Priorities for big biodiversity data

Laurance *et al.* (*Front Ecol Environ* 2016; **14**: 347) provided an insightful overview of advances in environmental data collection and access to Earth Observation datasets. If remaining challenges can be conquered (Secades *et al.* 2014; Turner *et al.* 2015), such satellite-based remote sensing (SRS) can contribute substantially to biodiversity monitoring. We agree with the need to use SRS to measure natural systems and human impacts, to move from data collection to action, and to develop better algorithms to process large volumes of data, but here we highlight additional priorities.

It is essential that SRS is complemented by in situ monitoring to gather data on aspects of biodiversity that are difficult or impossible to detect from space (eg distributions and abundance of species, including invasives; levels of exploitation; concentrations of pollutants). Observations of species and threats are most valuable when generated from systematic protocols. Examples include Important Bird and Biodiversity Area monitoring (eg Buchanan *et al.* 2013), the Spatial Monitoring and Reporting Tool (SMART; www.smartconservationsoftware.org; Figure 1), and the TEAM Wildlife Monitoring Solution (www.teamnetwork.org/solution). Moreover, citizen science data continue to increase in volume and scope (eg approximately 10 million observations are added monthly to eBird; www.ebird.org). Technological innovations allow greater automation of in situ data collection and processing. For example, advances in camera trap technology and associated monitoring protocols (Fegraus *et al.* 2011; Beaudrot *et al.* 2016) and acoustic recording devices allow the collection of species images and sounds in the field alongside direct observations to complement images of habitat extent captured from space. Other tools such as drones, weather dataloggers, and audio and image recognition software hold promise for the future. The focus of data collection should expand beyond large mammals, birds, and trees to address taxonomic imbalances in datasets (eg Butchart *et al.* 2010; Stephenson *et al.* 2015). While SRS and in situ monitoring are complementary – indeed, the application of SRS to conservation problems is strongly dependent on high-quality in situ data – the scientific communities behind them need to collaborate more closely to increase synergies and efficiencies.

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Figure 1. *Field data being collected to feed into SMART (the Spatial Monitoring and Reporting Tool) in Nepal. Such methods for in situ data collection complement satellite-based remote sensing and help provide a more complete picture of the status of species, their habitats, and threats.*

The development of capacity for data collection and use within biodiversity-rich countries is vital. National capacity building should be linked to existing monitoring plans, such as those associated with national biodiversity strategies, to ensure government agencies are supported in implementing multilateral environmental agreements such as the Convention on Biological Diversity and the Strategic Plan for Biodiversity 2011–2020 (www.cbd.int/sp). While the increasing volume of available data undoubtedly represents an opportunity, converting data into usable information is not straightforward (eg Knight *et al.* 2010) and many national decision makers do not receive the information they need in formats they can use, especially if internet access is inadequate. Capacity and tools are required to convert data into derived products (synthesized reports, maps, dashboards, etc) for easier interpretation by decision makers; this will be enhanced if products are developed and verified through appropriate science–policy interfaces that facilitate dialogue between data collectors and data users (Stephenson *et al.* 2016).

More harmonization of monitoring systems is required. There is a proliferation of environmental monitoring systems, databases, and tools, some of which are similar to each other or not well-coordinated (eg the multiple platforms for species and protected areas). Although this diversity reflects a dynamic sector, it is potentially confusing to end-users and

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spreads resources thinly while most existing databases – such as the IUCN Red List of Threatened Species (www.iucnredlist.org), Protected Planet (www.protectedplanet.net), and the Living Planet Index (www.livingplanetindex.org) – are underfunded (Juffe-Bignoli *et al.* 2016). We support innovation and the development of improved systems but encourage all actors to collaborate in harmonizing databases and platforms and in enhancing interoperability and version control between them. New platforms should be based on adequate assessments of user needs, and should respect terms of use of data providers, focus on filling data gaps, and support the maintenance of underlying databases. System harmonization will require improved dialogue between SRS and conservation communities (Skidmore *et al.* 2015).

Several initiatives are harmonizing systems and building capacity for data collection and use, including the Eye on Earth Alliance (www.eoesummit.org), the IUCN SSC Species Monitoring Specialist Group (www.speciesmonitoring.org), and the work of GEO BON and its partners on Essential Biodiversity Variables (Pereira *et al.* 2013; Kissling *et al.* 2015). Key Biodiversity Areas (KBAs; www.keybiodiversityareas.org) offer an additional opportunity to focus efforts on a common unit of monitoring, particularly given the breadth of the new KBA Partnership.

We agree with Laurance *et al.* that SRS has huge potential for conservation and research but argue for more investment in complementary in situ data collection and analysis, combined with greater capacity building and systems harmonization, to fill observation gaps. A more holistic approach, integrating SRS and in situ observations, will promote effective monitoring of natural systems and anthropogenic impacts upon them and ultimately improve the quality of environmental decision making and conservation action.

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