Out of Africa comes no support for global biodiversity catastrophes

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The Living Planet Index and the ever-changing iterations of planetary boundaries for biodiversity integrity or health are inappropriate, misleading, and will harm on-the-ground conservation efforts.

LINKED ASSERTIONS ABOUT BIODIVERSITY DECLINES

Two linked assertions based on global biodiversity metrics claim to be vital for informing conservation practice. The first is the assertion that the biosphere is "well outside a safe operating space" because critical boundaries of "biotic integrity" have been crossed (*1*, *2*). Second, the Living Planet Index (LPI) (*3*) reports a "catastrophic 73% decline in the average size of monitored wildlife populations over just 50 years," revealing "A System in Peril" (*3*). These alarms suggest that Earth has or will soon cross an irreversible tipping point leading to the collapse of our life-sustaining systems. While the state of biodiversity is dire (*4*), we must separate alarmist claims based on abstract, theoretical, or hypothetical conjectures from more concrete claims based on carefully documented, empirically derived evidence. Only the latter can expect to inform conservation practice (*5*).

Without question, human population growth and increased per-capita consumption have modified large areas of the planet: NASA estimates that 80% of the land is affected, with half of that in agriculture (*6*). Deforestation, especially of the tropical moist forests that house two-thirds of known terrestrial species, continues to erode biodiversity. Actions to stem forest loss and the widely recognized need to expand protected areas (*7*) are essential. However, the claimed catastrophic declines in the LPI and of safe operating spaces with catastrophes if transgressed—henceforth "planetary boundaries"—are sweeping statements about biodiversity writ large. They purport to say much more than the well-documented decline in the extent of natural areas. The concepts are intertwined. One might expect that if human actions have transgressed a planetary boundary for biodiversity—however, one defines it—this should be apparent in widespread declines in populations, just as the LPI contends. A recent assessment of a biodiversity boundary notes that it "relies on … temporal changes in species abundances…" (*1*).

The World Wildlife Fund originally developed the LPI in 1997 as "a measure of the changing state of the world's biodiversity over time." Despite serious analytical concerns (*8*, *9*), the LPI has become a high profile, consistently cited indicator of global biodiversity. The Aichi biodiversity targets set by the Convention on Biological Diversity in 2010 incorporated it. The Kunming-Montreal Biodiversity Framework considered it a "component indicator" (*7*) used by dozens of conservation organizations.

Likewise, there are technical criticisms of planetary boundaries, now enfolded into a "Planetary Health Check," (PHC) (*2*). The definitions of the boundaries of biosphere integrity have changed over time, with the admission that they are "challenging to apply" (*2*), and without ever providing practical guidance on what determines a boundary or explaining the ecological mechanisms involved (*10*). Various papers have defined the critical measure of biodiversity, initially simply described as "biodiversity loss," including measures of extinction rate and biodiversity intactness and, most recently, "biosphere integrity," purportedly integrating both species extinctions and loss of genetic diversity, and a component of ecosystem function indexed by the proportion of net primary productivity appropriated (*1*).

Nonetheless, the PHC argues that because the biosphere has now transgressed these arbitrary benchmarks, there is a tipping point beyond which a long list of environmental harms will follow, with the LPI being one measure (*11*). Thus, the LPI and PHC concepts appear to be internally consistent with each other, indeed, self-reinforcing. Putatively, losses of biodiversity push us further beyond our already exceeded "safe operating space," reducing ecosystem functioning, driving further wildlife population declines.

SUB-SAHARAN AFRICA AS A CASE STUDY

To show that the data do not support the "tipping point" and "collapse" assertions, we examined terrestrial data from Africa. Sub-Saharan Africa's human population has grown three and a half times in the past 50 years, by far the fastest growth of any continent. Although per capita consumption may be relatively low, globalization—the export of palm oil and other commodities to richer continents, for example—must also affect its environments. Surely, the transgression of the biosphere's planetary boundaries should be most evident here, especially in African savannahs, as a 2024 report confirms (*2*), and where we would expect definitive catastrophic declines in wildlife populations.

Africa presents a unique and important challenge for conservation. It hosts numerous species—elephants, lions, and rhinos—that are conservation icons for large organizations that

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fundraise to protect them. African species constitute nearly 30% of the World Wildlife Fund's target species (3). That said, large-bodied species are also relatively easy to count. Simply, Africa provides a unique case to test dramatic claims derived from the LPI and planetary boundary transgressions.

POPULATION DATA FROM AFRICA

To avoid well-documented statistical issues of the LPI (*9*) and the limitations of few data (*8*), we calculated the observed population trend for each series over the length of time data that were collected using the methods in (*12*). LPI data are almost all from vertebrates; long-term population studies of plants and insects are few. Of the 1623 series, 65% involve only two, three, or four counts—that is, the number of times a species was surveyed in each series. Across series with the same number of counts, the SDs of the growth rates are relatively high when there are fewer than seven counts. For the 584 populations with only two counts, there are large, sometimes order-of-magnitude, increases and decreases between adjacent years that likely reflect uncertainties in counting rather than genuine population changes (Fig. 1). When there are seven or more counts, the average growth rates across series show increases in numbers over time or else are very close to zero. All the averages show higher values than the ~3% annual decrease that would give a 73% decline over 50 years (76% reportedly for Africa).

Consider next the frequency distribution of population changes for the 14 species—all mammals—for which there are at least five annual counts for at least 10 populations (Fig. 1). Only one, the black rhino (*Diceros bicornis*), shows a preponderance of declines, a reflection of the massive poaching the species experiences for its horn.

Last, there are two sets of species, the savanna elephant (*Loxodonta africana*) and three species of zebra (plains, *Equus burchelli)*, Cape Mountain (*Equus zebra zebra*), and Grevy's (*Equus grevyi*) for which there are extensive and long-term surveys. These species are spread across savannah Africa from Ethiopia to South Africa. IUCN considers them Endangered, Near-Threatened, Endangered, and Endangered, respectively.

The data show that, for the time series of plains zebra with few counts from 2000 and later, there are order-of-magnitude fluctuations between adjacent years. Almost certainly, these changes reflect the difficulty of obtaining accurate counts in some areas.

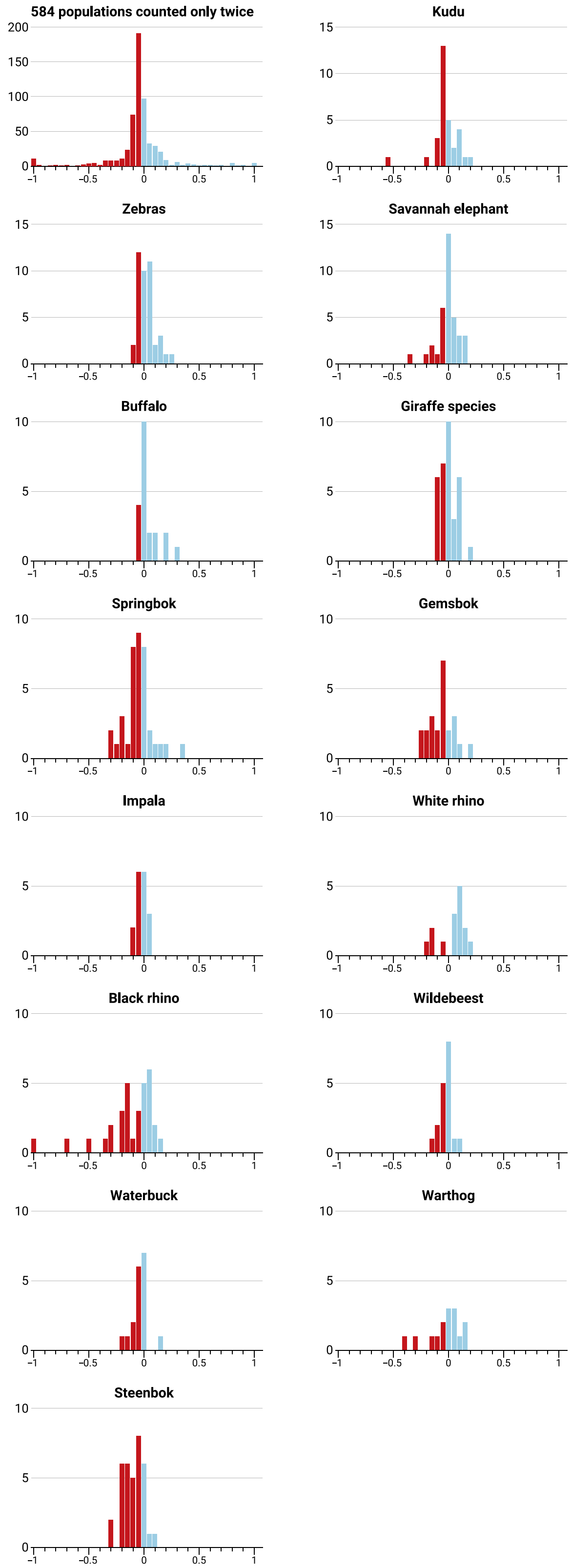

Fig. 1. The frequency distribution of growth rates (based on ln of population estimates) for 14 species with the most comprehensive counts at least five annual counts and for ten populations. (**Top left**) Data for just two counts show large ranges of values. The histogram is truncated below −1 and above +1.

Intrinsic population growth rates cannot explain the magnitude of many reported population increases. Conversely, we might assume large, reported declines over short periods are just as likely to represent undercounts as population collapses. Longer time series fluctuate less, likely representing more accurate counts generated from systematically planned surveys.

For the savannah elephant, Huang *et al.* (*12*) provide a recent, independent, and more comprehensive assessment. They examine populations in southern Africa (which they define as the middle of Tanzania southward), an area that contains 75% of their total numbers. Total numbers have increased slowly in the last 25 years—a result at odds with the published LPI conclusions but entirely compatible with the data contained in their database. Some countries have deep concerns about having too many elephants and consider initiating culls to control the numbers. Some protected areas now use contraception. Populations that are fenced create management problems and lead to calls for solutions that allow elephants "room to roam (*12*)."

NO CATASTROPHIC DECLINE

If we have transgressed a planetary boundary for biodiversity with its expected tipping point or the "catastrophic" and globally pervasive declines that the LPI posits, then these events are not manifest in Africa's monitored wildlife population trends. When we separate populations from the direct pressures that threaten them, especially poaching and habitat loss, they are just as likely to show positive growth as decline. This is true even for species recognized as in peril and with life histories that predispose them to extinction.

Catastrophism and an ever-changing narrative of global transgressions, however defined and measured, might draw attention to the very real crisis of biodiversity loss. Nonetheless, it exposes conservation science to "merchants of doubt," who point to the contra-examples, and detract attention from where practical conservation action is most urgently needed and most effective.

Certainly, large areas of Africa have been converted to human use as the population has increased, and the range extents of many of the species we examine here are a fraction of their historical sizes. These are genuine concerns. However, the data used to support alarmist claims do not, and thus these claims offer no useful insight into the management of Africa's biodiversity. Good management has allowed populations to stabilize and sometimes increase; we must learn its lessons and, as is the case for elephants, understand the complexities and challenges of doing so (*12*).

REFERENCES

1. K. Richardson, W. Steffen, W. Lucht, J. Bendtsen, S. E. Cornell, J. F. Donges, M. Drüke, I. Fetzer, G. Bala, W. von Bloh, G. Feulner, S. Fiedler, D. Gerten, T. Gleeson, M. Hofmann, W. Huiskamp, M. Kummu, C. Mohan, D. Nogués-Bravo, S. Petri, M. Porkka, S. Rahmstorf, S. Schaphoff, K. Thonicke, A. Tobian, V. Virkki, L. Wang-Erlandsson, L. Weber, J. Rockström, Earth beyond six of nine planetary boundaries. *Sci. Adv.* **9**, eadh2458 (2023).
2. Stockholm resilience centre, Planetary Boundaries (2025); https://www.stockholmresilience.org/research/planetary-boundaries.html.
3. Worldwide Fund for Nature, Living Planet Report 2024 (2024).
4. S. L. Pimm, C. N. Jenkins, R. Abell, T. M. Brooks, J. L. Gittleman, L. N. Joppa, P. H. Raven, C. M. Roberts, J. O. Sexton, The biodiversity of species and their rates of extinction, distribution, and protection. *Science* **344**, 1246752 (2014).
5. S. L. Pimm, B. J. van Rensburg, K. S. van Houtan, C. M. Roberts, D. Simberloff, J. L. Gittleman, Conservation targets and how to achieve them. *Proc. R. Soc. B* **292**, 20252626 (2026). https://doi.org/10.1098/rspb.2025.2626.
6. NASA, (2025); https://science.nasa.gov/mission/landsat/benefits/.
7. Convention on Biological Diversity, The Biodiversity Plan for Life on Earth (2024); https://www.cbd.int/gbf.
8. F. T. Buschke, J. G. Hagan, L. Santini, B. W. T. Coetzee, Random population fluctuations bias the Living Planet Index. *Nat. Ecol. Evol.* **5**, 1145–1152 (2021).
9. L. McRae, R. Cornford, V. Marconi, H. Puleston, S. E. H. Ledger, S. Deinet, P. Oppenheimer, M. Hoffmann, R. Freeman, The utility of the Living Planet Index as a policy tool and for measuring nature recovery. *Philos. Trans. R Soc. Lond. B Biol. Sci.* **380**, 20230207 (2025).
10. J. M. Montoya, I. Donohue, S. L. Pimm, Planetary boundaries for biodiversity: implausible science, pernicious policies. *Trends Ecol. Evol.* **33**, 71–73 (2018).
11. WWF., *Living planet: Report 2016: Risk and resilience in a new era* (World Wide Fund For Nature, 2016).
12. R. M. Huang, C. Maré, R. A. Guldemond, S. L. Pimm, R. J. van Aarde, Protecting and connecting landscapes stabilizes populations of the Endangered savannah elephant. *Sci. Adv.* **10**, eadk2896 (2024).

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