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Climate change driving global shifts in functional diversity patterns

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Anthropogenic climate change poses a threat to ecosystems and the biodiversity they host. This threat will only become more severe as global temperatures continue to rise. Few studies about biodiversity responses to climate change attempted global assessments, and those that did were often limited in spatial detail. Moreover, previous research mostly focussed on species richness, disregarding biodiversity's multidimensional character and providing only a loose link to ecosystem functioning. In addition, terrestrial ecosystems generally receive the most attention in research, whereas especially marine ecosystems are comparatively neglected.

To fill these gaps, we assessed climate change effects on the global functional diversity of terrestrial, freshwater, and marine ecosystems at the grid-cell level. Climate change at various warming levels reflected changes in thermal and hydrological conditions, going beyond climate averages. Functional richness, evenness, and divergence captured three complementary facets of functional diversity. Terrestrial ecosystems were represented by amphibians (7,727 species), and freshwater and marine ecosystems by fish (11,425 and 4,150 species), with some of their trait values being imputed. Two dispersal assumptions allowed either no dispersal (i.e., only range contractions and extirpations) or maximum dispersal within certain boundaries (i.e., also range expansions and colonizations).

Functional diversity responses to climate change exhibited strong spatial variation. Hotspots in which the full trait space was affected occurred especially in India for terrestrial ecosystems, in the Amazon River basin for freshwater ecosystems, and in the Coral Triangle for marine ecosystems. The three functional diversity facets showed contrasting patterns. In regions with biodiversity changes, functional richness almost always declined, while functional evenness and divergence sometimes increased. Only amphibians also experienced gains in functional richness in some locations when assuming maximum dispersal. Although changes in phenology and behaviour of species as means of climate change adaptation have not been considered in this study, it still provides a clearer picture of global functional diversity patterns under current conditions and future climate scenarios, which can support conservation strategies aiming at biodiversity preservation.