GEO BON Strategy for development of Essential Biodiversity Variables

Version 2.0

Produced by
GEO BON Management Committee
Jan 2017

Index

1. Overview and purpose of this white paper

The Group on Earth Observations - Biodiversity Observation Network (GEO-BON) is working towards the implementation and progression of Essential Biodiversity Variables (EBVs) that could serve as the foundation for interoperable sub-national, national, regional and global monitoring initiatives. With this goal in mind, GEO BON will create an open, online platform to facilitate the development of EBVs by the broad biodiversity observations community.

GEO BON will facilitate this process by providing an initial candidate reference list of EBVs and invite potential EBV developers to adopt and develop EBVs from the reference list, though additional novel and creative contributions are also encouraged. GEO BON will also provide guidance on EBV criteria so as to promote consistency and ensure focus on the essential dimensions of biodiversity.

The purpose of this white paper is to convey the end-end process that GEO BON plans to use for EBV development so that we can get feedback from the broader biodiversity community on that process. It first provides a brief background on EBVs and then describes the process GEO BON is considering to facilitate their development. That process will ask potential EBV developers to submit their ideas on EBV content and standards, as well as to suggest new EBV candidates. The web-based framework that will support that development and communicate progress is also described here. For EBVs to be successful, community buy-in at all stages will be required.

2. Background

2.1. The need for Essential Biodiversity Variables

Although the importance and usefulness of EBVs have been described elsewhere (Pereira *et al.* 2013; Geijzendorffer *et al.* 2015; Schmeller *et al.* 2015; Skidmore *et al.* 2015) a brief summary is provided here.

There is a plethora of local, national, regional and global initiatives dedicated to collecting biodiversity data. Protected areas and biological stations have been collecting data on biological communities and ecosystem functioning for decades. Museums and herbariums hold hundreds of millions of biodiversity records, many of which go back centuries. Conservation societies, volunteer naturalists and, more recently, citizen scientists have exponentially expanded the number of distribution records, morphological measurements,

and behavioral observations. Also, space agencies have made available petabytes of remotely sensed data from earth-orbiting instruments.

More data should translate into better monitoring, more informed policy-making and more accurate forecasting. However, local data is often inaccessible from outside, or even within, countries. And the great majority of species occurrence data, hosted in museums and herbariums, have not been georeferenced and digitized. To further complicate the situation, the biodiversity community has not yet been able to clearly articulate their needs to the remote sensing community and exploit the full potential of data from airborne and space-based instruments to detect and monitor pressure, state and response of biodiversity, although there are some promising exceptions (e.g., land usage, deforestation, ecosystem health and structure, and chemical composition).

Most of these efforts have been independently motivated, lacking much coordination. Differences in methods, schemas, protocols, and standards from different sources often make datasets irreconcilable. The Group on Earth Observations (GEO) was in fact created to address this lack of coordination and to increase data sharing and accessibility. EBVs, as a GEO BON initiative, respond to this lack of coordination, providing guidance to observation systems as to what the key observations should be so that biodiversity change can be efficiently monitored and information can be provided to support decisions and the science that underlies them. Such guidance will, additionally, increase the degree of observation harmonization, facilitating data sharing and cross-BON (e.g. regional) activities.

As one response to the clear need to improve coordination among the many players engaged in biodiversity conservation activities, GEO BON held a workshop in Frascati, Italy in February of 2012. A conceptual framework was developed and key questions formulated to help guide the harmonization of existing biodiversity monitoring initiatives and implementation of new ones. That workshop led to the publication of the initial concept (Pereira *et al.* 2013). Since then follow-on work has progressed the concept (e.g. Geijzendorffer *et al.* 2015; Schmeller *et al.* 2015; Skidmore *et al.* 2015) and there have been several additional workshops that included interested parties from diverse backgrounds.

2.2. What are Essential Biodiversity Variables?

A central question to GEO BON is: what is the magnitude and direction of biodiversity change for the essential dimensions of biodiversity? But what are the "essential dimensions of biodiversity"? A useful approach is to use the different levels of biological organization: genes, species, populations, and ecosystems, as well as some general, though sometimes overlapping categories: genetics, taxonomy, function, and structure. These dimensional categories were used to form the EBV "Classes" around which the overall EBV concept has been organized (Fig. 1)

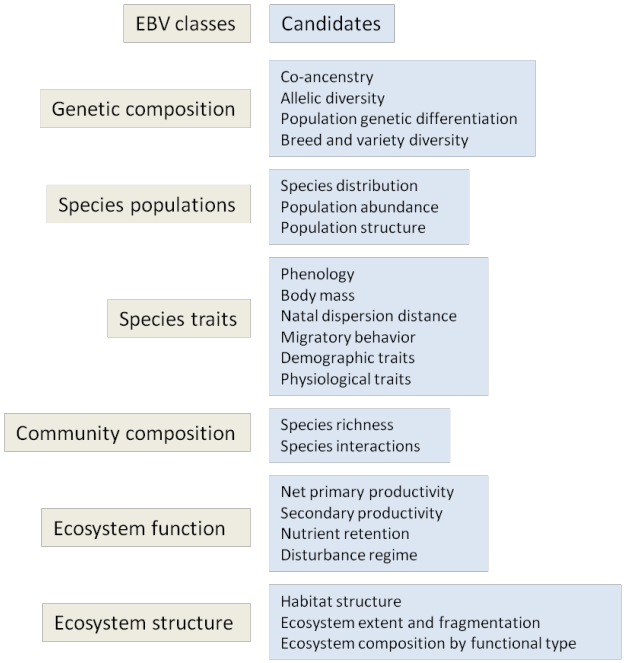

Figure 1: EBV classes and EBV Candidates

This makes for a good conceptual framework, but by itself is not sufficient to define a manageable number of relevant EBVs that can provide guidance to biodiversity observation systems. Therefore, some additional criteria were developed. These criteria were the result of extensive discussions before, during, and after the Frascati workshop, in 2012.

EBVs should be State variables. Drivers and Pressures of change are of obvious importance to biodiversity change, and must be considered to properly understand and manage change. But including them greatly complicates the discussion and results in a very long list of variables. Additionally, most Drivers and Pressures are not biological entities, and lie outside the field of expertise of most biodiversity scientists. So, while the importance of Drivers and Pressures is fully acknowledged, they fall into a different realm than EBVs.

EBVs should be biological. There are a very large number of non-biological variables hat can cause changes in biodiversity. While these can be extremely important— changes in precipitation or temperature due to climate change, for example—including them causes a number of redundancies and complications. First, many of these variables are being coordinated by other organizations such as GCOS (for climate) and GOOS (for marine). (Not all, however, are handled by such other organizations and these need to be identified and tracked lest information important to biodiversity change continue to be lacking—but that does not imply they must be EBVs.) Second, including non-biological variables makes the number of EBVs unmanageably large.

EBVs should be sensitive to change. This is perhaps obvious, but must be made clear so that static variables--that may be biologically relevant but not useful for change monitoring--are not considered.

EBVs should strive to be ecosystem agnostic. This may be challenging for some situations, but the idea would be that an EBV would be appropriate for, for example, marine, freshwater, forest, and grassland systems. Such coherence facilitates comparisons across disciplines, simplifies aggregation, and has a variety of other advantages.

With this conceptual framework GEO BON, based on a consensus process among a diverse body of experts, proposes a list of EBV Classes and Candidate EBVs (Fig 1).

It is noted that some candidates in this reference list are composite entities and perhaps not even "variables" in the literal sense; "subclasses" may be a better term but for simplicity they are referred to here as Candidate EBVs. Thus, an "EBV" may be a combination of actual variables, each of which best fits local conditions.

EBVs must align well with the general needs of policy, decision-making, and the science that underlies these activities. They should help populate the Indicators that assess progress towards the 2020 Aichi Targets, the Sustainable Development Goals and also contribute to other initiatives such as the IPBES Regional Assessments. However, policies can change over time and Indicators that are tailored too narrowly to meet specific policies can become irrelevant.

An important characteristic of EBVs is that they lie between primary observations and indicators (Fig 2). This is important for two reasons. First, because they are a level of abstraction away from the indicators (and policies) they support, they are shielded from changes in policy. Second, in the other direction, they isolate indicators from heterogeneous observation methods and sources and, also, largely shield the indicators from advances in observation technology or science. Of course, major policy direction changes and advances in both technology and science mean that EBVs cannot be completely static, so they will be updated periodically, on perhaps a five- or six-year cycle.

Figure 2: EBV relationship to high level indicators

3. Appendices

3.1. Extended list of EBVs components

GEO BON will provide the guidelines and tools to EBV developers to publish their methods, protocols and dataset inside a dynamic virtual environment. The criteria required to clearly define an EBV have the following components:

Definition of the metric and the spatial, temporal and taxonomic scope		
Conceptual definition	Sufficient theoretical foundations for the formulation of the EBV as a measurable occurrence.	The idea has been formulated. A conceptual model exists. Solid theoretical foundations exist.
Spatial coverage	Definition of the geographic area covered by the EBV.	Extremely sparse coverage. Global coverage with large gaps. Full global coverage.
Spatial density or spatial/spectral resolution	For in situ measurements, the ability of the EBV to detect change based on the proposed spatial density of the sample points. For EO, the ability of the EBV to detect change based on the spectral resolving power of the proposed sensor from which the EBV will be derived.	Current density or resolution clearly insufficient to address change. Density or resolution barely accommodates current users requirements. Density or resolution meets current user requirements and there is evidence that can accommodate future requirements.
Periodicity	Definition and appropriateness of the revisit time related to the changes proposed to be detected by the EBV.	There is no clear scientific understanding on what is the appropriate revisit time. The appropriate frequency at which a site should be revisited has been defined but revisit time for current measurement is insufficient. Revisit time for current initiatives are at the same or higher frequency than the required.
Delivery latency	The waiting period between the time when a new measure is made and the time when this measure is fully integrated into the process and the updated EBV is ready and accessible.	There are no clear data delivery requirements. The time it takes to get an updated EBV is longer than the periodicity. The time it takes to get an updated EBV is shorter than the periodicity.
Taxonomic coverage	Identification of the taxon or taxa that are being proposed for monitor and evaluation by the EBV.	The taxon or taxa has not been identified The EBV is very taxon or oriented. The EBV can be applied across a a wide range of taxa, or the methods to integrate different taxon specific approached are well developed.
Uncertainty	Characterization of the sensitivity, constrains, limitations and dependencies related to ability of the EBV to capture change as proposed.	There is limited or no understanding regarding the sensitivity, constrains, limitations or dependencies of the variable. There is enough understanding about regarding the sensitivity, constrains, limitations or dependencies of the variable. Sensitivity, constrains, limitations and dependencies are clearly characterized and made evident along with the variable.
Monitoring methods		
Operational definition	A demonstration or proof of concept that the EBV can realistically be made.	The candidate technologies have been identified but proof of concept is not available yet. Idea has been tested under limited conditions or rough prototype exists There are multiple pilot projects underway.
Documentation	How much open and accessible documentation exists regarding the standards, guidelines and protocols and how is it made available for the particular EBV.	No guidelines or documentation exist outside the scientific literature. Documentation and/or guidelines exists but still limited. Exhaustive documentation on standards guidelines and protocols exist in multiple languages.
Abstraction	Degree of abstraction in the methods and interpretation of the results. The number of steps involved in the creation of the final EBV product. The amount of control over the ingredients and their assumptions towards the creation and interpretation of the resulting variable.	Several steps involved in the derivation of the variable and no definition of the assumptions neither how they reverberate into the interpretation of the final product Few steps involved in the creation of the product and limited control over some of the ingredients Clear definition on the steps involved in the derivation of the variable and full control over ingredients and assumptions

Monitoring schemas		
Measurement & sampling schema	Definition of a systematic plan of action for: what data will be collected and how it will be collected.	No reference system exists for the measurements nor the sampling strategy. There are multiple reference systems and/or sampling strategies, alignment is required. The requirements and the sampling strategy to measure the variable are clearly defined.
Automatization	Description of steps that are currently automated, steps that have the potential to be automated and steps that can not be automated and their impact in the EBV production process.	Opportunities for semi or full automation using new technology do not exist. Opportunities have been identified but not implemented. Technology that allows full automatization are already implemented.
Data standards		
Interoperability	The degree of harmonization in data and metadata formats. The availability of standards for data transfers and communication protocols.	High probability for individual initiatives to drift away from a global harmonized system. Data formats, transfer and communication protocols have been clearly defined. Full semantic interoperability has been achieved that allows synthetic analysis.
Data flows	Data fluency and coherence among the different data stages along the EBV development process.	There are no coherent data workflows. Data flows defined but infrastructure limited and/or ontological alignment required. Harmonic data flows and relevant infrastructure fully operational.
Data policies	Availability and consensus regarding management policies for data archive and distribution.	Data management policies do not exist. Policies exist but they are not implemented. Policies exist and they are fully implemented.
Data management	Agreements on: representation, format, definition, structuring, and use of data.	Data management plan doesn't exist. Data management plan exist but is not currently implemented. Data management plan is fully implement including archive, curation and distribution infrastructure.
QC&QA	Mechanisms to internally audit and verify critical steps in the EBV development process; as well as availability of clear mechanisms to make amendments and revisions if issues are detected.	QC audits & QA practices do not exist. QC audits & QA practices are defined but not implemented. QC audits & QA practices are implemented along with the process to revise and amend errors.
Datasets		
Data availability	Minimum data requirements vs. currently available data for EBV development as well as opportunities for data mobilization.	Data doesn't exists at all. Data exists but it currently doesn't meet the requirements. There are oportinutes for data mobilization. Data availability meets specified minimum data requirements.
Validation	External continuous audits and verifications of EBV products by peers, as well as availability of clear mechanisms to make amendments and revisions if issues are detected.	Data is not currently validated. Data is subject to validation but mechanism to amend and revise is not yet clear. Fully operational data validation process on place that includes external audits, verification and mechanisms to make revisions and amendments.
Provenance	Identification of the conceptual model and availability of the management system to capture and record information on: data sources and data transformations in the process of developing the final EBV product.	Conceptual model on data provenance has been specified. Limited information on the origins of the raw data used to derive the EBV is provided along with the model. Full provenance is clearly specified.
Temporal sustainability	Specification of the path and the clear steps towards the long term maintenance and repeatability of the EBV.	Short-term sustainability secured (1 to 2 years). Mid-term sustainability secured (2 to 5 years). Long-term sustainability secured (5 to 10 years).
Baseline	Availability of past measurements that can be used to provide a baseline from which to measure change.	Historical data for baseline doesn't exist. Available historical data that can provide a baseline but it requires considerable effort to be usable. Baseline already exists.

Additional information		
Relevancy	The degree that the variable addresses multiple users needs (e.g., scientific and societal), how it directly benefits users and their requirements and how much of the information is provided already by other EBVs.	Variable is not directly linked to users and questions. Requests from the community have been made. Clear identification of the potential uses and users.
Consensus	Degree of current agreement among the experts in community regarding: what to measure, how to measure, who will use it and how it will be used for a particular EBV.	Highly dissenting ideas exist and/or the EBV related community is fragmented. Few competing ideas on the same variable exist and the process to reach consensus is already underway. Unanimous agreement exists among the community regarding what to measure, how to measure, and how to use the variable to inform about biodiversity change.
Scalability	The robustness of the proposed EBV to changes in user requirements.	No proof of scalability exists. Some evidence that suggest that the metric can address current users requirements but also potential future requirements and users. There is solid evidence that the variable is robust to change in user requirements.
Institutional support	Define institutional support for the each level of the EBV development process (e.g., data collection, processing, management, archive, distribution and socialization).	Institutions and/or organizations do not exist. Institutions and/organizations at some levels of the EBV development process have been identified or are currently working at very limited capacity. Institutions and/organizations are actively working on all aspects of the development and nothing needs to be done.
Financial support	Day to day operational support as well as long term management, planning and maintenance of operations. Should address specifically information technology related expenses.	There is no clear funding body to support the initiative. Funding body has been identified but funding mechanism is still unclear. There is already a clear pathway and mechanism to fund the initiative that includes seed money for development, implementation and long term maintenance.
Socialization	Degree of the dissemination, acceptance and usage of the final EBV products.	Products have not yet permeated the scientific community. Products are currently being used for policy. Products are being used in management with high level of involvement at national level.

The colors represent readiness level for each subcategory. Red represents low level; yellow represents medium level; and green, high level.

3.2. Acronyms and Abbreviations

GEO BON	GEO Biodiversity Observation Network
GEO	Group on Earth Observations
GCOS	Global Climate Observing System
GOOS	Global Ocean Observing System
EOV	Essential Ocean Variable
ECV	Essential Climate Variable
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
GBIF	Global Biodiversity Information Facility
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
Ramsar	Convention on Wetlands of International Importance