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Dr. Donald R. Strong

*Ecology* Editor-in- Chief

Dear Dr. Strong,

With this letter, we are submitting to *Ecology* an article manuscript entitled "Large upward shifts in cold-adapted, montane mammals as temperature warms."

This manuscript describes unexpectedly large changes in the elevational ranges of mammal species occurring at mid- to high-elevations in the tallest, most interconnected mountains in the contiguous United States. The only other studies of climate change responses across large spatial scales in the Rockies detected little or no change: almost no local extirpation in American pika (Erb et al. 2011) and no elevational shifts in grasshoppers (Nufio et al. 2010). This is the first comprehensive study of climate change shifts across multiple species in the Southern Rockies for vertebrates, and we document considerable change despite the potential of the Rockies to buffer change due to their size and variability. Overall, most species shifted upward by an average of 122 m, consistent with regional warming. However, we detected more drastic change in montane, cold-adapted mammals that shifted up by an average of 337m or 16% of the montane gradient. In comparison to a range shift review (Chen et al. 2011), Colorado mammals shifted upward by 85 m per decade compared to the average of 11 m per decade in other studies. Conservation efforts are thus critical for cold-adapted, montane mammals in the southern edge of their distributions. If this rate of upward shift continues unabated, montane species will be losing considerable habitat area and will be at risk of local extinction within another several decades.

In addition to the critical ecological and conservation importance of the detected range shifts, we also present (a) a new methodology for compiling range shift datasets, (b) Bayesian undersampling models, and (c) trait-based analyses. First, we use a broader—both temporally and spatially—dataset compiled from well-vetted specimen records across 100 years of records from museums and literature for two mountain ranges in Colorado to detail historical elevational ranges. Then we use over a decade of contemporary mammal trapping by the authors in those two mountains, plus other researchers’ data and specimens, to detail contemporary elevational ranges. This methodology allows more species to be tracked for climate change responses than would be possible using only historical transect studies like the rare Grinnell data. Second, we present new Bayesian undersampling models as an alternative to occupancy models that rely on repeat samples from single sites, which are not available using historical compilations. This method leverages individual-level detection probabilities for each species, the number and patchiness of detections across 50 m bands of elevation, and a decaying likelihood of presence from last known detections. The computer code is included and this method is applicable to many other historical datasets. Lastly, and importantly, this is the first trait-based analysis on montane gradients to attempt to disentangle the variability in climate change responses among species—upward, downward shifts and no detected change. We examine if body size, activity times, elevational affiliations, high latitude ranges, and mountain location within the species’ biogeographic range or near the species’ geographic range edge is associated with predicted or non-predicted responses. We detected strong evidence that species traits related to cold adaptation were more likely to respond as predicted, whereas low-elevation species adapted to warmer, drier conditions were most likely to display trends not predicted by warming temperatures. Overall, we feel this work is critical for mammal conservation on a warming planet and for the advancement in studies of organismal responses to climate change.

We followed the *Ecology* guidelines for an article: the abstract is under 300 words and the length is 29 pages, including four figures and no tables. Supplementary Information includes Supplementary Methods (including computer code), Supplementary Results, and the dataset. All authors have read and approved the manuscript in its current form. This manuscript and the climate change dataset is unpublished in print or online, and it is not under consideration elsewhere. As this work included vertebrates, the CU IACUC committee approved each year of our field research, as did the National Park Service when necessary.

Thank you for your consideration.

Yours sincerely,



Dr. Christy McCain for Drs. King & Szewczyk