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POLICY PERSPECTIVE

# An inconvenient misconception: Climate change is not the principal driver of biodiversity loss

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**Abstract**

The current perception that climate change is the principal threat to biodiversity is at best premature. Although highly relevant, it detracts focus and effort from the primary threats: habitat destruction and overexploitation. We collated causes of vertebrate extinctions since 1900, threat information for amphibia, birds, and mammals from the IUCN Red List, and scrutinized others' attempts to compare climate change with commensurate anthropogenic threats. In each analysis, none of the arguments founded on climate change's wide-ranging effects are as urgent for biodiversity as those for habitat loss and overexploitation. Present conservation efforts must refocus on these issues. Conserving ecosystems by focusing on these major threats not only protects biodiversity but is the only available, economically viable, global strategy to reverse climate change.

**KEYWORDS**

biodiversity loss, extinction, global change, population declines, vertebrates

## 1 | HOW IMPORTANT?

Climate change is now on everyone's itinerary, but we are concerned that threats to biodiversity are increasingly seen through the single myopic lens of climate change (Urban, 2015) dwarfing conventional conservation threats: habitat loss and fragmentation, agricultural expansion, overexploitation, pollution, and invasive species. Additionally, this distortion detracts from understanding that biodiversity conservation is the major viable route to reversing climate change.

During the last 30 years, the proportion of scientific papers addressing climate change and global warming as being anthropogenic drivers of changes in patterns of biodiversity has steadily increased (Figure 1ai). Media coverage on climate change in relation to biodiversity has followed similar trends over this period (Figure 1aii) and is currently standing more than three times higher than related stories on pollution, disease, and deforestation (Legagneux et al., 2018). Such patterns are driven by media focus on global climate summits and efforts to increase public awareness of climate threats which, in turn, are bolstered by 15 years of projections about future climate change (e.g., Thomas et al, 2004). Humans' biggest environmental concern is now seen as climate change dangerously ignoring the stresses of dirty air and unsafe drinking water due to forest loss and degradation of watersheds. A misunderstanding of the role of climate ignores forests' and savannahs' potential to absorb carbon and reverse climate change. Global focus on reducing carbon emissions is vital but will only slow atmospheric greenhouse gas buildup; savannahs and forests actively remove car-

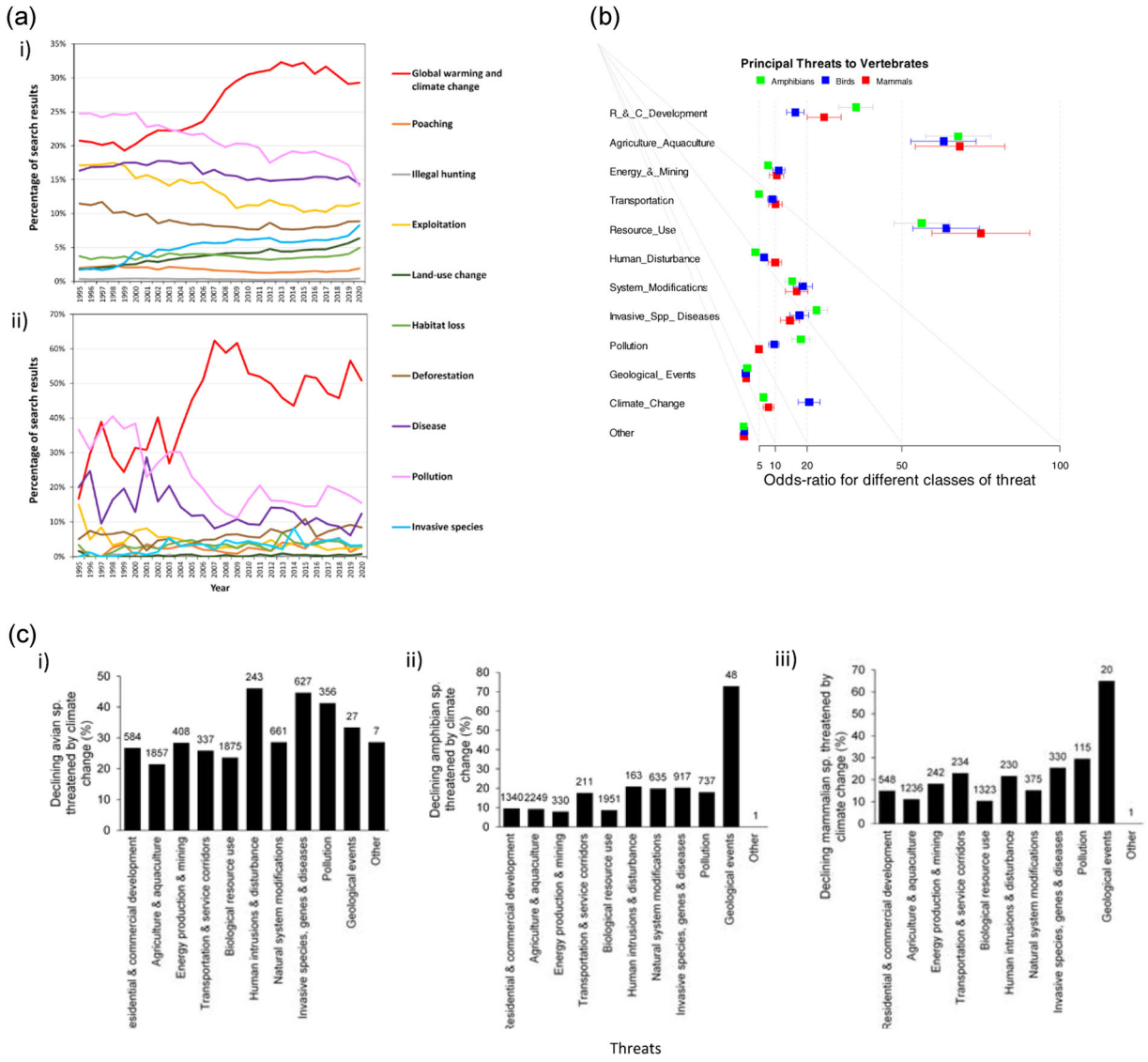


**FIGURE 1** (a). Proportion of searches in (**i**) the scientific literature, and (**ii**) media. Google Scholar and LexisNexis UK news database were respectively used to measure the number of search results that contained each anthropogenic factor (represented by the colored lines) and the word biodiversity broken down by year (1995-2020). Note the rise in climate change and global warming since 2003. (**b**) Odds ratios comparing IUCN declining species whose decline is directly attributable to different threats. The odds-ratio is calculated relative to the background rate of threat which we assumed was 0.005 - roughly equal to the threat from geological events and a rate similar to those reported for natural extinctions by Pimm et al (2014). Odds ratios are different from each other in magnitude if their confidence limits do not overlap and the further apart they are the larger the difference. N bird species = 11,147; N amphibian species = 6,794; N mammal species = 5,850. We have added emphasis to the geological causes of extinction because these essentially most closely mimic the background rates of extinction in the absence of any anthropogenic effects. (**c**). The proportion of declining species ascribed to different categories of threat that were also listed as being threatened by climate change for avian species, amphibian species, and mammalian species. Numbers above each histogram refer to the total number of times each type of threat was listed totaled across all declining species in that class.

bon dioxide from the atmosphere—a process observed in the annual cycles of carbon dioxide measured on Mauna Loa. Extensive tropical forests are both central to the conservation of biological diversity and to reversing climate warming.

Concern among the public about climate change has been so successful that some conservationists now argue that it is too late to stop this distortion; at best we can only hitch the other horsemen of the apocalypse to this runaway bandwagon (Verissimo et al., 2014); simultaneously, climate adaptation strategies are gaining increasing momentum in conservation practice (Brodie et al., 2021; Mason et al., 2021). In short, there is an assumption that climate change is now the most important "horseman of the biodiversity apocalypse."

We strongly reject this argument and expand on earlier evidence for this case (Dobson et al, 2021; Maxwell et al., 2016). We contend that compared to rampant land-use alteration and direct exploitation, the climate is more of a mule, powerful, but operating slower than other factors that mediate biodiversity loss and alter community dynamics (Burrows et al., 2011; Jetz et al., 2007). We use three independent sets of data to assess the relative merits of these viewpoints in an objective way.

We first examined the causes of species extinctions since 1900 in vertebrates, the best-known taxonomic group. We found that for the 'extinct in the wild' category of amphibian species there were 12 extinctions listing 27 causes but only 11% of these reported climate change, whereas 37% listed habitat loss. The same pattern holds for the nine reptile species extinctions, 42 bird extinctions, and 21 mammal extinctions: 12%, 3%, and 12%, respectively, reported climate change as a precipitating factor whereas habitat loss amounted to 29%, 35%, and 37%, respectively (Table S1). In every case, habitat loss exceeds climate change risk by a factor of three or more.

Second, we quantified contemporary major threats to extant vertebrate populations in the IUCN Red List (see SOM Methods). These data assess population declines across three generations, or over a ten-year period, (whichever is greater); they constitute a robust contemporary global database for population changes for threatened taxa. The majority of listed drivers of population declines were agriculture (production of crops, livestock farming, aquaculture, and tree cultivation) and biological resource use (overexploitation of species through hunting) (Figure 1b). Threats faced by the three vertebrate groups are proportionally similar. The relative magnitude of threats due to land-use change versus climate change again suggests the former exceeds the latter by three to ten times.

It is, of course, an over-simplification to consider threats to populations as discrete; the majority of species experience declines due to a combination of factors (Oliver & Morecroft, 2014; Pounds et al., 2006). To investigate this, the number of IUCN declining species affected by each threat, including climate change, was totaled as a coarse metric of potential interactions. We found that the proportion of declining populations for each type of threat that was additionally threatened by climate change was generally low for amphibians and mammals (~20% across most threat categories) although slightly higher for birds (~30-40%; Figure 1c). Although these proportional threats involving climate change are low, we acknowledge that synergies between climate change and other threats are not yet well understood and some emerging case studies suggest that they could be important. For example, recent fires in Australia highlight that anthropogenic climate change is indeed worsening the threat of fire in some regions (Abram et al., 2021). Elsewhere, agricultural responses to a shifting climatic envelope, and behavior of invasive species and diseases under changing temperature and precipitation, could potentially be catastrophic for native biodiversity in the future. To date, evidence in support of these conjectures is limited and poorly documented.

Third, we examined studies that specifically contrasted future effects of climate change with other anthropogenic drivers (see SOM Methods and Table S2). Among metrics used are changes in species distributions, species abundance, fitness measures, and species richness. In the majority, conventional anthropogenic factors (habitat loss, land-use change, and deforestation) were more important than climate change (61.4%, 27 of 44 studies), a finding primarily driven by conventional drivers trumping climate change in altering species distributions. Attempts to titrate the relative importance of anthropogenic drivers against climate change consistently indicate multiple causes, but climate change is never paramount.

## 2 | CLIMATE CHANGE IS IMPORTANT FOR BIODIVERSITY BUT NOT YET

The contemporary causes of population declines driving species towards extinction are land-use change and exploitation. Maxwell and colleagues (2016) reached a similar conclusion about exploitation and agriculture. Detailed case studies, using a variety of metrics, point to climate change being of less immediate importance than other anthropogenic factors, principally habitat loss. Even in northern latitudes, where climate change might be expected to be the primary force adversely affecting populations, the situation is similar: for endangered species in Canada, 44% of risk assessments identified climate change as a threat, but 56% did not (Naujokaitis-Lewis et al, 2021). Taken together, our examinations and those of others (e.g., Maxwell et al., 2016) reveal that climate change is not the principal driver of current population declines or species extinctions.

Some additional context is needed for the two drivers. First, the debilitating role of agriculture is indisputable (Figure 1b); areas of high biodiversity are attractive for livestock and crop production. This attraction creates an unfortunate feedback loop in which underlying soil nutrients are depleted and further land clearance is often an inevitable result – a process replicated throughout the tropics. A second clear driver of vertebrate population declines is direct exploitation (Figure 1b). Consumption of bush meat is an enormous drain on wild vertebrate populations resulting in significant declines among Asian and

sub-Saharan mammals (Corlett, 2007; Lindsey et al., 2013) driven by people with low income on poor protein diets, those enjoying a recent increase in wealth, and by increases in population density.

## 3 | WHY THE EMPHASIS ON CLIMATE CHANGE?

We suspect that the present emphasis on linking climate change to biodiversity loss has five components. First, climate change can potentially affect wildlife populations in many ways including shifting species' distributions, altering phenology, affecting population demography, decoupling coevolved interactions, changing species interactions, extirpation of range-restricted species, direct habitat loss, and fostering spread of invasives or disease. Given these possibilities, climate change is certainly important, but its potential impact is less "imminent" than habitat loss and overexploitation as causes of local extirpations.

Second, many studies are prospective exercises: long- and middle-distance forecasting has been attempted by literally hundreds of studies (Jetz et al., 2007; Thomas et al., 2004; Urban et al., 2016). Very few conservation efforts are targeted at ameliorating threats that may be severe in half a century from now. Instead, conservation biologists try to tackle present-day problems threatening populations. Put bluntly, why worry about future melting permafrost if woodland caribou *Rangifer tarandus* population size is declining due to timber harvesting removing vital habitat (Nagy-Reis et al., 2021), or worry about the genetic recovery of future black rhinoceros *Diceros bicornis* populations when poaching reduced their global population by 95% in three decades (Berger, 1994). Far too many species will count themselves lucky to run the gamut of climate change if they manage to survive more urgent and direct impacts on their viability.

Third, conservation research is primarily conducted in the Palearctic rather than the tropics (Lawler et al., 2006; Wilson et al., 2016). When research is skewed to well-developed, richer countries with cooler climates and larger carbon footprints, there will be a natural tendency to focus on anthropogenic climate change (Pasgaard et al, 2015). As a consequence of this bias, Western media attention turns to climate change rather than biodiversity loss.

Fourth, it is possible that conservation research that includes climate change as a possible driver of population change may be more fundable than proposals that do not mention it, although we have no empirical evidence to support this.

Fifth, justifiable concerns about global warming have overshadowed anxiety about species extinction. Increasing extreme weather events and rising sea levels effects will lead to starvation, water shortage, mass migration, and conflict over resources. There is a tendency to link these threats to both humans and other species, partly driven by conservation biologists' concern to stop species extinctions drifting from the public eye. Optimistically, solving a single problem, the climate crisis, can be viewed as easier than solving a multitude of threats that constrain our ever-increasing land-use footprint.

## 4 | CONCLUSION

Our analyses demonstrate that climate change is not the dominant factor responsible for declining vertebrate populations; instead, loss of biodiversity is driven by a combination of several important actions, dominated by land-use change and over-exploitation. Maxwell and colleagues (2016) reached a similar conclusion using an orthogonal and more limited data set. We urge conservationists to make greater efforts to reduce contemporary threats: illegal hunting, wildlife trade, the footprint of small-scale agriculture through more efficient and locally intense farming, eradication of feral and other invasive species, and habitat restoration. Conservation biology will have failed as a discipline if it fails to recognize this.

It is worth reiterating that slowing rates of tropical deforestation as well as reducing the wildlife trade would also significantly lower risks of future pathogen outbreaks (Dobson et al., 2020; Bernstein et al. in press). The Covid-19 virus pandemic has already killed 10 million people and rocked the global economy. Reducing tropical deforestation will concomitantly slow rates of climate change, reduce a major threat to biodiversity, and diminish the risk of future pathogen emergence. This creates a "win-win-win" situation for conservation biology that would strengthen the discipline's appeal to economists and politicians. In contrast, a misguided focus on climate change as the major threat to biodiversity undermines the credibility of conservation biology as an evidence-based scientific discipline. Ultimately climate change is containable, particularly if we have enough remaining biodiversity to scrub the atmosphere and store carbon. Extinction is not reversible and land-use change and overexploitation are its primary drivers.

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## AUTHORS CONTRIBUTIONS

TC, JB, and AD conceived of the idea; PW analyzed IUCN data, ZWR the rest of the data; PW wrote the initial draft, TC rewrote it, and TC, JB, and AD revised numerous drafts.

## ETHICS STATEMENT

These meta-analyses contravene no ethical issues.

## DATA AVAILABILITY STATEMENT

Data are available in the supplementary material.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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