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Original Research Article

At a global scale, do climate change threatened species also face a greater number of non-climatic threats?

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ABSTRACT

For many species the threats of climate change occur in a context of multiple existing threats. Given the current focus of global change ecology in identifying and understanding species vulnerable to climate change, we performed a global analysis to characterize the multi-threat context for species threatened by climate change. Utilizing 30,053 species from the International Union for Conservation of Nature's (IUCN) Red List of Threatened Species, we sought to evaluate if species threatened by climate change are more likely threatened by a greater number of non-climatic threats than species not threatened by climate change. Our results show that species threatened by climate change are generally impacted by 21% more non-climatic threats than species not threatened by climate change. Across all species, this pattern is related to IUCN risk status, where endangered species threatened by climate change face 33% more non-climatic threats than endangered species not threatened by climate change. With the clear challenges of assessing current and projected impacts of climate change on species and ecosystems, research often requires reductionist approaches that result in downplaying this multi-threat context. This cautionary note bears relevance beyond climate change threatened species as we also found other (but not all) anthropogenic threats are also similarly associated with more threats. Our findings serve as a reminder that ecological research should seriously consider these potential threat interactions, especially for species under elevated conservation concern.

1. Introduction

Climate-related threats may pose the greatest challenges to conservation in the 21st century (Thomas et al., 2004; Parry, 2007; Rosenzweig et al., 2008; Hooper et al., 2012). Past ecological research has vastly improved our understanding of climate change impacts on biodiversity and how species respond to change (Walther et al., 2002; Rahel and Olden, 2008; Dickinson et al., 2014); including, for example, range (Parmesan and Yohe, 2003) and habitat shifts (Pimm, 2008; Crossman et al., 2012), and food web disruption (Winder and Schindler, 2004; Pörtner and Knust, 2007). Still, despite these and other advances, there is increasing recognition that the interaction between climate stress and other threats can be extremely important (Keith

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et al., 2014) and must be understood comprehensively (Berglund et al., 2013). The multi-threat context of ecological climate change impacts has been the subject of an increasing number of studies at various scales, from populations (Moe et al., 2013) to species (Halpern et al., 2007). In some cases, the potential synergy between climate change and other existing threats may exceed the expected sum of all combined effects (Brook et al., 2008). Until recently, few analyses have explored the magnitude of this multi-threat context at broader scales. Laurance and Useche (2009), for instance, found that because of environmental synergies, species in the tropics are more likely to suffer from a combination of climatic and non-climatic stressors.

Using categorized species threat information from the International Union for Conservation of Nature (IUCN) Red List, we give a first approximation of the multi-threat context faced by species at a global scale. Given the current focus of global change ecology in identifying climate change vulnerable species, we sought to evaluate if species categorized as threatened by climate change are more likely threatened by a greater number of non-climatic threats than species not threatened by climate change. We focused on climate change threat as it is the focus of a rapidly growing area of ecological research that, due to compounding climatic and ecological complexity, often requires reductionist approaches that exclude these potential threat interactions.

2. Methods

2.1. Red List data

The IUCN Red List is the largest collection of global species risk assessments (Keith et al., 2014) and the most widely cited resource for species evaluations and decision-making (Fourcade et al., 2013). Quality standards are rigorous for the nearly 11,000 volunteer reporting IUCN experts – each requiring, at minimum, a master's degree in relevant disciplines (IUCN, 2014). Since 2011 the IUCN adopted the Conservation Management Partnerships' Unified Classification of Direct Threat (UCDT) metric that is used to associate each species to a comprehensive array of 118 threats arranged within 12 comprehensive categories. We used count of threats within the 10 anthropogenic threat categories (excluding "geological events" and "other threats") as the basis for our analyses.

2.2. Data processing

The Red List (v3.2) information, including taxonomy, IUCN Red List category, and threat data were retrieved from the IUCN Red List website (http://www.iucnredlist.org/search) on March 15 2015 using a combination of a web interface and a set of R scripts for information extraction (http://dx.doi.org/10.5066/F7BC3WQT). 76,199 IUCN evaluated species were available for our analysis. At the onset, 'Fungi' ($n = 5$) and 'Protista' ($n = 15$) were excluded from the dataset because sample size limitations would eventually lead to under-representation of these groups. Categories for 'Extinct in the Wild' ($n = 69$) and 'Extinct' ($n = 832$) were also omitted. We did not include species with data deficient ($n = 12{,}775$) assessments, as they have distribution and population gaps (Morais et al., 2013) and their use is discouraged (IUCN, 2014).

After inspecting the data for outliers, *Cnidaria* (corals – $n = 858$) were removed from the analysis, as all species in the group were associated with 15 identical non-climatic threats. Following these outlier removals, distribution of the dataset largely conformed to an expected Poisson distribution. Lastly, since our analysis solely focuses on species under multiple threats, we excluded all species that had no threat information available. Following these removals, a total of 30,053 species were kept for the analysis.

2.3. Data analysis

We calculated the total number of non-climatic threats associated with each species (hereafter, "non-climatic threats") as our dependent variable (DV), which describes the magnitude of a species' multi-threat context. We considered several independent variables (IVs) to explain the number of non-climatic threats across species. First, all species were differentiated as climate change threatened or not based on whether it was listed as threatened by any threat under the "climate change and severe weather" IUCN threat category. We also considered Red List category (*CR* - Critically Endangered, *EN* – Endangered, *VU* – Vulnerable, *NT* – Near Threatened and *LC* - Least Concern) and kingdom (*Plantae* versus *Animalia*) as additional independent variables.

Since our IVs were all categorical without a measure of rank, we used factorial ANOVAs to test their relationships to our DV, both with and without interaction terms. We used Poisson family grouping to address over-dispersion of parameters and additional Chi-square tests to determine the significance and goodness of fit among our explanatory variables. Because we could not ensure the adequate representation in the Red List database of taxonomic or geographic species subgroups, we focused our analyses in exploring global-level patterns. Lastly, we replicated our entire analyses considering the other IUCN threat categories as our dependent variable instead of IUCN's climate change threat status to evaluate the robustness of our climate-change focused analyses.