecosystem habitat types	User & Policy Needs Assessment	10x10m	1 year	EUNIS habitats
68	Terrestrial	Ecosystem function	Ecosystem carbon pool (above and below ground)	Expert workshop	10x10m - 30x30m	1 year	Ecosystem type
69	Terrestrial	Ecosystem function	Terrestrial primary productivity	User & Policy Needs Assessment	10x10m	10 days	Plants

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70	Terrestrial	Ecosystem function	Forest disturbance by fire	Internal review process	10x10m	10 days	EUNIS forest habitats
71	Terrestrial	Ecosystem function	Ecosystem disturbance as measured by HANPP	Internal review process	10x10m	10 days	EUNIS forest habitats
72	Terrestrial	Ecosystem function	Terrestrial ecosystem phenology	User & Policy Needs Assessment	10x10m	1 year	Trees

Table 3: More detailed definitions of generic EBVs.

Generic EBV	Definition
Genetic diversity	The count of the number of alleles in a population (richness) or expected proportion of heterozygotes in a population at equilibrium (evenness) measured at the population or individual level. Hoban et al. 2022.
Genetic differentiation	The number of genetic lineages/units within a species or alternatively, the degree of genetic differentiation among populations or units measured across species range or specific region. Hoban et al. 2022.
Effective population size	The size of an ideal population that loses genetic variation at the same rate as the focal population measured at the population level. Hoban et al. 2022.
Inbreeding	Degree of relatedness between pairs of individuals, mating among relatives, or identity by descent at the individual (pairs or families) or population level. Hoban et al. 2022.
Species distribution	The probability of occurrence over the chosen resolution of contiguous spatial and temporal units (often grid cells) across Europe of all the species in the taxonomic focus group. In some cases this could be just a binary variable (presence/absence), in others it corresponds to the occupancy level (probability of the spatial-temporal unit being occupied in multiple visits to the site) or the suitability for the species (probability that the cell is occupied by a species when cells with similar environmental conditions across Europe are considered). Jetz et al. 2019.
Species abundance	The estimated count of individuals at the chosen resolution of contiguous spatial and temporal units (often grid cells) across Europe of all the species in the taxonomic focus group. In some cases this could be a prediction from a model. The counts are often reported in logarithmic scales. Jetz et al. 2019.
Morphology	The mean Euclidean distance (sum of squared differences) between a target species and the centroid of higher taxa.
Physiology	The variation in physical attributes in the same species of the taxonomic focus group.

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Phenology	The timing of seasonal biological phenomena such as the presence, absence, abundance or duration of seasonal activities of organisms. This can include the date of emergence of leaves and flowers, the first flight of butterflies, the first appearance of migratory birds, the date of leaf colouring 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	The range and distance of the dispersal and migration routes for selected taxonomic groups.
Live cover fraction	The horizontal (or projected) fraction of area covered by living organisms, such as vegetation, macroalgae or live hard coral. The horizontal distribution of discrete ecosystem units.
Ecosystem distribution	The probability of occurrence or the amount of area of occurrence over the chosen resolution of contiguous spatial and temporal units (often grid cells) across Europe of all the ecosystems in the ecosystem focus group. In some cases this could be just a binary variable (presence/absence), in others it corresponds to the the suitability for the ecosystem (probability that the cell includes an ecosystem when cells with similar environmental conditions across Europe are considered), while in other cases this would be the total area (e.g. in hectares) covered by the ecosystem.
Ecosystem vertical profile	Percentage of the relative vertical distribution of volume and biomass in the ecosystem focus group.
Primary productivity	The rate at which energy is converted to organic matter by photosynthetic producers (photoautotrophs).
Ecosystem phenology	The timing of cyclic processes observed at the ecosystem level, such as the start or duration of vegetation activity, phytoplankton blooms, etc.
Ecosystem disturbance	The amount of deviance in the functioning of the ecosystem focus group from its regular dynamics.
Community abundance	The estimated count of all individuals in the community focus group at the chosen resolution of contiguous spatial and temporal units (often grid cells) across Europe. In some cases this could be a prediction from a model. Jetz et al. 2019.
Taxonomic/ phylogenetic diversity	The total number of species and/or amount of phylogenetic composition of organisms in focal communities.
Trait diversity	The number of different functional traits of organisms within the focal communities.
Interaction diversity	The richness and abundance of interactions between species, where richness is the number of unique interactions and abundance the total number of each interaction. Dyer et al. 2010.

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