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How Essential Biodiversity Variables and remote sensing can help national biodiversity monitoring

Petteri Vihervaara *, Ari-Pekka Auvinen, Laura Mononen, Markus Törmä, Petri Ahlroth, Saku Anttila, Kristin Böttcher, Martin Forsius, Jani Heino, Janne Heliölä, Meri Koskelainen, Mikko Kuussaari, Kristian Meissner, Olli Ojala, Seppo Tuominen, Markku Viitasalo, Raimo Virkkala

Finnish Environment Institute, Mechelininkatu 34a, P.O.Box 140, FI-00251 Helsinki, Finland

HIGHLIGHTS

- National biodiversity state indicators correspondence with EBVs was assessed.
- EBV approach revealed gaps in the current biodiversity monitoring scheme.
- Monitoring could be improved by using remote sensing applications and EBV approach.
- Four EBVs could benefit substantially from the use of remotely sensed data.
- Three new EBV-candidates were suggested to describe ecosystem function more comprehensively.

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ABSTRACT

Essential Biodiversity Variables (EBVs) have been suggested to harmonize biodiversity monitoring worldwide. Their aim is to provide a small but comprehensive set of monitoring variables that would give a balanced picture of the development of biodiversity and the reaching of international and national biodiversity targets. Globally, GEO BON (Group on Earth Observations Biodiversity Observation Network) has suggested 22 candidate EBVs to be monitored. In this article we regard EBVs as a conceptual tool that may help in making national scale biodiversity monitoring more robust by pointing out where to focus further development resources. We look at one country –Finland –with a relatively advanced biodiversity monitoring scheme and study how well Finland's current biodiversity state indicators correspond with EBVs. In particular, we look at how national biodiversity monitoring could be improved by using available remote sensing (RS) applications. Rapidly emerging new technologies from drones to airborne laser scanning and new satellite sensors providing imagery with very high resolution (VHR) open a whole new world of opportunities for monitoring the state of biodiversity and ecosystems at low cost. In Finland, several RS applications already exist that could be expanded into national indicators. These include the monitoring of shore habitats and water quality parameters, among others. We hope that our analysis and examples help other countries with similar challenges. Along with RS opportunities, our analysis revealed also some needs to develop the EBV framework itself.

* Corresponding author.
E-mail address: petteri.vihervaara@ymparisto.fi (P. Vihervaara).

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1. Introduction

In addition to climate change, biodiversity loss is recognized to pose one of the most serious threats to human well-being (GBO-4, 2014; MA, 2005; Rockström et al., 2013). Up to date biodiversity monitoring is crucial because of: (1) social–ecological systems are ultimately the result of and dependent upon biodiversity, ecosystem functioning, and biosphere processes (i.e. *socio-economic, utilitarian reasoning*); (2) high-quality biodiversity data is an essential building block of many disciplines and environmental models that attempt to explain the world *per se* (*curiosity, scientific reasoning*) and; (3) biodiversity is included in environmental policies at many levels—people in societies have decided to protect biodiversity and report on this progress (*policy demand for monitoring and reporting, institutional reasoning*). Besides these human-focused reasons of explaining why biodiversity matters, the fundamental rationale is that biodiversity underpins ecosystem functioning (Hooper et al., 2012).

The launching of the concept of Essential Biodiversity Variables (EBVs) has stimulated progress to unify and harmonize biodiversity monitoring globally (CBD Subsidiary Body on Implementation, 2016; GEO BON, 2015a, b; Pereira et al., 2013; Pettorelli et al., 2016) and revitalized aspirations of constructing an encompassing global biodiversity index with an analogy from the stock markets (Brummitt et al., in press; cf. Balmford et al., 2005). The aim of EBVs is to find measurable parameters for all relevant dimensions of biodiversity, to attain consensus on what to monitor, and, subsequently, to decide where to focus the limited monitoring resources. The suggested top-level classes of EBVs are *Genetic composition*, *Species populations*, *Species traits*, *Community composition*, *Ecosystem structure* and *Ecosystem function* (UNEP/CBD/SBSTTA/17/INF/7, 2013; Pereira et al., 2013). Although the focus of EBV development has so far been on global and supranational monitoring, the approach can also be applied to a national level and even lower geographical or administrative scales. Since biodiversity is primarily a phenomenon of local eco-evolutionary processes, it can best be recognized and managed on a national or regional level. Looking at EBVs from a national monitoring perspective –having to think in practice which monitoring data sources and remote sensing techniques could be used to provide the information needed –also serves to make the EBVs more concrete.

The development of national, continental scale and global biodiversity indicators has received increasing interest after the turn of the Millennium. Individual countries started from different outsets. Countries like The Netherlands (Wondergem and Klein, 2010) and Finland (Auvinen and Toivonen, 2006) began by collecting data from all relevant monitoring schemes and building a comprehensive set of indicators based on them. Other countries linked biodiversity indicators from the beginning with political goals (e.g. Sweden's Environmental Objectives; Ministry of the Environment Sweden 2013). In contrast, Switzerland developed a whole new purpose-build monitoring scheme for biodiversity (Hinterman et al., 2002). At international level, one of the first ambitious attempts to make a multi-country set of biodiversity indicators was the Streamlining European Biodiversity Indicators 2010 (SEBI2010) project coordinated by the European Environment Agency (Biała, et al., 2012). The SEBI2010 project was also important for developing global biodiversity indicators for the Convention on Biological Diversity (CBD). After the launching of the Aichi Biodiversity Targets in 2010, the Biodiversity Indicator Partnership (BIP) has developed a global set of indicators which focuses on monitoring the 2020 Aichi targets in particular www.bipindicators.net/globalindicators; (CBD, 2014).

It is important to note the historical background against which EBVs have been introduced. As Geijzendorffer et al. (2015) remark, EBVs are a theory-driven and rather academic approach to biodiversity monitoring. On the contrary, much of previous indicator work has been practically oriented and data-driven. The previous work aims to provide at least some kind of answer to the question of reaching the biodiversity targets that have been set. In the case of Finland, all useable, relevant, and geographically comprehensive monitoring data were amassed and a collection of indicators was created on that basis. Steps are now taken both nationally and internationally to link indicators more closely to targets as seen by the Aichi Targets Passport created by the BIP (above). Perhaps time is now ripe to also look at our monitoring and indicator schemes from the theory-driven EBV perspective in order to find existing gaps and biases.

Technical development of remote sensing applications is another important reason why the establishment of comprehensive biodiversity monitoring schemes, covering relevant aspects of EBVs, is achievable today (Pettorelli et al., 2016). Growing amounts of remote sensing data are freely available. *In situ* data are also increasingly stored in GIS platforms and new observations accumulate all the time (Vihervaara et al., 2012, 2013). Combining remotely sensed and *in situ* data in modelling is a promising approach to fill in gaps in biodiversity monitoring (GEO BON, 2015a, b; CBD Subsidiary Body on Implementation, 2016). In addition, the applicability of automated environmental monitoring data is increasing. For instance, methods for DNA sampling in freshwater and ecological network studies are being developed (e.g. Thomsen and Willerslev, 2015) –however, in this paper, we limit our discussion to remote sensing. Even though remotely sensed data have been produced already dozens of years, its use (and usability) in biodiversity monitoring has been narrow and limited.

2. Aims of the study

Given the present economic limitations in many countries it is not very realistic to aim to launch new monitoring programmes based on large-scale field work. In Finland, it has been estimated that some 70% of all biodiversity monitoring was done on a voluntary basis at the turn of the Millennium (Toivonen and Liukko, 2005), and this percentage is likely to have grown since due to budget cuts. It seems unrealistic to get government funding for any new field-based monitoring schemes as even many of the present monitoring programmes are at risk of being discontinued. Therefore, the most promising sources of new monitoring data lie in remote sensing and other automated or semi-automated data collection methods.