Species extinctions in biodiversity hotspots under scenarios of global climate change

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Although global warming is recognized as a key threat to biodiversity, few studies have assessed the magnitude of this threat at a global scale. We used major vegetation types (biomes) as proxies for natural habitats and, based on projections of future biome distributions under doubled-CO_2 climates, calculated changes in habitat area and associated extinctions of endemic species from biodiversity hotspots. Because of numerous uncertainties in this approach, we undertook a series of sensitivity analyses. First, to provide a broad sample of future projections, we used a suite of 14 combinations of 2 GVMs and 7 GCMs developed at the global level at a resolution of 0.5° latitude/longitude. Second, as a proxy for different degrees of habitat specificity, we varied the number of classes in our biome classification scheme. Third, to examine variation in migration capabilities, we examined two migration scenarios: a "perfect migration scenario," in which habitat loss was assumed to have occurred only if new biome types invaded a hotspot, and a "zero migration" scenario, in which habitat lost was equated with biome change. Species extinctions were estimated using both standard species-area relationships and more conservative endemic-area relationships. Projected numbers of extinctions varied enormously across the sensitivity analyses, from extinctions of <1 % of the total (tens of species) to >10% of the total (>15,000 species of plants and >1,000 species of vertebrates). By far the greatest source of variation was the migration scenario, indicating the potential importance of migration in reducing extinctions under global warming. Global plant extinctions averaged 331 species for the perfect migration scenario, but 7,890 for the zero migration scenario. The biome classification method was the next most influential factor, with plant species extinctions under a coarse classification averaging 19% of those under a narrow classification. A final factor that importantly influenced extinctions was the Global Vegetation Model, with plant extinctions for BIOME3 averaging 32% of those for MAPSS. The most vulnerable hotspots included the Cape Floristic Region, Caribbean, Mediterranean Basin, South-western Australia, and Tropical Andes, each of which showed the potential to lose thousands of species. Several lines of evidence suggest that our upper estimates of habitat loss are more likely to apply than our lower estimates, indicating the potential for extensive species extinctions under climate change, which rival those due to deforestation. Research priorities for reducing uncertainties are discussed.