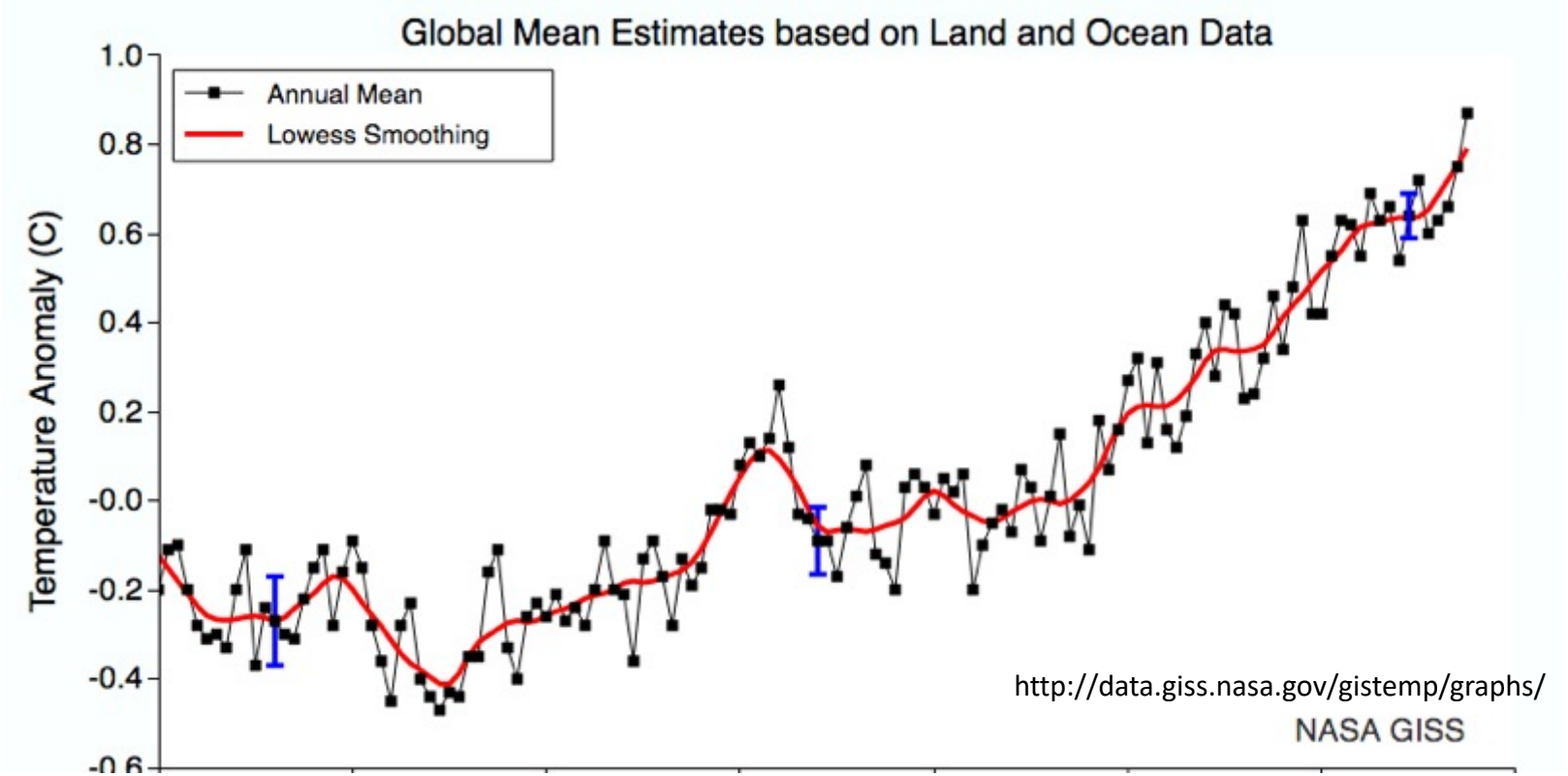
Essential Biodiversity Variables-EBVs

Andrew Skidmore and Elnaz Neinavaz

University of Twente/ITC

Essential Climate Variables-ECVs



GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

- **An example: global temperature**

Essential Climate Variables

- 50+ GCOS Essential Climate Variables (ECVs) (2010)
- GEOSS/GEOBON Essential Biodiversity Variables (EBVs)
  - Land cover, fAPAR, LAI, biomass, (fire) disturbance, soil moisture, soil carbon

Domain	GCOS Essential Climate Variables
Atmospheric (Over land, sea and ice)	**Surface:** Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. **Upper-air:** Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). **Composition:** Carbon dioxide, Methane, and other long-lived greenhouse gases, Ozone and Aerosol, supported by their precursors.
Oceanic	**Surface:** Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton. **Sub-surface:** Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.

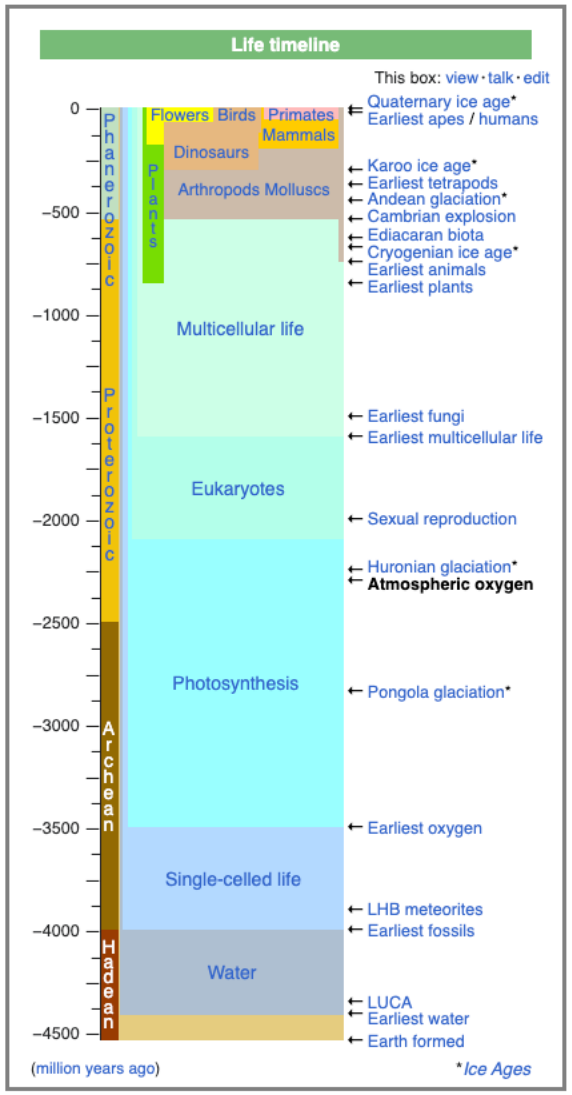
http://gosic.org/ios/MATRICES/ECV/ECV-matrix.htm

EBVs

- …global geosystems have been altered
- How have humans impacted on the Earth's ecosystems and biology that may be creating a global signal in the permanent geological record?
- Monitoring the change with Essential Biodiversity Variables


Google Earth

Definitions of Biodiversity



Biodiversity: more than just a number

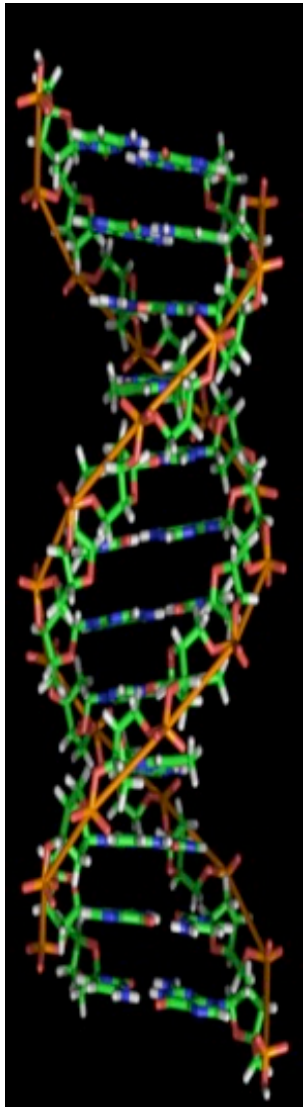
The term Biodiversity was proposed by *Raymond F. Dasmann* in 1968.

Definition adopted by the United Nations Convention on Biological Diversity:

"Biodiversity is the variability among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems." (UN 1992)

Biodiversity and evolution – phylogeny (tree of life)

Biodiversity: the variety of Life



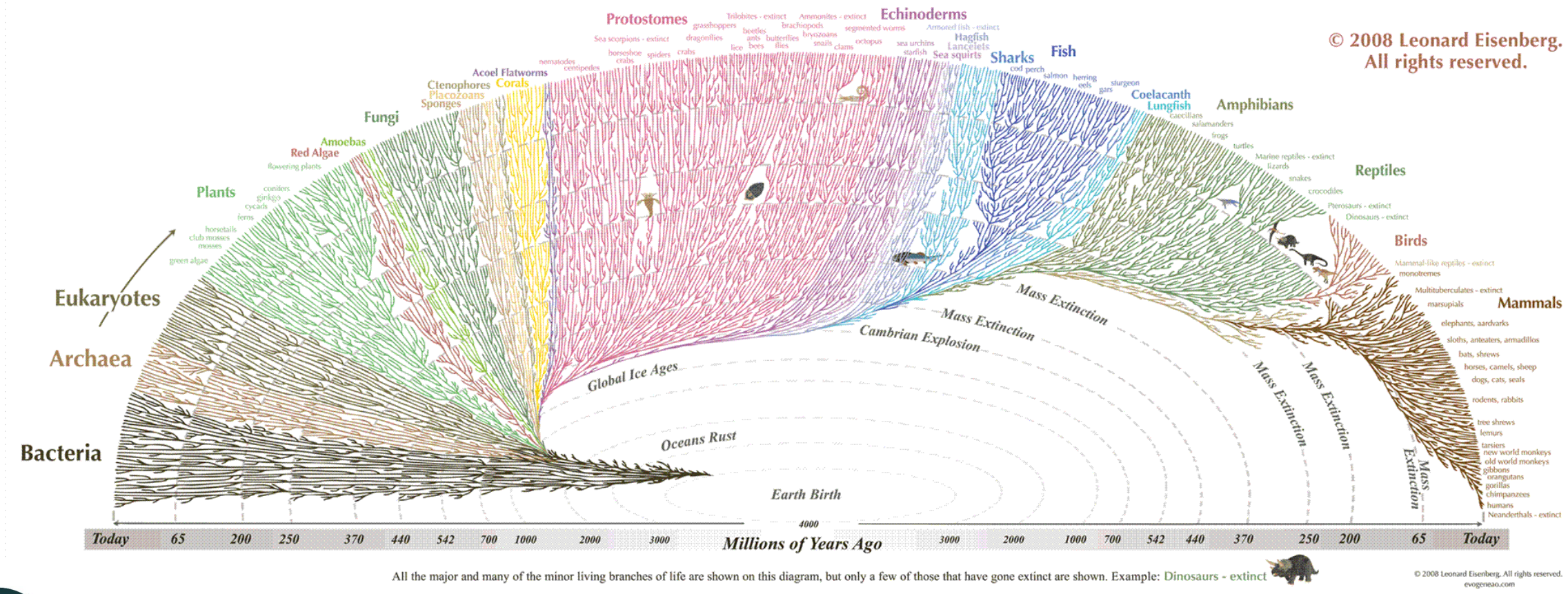
Biological organization levels

- Genetic Diversity
  The genetic variation contained in the genes of all species.

- Species Diversity
  The total number of species and the number of individuals per species.

- Ecosystem Diversity
  The variety of habitats, communities and ecological processes.

"LIFE ON EARTH IS ONE BIG EXTENDED FAMILY!"

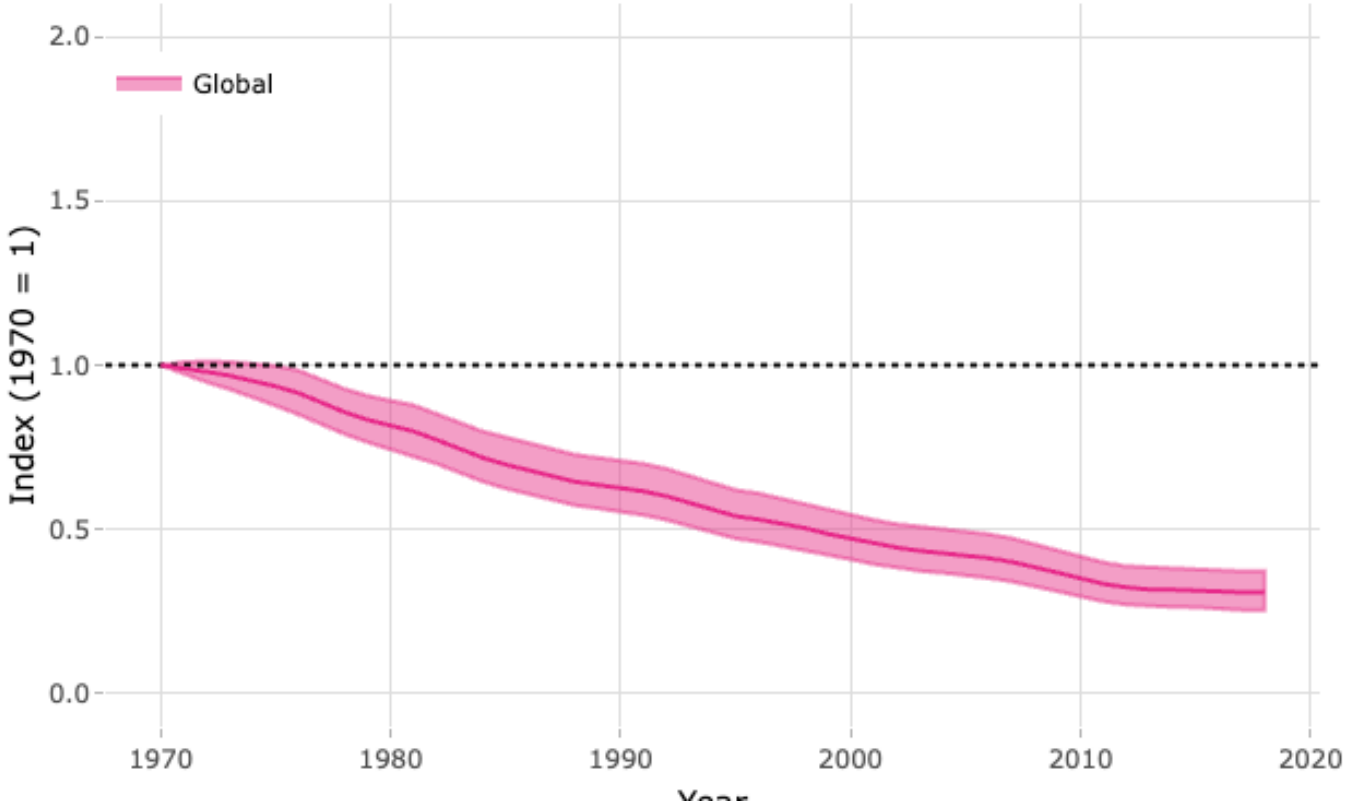


https://www.evogeneao.com/en/learn/tree-of-life

WHY BIODIVERSITY MATTERS: THE EXAMPLE OF ECOSYSTEM SERVICES

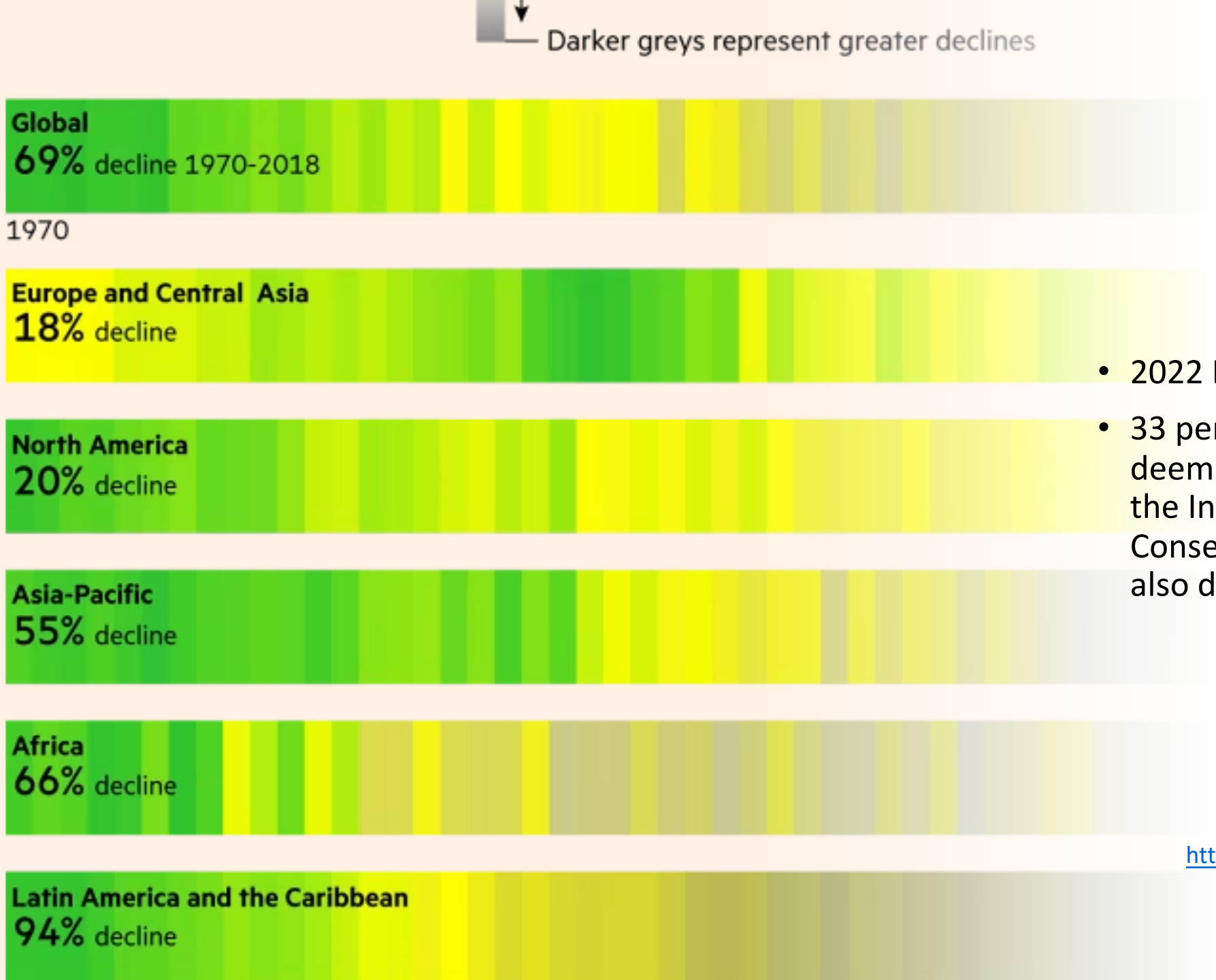
Indicators using species observation

- A single indicator (like temperature increase)
- Problems: weighting, technique changes over time
- Scalability
- Comparison



Global Living Planet Index shows a decline of 70% between 1970 and 2018 (https://www.livingplanetindex.org/latest_results)

http://www.livingplanetindex.org/search



- 2022 Living Planet Index
- 33 per cent of the species deemed “non-threatened” by the International Union for Conservation of Nature were also declining

https://www.ft.com/content/5c8c2aa5-8735-4123-8092-aca3fcda37a4

International Response ------
UN Sustainable Development Goals & CBD Aichi targets

Summary of linkages between SDGs and Aichi Biodiversity Targets

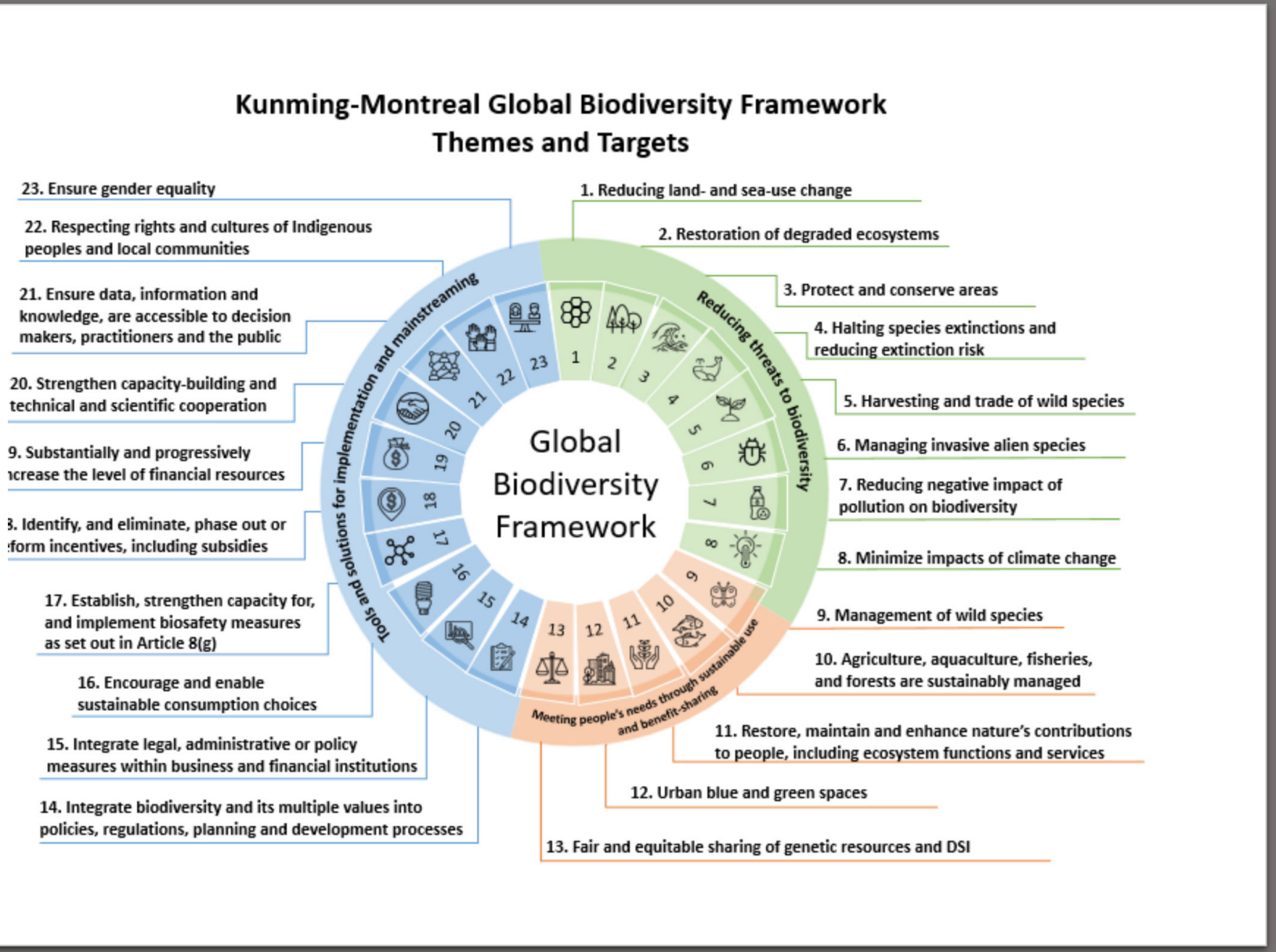
Sustainable Development Goal	Relevant Aichi Biodiversity Target*
1. End poverty in all its forms everywhere	2, 6, 7, 14
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	4, 6, 7, 13, 18
3. Ensure healthy lives and promote well-being for all at all ages	8, 13, 14, 16, 18
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	1, 19
5. Achieve gender equality and empower all women and girls	14, 17, 18
6. Ensure the availability and sustainable management of water and sanitation for all	8, 11, 14, 15
7. Ensure access to affordable, reliable, sustainable and modern energy for all	5, 7, 14, 15, 19
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	2, 4, 6, 7, 14, 16
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	2, 4, 8, 14, 15, 19
10. Reduce inequality within and among countries	8, 15, 18, 20
11. Make cities and human settlements inclusive, safe, resilient and sustainable	2, 4, 8, 11, 14, 15
12. Ensure sustainable consumption and production patterns	1, 4, 6, 7, 8, 19
13. Take urgent action to combat climate change and its impacts	2, 5, 10, 14, 15, 17
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 14, 15, 17, 19
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss	2, 4, 5, 7, 9, 11, 12, 14, 15, 16
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	17
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development	2, 17, 19, 20

Overview of Aichi Biodiversity Targets

GOAL 15: PROTECT, RESTORE AND PROMOTE SUSTAINABLE USE OF TERRESTRIAL ECOSYSTEMS, SUSTAINABLY MANAGE FORESTS, COMBAT DESERTIFICATION AND HALT AND REVERSE LAND DEGRADATION AND HALT BIODIVERSITY LOSS

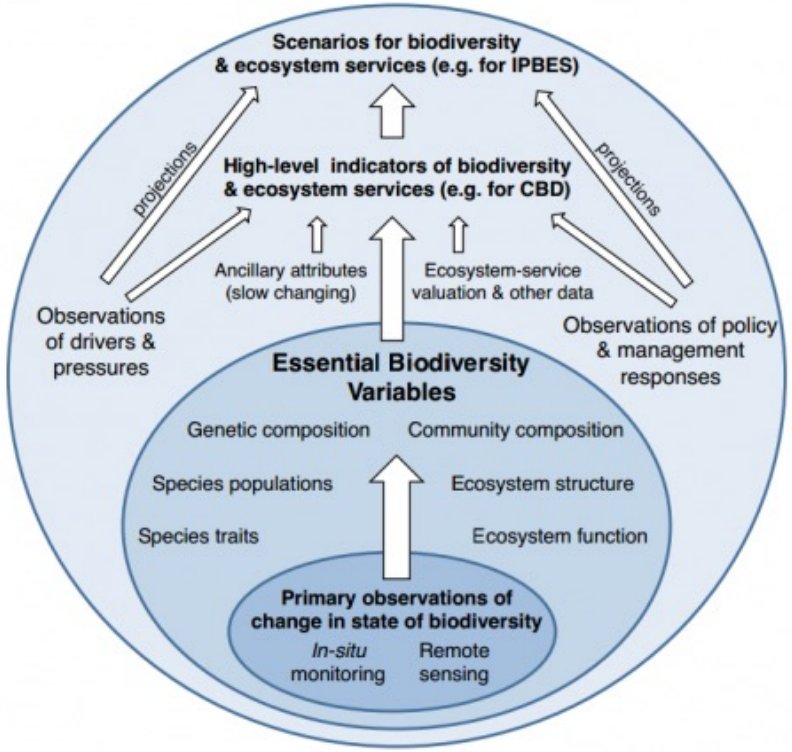
Sustainable Development Targets	Relevant Aichi Biodiversity Targets
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	4, 5, 7, 11, 14, 15
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	4, 5, 7, 14, 15
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	4, 5, 15
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	11, 14, 15
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	5, 12
15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	16
15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	12
15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	9
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	2

- 20 biodiversity indicators proposed by the convention on biodiversity in 2010
- Aichi #15 Restore at least 15% of degraded systems
- Aichi #5 Halve rate of loss by 2020



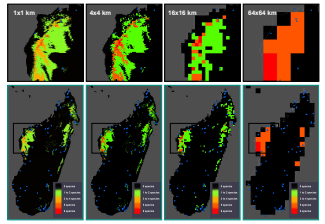
CBD Kunming-Montreal Post 2020 biodiversity targets

https://www.cbd.int/gbf/targets/

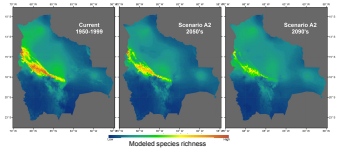


Defining how to measure biodiversity ??????????????

- ESSENTIAL
- BIOLOGICAL
- POLICY
- FEASIBLE



- SCALABLE
- ECOSYSTEM AGNOSTIC
- CHANGE



The Essential Biodiversity Variables (EBVs), defined "*as the derived measurements required to study, report, and manage biodiversity change, focusing on status and trend in elements of biodiversity should play the role of brokers between monitoring initiatives and decision makers*."

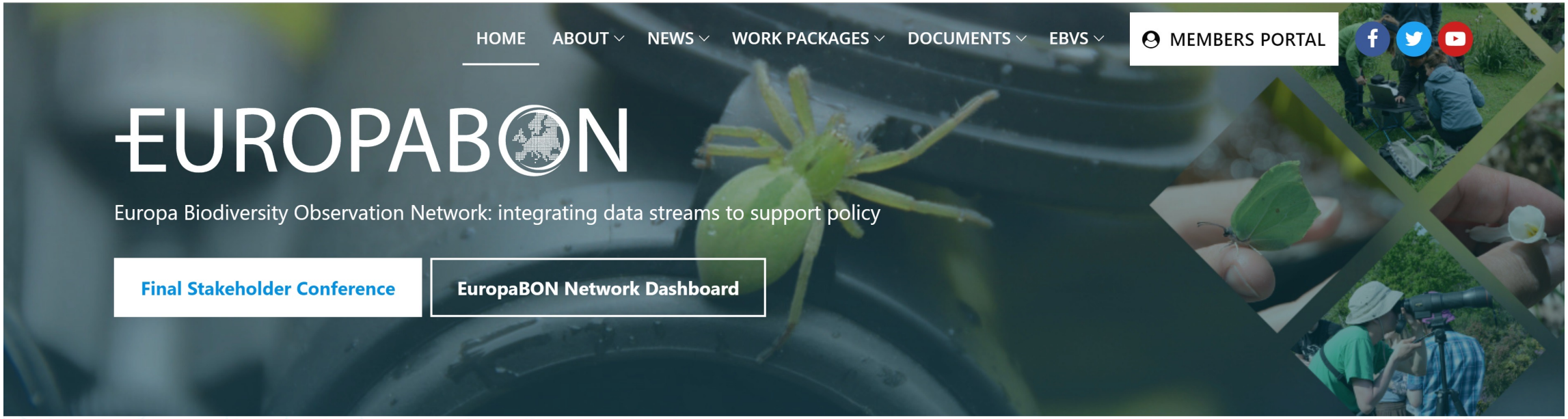
What are Essential biodiversity variables (EBVs)

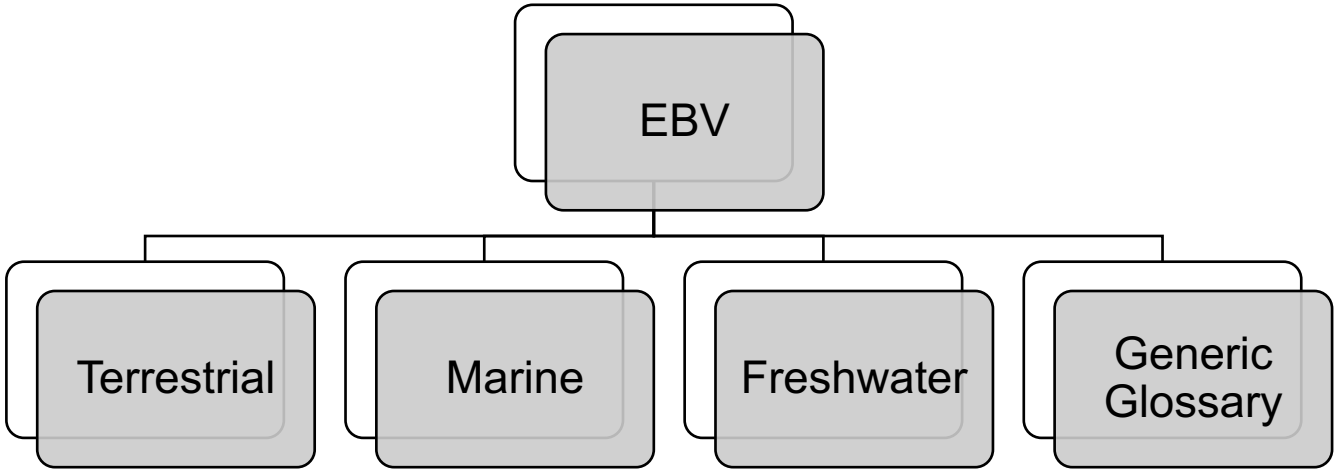
Examples of candidate Essential Biodiversity Variables

EBV class	EBV examples	Measurement and scalability	Temporal sensitivity	Feasibility	Relevance for CBD targets and indicators (*1,9*)
Genetic composition	Allelic diversity	Genotypes of selected species (e.g., endangered, domesticated) at representative locations.	Generation time	Data available for many species and for several locations, but little global systematic sampling.	Targets: 12, 13. Indicators: Trends in genetic diversity of selected species and of domesticated animals and cultivated plants; RLI.
Species populations	Abundances and distributions	Counts or presence surveys for groups of species easy to monitor or important for ES, over an extensive network of sites, complemented with incidental data.	1 to >10 years	Standardized counts under way for some taxa but geographically restricted. Presence data collected for more taxa. Ongoing data integration efforts (Global Biodiversity Information Facility, Map of Life).	Targets: 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15. Indicators: LPI; WBI; RLI; population and extinction risk trends of target species, forest specialists in forests under restoration, and species that provide ES; trends in invasive alien species; trends in climatic impacts on populations.
Species traits	Phenology	Timing of leaf coloration by RS, with in situ validation.	1 year	Several ongoing initiatives (Phenological Eyes Network, PhenoCam, etc.)	Targets: 10, 15. Indicators: Trends in extent and rate of shifts of boundaries of vulnerable ecosystems.
Community composition	Taxonomic diversity	Consistent multitaxa surveys and metagenomics at select locations.	5 to >10 years	Ongoing at intensive monitoring sites (opportunities for expansion). Metagenomics and hyperspectral RS emerging.	Targets: 8, 10, 14. Indicators: Trends in condition and vulnerability of ecosystems; trends in climatic impacts on community composition.
Ecosystem structure	Habitat structure	RS of cover (or biomass) by height (or depth) globally or regionally.	1 to 5 years	Global terrestrial maps available with RS (e.g., Light Detection and Ranging). Marine and freshwater habitats mapped by combining RS and in situ data.	Targets: 5, 11, 14, 15. Indicators: Extent of forest and forest types; mangrove extent; seagrass extent; extent of habitats that provide carbon storage.
Ecosystem function	Nutrient retention	Nutrient output/input ratios measured at select locations. Combine with RS to model regionally.	1 year	Intensive monitoring sites exist for N saturation in acid-deposition areas and P retention in affected rivers.	Targets: 5, 8, 14. Indicators: Trends in delivery of multiple ES; trends in condition and vulnerability of ecosystems.

Offical GEOBON EBVs and EBV Classes

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

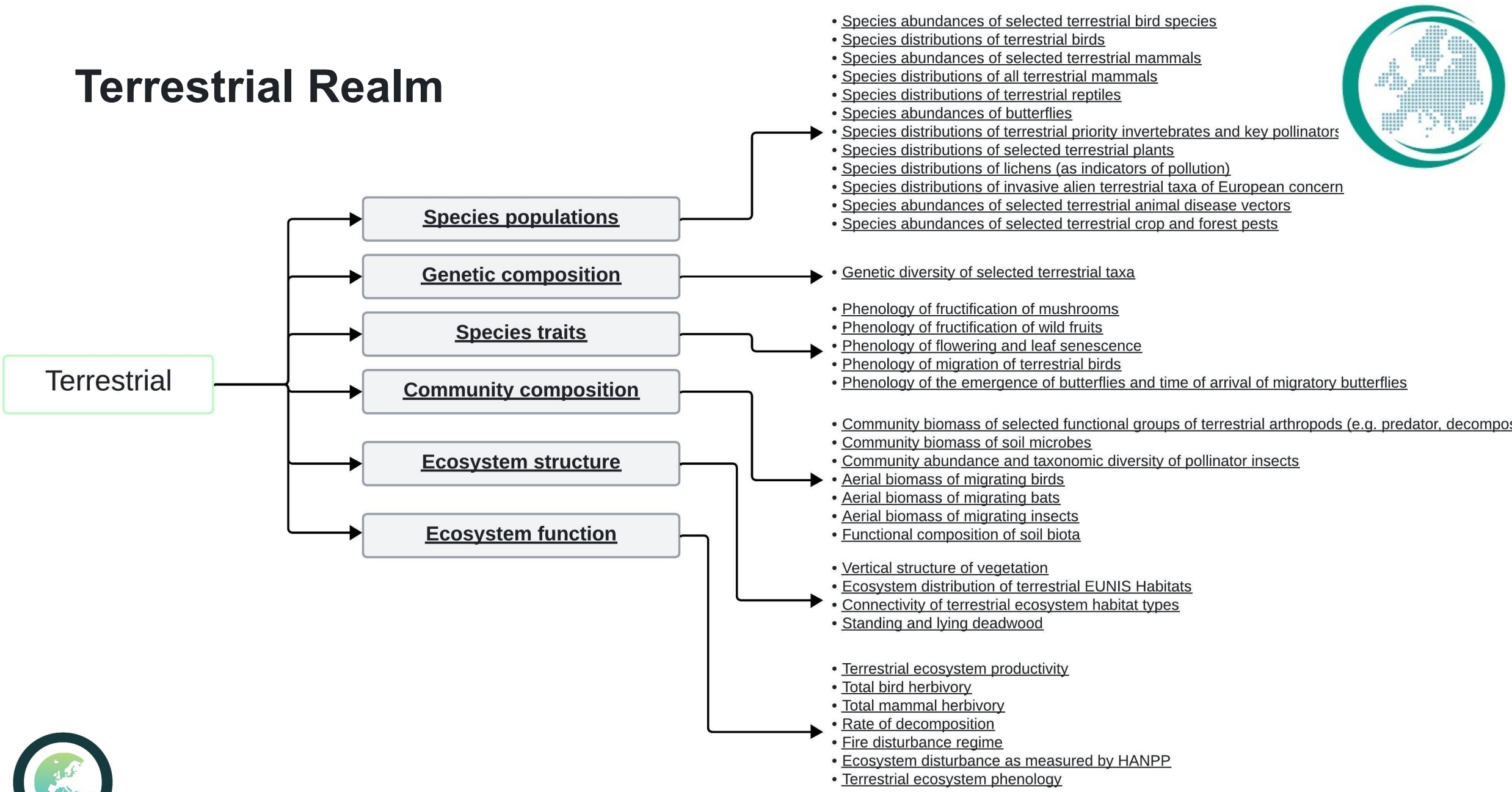




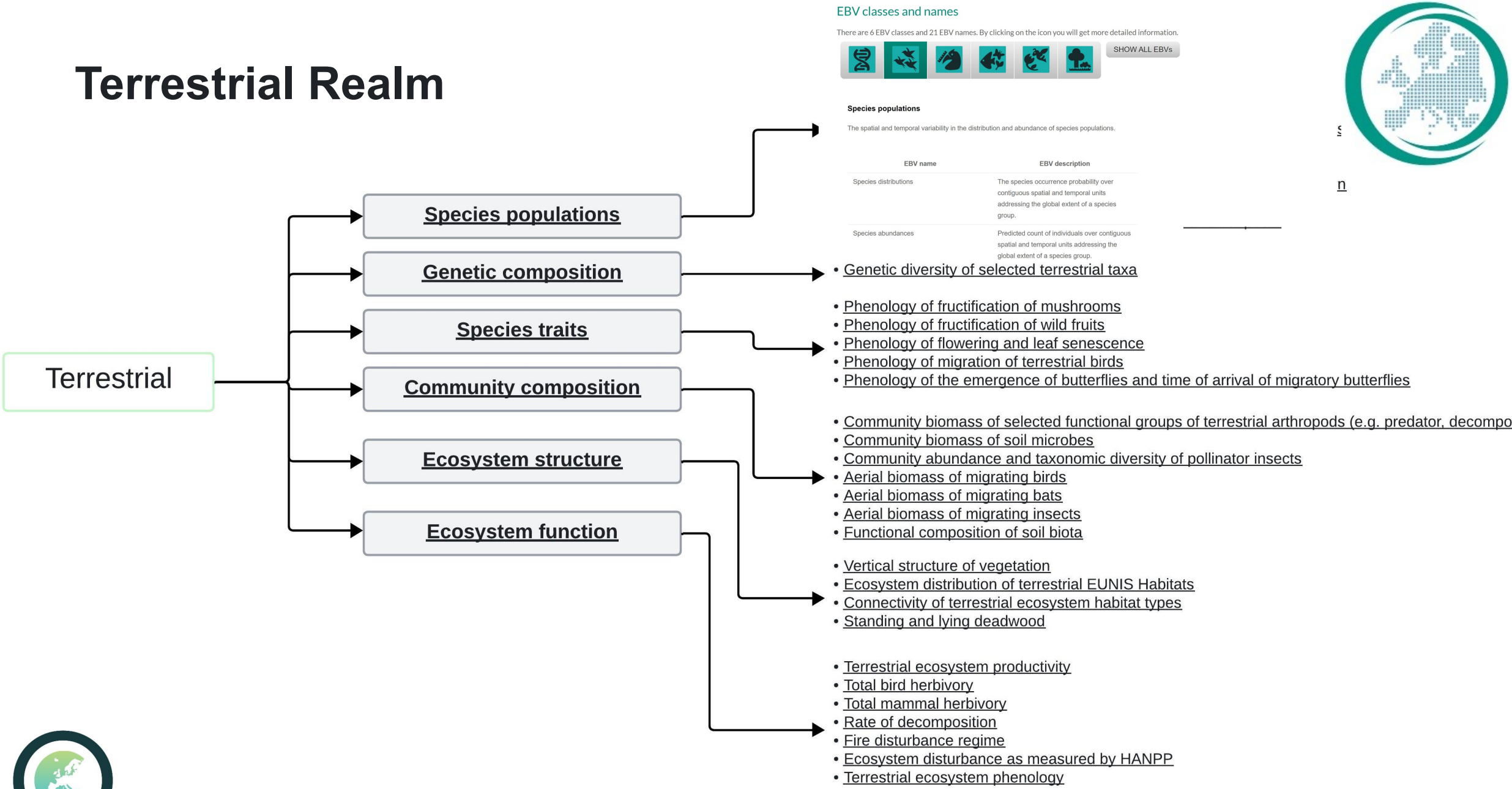
Identifying 84 EBV candidates

This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003553

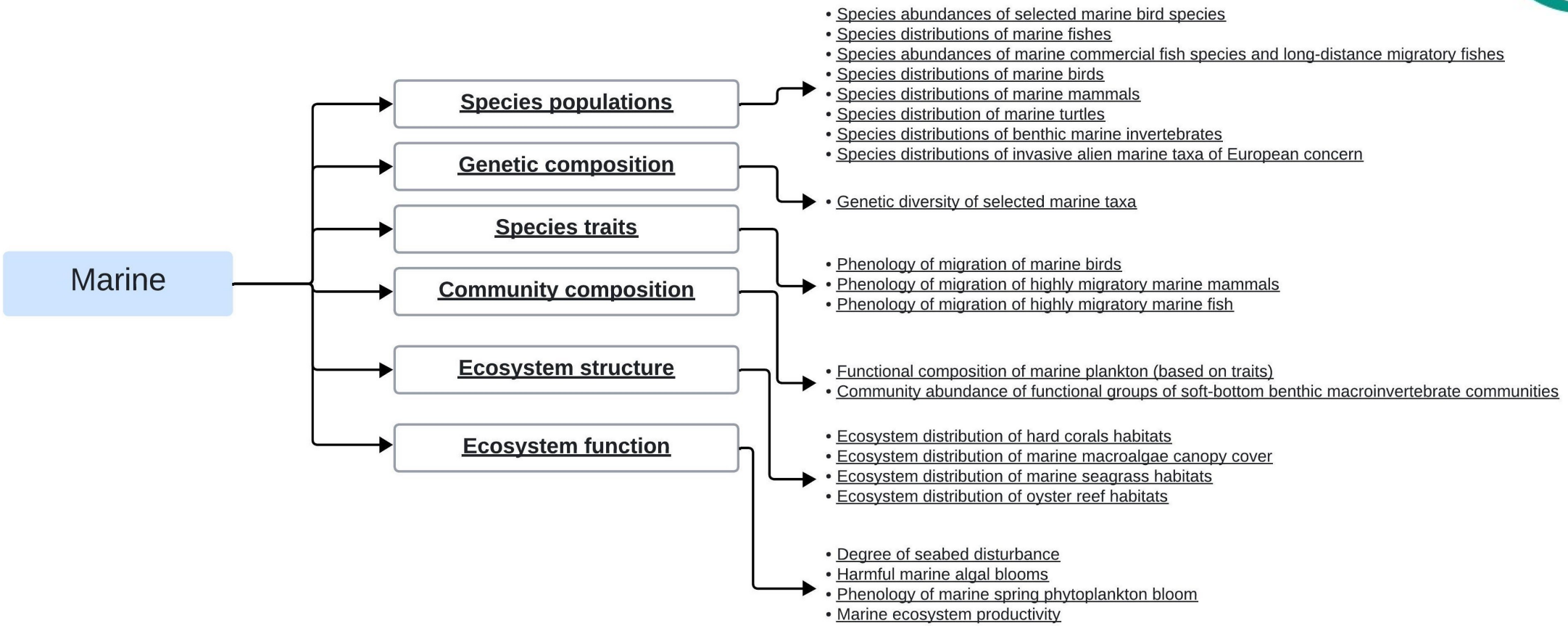
Terrestrial Realm



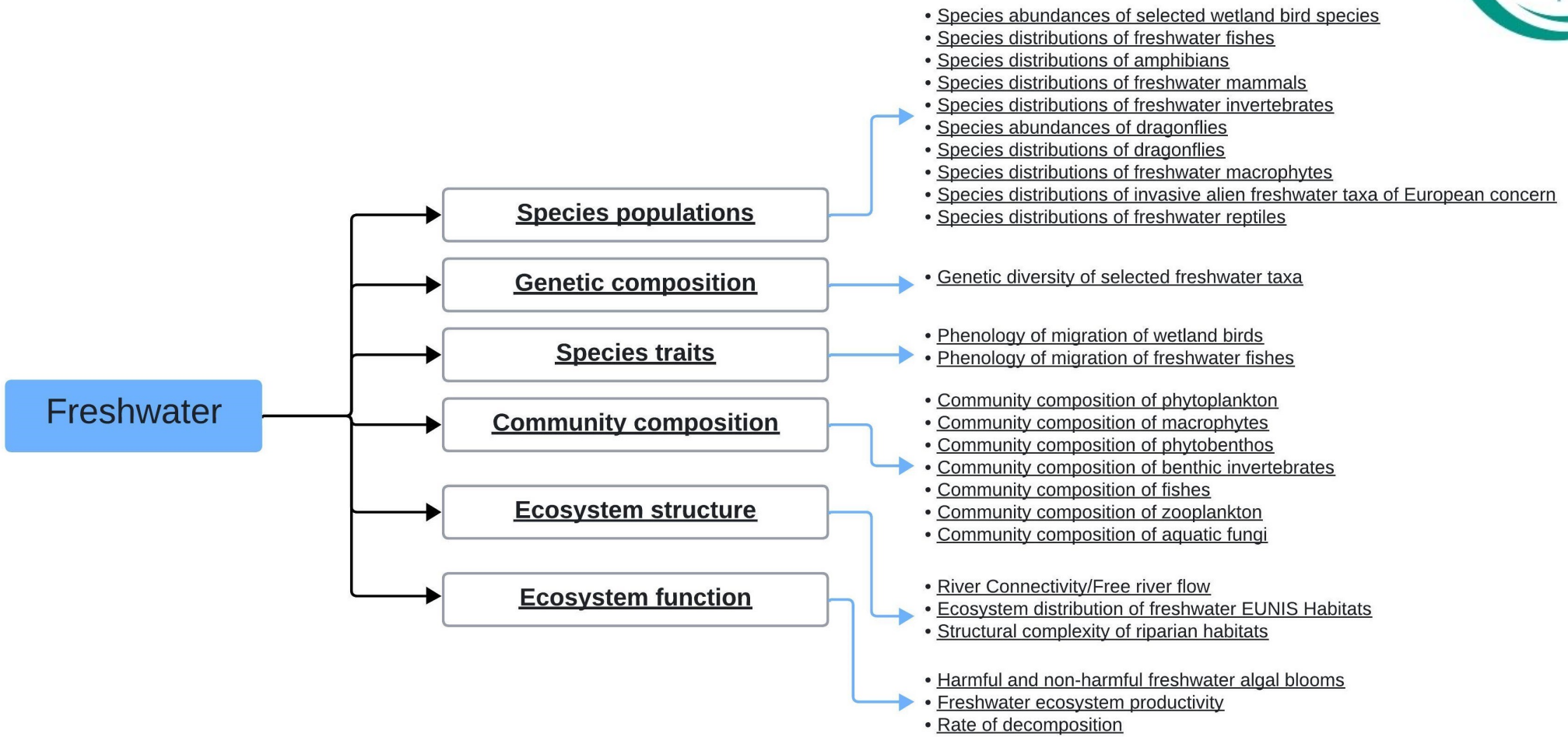
Terrestrial Realm



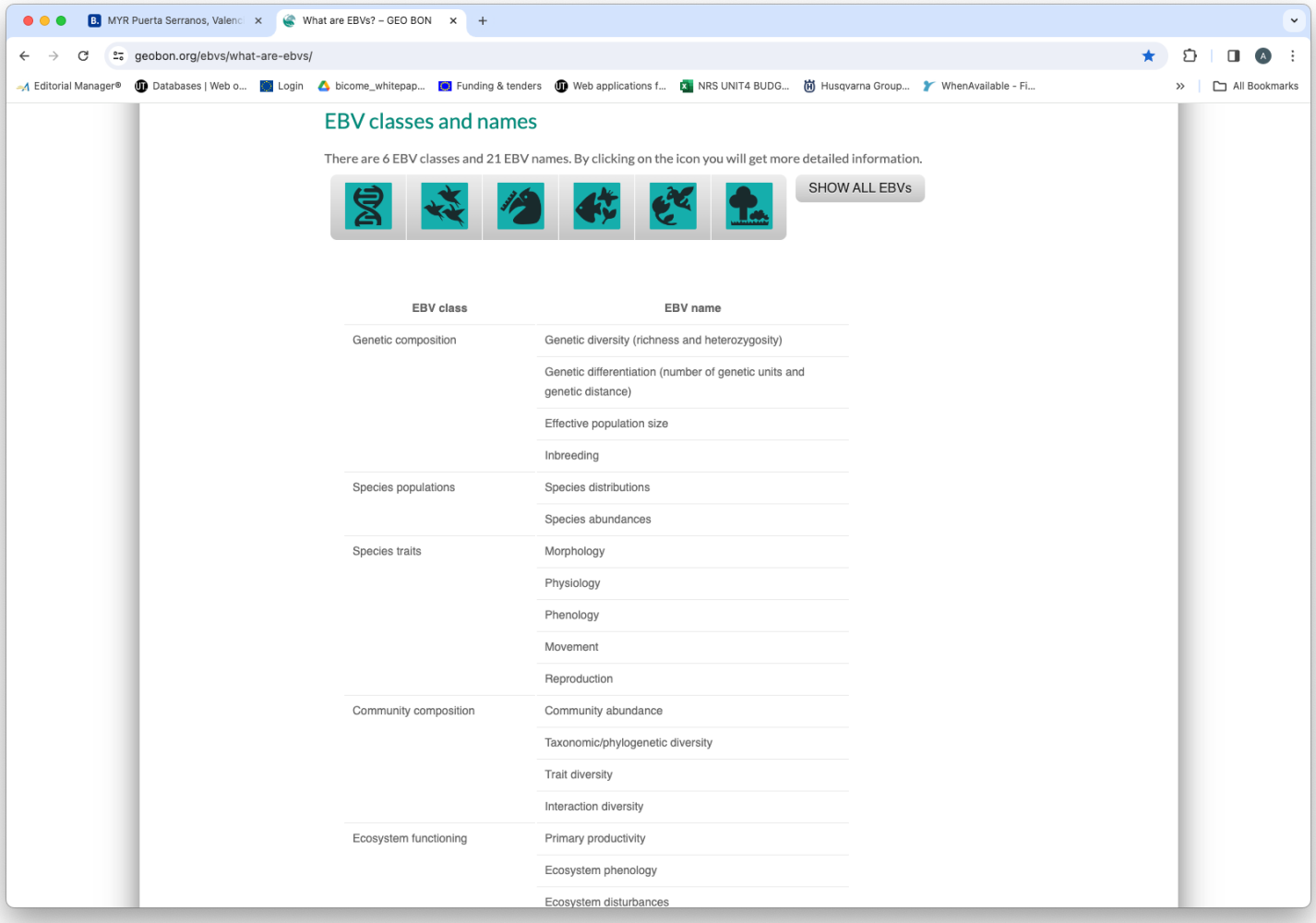
Marine Realm



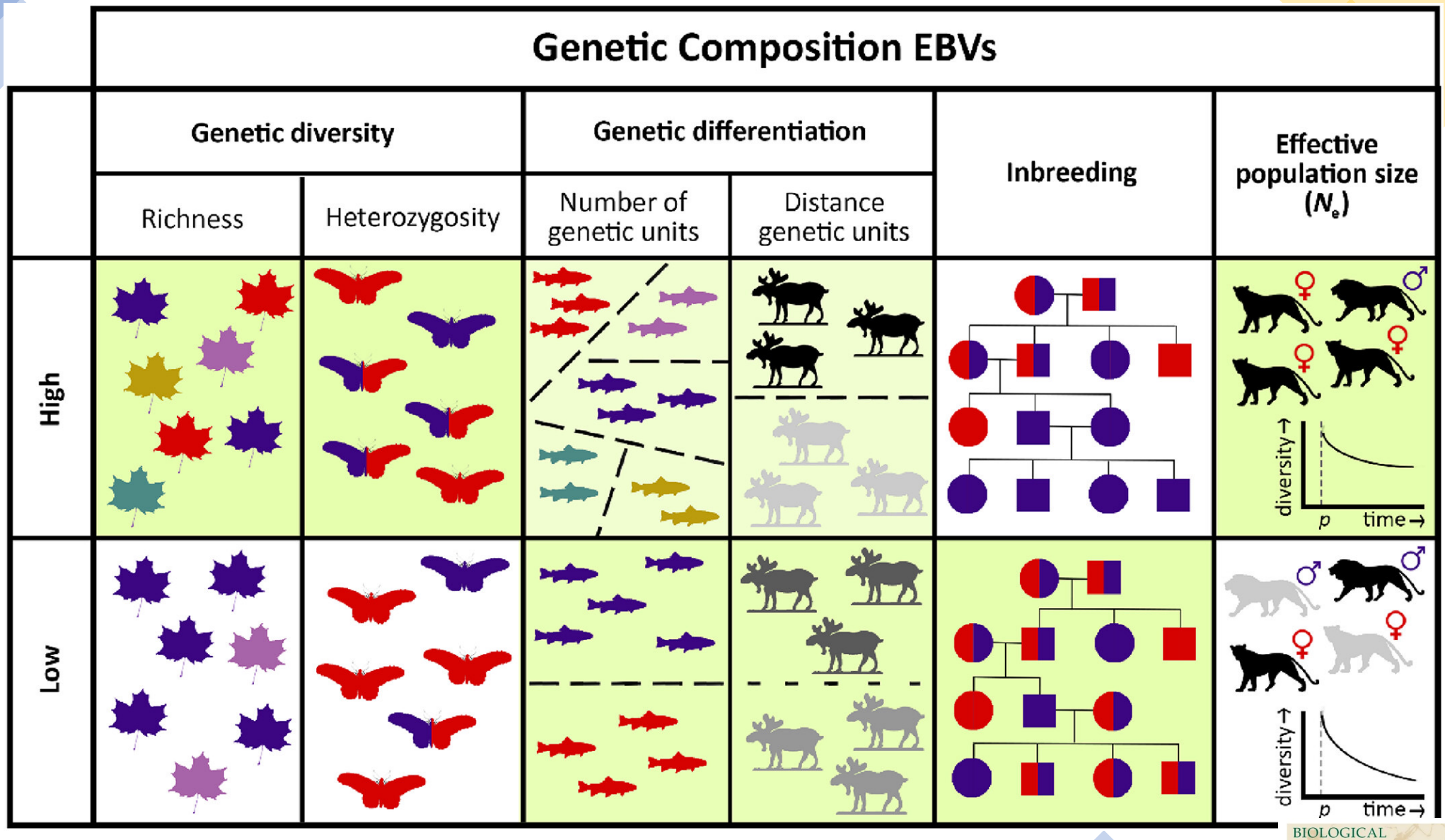
Freshwater Realm



OBSGESSION uses the official GEOBON EBVs



EBV class	EBV name
Genetic composition	Genetic diversity (richness and heterozygosity)
	Genetic differentiation (number of genetic units and genetic distance)
	Effective population size
	Inbreeding
Species populations	Species distributions
	Species abundances
Species traits	Morphology
	Physiology
	Phenology
	Movement
	Reproduction
Community composition	Community abundance
	Taxonomic/phylogenetic diversity
	Trait diversity
	Interaction diversity
Ecosystem functioning	Primary productivity
	Ecosystem phenology
	Ecosystem disturbances



BIOLOGICAL REVIEWS
Cambridge Philosophical Society
Original Article | Open Access

Global genetic diversity status and trends: towards a suite of Essential Biodiversity Variables (EBVs) for genetic composition

Sean Hoban, Frederick I. Archer, Laura D. Bertola, Jason G. Bragg, Martin F. Breed, Michael W. Bruford, Melinda A. Coleman, Robert Ekblom, W. Chris Funk, Catherine E. Grueber ... See all authors

Conservation Biology

REVIEW | Open Access

A quantitative global review of species population monitoring

Caroline Moussy, Ian J. Burfield, P. J. Stephenson, Arabella F. E. Newton, Stuart H. M. Butchart, William J. Sutherland, Richard D. Gregory, Louise McRae, Philip Bubb, Ignacio Roesler ... See all authors

First published: 17 February 2021 | https://doi-org.ezproxy2.utwente.nl/10.1111/cobi.13721 |
Citations: 24

Species populations

- A population is a group of individuals of the same species that live in the same geographic area that interbreed with each other. Many species consist of multiple populations dispersed over a few to many geographic areas.
- EBVS
  - Species abundance
  - Species distribution

nature ecology & evolution

Explore content | About the journal | Publish with us

nature > nature ecology & evolution > perspectives > article

Perspective | Open access | Published: 17 September 2018

Towards global data products of Essential Biodiversity Variables on species traits

W. Daniel Kissling, Ramona Walls, Anne Bowser, Matthew O. Jones, Jens Kattge, Donat Agosti, Josep Amengual, Alberto Basset, Peter M. van Bodegom, Johannes H. C. Cornelissen, Ellen G. Denny, Salud Deudero, Willi Egloff, Sarah C. Elmendorf, Enrique Alonso García, Katherine D. Jones, Owen R. Jones, Sandra Lavorel, Dan Lear, Laetitia M. Navarro, Samraat Pawar, Rebecca Pirzl, Nadja Rüger, Sofia Sal, ... Robert P. Guralnick + Show authors

Nature Ecology & Evolution **2**, 1531–1540 (2018) | Cite this article

Species traits are defined as qualities of all organisms of a species, like body mass, length or height. Due to intraspecific variation different organisms of a species have different trait values, e.g. different body masses, but together they define a distribution, which is characteristic for each species.

- EBVs
  - Phenology
  - Morphology
  - Reproduction
  - Physiology
  - Movement

Community composition

is the identity and relative abundances of all taxa in a community.

- EBVs
  - Community abundance
  - Taxonomic/phylogenetic diversity
  - Trait diversity
  - Interaction diversity

Soil Biology and Biochemistry 161 (2021) 108393

Contents lists available at ScienceDirect

Soil Biology and Biochemistry

journal homepage: www.elsevier.com/locate/soilbio

Changes in soil bacterial and fungal community composition and functional groups during the succession of boreal forests

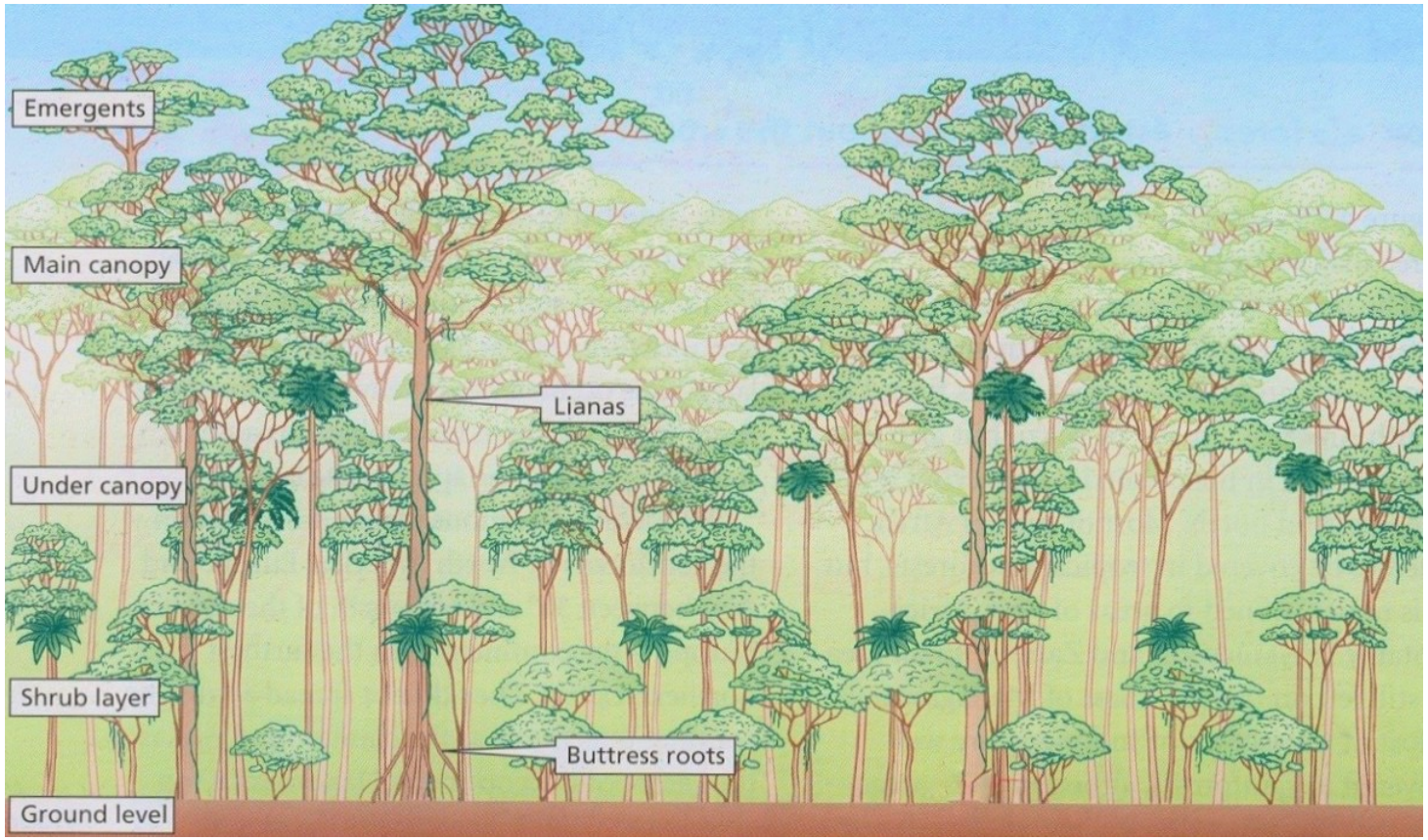
Shuai Jiang [a,b], Yajuan Xing [b], Guancheng Liu [c], Chunyi Hu [d], Xiaochun Wang [c], Guoyong Yan [b,**], Qinggui Wang [a,b,*]

- Ecosystem functions are broadly defined as the biological, geochemical and physical processes that take place or occur within an ecosystem.

- EBVS
- Ecosystem productivity
- Ecosystem phenology
- Ecosystem disturbances

- Ecosystem structure **The spatial arrangement of ecosystem units collectively defined by organisms forming these units**.

- EBVS
- Live cover fraction
- Ecosystem distribution
- Ecosystem vertical profile



Prioritizing RS Biodiversity Products

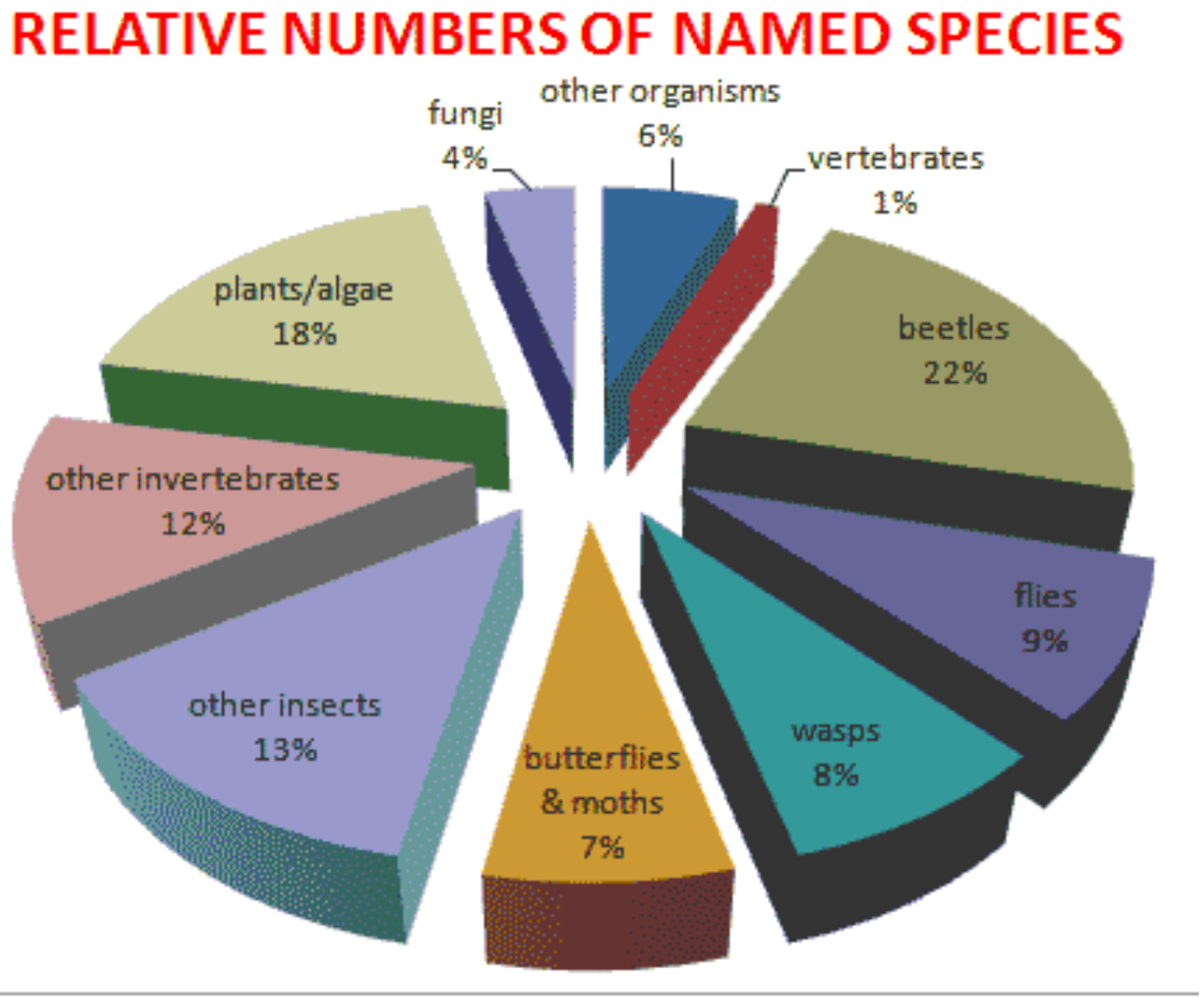
Taxonomic Gaps in Biodiversity

Current Biology Vol 22 No 21
R900

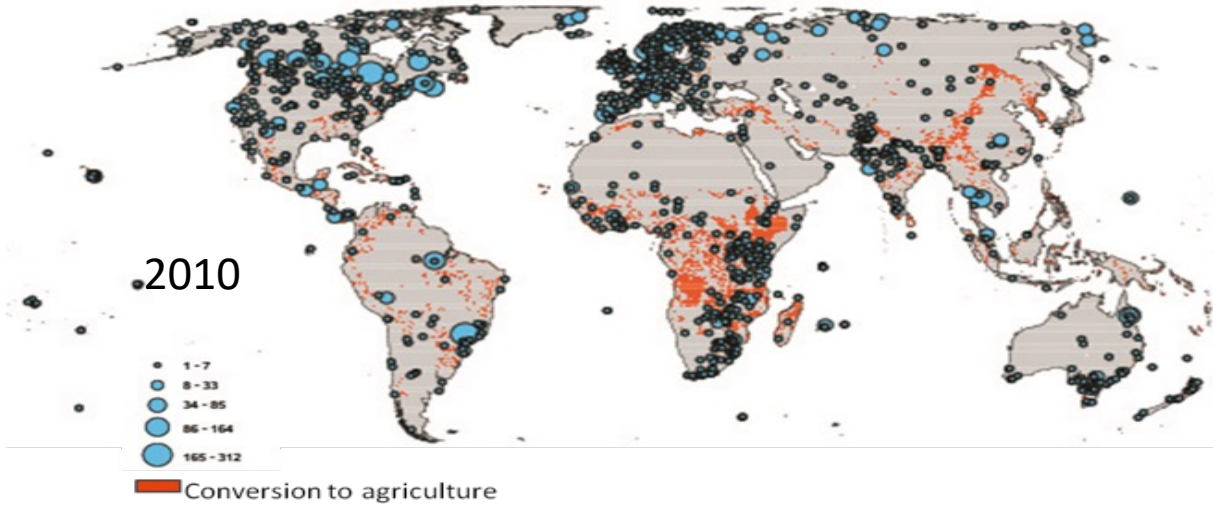
Primer

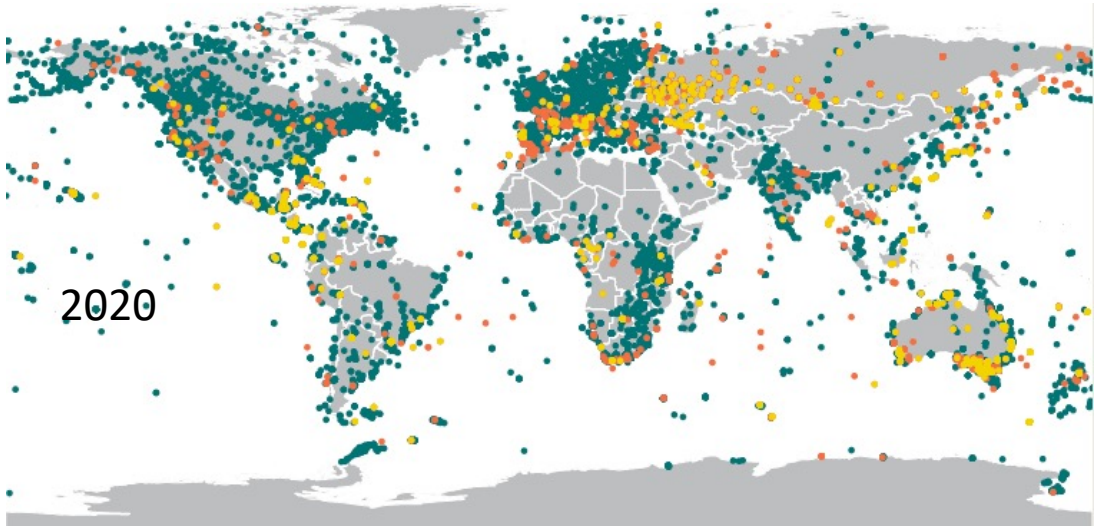
Biodiversity in water and on land

Richard K. Grosberg[1,*],
Geerat J. Vermeij[2],
and Peter C. Wainwright[3]



Spatial Gaps in Biodiversity Monitoring





The Living Planet Database Index (WWF) holds time-series data for 21,000 populations of more than 4392 species

Systematic stratified sampling

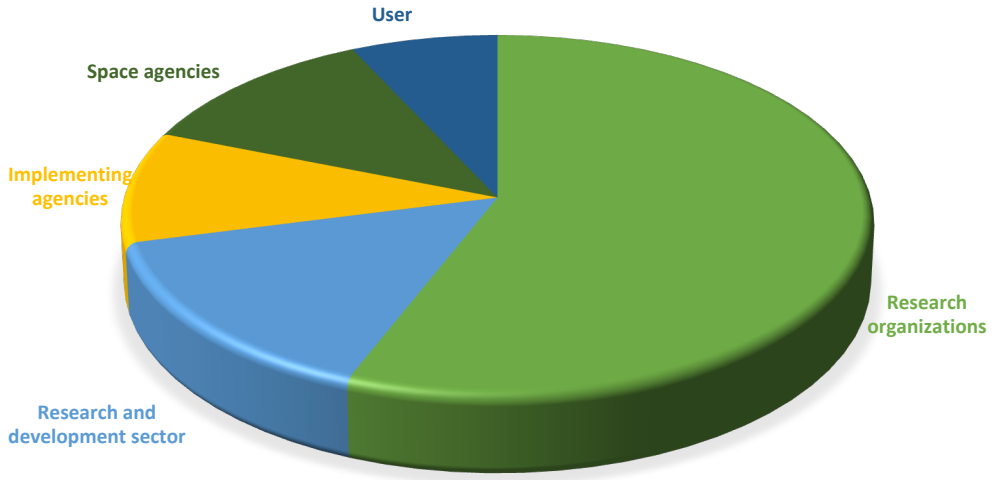
Over-representation of groups

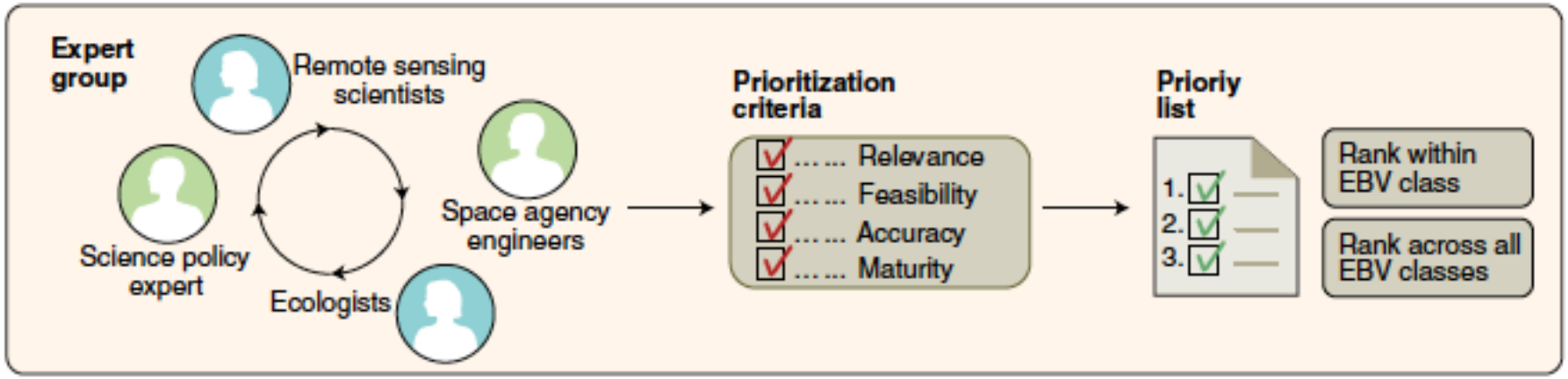
Over-representation of regions

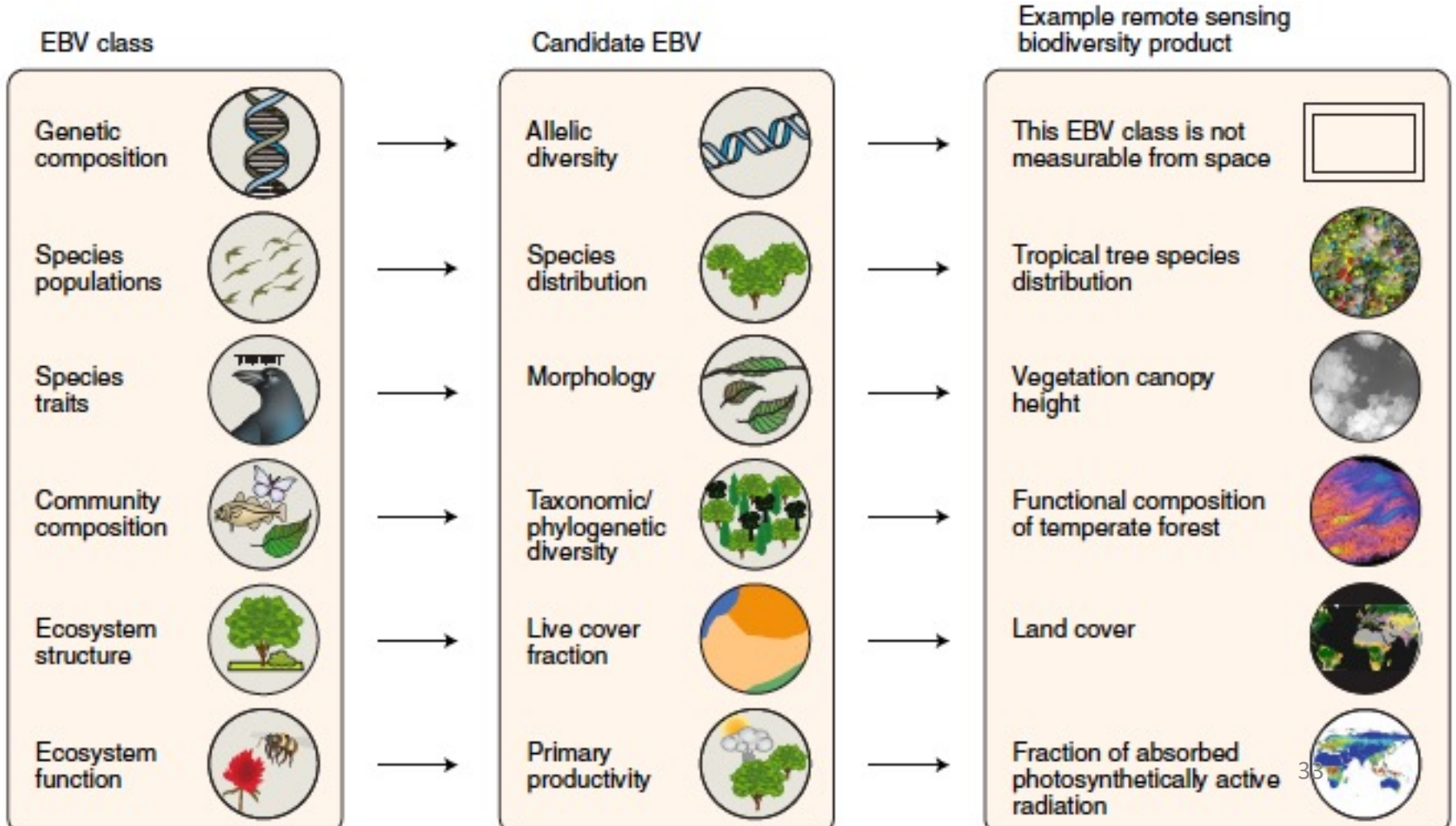
Scientific and government literature

Identifying Essential Remote Sensing Biodiversity Products

1. Brainstorm
2. Organise by EBV classes
3. Reduce to ESSENTIAL EBVs by
    - a) Coalesce EBVs into biological groups
    - b) EBVs remote sensing relevant
4. Expert agreement (RS & biodiversity communities)
5. Prioritize




Expert group
Remote sensing scientists
Space agency engineers
Ecologists
Science policy expert
Prioritization criteria
Relevance
Feasibility
Accuracy
Maturity
Priority list
1.
2.
3.
Rank within EBV class
Rank across all EBV classes


EBV class
Candidate EBV
Example remote sensing biodiversity product
Genetic composition
Allelic diversity
This EBV class is not measurable from space
Species populations
Species distribution
Tropical tree species distribution
Species traits
Morphology
Vegetation canopy height
Community composition
Taxonomic/ phylogenetic diversity
Functional composition of temperate forest
Ecosystem structure
Live cover fraction
Land cover
Ecosystem function
Primary productivity
Fraction of absorbed photosynthetically active radiation

Prioritizing 120+ Remote Sensing Biodiversity Products

- Relevance
- Feasibility
- RS status: accuracy
- RS status: maturity

Table 1 | Remote sensing biodiversity product prioritization criteria and ranking factors

Prioritization criteria	Description	Ranking = 1 (good)	Ranking = 3 (poor)
Relevance	It is known who wants the remote sensing biodiversity product, what they will do with it and how it will be used. The remote sensing biodiversity product is relevant: (1) for management questions; (2) to inform the CBD targets; (3) to inform the SDG(s); and (4) to provide data for the IPBES risk assessment processes.	Use and user fully identified.	Remote sensing biodiversity product less directly linked to science and societal questions.
Feasibility	The science community knows how to measure the remote sensing biodiversity product at such scales that measurements can realistically be made and/or observations already exist. This criterion considers the availability of remote sensing data, the ease of access to such data, the completeness of remote sensing in space and time and the ease and affordability of data integration and analysis.	Indicates maturity of the science, technology and experience needed to make the remote sensing biodiversity product.	Indicates that considerable research and development effort remains or that remote sensing biodiversity products on the scale needed are technically, logistically or financially difficult to make.
Remote sensing status: accuracy	A measure of the current activity for the accurate observation of a given remote sensing biodiversity product. This criterion considers the effectiveness of remote sensing data and techniques to achieve an accurate and precise value of the remote sensing-enabled biodiversity product.	A fully operational network or service is in place, generating remote sensing biodiversity products that are accurate for the purpose.	Indicates that no or very limited action has been taken to generate accurate remote sensing biodiversity products.
Remote sensing status: maturity	Institutions/organizations with hopes to generate remote sensing biodiversity products can be identified and/or proposed to a funding body.	Operationa satellite re who needs needs to b remote ser can now b	

nature ecology & evolution PERSPECTIVE
https://doi.org/10.1038/s41559-021-01451-x

Priority list of biodiversity metrics to observe from space

Andrew K. Skidmore[1,2], Nicholas C. Coops[3], Elnaz Neinavaz[1], Abebe Ali[1,4], Michael E. Schaepman[5], Marc Paganini[6], W. Daniel Kissling[7], Petteri Vihervaara[8], Roshanak Darvishzadeh[1], Hannes Feilhauer[9,10], Miguel Fernandez[11,12], Néstor Fernández[13,14], Noel Gorelick[15], Ilse Geijzendorffer[16], Uta Heiden[17], Marco Heurich[18,19], Donald Hobern[20], Stefanie Holzwarth[17], Frank E. Muller-Karger[21], Ruben Van De Kerchove[22], Angela Lausch[23,24], Pedro J. Leitão[25,26], Marcelle C. Lock[1,2], Caspar A. Mücher[27], Brian O'Connor[28], Duccio Rocchini[29,30], Woody Turner[31], Jan Kees Vis[32], Tiejun Wang[1], Martin Wegmann[33] and Vladimir Wingate[34]

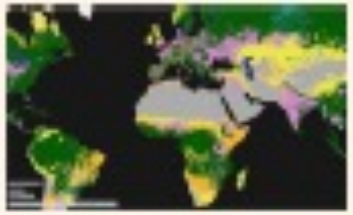
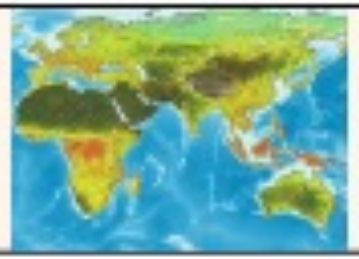
Priority List of RS Products Important for Biodiversity

- Top 30 RS biodiversity products listed in paper
- Ecosystem Function: products include capturing biological effect of disturbance & ecosystem physiology
- Ecosystem Structure: products include habitat structure, fragementation & vegetation traits

Table 2 | The 30 remote sensing biodiversity products with the highest rankings

Number	Remote sensing biodiversity product	Remote sensing-enabled biodiversity variable	EBV class	Rank within EBV class	Rank across all EBV classes
1	Biological effects of fire disturbance (direction, duration, abruptness, magnitude, extent and frequency)	Ecosystem disturbance	Ecosystem function	1	1
		Habitat structure	Ecosystem structure	1	1
2	Biological effects of irregular inundation	Ecosystem disturbance	Ecosystem function	1	1
		Habitat structure	Ecosystem structure	1	1
3	LAI	Ecosystem physiology	Ecosystem function	3	5
		Habitat structure	Ecosystem structure	3	5
		Species physiology	Species traits	1	21
4	Land cover (vegetation type)	Habitat structure	Ecosystem structure	3	5
5	Ice cover habitat	Habitat structure	Ecosystem structure	5	8
6	Above-ground biomass	Habitat structure	Ecosystem structure	6	9
7	Foliar N/P/K content	Ecosystem physiology	Ecosystem function	4	9
		Species physiology	Species traits	2	28
8	Net primary productivity	Ecosystem physiology	Ecosystem function	5	11
		Species physiology	Species traits	2	28
9	Gross primary productivity	Ecosystem physiology	Ecosystem function	5	11
		Species physiology	Species traits	2	28
10	Fraction of absorbed photosynthetically active radiation	Ecosystem physiology	Ecosystem function	5	11
11	Ecosystem fragmentation	Spatial configuration	Ecosystem structure	7	11
12	Ecosystem structural variance	Spatial configuration	Ecosystem structure	7	11
13	Urban habitat	Habitat structure	Ecosystem structure	7	11
14	Vegetation height	Habitat structure	Ecosystem structure	7	11
15	Plant area index profile (canopy cover)	Habitat structure	Ecosystem structure	7	11
16	Habitat structure	Habitat structure	Ecosystem structure	7	11
17	Fraction of vegetation cover	Habitat structure	Ecosystem structure	7	11
18	Specific leaf area	Ecosystem physiology	Ecosystem function	8	22
		Species morphology	Species traits	2	28
19	Chlorophyll content and flux	Ecosystem physiology	Ecosystem function	8	22
		Species physiology	Species traits	2	28
20	Land surface peak (maximum of season)	Ecosystem phenology	Ecosystem function	8	22
	Land surface green-up (start of season)	Ecosystem phenology	Ecosystem function	8	22
	Land surface senescence (end of season)	Ecosystem phenology	Ecosystem function	8	22

Examples of Prioritized Remote Sensing Products

Remote sensing product		Ranking factor		Ranking across all EBV classes	Explanation
Biological effects of fire disturbance ($gC\ m^{-2}$)		Relevance	1	1	Highly relevant data layer widely used for protected area and land management, as well as informing about biodiversity for national and international reporting. Data are available in virtually real time. The data are accurate and the technology is mature.
		Feasibility	1		
		Accuracy	1		
		Maturity	1		
Land cover		Relevance	1	5	Highly relevant data layer widely used for ecological research and management, as well as monitoring biodiversity for national and international reporting. Data are available in virtually real time. The technology is mature but cover classes are subjective (for example, 'define forest').
		Feasibility	1		
		Accuracy	1.5		
		Maturity	1		
FAPAR		Relevance	2	11	Interpreting FAPAR remains challenging for many managers and ecologists as its use as a biodiversity indicator is not fully established. Data are available in virtually real time. The technology is mature but calibration and validation of global FAPAR over time requires more in situ data.
		Feasibility	1		
		Accuracy	2		
		Maturity	1		

RS Products Linked to SDGs and Aichi Targets

RS products important for biodiversity

RS products directly map into the SDG and CBD Targets

Original EBV candidates	Typical RS-enabled biodiversity variable	RS-biodiversity products	Aichi targets	SDG targets	
		Senescence (end of the season)	5,7,9,12,14,15	15.4	
Taxonomic diversity	Community diversity	Taxonomic (Species diversity/ richness)	8, 10, 12, 14	15.1, 15.5	(Foody and Cutler 2006; Kerr e
		Functional diversity	5,7,10,12,14,15	15.1, 15.2, 15.4	(Alcaraz-Segura et al. 2013; Je
Species interaction	Community composition	Percentage of species which grow or occur together	5,7,10,12,14,15	15.1, 15.2, 15.4	(Franklin et al. 2000; Hill and T
Habitat structure	Habitat structure	Land cover (Vegetation type)	5,7,9,14,15	15.2, 15.3, 15.5	(Sobrino and Raissouni 2000;
		Fraction of vegetation cover	5,7,9,14,15	15.2, 15.3, 15.5	(Carlson et al. 1990; Carlson a Hansing 1995)
		Above-ground biomass	5,7,9,10,12,14,15	15.2, 15.3, 15.5	(Baccini et al. 2008; Drake et a
		Leaf area index	5,7,9,10,12,14,15	15.2, 15.3, 15.5	(Asner et al. 2003; Spanner et
		Urban habitat	5,7,9,14,15	15.2, 15.3, 15.5	(Esch et al. 2009; Höfle et al. 2
		Ice cover habitat	5,7,9,14,15	15.2, 15.3, 15.5	(Comiso et al. 1992; Surdu et a
		Deadwood habitat	5,7,9,14,15	15.2, 15.3, 15.5	(Bater et al. 2009; Chojnacky a
		Vegetation height	5,7,9,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Means et al. 2000; Streutker
Ecosystem composition by functional type		Plant area index profile (canopy cover)	5,7,9,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Carreiras et al. 2006; Stojano
		Habitat structure	5,7,9,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Hinsley et al. 2002; Hyde et al
		Biological effects fire disturbance (direction, duration, abruptness, magnitude, extent, frequency)	7,9,10,12,14,15	15.2, 15.3	(Giglio et al. 2003; Robinson 1
		Biological effects of Irregular inundation	5,7,9,10,12,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Bates 2004; Khan et al. 2010;
Ecosystem extent and fragmentation	Spatial configuration	Ecosystem fragmentation	5,7,9,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Gong et al. 2013; Heilman et
		Ecosystem structural variance	5,7,9,14,15	15.1, 15.2, 15.3, 15.4,15.5	(Gaitán et al. 2013)
		Land surface peak (max of the season)	5,7,9,12,14,15	15.4	

Copernicus Global Land Service

Providing bio-geophysical products of global land surface

Home | Products | Use cases | Product Access | Viewing | Library | Get Support

https://land.copernicus.eu/global/products/lai

Conclusions

- What is biodiversity?
- How much biodiversity is being lost?
- How to measure biodiversity?
- Outcome: Substantially improve reporting on the state of biodiversity