## Matters Arising

# Do not downplay biodiversity loss

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**The Living Planet Index (LPI), which seeks to summarise population trends of wildlife, has been used as evidence for current biodiversity loss. Leung et al.[1] (hereafter LEUNG), reanalysing the LPI data, found that 98.6% of vertebrate populations showed no overall trend, and concluded that "many systems appear to be generally stable or improving". Here we show that LEUNG's methodological approach is ineffective as it would fail to detect trends in either global warming or continental bird abundance data. Detecting trends in biodiversity requires long-term data, appropriate methods, and careful interpretation; otherwise, there is a very serious danger of downplaying biodiversity loss.**

Summarising complex datasets using aggregate indices can hide meaningful variation, and we commend LEUNG's attempt to identify sources of temporal variations in the LPI. But the methodology they devised has limitations that strongly restrict its ability to deliver biologically significant results and conclusions.

First, their methodology uses summary statistics of short-term population changes that are ineffective at detecting long-term trends. To understand why, consider an analogy with climate change. Scientists agree that global warming is taking place currently; indeed, the global annual mean temperature shows a clear historical trend (Fig. 1A). When these same data are plotted as a frequency distribution of annual temperature changes, however, they fail to reveal any significant global warming signal (Fig. 1B), because long-term trends are then masked by short-term, year-to-year variability. Logically, analyses of the full time-series are much more appropriate than analyses of the statistical properties of its many pieces to detect trends. Yet LEUNG's methodology follows the approach of Fig. 1B since it uses the mean and standard deviation of the distribution of year-to-year changes in population abundance as its building blocks (the only difference with climate change being that it uses a log-transformed ratio of population abundances, which is appropriate since demographic processes are typically multiplicative). We do not claim that this approach is totally incapable of detecting trends. Rather, we claim that breaking time-series up into many pieces is not an effective approach to detecting long-term trends, and that failing to detect trends using this approach cannot be held as evidence that no long-term trend exists.

Second, the previous limitation is compounded by the extreme heterogeneity of the LPI data, which is known to limit the reliability of the LPI[2]. Data heterogeneity strongly reduces the ability to detect and interpret trends. Although the sheer number of population time-series included in the LPI dataset contributes to enhancing the power of trend detection across populations, their heterogeneity has the opposite effect because it aggregates populations with qualitatively different trends. Data heterogeneity also increases the likelihood of either obtaining unrepresentative trends or misinterpreting them. As a hypothetical but plausible example, suppose that populations in protected areas were increasing in abundance because of effective conservation in these areas and simultaneously overrepresented in the LPI dataset because they are censused more comprehensively than elsewhere. This would generate an artefactual increasing trend driven by overrepresentation of protected populations. Experts in meta-analyses have repeatedly warned about misinterpretations that can result when authors do not properly control for major sources of heterogeneity among studies[3], in particular in datasets that were collected for differing purposes[4].

Instead of addressing these fundamental issues directly, LEUNG used a Bayesian hierarchical model that split LPI data into two clusters: a small, homogeneous cluster that isolates strongly declining populations, and a large, heterogenous primary cluster that aggregates all the remaining populations. These two clusters did not result from any objective data analysis; rather, they were dictated by LEUNG's subjective decision to look for two overly simple alternatives, which they called the "catastrophic declines" and "clustered declines" hypotheses. Although looking at these alternatives might serve as a first step in disaggregating LPI data, the resulting clusters are largely arbitrary and neither cluster provides particularly useful new information on population trends.

The small outlying clusters show a particularly extreme form of population decline, with an average decline of 98% per year. With such a precipitous decline, a large population of five million individuals would go extinct in only four years. We know that many populations go extinct because of such factors as wholesale habitat destruction, but it is unclear whether the small extreme clusters identified in LEUNG's analysis are representative of such extinctions, and how they can help devise new conservation strategies.

On the other hand, the large primary clusters are very heterogeneous as they include populations that show all sorts of trends, including populations that increase steeply for a variety of reasons (e.g., they might be recovering from previous declines because of successful conservation efforts, or they might be invasive species). Since steeply declining populations were removed from primary clusters while steeply increasing populations were kept, at least in LEUNG's main analyses, it is unclear what can be learned from the absence of trend in these clusters. When steeply increasing populations are also removed, the declining trend of the LPI reappears (see LPI webpage, http://stats.livingplanetindex.org/, Data, Clusters, extremes and biodiversity loss). Most populations (about 94%) in the LPI database show either an increasing or a decreasing trend (same website, page Mixture of trends). Thus, LEUNG's failure to detect an aggregate trend in primary clusters does not allow any meaningful conclusion to be drawn. This failure clearly does not support their conclusion that the vast majority of populations are not in decline and that, therefore, biodiversity loss is not as catastrophic as commonly thought.

This optimistic conclusion also stands in stark contrast with a broad suite of studies that have accumulated evidence for population declines across a wide range of taxonomic groups, ecosystems, and geographic regions. Declines in vertebrate abundance are not restricted to a few systems in the Indo-Pacific realm, as LEUNG suggest. They are widespread even in Europe and North America, two continents that are losing biodiversity at much lower rates, mostly because they already lost a significant part of their native vertebrate fauna centuries or millennia ago. For instance, recent studies estimated that Europe lost 20% of total bird abundance in 30 years from 1980[5], while North America lost 29% of total bird abundance in 48 years from 1970[6]. These figures show massive declines of bird abundance on both continents despite the fact that they represent an average loss of only 0.7–0.8% per year. Such a small average loss would likely be swamped by yearly fluctuations in abundance if one were to use annual population change data, and certainly be drowned in LEUNG's primary clusters showing no aggregate trend. This again shows how deceptive short-term fluctuations in abundance can be.

While new data can certainly bring information to bear that contradicts and even overturns the conclusions of prior studies, it is incumbent on authors to resolve their data, analyses, and conclusions with prior work before suggesting other scientists may have exaggerated the biodiversity crisis. LEUNG's optimistic conclusion not only stands in conflict with more rigorously designed studies that have used data appropriate for measuring biodiversity change, but they run the risk of generating misinformation for conservation efforts.

We feel two important lessons can be drawn. First, population decline and biodiversity loss are long-term processes, which need to be assessed using appropriate methods. Detecting trends in biodiversity requires long-term data[7], and thus a reliable and coordinated global biodiversity observation system[8], which is still sorely missing. Data analyses need to account for known sources of heterogeneity and representativity biases. Current trends should be interpreted carefully and compared with baseline historical data whenever possible, as is common practice with climate change.

Second, LEUNG claimed that their results "provide a reason to hope that our actions can make a difference". Hope, however, will not come from downplaying biodiversity loss — hope will only come from new perspectives and approaches to resolve the current biodiversity crisis once the seriousness of this crisis has been fully acknowledged.

**References**

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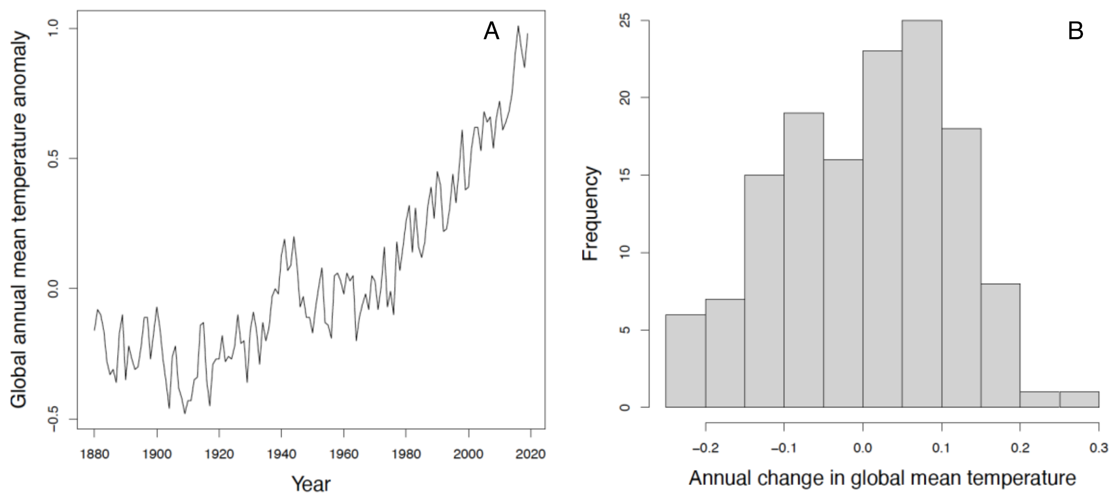


**Fig. 1.** The methodology adopted by Leung et al. would not detect global climate change. **A.** Changes in the global annual mean temperature anomaly from 1880 to 2019 (data from the Goddard Institute for Space Studies, https://data.giss.nasa.gov/gistemp/) reveal an exceedingly strong global warming signal (Spearman's rank correlation coefficient between temperature anomaly and year = 0.88, $P < 10^{-15}$). **B.** When plotted as a frequency distribution of annual changes in global mean temperature (as the LPI does for population abundance), the same data fail to detect any global warming signal (mean annual increase = 0.0082, which is not significantly different from zero by a *t*-test, $P = 0.38$).