Biological Conservation 213 (2017) 280–294

Contents lists available at ScienceDirect

Biological Conservation

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

Contribution of citizen science towards international biodiversity monitoring

Mark Chandler [a,*], Linda See [b], Kyle Copas [c], Astrid M.Z. Bonde [d], Bernat Claramunt López [e,f], Finn Danielsen [d], Jan Kristoffer Legind [c], Siro Masinde [c], Abraham J. Miller-Rushing [g], Greg Newman [h], Alyssa Rosemartin [i], Eren Turak [j,k]

[a] Earthwatch Institute, 114 Western Avenue, Boston, MA 02143, USA
[b] International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburg, Austria
[c] Global Biodiversity Information Facility (GBIF), Universitetsparken 15, 2100 Copenhagen Ø, Denmark
[d] Nordic Foundation for Development and Ecology (NORDECO), Skindergade 23, 3rd floor, DK-1159 Copenhagen K, Denmark
[e] CREAF, Universitat Autònoma de Barcelona, 08193, Bellaterra, Barcelona, Spain
[f] Ecology Unit, Department of Animal Biology, Plant Biology and Ecology, Universitat Autònoma de Barcelona, 08193, Bellaterra, Barcelona, Spain
[g] National Park Service, Acadia National Park, Bar Harbor, ME 04609, USA
[h] Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, CO 80523-1499, USA
[i] USA National Phenology Network, National Coordinating Office, Tucson AZ, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ, USA
[j] NSW Office of Environment and Heritage, PO Box A290, Sydney South, NSW 1232, Australia
[k] Australian Museum, 6 College St Sydney, NSW 2000, Australia

ARTICLE INFO

Article history:
Received 30 March 2016
Received in revised form 23 August 2016
Accepted 6 September 2016
Available online 2 November 2016

Keywords:
Citizen science
Community-based monitoring
Databases
Essential biodiversity variables (EBV)
Global Biodiversity Information Facility (GBIF)
Group on Earth Observations Biodiversity Observation Network (GEO BON)

ABSTRACT

To meet collective obligations towards biodiversity conservation and monitoring, it is essential that the world's governments and non-governmental organisations as well as the research community tap all possible sources of data and information, including new, fast-growing sources such as citizen science (CS), in which volunteers participate in some or all aspects of environmental assessments. Through compilation of a database on CS and community-based monitoring (CBM, a subset of CS) programs, we assess where contributions from CS and CBM are significant and where opportunities for growth exist. We use the Essential Biodiversity Variable framework to describe the range of biodiversity data needed to track progress towards global biodiversity targets, and we assess strengths and gaps in geographical and taxonomic coverage. Our results show that existing CS and CBM data particularly provide large-scale data on species distribution and population abundance, species traits such as phenology, and ecosystem function variables such as primary and secondary productivity. Only birds, Lepidoptera and plants are monitored at scale. Most CS schemes are found in Europe, North America, South Africa, India, and Australia. We then explore what can be learned from successful CS/CBM programs that would facilitate the scaling up of current efforts, how existing strengths in data coverage can be better exploited, and the strategies that could maximise the synergies between CS/CBM and other approaches for monitoring biodiversity, in particular from remote sensing. More and better targeted funding will be needed, if CS/CBM programs are to contribute further to international biodiversity monitoring.

1. Introduction

International treaties such as the Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora, and the Convention on the Conservation of Migratory Species recognise the need to assess change in the status and trends of global biodiversity. Moreover, one of the four main functions of the Intergovernmental Panel on Biodiversity and Ecosystem Services is to "perform regular and timely assessments of knowledge on biodiversity" (IPBES, 2013).

Current biodiversity informatics programs allow for inferences about the status and trends of global biodiversity, and gaps and priorities have already been identified (Ariño et al., 2016; Meyer et al., 2015; Peterson et al., 2015; Peters et al., 2014; Ruete, 2015; Wetzel et al., 2015). To help track global biodiversity change, the Group on Earth Observations Biodiversity Observation Network (GEO BON) proposed a candidate set of Essential Biodiversity Variables (EBVs; Pereira et al.,

* Corresponding author.
E-mail addresses: mchandler@earthwatch.org (M. Chandler), see@iiasa.ac.at (L. See), kcopas@gbif.org (K. Copas), amz.schmidt@gmail.com (A.M.Z. Bonde), bernat.claramunt@uab.cat (B.C. López), fd@nordeco.dk (F. Danielsen), jlegind@gbif.org (J.K. Legind), smasinde@gbif.org (S. Masinde), abe_miller-rushing@nps.gov (A.J. Miller-Rushing), gregory.newman@colostate.edu (G. Newman), alyssa@usanpn.org (A. Rosemartin), eren.turak@environment.nsw.gov.au (E. Turak).

http://dx.doi.org/10.1016/j.biocon.2016.09.004

Table 1
Examples of the coverage of Essential Biodiversity Variables (EBVs) by citizen science (CS) and community-based monitoring (CBM) programs. Additional columns indicate the scale of the projects and the feasibility of data collection by citizens and community members. Green indicates EBVs with high adequacy in terms of remotely sensed products, yellow indicates medium adequacy while red is low adequacy or no remotely sensed products that can monitor these EBVs (O'Connor et al., 2015). References to CBM programs is available in Appendix 5.

EBV class	EBV	Scale of CS/CBM measurement	Feasibility	Examples from Global CS database	Examples from CBM database
Genetic composition	Co–ancestry	Local	Rare data, collected mostly by specialized projects and professional monitoring	–	–
	Allelic diversity				–
	Population genetic differentiation				–
	Breed and variety diversity				Suitability of different Mongolian pasture plants (Fernandez–Gimenez, 2000)
Species populations	Species distribution	Global, regional, local	Most abundant biodiversity–related citizen science observation	Christmas Bird Count, eBird, FeederWatch, India Biodiversity Portal, iNaturalist, iSpot, Reef Life Survey	Identification of multiple species in Madagascar and elsewhere (e.g. Andrianandrasana et al., 2005)
	Population abundance	Global, regional, local	Data collected as a part of many species distribution surveys and some local studies	Breeding Bird Survey, Butterfly Conservation (Europe), eBird, Extreme Citizen Science, International Waterbird Census	Monitoring of hornbills in India (Bachan et al., 2011) and mammals, birds and resource use in Philippines, Madagascar, Tanzania and Nicaragua (Danielsen et al. 2014d)
	Population structure by age/size class	Regional, local	Largely studied at local sites, but there are several regional programs for particular taxa	Monarch Larvae Monitoring Project, Monitoring Avian Productivity and Survivorship (MAPS), North American Butterfly Monitoring Network, several Earthwatch projects	Sea turtle nest counts (Granek and Brown, 2005); piscivorous and herbivorous reef fish (Uychiaoco et al., 2005); trophy size (Lyons, 1998)
Species traits	Phenology	Regional, local	Most abundant trait observation made by citizen science volunteers; many long–term datasets	Climatewatch (Australia), Nature's Calendar (UK), Phenoclim (France), USA National Phenology Network, Project Budburst	Monitoring of caribou migration timing in the Arctic (Huntington et al., 2004); migratory mammals in Tanzania (Topp–Jørgensen et al., 2005); grazing seasons in rangelands in Kenya (Roba and Oba, 2009)
	Body mass	Regional, local	Rare data, collected mostly by specialized projects	Some Earthwatch projects, MAPS, OpenTreeMap	Surveying of fish populations in Peru (Carvalho et al., 2009)
	Natal dispersal distance	Local	Only collected via professional monitoring	–	–
	Migratory behaviour	Global, regional, local	Abundant data for observing species across migratory ranges; much rarer data on migratory behaviours of individual organisms	eBird, Hawk Count, Journey North, Monarch Watch, Hawkwatch (Hawk Migration Association North America), documentation of amphibian migrations to breeding ponds	Monitoring of timing of large–mammal migrations (Huntington et al., 2004; Topp–Jørgensen et al., 2005).
	Demographic traits	Regional, local	Rare data, collected mostly by specialized projects	MAPS; Nest Record Scheme UK; Nestwatch; Projecte Orenetes "Swallow Project" and Projecte Nius "Nests Project"; Earthwatch projects	Assessment of the clutch size of turtles (Townsend et al., 2005).

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