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Dear Nature Ecology and Evolution editorial board,

We would like to submit for your consideration as a *Perspective* our manuscript: "Representation of global change drivers across biodiversity datasets".

Large-scale compilations of biodiversity data are increasingly being used to quantify the impacts of human activities on Earth's biodiversity. Such data are also often the foundation of national and international biodiversity indicators for conservation decision-making, such as the post-2020 global biodiversity framework of the Convention on Biological Diversity that will be agreed upon in October of this year at COP-15. While the implications of geographic and taxonomic biases in biodiversity data are commonly discussed, the scientific community has yet to recognize the multiple axes of data representation including global change driver intensity around the world. The big five drivers of global change are widely identified as habitat loss, climate change, pollution, exploitation and invasive species but it is far from clear whether these drivers are being sampled representatively. Yet, knowing to what degree the sampling sites within biodiversity databases captures global change is vital to interpret results derived from data syntheses and ensure global biodiversity indicators remain fit-for-purpose.

In our proposed *Perspective*, we develop the concept of global change space and how it can be used to improve inference from biodiversity syntheses, develop scenarios for future shifts in species composition as well as the target future data collection to fill gaps. We used data indicating the five big drivers and mapped the 'global change space' using the dominant orthogonal axes of change (similar to the concept of trait or niche space). We then quantified how much of this global change space is currently captured with existing global-scale terrestrial and marine biodiversity data from the Living Planet, BioTIME and PREDICTS databases, and further highlighted the gaps and their implications.

We believe that the broad relevance of our *Perspective* and its timely implications for biodiversity policies and scenarios for future change, such as the partnership between IPBES and IPCC,

make our work suitable for Nature Ecology and Evolution. Below we include a referenced summary paragraph as well further details on suitability for Nature Ecology and Evolution.

We suggest the following reviewers: Daniel Metcalf (Umea University, daniel.metcalfe@umu.se), Jonathan Lenoir (Université de Picardie Jules Verne, jonathan.lenoir@u-picardie.fr) and Cristina Banks-Leite (Imperial College, c.banks@imperial.ac.uk).

We confirm that our manuscript is not concurrently submitted for publication in other peer-reviewed journals. We plan to publish a pre-print of our manuscript on EcoEvoArxiv in the coming week.

Thank you for considering our manuscript for publication in Nature Ecology and Evolution.
Gergana Daskalova on behalf of all co-authors

23 July 2021

Representation of global change drivers across biodiversity datasets

Perspective piece written by Gergana N. Daskalova[1]*, Diana E. Bowler[2], Isla H. Myers-Smith[1], Maria Dornelas[3]

Summary

An ecological data revolution is underway with more open-access data available now than ever before[1–3]. These data are instrumental to assess the consequences of the human activities on biotic communities across land and sea. Large-scale data compilations have been analyzed to test patterns of biodiversity change and impacts of anthropogenic drivers[4–9], and to develop indicators for global conservation policies such as Essential Biodiversity Variables[10] and the Convention on Biological Diversity's Post-2020 Global Biodiversity Framework[11,12]. The biodiversity data underlying many of these syntheses have already been shown to be biased geographically and taxonomically[13–16]. Surprisingly, much less attention has been given to whether the data are also biased with respect to global change drivers, such as climate change and habitat change. Here, we present our perspective on the need to consider this new dimension of bias by quantifying the representativeness of biodiversity data in large-scale syntheses and discussing the implications for research interpretation and conservation policy. We linked three of the largest, open-access biodiversity databases (Living Planet[17], BioTIME[1] and PREDICTS[2]) with maps of global change drivers[18]. We focused on four aspects of representativeness – global change intensity over space, global change intensity over time, geography, and taxonomy. We found that global biodiversity datasets capture a large proportion of the intensity of global change, but not uniformly. Over space, existing data capture most of the spatial variance in global change drivers, but more so at sea than on land. Over time, monitoring often starts after the peak intensity in environmental change for drivers like primary forest loss, but more closely coincides with the period of rapid climate change. Our perspective serves two important purposes: 1) to highlight the variation in global change drivers that is already captured by global datasets and hence the driver impacts that we can quantify in current studies, and 2) to identify the gaps in data representativeness that future studies, monitoring and data mobilization actions should target. By making biodiversity databases more representative of multiple axes of natural and anthropogenic variation, we can improve estimates of the global state and trends of biodiversity and predict possible future scenarios.

Interest of our work to a broad scientific readership and suitability for Nature Ecology and Evolution

Biodiversity data gaps across variation in global change compromise the quantification of the impacts of anthropogenic drivers on biodiversity. Large-scale biodiversity databases are used to address a broad range of questions by scientists of multiple disciplines, including global change ecology, conservation, evolutionary biology and more. To interpret the findings of any data synthesis, including IPBES reports, scientists need to consider if the underlying data are sampled from sites over the range of real-world driver intensities, or rather are biased towards either heavily impacted sites or intact wilderness areas. We argue that understanding the representativeness of biodiversity data across global change axes is essential to interpret estimates of regional or global-scale biodiversity change based on biodiversity databases. With continued calls for more biodiversity data such as from the GeoBON initiative and the recent IPBES-IPCC co-sponsored workshop report on biodiversity and climate change, we advocate for a broader perspective on the design and synthesis of future ecological monitoring to target not just geographic gaps, but also underrepresentation of global change. We believe that our *Perspective* will be of broad interest since it is relevant to not only people conducting data syntheses but also to those using the findings of such studies in reports like the IPBES-IPCC co-sponsored workshop report, policy making and conservation management.

List of key findings

1. We found that biodiversity data from the Living Planet, BioTIME and PREDICTS databases capture a surprisingly high amount of the spatial variation in global change intensity around the planet, especially in the marine realm (Figure 1, Additional materials).
2. Among the five global change drivers we tested, climate change and pollution in the marine realm were sampled the most representatively, suggesting that we can test the effects of these drivers with higher confidence and the underlying data could be used when creating global scenarios for the future (Figure 2, Additional materials).
3. We found mismatches between when global change occurred and the timing of biodiversity data collection, which were more frequent for land-use change than for climate change (Figure 3, Additional materials).
4. Underrepresentation in geographic space did not directly translate into gaps in global change space and thus an incomplete geographic sample can capture a surprising amount of variation in global change driver intensity (Figures 1-2, 4, Additional materials)

5. We found that birds were the best-, and arthropods the worst-represented taxa across the Living Planet, BioTIME and PREDICTS databases (Figure 5, Additional materials).

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