European Biodiversity Monitoring: from scientific challenges to implementation opportunities

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8 Nov 2022, 2022 EuropaBON/Biodiversa+ Conference

This project receives funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101007492.
EU Biodiversity Strategy for 2030 and the Implementation Gap

Perino et al 2021 Con Letters
The problem

- Biodiversity change has complex spatial scaling patterns and temporal dynamics
- Biodiversity monitoring data is still very sparse in time and space and covers only some taxa
- Limited resources for monitoring, although some studies suggested that monitoring in some cases already takes large proportions of conservation budgets (50%, see Buxton et al. 2020)
- Limited taxonomic and scientific expertise
- **Solution**: integration of available data from multiple sources and targeting new monitoring schemes by using biodiversity models
The EuropaBON project

Horizon 2020 Programme

The action should design an **EU-wide framework for monitoring biodiversity and ecosystem services**.
A network of members

- Over 1000 members in the EuropaBON members and stakeholders webpage, http://europabon.org

- Members receive project newsletter, are invited to stakeholder consultations, and will play a role in implementing EuropaBON in the future
Designing an European Biodiversity Monitoring Framework

EBV Selection

- Policy questions
  - Research-driven
  - Citizen-driven
  - Management-driven

Identify Variables

Matching generic EBVs

EBV Workflow Design

1. Primary observations
   - Earth observations from in situ surveys, structured monitoring, citizen-science and space missions

2. EBV-ready FAIR data
   - EBV data cubes
     - Analysis-ready information about states of biodiversity across space and time

3. EBV data cubes
   - Hierarchization
     - Continuously integrated information in space and time
   - Model-based integration
     - Location, Time, Entity

4. Downstream information
   - EBV products
     - Share GEO BON Data Portal
     - Synthesize EBV-based change indicators
     - Report: Local to global assessments

EBVs Selection

Matching generic EBVs
From EBV Selection to Monitoring Design

**Monitoring design**

1. How to design sampling?

2. What models to use?

**EBV Selection**

1. Which EBV are needed for each policy question?

**EBV Specification**

1. What taxa and ecosystems?

2. What is the desired spatial and temporal resolution of EBV?

Fernández ... Pereira (2020) in Remote Sensing of Plant Biodiversity
An overview of the proposed EBV list

Criteria:
Feasibility, policy relevance, balance across taxa and realms, complementarity, irreducibility

Species level variables mostly addressing questions about status of species of conservation interest (Habitats, Birds Directives), and some species groups for which enough interest exists.

Ecosystem level variables mostly addressing questions about trends in ecosystem condition and restoration, across a range of taxonomic groups

Some species level variables and some ecosystem level variables important to estimate ecosystem services, risks, and status of invasive species

https://github.com/EuropaBON
How do EBVs map to policy questions: Article 17 Habitats Reporting for Species

Parameters for the conservation status assessment of species
- Range
- Population
- Habitat for the species
- Future prospects

Relevant Generic EBVs
- Species distribution
- Species abundance
- Genetic diversity

For each realm: marine, terrestrial, freshwater

Taxonomic Scope
- Entire taxonomic group
- Priority species
- Selected Priority species

Taxonomic group: mammals, amphibians, fish, plants, invertebrates, lichens

Spatial resolution: 1x1km - 10x10km - 100x100km - Populations
Temporal resolution: yearly – 6 years – 10 years
Assessing current monitoring initiatives

http://monitoring.europabon.org
Identifying gaps and bottlenecks in EBV generation at the European level

European Butterfly Monitoring Scheme (eBMS)
Co-designing EBV workflows

### Concept

- Extended or new sampling schemes, power analysis, standardization of sampling protocols, capacity building
- Automated data streams, national integration nodes, standardized data entry and sample analysis, open data and code, user-friendly software
- Trend estimation, data fusion, geospatial extrapolation, species distribution & state-space models, machine learning
- Metadata standards with machine-readable (meta)data, machine-readable open access licenses, APIs, provenance tracking
- Data storage, central repositories, scalable computing, cloud services, virtual research environments, visualization platforms

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<table>
<thead>
<tr>
<th>EBV</th>
<th>Data collection and sampling</th>
<th>Data integration</th>
<th>Models</th>
<th>Interoperability</th>
<th>IT Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest disturbance by fire</td>
<td>Satellite remote sensing (e.g. Sentinel missions from ESA)</td>
<td>Centralized at EU (Copernicus services)</td>
<td>Classification with machine learning algorithms</td>
<td>Standardized (meta)data formats</td>
<td>Copernicus space and ground segment (ESA, EUMETSAT, national public and private facilities)</td>
</tr>
<tr>
<td>Species abundance of terrestrial mammals</td>
<td>Wildlife camera traps (currently no European sensor network)</td>
<td>ENETWILD project works on a harmonized European data framework</td>
<td>AI species identification Occupancy models</td>
<td>Some data exchange formats available for camera trap data (e.g., Camtrap DP)</td>
<td>Not available at EU-level</td>
</tr>
<tr>
<td>Free river flow/River continuity</td>
<td>Citizen science phone application (AMBER project) &amp; in-situ monitoring</td>
<td>Centralized at EU (Barrier Atlas from AMBER project)</td>
<td>Machine learning (random forest) to quantify barrier density</td>
<td>Common standard for barrier data (AMBER project)</td>
<td>AMBER database, user friendly app, web interface for visualization</td>
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The EuropaBON showcases

<table>
<thead>
<tr>
<th></th>
<th>Birds</th>
<th>Habitats</th>
<th>Water</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networks</td>
<td>✓</td>
<td>✘</td>
<td>●</td>
<td>✓</td>
</tr>
<tr>
<td>Data curation</td>
<td>✓</td>
<td>✘</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Data accessible</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>✓</td>
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<tr>
<td>Open data</td>
<td>✘</td>
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Open EBV Datasets with the EBV Cube Standard

- **NetCDF** specification with a **unified hierarchical structure** for organizing EBV data

- A **minimum information** specification using **ACDD** terms (with translation into **EML**)
  
  - Self-described
  - Compliant with **FAIR** and **GEOSS-DMP**
Implementing EuropaBON

European Biodiversity Monitoring Center

Joint Research Centre (JRC)

Eurostat

European Bird Census Council (EBCC)

National monitoring programs

Horizon Europe

Knowledge Centre for Biodiversity

Eurostat LUCAS

European Environment Agency

European Topic Centre on Biological Diversity

Knowledge broker

Policy making

Reporting

EBV Data Portal

European Biodiversity Partnership

Funding research on monitoring

GBIF

Biodiversa+
THANK YOU
How do EBVs map to other policy demands

<table>
<thead>
<tr>
<th>Nature restoration law</th>
<th>Ecosystem services and risks (ecological supply)</th>
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<tbody>
<tr>
<td>Abundance and diversity of pollinators</td>
<td>Species abundances of marine commercial fish</td>
</tr>
<tr>
<td>Populations of farmland birds</td>
<td>species and long-distance migratory fishes</td>
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<tr>
<td>Grassland butterfly index</td>
<td>Harmful freshwater algae blooms</td>
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<tr>
<td><strong>Standing and lying deadwood</strong></td>
<td><strong>Phenology of fructification of mushrooms and</strong></td>
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<tr>
<td><strong>Share of forests with uneven-aged structure</strong></td>
<td>wild fruits</td>
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<tr>
<td>Forest connectivity</td>
<td><strong>Community abundance and taxonomic diversity</strong></td>
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<tr>
<td>Common forest bird index</td>
<td>of pollinator insects</td>
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<td>Stock of organic carbon</td>
<td><strong>Ecosystem carbon pool</strong></td>
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<td><strong>Share of agricultural land with high-diversity</strong></td>
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<tr>
<td>landscape features</td>
<td></td>
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<td>Area of urban green space and tree canopy</td>
<td></td>
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<td><strong>cover in cities and towns and suburbs</strong></td>
<td></td>
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<tr>
<td>Area and condition of the areas covered by the</td>
<td></td>
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<tr>
<td>habitat types listed in Annexes I and II</td>
<td></td>
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</tbody>
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How do EBVs map to policy questions: Article 17 Habitats Reporting for Habitats

For each realm: marine, terrestrial, freshwater

<table>
<thead>
<tr>
<th>Relevant Generic EBVs</th>
<th>Community biomass or abundance</th>
<th>Community taxonomic diversity</th>
<th>Community EQR</th>
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<tbody>
<tr>
<td>Ecosystem distribution</td>
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<tr>
<td>Ecosystem connectivity</td>
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<td>Primary productivity</td>
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<tr>
<td>Ecosystem phenology</td>
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<tr>
<td>Ecosystem disturbance</td>
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</table>

Can also be measured from stacking species population EBVs

<table>
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<tr>
<th>Parameters for the conservation status assessment of habitat types</th>
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<tbody>
<tr>
<td>Range</td>
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<tr>
<td>Area</td>
</tr>
<tr>
<td>Structure and functions</td>
</tr>
<tr>
<td>Future prospects</td>
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</table>

Spatial resolution: 1x1km - 10x10km - 100x100km - Populations
Temporal resolution: yearly – 6 years – 10 years