Emphasizing declining populations in the Living Planet Report

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The Living Planet Report[1], which has been published biannually since 1998, is key for understanding trends in wildlife populations and promoting sound conservation[1–4]. Leung et al.[5] recently disagreed with the conclusions of the Living Planet Report and found that the overall pattern of population declines stems from very few populations (extreme clusters), beyond which global vertebrate populations are not declining. However, when properly accounting also for the influence of the fastest-increasing populations, we find that the overall declines in the Living Planet Report are practically unchanged. Moreover, the Living Planet Database is heavily biased towards populations that receive more conservation attention, indicating that the true population trends are indeed dire and may actually be worse than depicted in the Living Planet Report.

The Living Planet Index (LPI) represents the weighted average change in the population of species over time across regions[6]. Leung et al.[5] suggested that the LPI is an oversimplification of regional trends and that it is an unreliable index for global declines. They removed the 2.4% most declining populations and found that this removal reverses "global vertebrate trends from a loss of more than 50% to a slightly positive growth"[5]. Using the updated Living Planet Database, we replicated their analyses and found that the removal of 3.1% of the most decreasing populations indeed reverses the overall declining trend (Fig. 1a). However, such a procedure misrepresents the true trends in these data. By removing only the most declining populations, the overall trend in the remaining data is heavily influenced by the fastest-increasing populations. To correct this, we simultaneously removed the 1.55% populations doing the best and the 1.55% populations doing the worst (that is, 3.1% of the populations from both extremes; Supplementary Information). The trend in the remaining data mimics the major declines reported in the Living Planet Report (65% decline for the remaining 96.9% of the data compared to a 67% decline for all 21,639 populations in the complete dataset). To achieve no net overall population declines, we needed to remove at least 43.3% of the extreme data (21.65% from each end) (Fig. 1a). Moreover, when removing 3.1% of populations from both extremes, the time series (from 1970 to 2014) mirrors the complete dataset very closely with pronounced declines in recent decades (Fig. 1b (orange and black lines)). Therefore, the analysis by Leung et al.[5] greatly exaggerates the effect of extreme-increasing populations and misrepresents the overall trends.

Moreover, Leung et al.[5] devised a method to identify extreme and primary clustered population growth trends (Bayesian hierarchical mixture model). They used this method to highlight the effects of either of these population types on overall trends. When they removed extreme clusters (populations with a growth rate of 1 s.d. away from the mean of the primary cluster), they found no mean global trend for the remaining 98.6% of the Living Planet Database populations[5]. This further emphasizes the effect of clustered populations on the LPI. However, it ignores the fact that this threshold delineates 147 decreasing populations but only 58 increasing populations (two-and-a-half times more decreasing populations). The LPI summarizes population trends to highlight global patterns[6]. The non-symmetric removal of extreme clustered declining populations is biased and negates the entire point of the LPI, and of conservation biology in general. As conservation biology focuses on declining and small populations[7], we should not ignore them in our global tallies of trends. Ultimately, there are many more extreme-decreasing populations than extreme-increasing ones. Failing to emphasize this point undercuts a central tenet of biodiversity conservation.

We further examined whether populations in the Living Planet Database received disproportionate conservation attention, which may bias conclusions drawn from their analysis. We assessed the location of populations sampled in the Living Planet Database relative to the global protected area network. We found that populations in the Living Planet Database are significantly more likely to be sampled inside protected areas than expected by chance (Fig. 2 and Supplementary Table 1). This trend is consistent across taxa (Extended Data Fig. 1) and most regions (Extended Data Fig. 2). Species and populations that are better covered by protected areas are usually less threatened than those that are less covered[8,9]. Thus, populations in the Living Planet Database are probably doing better than those that are not studied, and the true global population trends are probably worse than analyses based on the Living Planet Database suggest.

Although optimistic messages regarding conservation provide much-needed hope[5], we should strive to represent the accurate status of biodiversity. Biased or misinterpreted data can undermine conservation efforts[10]. Although the removal of only 3% of populations in the LPI reverses substantial declines, these results arise from not accounting for the effect of extremely increasing populations[5]. Moreover, the clustering methods of Leung et al.[5] find that there are 2.5 times more extreme-decreasing populations than extreme-increasing populations, a fact that they did not highlight. Thus, although extreme populations have much influence on the LPI, one should not ignore them in tallying the overall state of nature. The Living Planet Report is a commendable effort to summarize the status of global wildlife populations. It regularly reports major declines. Nevertheless, it is subject to biases such as the one that

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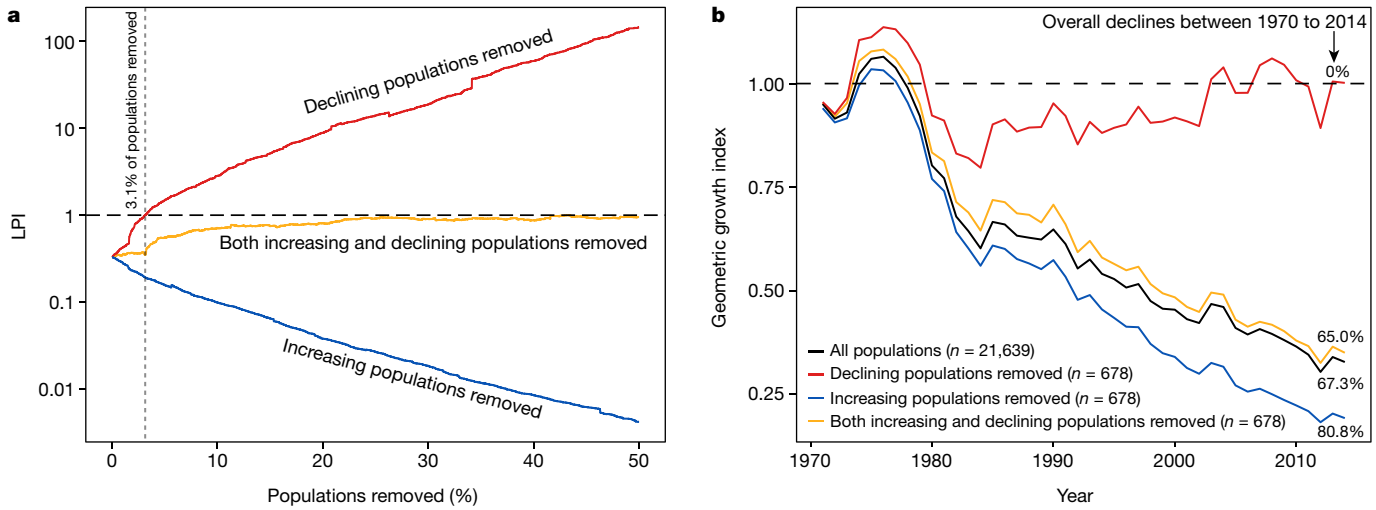

Fig. 1 | The effects of three different extreme population removal strategies to assess the sensitivity of overall growth rates. a, Changes in overall growth rates when removing populations under the three different strategies (up to 50% removal). The vertical dashed line represents the percentage of declining populations to be removed for the overall trend in LPI to be reversed from a decline to positive growth (3.1%; that is, 678 populations). **b**, Temporal variation in the overall global geometric growth rates (black line), and temporal variation after removing 3.1% of the populations under the three strategies. The horizontal dashed lines in **a** and **b** represent no population growth or decline.

we show for protected areas. As a consequence, the true status of nature is probably even worse than the Living Planet Report depicts. Addressing such biases and gaps is an important conservation task. Rather than discouraging efforts such as the Living Planet Report, we want to use this opportunity as a call to arms for greater monitoring of populations of diverse groups globally.

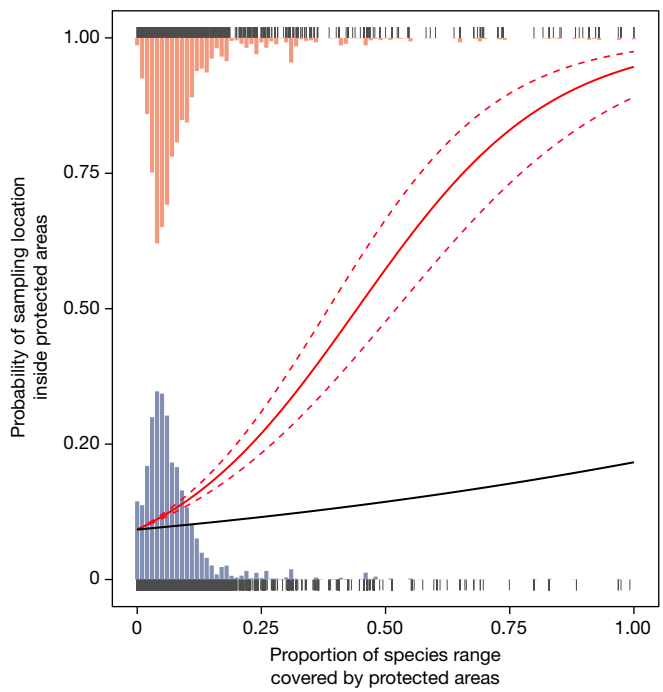

Fig. 2 | The probability of LPI populations' sampling location to be inside protected areas for given species range overlap with protected areas. The solid red line represents a generalized linear mixed model with a binomial fit, and the dashed lines represent the 95% confidence interval. The black line represents the expected slope of 1 if the populations were sampled at random in the species' range. The histograms represent the proportion of overlap of species ranges with protected areas. Red, LPI locations found within protected areas; blue, LPI location found outside protected areas.

Reporting summary

Further information on experimental design is available in the Nature Research Reporting Summary linked to this paper.

Online content

Any methods, additional references, Nature Research reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41586-021-04165-z.

Data availability

The Living Planet Database is available from the LPI website (https://livingplanetindex.org). The Protected Area maps are available at the World Database of Protected Area (https://www.protectedplanet.net). Species range size was obtained from the IUCN, BirdLife databases (https://www.iucnredlist.org; https://www.birdlife.org) and from Roll et al.[10] for reptiles.

Code availability

The R codes associated with the study are provided in the Supplementary Information.

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Author contributions All of the authors conceived the study. G.H.d.O.C. downloaded LPI data and conducted sensitivity analyses. G.H.d.O.C., G.B. and G.M. assembled and analysed the dataset. All of the authors drafted and substantially revised the manuscript.

Competing interests The authors declare no competing interests.

Additional information

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41586-021-04165-z.

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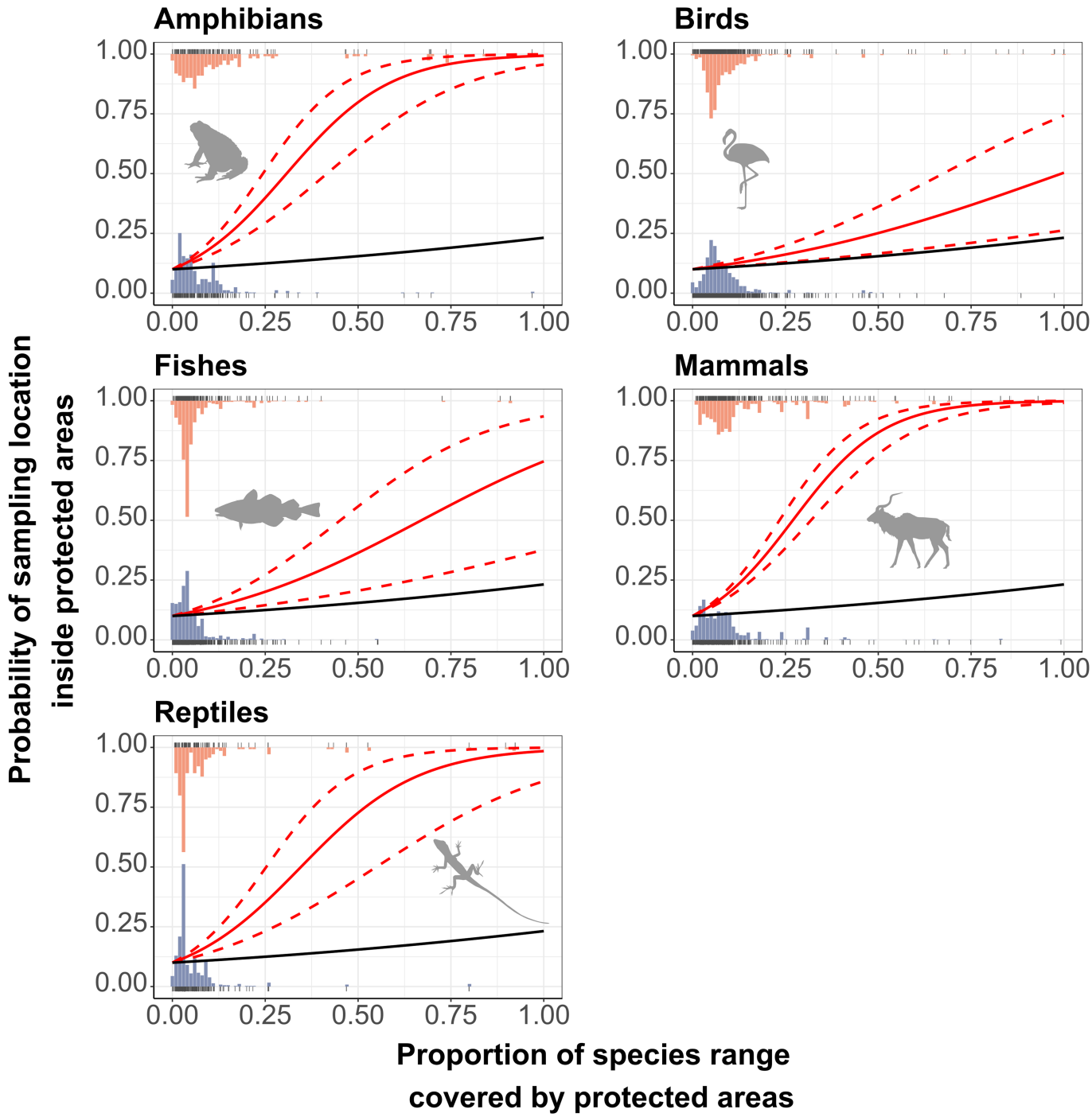
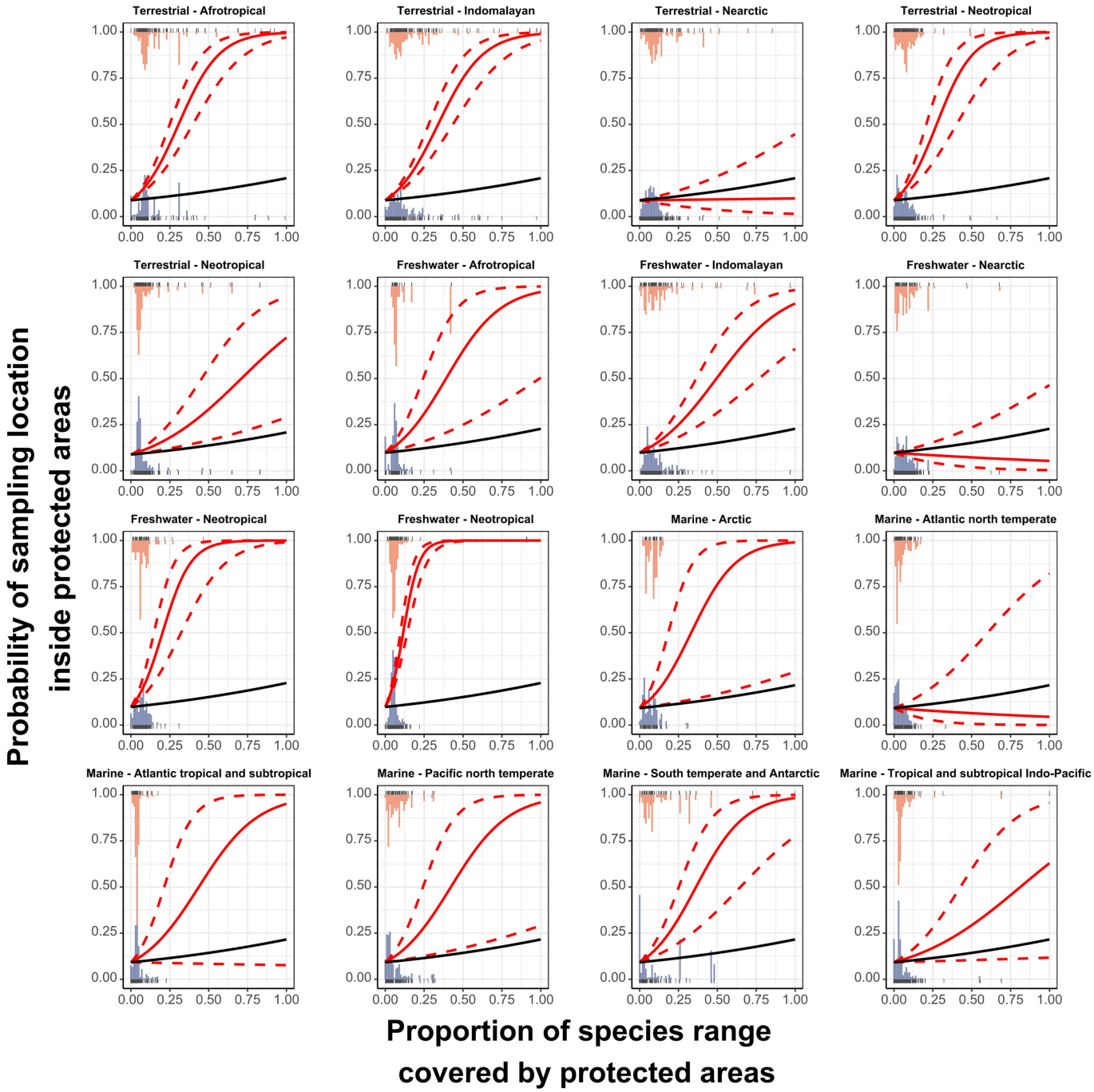


Extended Data Fig. 1 | The probability of LPI populations' sampling location to be inside protected areas for given species range overlap with protected areas (by taxon). Taxon was included as an interaction with the overlap area. The solid red line represents a generalized linear mixed model with the binomial fit and dashed lines 95% confidence interval. The black line represents the expected slope of 1 if populations were sampled at random in the species' range. The histograms represent the proportion of overlap of species ranges with protected areas. Red, LPI locations found within protected areas; blue, LPI location found outside protected areas.



Extended Data Fig. 2 | The probability of LPI populations' sampling location to be inside protected areas for given species range overlap with protected areas (by realm–domain combination). Realm-domain combination was included as interaction with overlap area. The solid red line represents a generalized linear mixed model with the binomial fit and dashed lines 95% confidence interval. The black line represents the expected slope of 1 if populations were sampled at random in the species' range. The histograms represent the proportion of overlap of species ranges with protected areas. Red, LPI locations found within protected areas; blue, LPI location found outside protected areas.