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Fraixedas, Sara

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Nationally reported metrics can't adequately guide transformative change in biodiversity policy

Sara Fraixedas[a], Tomas Roslin[b,c,1], Laura H. Antão[a], Juha Pöyry[d], and Anna-Liisa Laine[a,e,1]

Biodiversity loss is rampant (1–3). To safeguard the future of life on Earth, there are growing calls for transformative change in biodiversity policy [i.e., for a fundamental and system-wide reorganization of how such policy is designed, implemented, and enforced across scales and sectors (1)]. Here we argue that to achieve this change, nations need to urgently implement robust biodiversity metrics into decision-making processes and policy.

Because biodiversity sustains human life and economy, biodiversity metrics should be elevated to the same level as other core statistics and should be regarded as essential for guiding societies toward transformative change. Biodiversity metrics should be held to the same standards, rigor, and accuracy as any other nationally reported data, such as those on human population size, age structure, economic growth, and agricultural or industrial production. Measures of the state of biodiversity should thus be published as part of national statistics and mandated by legislation to ensure delivery. In March 2021, the 52nd United Nations Statistical Commission introduced the notion of biodiversity accounting in economic and financial decision-making, a move that represents an important step in changing international attitudes toward enhancing biodiversity policies. As researchers continue to gather knowledge on the structure, mechanisms, and determinants of biodi-

To have any chance of retaining the globe's biodiversity, nations must implement better, more robust biodiversity metrics into decision-making processes and policy. Image credit: Shutterstock/Stu Shaw.

[a]Research Centre for Ecological Change, Organismal and Evolutionary Biology Research Programme, Faculty of Biological and Environmental Sciences, University of Helsinki, 00014 Helsinki, Finland; [b]Department of Ecology, Swedish University of Agricultural Sciences, 750 07 Uppsala, Sweden; [c]Department of Agricultural Sciences, University of Helsinki, 00014 Helsinki, Finland; [d]Biodiversity Centre, Finnish Environment Institute, Helsinki, 00790 Finland; and [e]Department of Evolutionary Biology and Environmental Studies, University of Zurich, 8006 Zurich, Switzerland

The authors declare no competing interest.

[1]To whom correspondence may be addressed. Email: tomas.roslin@helsinki.fi or anna-liisa.laine@uzh.ch.

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versity, governments should leverage that knowledge to guide policy. We therefore call for stronger efforts to implement monitoring schemes that provide species abundance data and for metrics that are globally harmonized to provide a more accurate quantification of patterns of biodiversity change (4, 5).

Moving Beyond Red Lists

To guide policy, governments and institutions require statistics that adequately and sensitively reflect ongoing change. Most current assessments of biodiversity status and trends are based on evaluating the risk or rate of species loss and are therefore underpinned by data from the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. Red Lists therefore constitute an essential tool for classifying species according to their extinction risk based on their distribution and/or population status.

To overcome these caveats, we argue that current practices need to be complemented by collecting highly resolved abundance data from which trends can be compared within groups as well as calculating metrics at more aggregate levels.

The Red List Index (RLI) was widely adopted by the Convention on Biological Diversity (CBD) in 2010 as the basic currency for reporting national progress on the status and trends of biodiversity (6, 7). Red List categories and criteria have indeed been communicated with commendable clarity. However, there are caveats to this approach (8, 9), because species loss is only one extreme outcome of the many dimensions of ongoing biodiversity change (10).

Importantly, species extinction and overall biodiversity change may be only loosely coupled (10, 11). Extinction is usually preceded by long-term declines, and often researchers can only indirectly infer whether a species is subject to an acute threat. Although direct effects of some anthropogenic drivers do lead to species loss, natural communities around the world often show little or no consistent species loss over time across taxa and biomes (11). However, the absence of or minimal net species loss does not mean that biodiversity has remained unaltered. Multiple co-occurring drivers can lead to contrasting trends and rates of change in, for example, genetic diversity, species richness, abundance, and composition (2, 11, 12). These changes can have far-reaching consequences for vital ecosystem functioning, regardless of whether or not they are associated with species loss (13).

Red List data have played a fundamental role in conservation efforts. However, we argue that the strong reliance on this metric has important shortcomings that limit how researchers measure and report biodiversity change—and how those changes are perceived by the public. First, the link between the global extinction crisis and national Red Lists is complicated by the arbitrary character of national borders: Only a minority of species included in national Red Lists are threatened at a planetary scale (14). Second, the mismatch between national and global scales is compounded by added circularity. Nations lacking regional and national assessments of species' extinction risk tend to rely on global listings. Third, for most species on the globe—even plants (9)—no assessment of extinction risk can be undertaken either nationally or globally, because their diversity is yet to be described. Indeed, most species undiscovered to date risk being threatened if and when described (15). Fourth, the fact that only a small subset of species is Red Listed may bias our perception of how other at-risk species respond to global change. Fifth, there is currently no statistical uncertainty associated with Red List categories, making it difficult to communicate the uncertainty associated with RLI values and trends (16). And sixth, there's still some question as to how representative Red Listed species actually are when it comes to overall biodiversity. The best-known classes (i.e., vertebrates) are the least diverse; thus, information from some organisms may overshadow how little is known about more diverse taxonomic groups. The resulting lack of data makes the evaluation process rely strongly on expert judgment and is further complicated by funding limitations (8, 9). Consequently, researchers and decision makers risk underestimating ongoing biodiversity change and the resulting ecosystem level consequences (10). This can severely undermine prospects for transformative biodiversity governance.

Perhaps the biggest concern when using Red Listed species as indicators of biodiversity change derives from an implicit assumption rarely spelled out and even less often tested: that changes among currently Red Listed species may serve as proxies of changes for other, nonlisted species. Researchers and decision makers both tend to see Red Listed species as the tip of the iceberg—they assume that these species may reveal something about what's below the surface (Fig. 1A). This is a bold conjecture: Imagine a scenario in which nations would base their assessment of human population structure, economy, food production, or any other key aspect on a single statistic, let alone on a metric characterizing the extreme of a distribution, and resorting to estimations rather than data if needed. If national demographics were inferred from the number of people in the 95+ age group, it would not confer much useful information if data on all other age groups were missing. The implicit assumption is thus clear: For Red Listed species to serve their currently assigned purpose, their responses should be indicative of the responses of less-known groups, because they represent the visible tail of a distribution of responses, which includes less-known taxa (Fig. 1B). This assumption may frequently be violated (Fig. 1C).

To overcome these caveats, we argue that current practices need to be complemented by collecting highly resolved abundance data from which trends

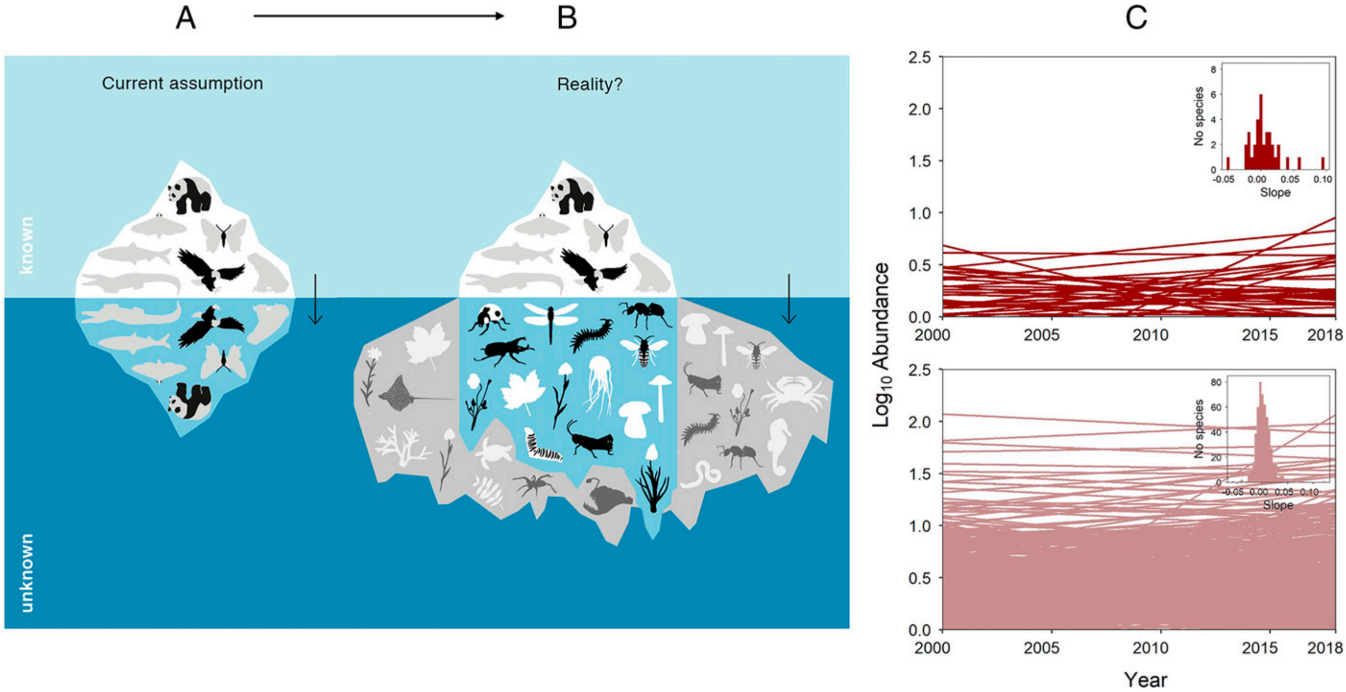

Fig. 1. **Why Red Listed species may offer an incomplete and biased understanding of biodiversity change. (*A*) Current metrics of biodiversity change tend to focus on the tip of the iceberg (i.e., Red Listed species). (*B*) When biodiversity strategies and policy are built on such metrics, the implicit assumption is that patterns hidden under the surface will mirror those above the surface. (*A* and *B*) Image credit: Christina Grob/Research Centre for Ecological Change (REC). (*C*) This assumption is rarely tested but likely to be frequently violated. Extensive monitoring data on the moths of Finland show that trends among Red Listed species (*Top*; $N = 35$ species included in the 2010 Finnish Red List assessment) do not reflect those of other moth species (*Bottom*; $N = 530$), and vice versa. Rather, species-specific abundance trends in 2000–2018 vary substantially within both groups (from staggering increases to huge annual declines; see range of positive to negative slopes). The inset histograms in *C* show the estimated slope distributions (change per year) across species on a logarithmic scale. Trends were calculated using linear mixed models fitted to each species from the Finnish National Moth Monitoring Scheme (Nocturna) observed in at least 10 years and three traps (41 traps), with "year" as fixed effect and "trap" as random factor. Image credit: Laura H. Antão and Sara Fraixedas (University of Helsinki, Helsinki, Finland).**

can be compared within groups (Fig. 1C) as well as calculating metrics at more aggregate levels. Specifically, abundance data on populations allow estimating community-level indices, whereas the opposite is not true. In tandem, poorly known groups should be given more importance than they have received thus far (15). Characterizing diversity based on distinctly nondiverse taxa is not justified. Systematic, taxonomically stratified monitoring schemes are needed, allowing us to glean *inter alia* the extent to which changes in Red Listed species are indicative of other biodiversity changes. Broadening taxonomic representation is essential to gain insight into more complex ecological processes and their determinants.

Progress toward these two aims can be built on recent initiatives compiling biodiversity time-series [e.g., BioTIME (17)] and by implementing sampling approaches that allow the assessment of the conservation status and population trends of large, species-rich groups [e.g., The Sampled Red List Index (18)]. Although these initiatives are still incipient and not yet globally representative, they do leverage the availability of existing data on the one hand and are being adopted at long-term monitoring sites on the other. Such efforts provide crucial data for the robust analysis of a growing proportion of the world's biodiversity.

Widespread and systematic collection of abundance data across taxa requires not only research investment but also additional investment into harnessing already existing data, as well as strategic planning to fill in taxonomic and geographic gaps. Datasets voluntarily compiled by nature enthusiasts such as bird watchers and lepidopterists provide a solid foundation for continued assessment of abundance changes in these groups (19). Strategic monitoring of added taxa will require careful planning and new incentives, and to some extent additional funding. However, some new efforts may be low-cost. Crowd-sourced biodiversity monitoring is an underused means of achieving new taxonomic and regional biodiversity coverage (20). Similarly, distributed sampling designs in which individual researchers commit to monitoring an area could be used to monitor biodiversity change. In addition, large-scale distributed experiments and monitoring efforts have gained traction as tools to quantify global ecological processes [e.g., Lifeplan (21) and Plantpopnet (22)].

Biodiversity Stats Take Center Stage

The implementation of national programs for taxonomically stratified, cost-efficient, community-level monitoring no doubt entails challenges. To date, CBD signatory countries have not succeeded in using a common metric to report biodiversity changes. Even when using Red List data, mixed approaches remain—because it is up to the countries to decide how to implement CBD commitments. Additionally, there is no internal mechanism within CBD to monitor national-level compliance and implementation, both of which are urgently needed to evaluate implementation deficits (23). Thus, significant efforts are required to translate global conservation targets into national commitments in line with parallel international climate change agreements (24).

The generation of comprehensive biodiversity metrics that are consistent and comparable across nations should be made a global priority in the context of growing policy efforts to support transformative change (1). GEO BON, the Group of Earth Observations Biodiversity Observation Network (4), is a recent initiative paving the way forward. It aims at improving the acquisition, coordination, and delivery of biodiversity observations toward effective decision-making and management policies. At its core is the definition of 20 Essential Biodiversity Variables (5)—that is, a minimum set of complementary biological state variables required to study, report, and manage biodiversity change, and the development of a novel set of global indicators that combine biodiversity observations, remote sensing data, and model-based integration of multiple data sources and types. Our call for cross-taxa abundance-based national monitoring efforts directly aligns with GEO BON's vision. Measuring and reporting a broadened nationally relevant yet globally comparable suite of metrics capturing biodiversity change is fundamental to preserving biodiversity and to safeguarding the services that underpin human well-being. But for this to happen, biodiversity statistics should be center stage; their collection should be enforced through legislation, and they should be reported as part of national statistics. Only by granting biodiversity metrics the relevance they deserve can we achieve transformative change in biodiversity policy.

Data Availability. The case study presented in Fig. 1*C* builds on data from the Finnish National Moth Monitoring Scheme (Nocturna). These data are freely available at the Finnish Biodiversity Information Facility (FinBIF) open access data depository (https://laji.fi/en/observation/list?sourceId=KE.1501).

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