# Scientists map speed of climate change

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New study finds that the average ecosystem will need to shift about a quarter mile per year to keep pace with global climate change.

From beetles to barnacles, pikas to pine warblers, many species are already on the move in response to shifting climate regimes. But how fast will they—and their habitats—have to move to keep pace with global climate change over the next century? In a new study, a team of scientists including Dr. Healy Hamilton from the California Academy of Sciences have calculated that on average, ecosystems will need to shift about 0.42 kilometers per year (about a quarter mile per year) to keep pace with changing temperatures across the globe. Mountainous habitats will be able to move more slowly, since a modest move up or down slope can result in a large change in temperature. However, flatter ecosystems, such as flooded grasslands, mangroves, and deserts, will need to move much more rapidly to stay in their comfort zone—sometimes more than a kilometer per year. The team, which also included scientists from the Carnegie Institute of Science, Climate Central, and U.C. Berkeley, will publish their results in the December 24 issue of Nature.

"One of the most powerful aspects of this data is that it allows us to evaluate how our current protected area network will perform as we attempt to conserve biodiversity in the face of global climate change," says Healy Hamilton, Director of the Center for Applied Biodiversity Informatics at the California Academy of Sciences. "When we look at residence times for protected areas, which we define as the amount of time it will take current climate conditions to move across and out of a given protected area, only 8% of our current protected areas have residence times of more than 100 years. If we want to improve these numbers, we need to both reduce our carbon emissions and work quickly toward expanding and connecting our global network of protected areas."

The team calculated the velocity of global climate change by combining data on current climate and temperature regimes worldwide with a large suite of climate model projections for the next century. Their calculations are based on an "intermediate" level of projected greenhouse gas emissions over the next century (the A1B emissions scenario from The Intergovernmental Panel on Climate Change). Under these emissions levels, the velocity of climate change is projected to be the slowest in tropical and subtropical coniferous forests (0.08 kilometers per year), temperate coniferous forests (0.11 kilometers per year), and montane grasslands and shrublands (0.11 kilometers per year). The velocity of climate change is expected to be the fastest in flatter areas, including deserts and xeric shrublands (0.71 kilometers per year), mangroves (0.95 kilometers per year), and flooded grasslands and savannas (1.26 kilometers per year).

The vulnerability of these respective biomes depends not only on the average velocity of climate change they will experience, but also on the sizes of the protected areas in which they are found. For instance, while the velocity of climate change is expected to be high in deserts, this threat is mediated by the fact that protected areas for deserts tend to be larger. On the other hand, the small size and fragmented nature of most protected areas in Mediterranean temperate broadleaf and boreal forest biomes makes these habitats particularly vulnerable.

What does this mean for beetles, barnacles, and other groups of species? The researchers note that their index estimates the velocities and residence times of climates, not species. Individual species that have a wide tolerance for a range of temperatures may be able to adapt in place as the climate around them shifts. However, for species that can only tolerate a narrow band of temperatures, the velocity estimates in the study are a close approximation for the migration speeds needed to potentially avoid extinction. Nearly a third of the habitats in the study have velocities higher than even the most optimistic plant migration estimates, suggesting that plants in many areas will not be able to keep up with the shifting climate. Even more problematic is the fact that natural habitats have been extensively fragmented by human development, which will leave many species with "nowhere to go," regardless of their migration rates.

The team's results not only underscore the importance of lowering greenhouse gas emissions—they also provide data for conservation managers who must now plan for the impact of global climate change. The research was funded by the Gordon and Betty Moore Foundation and the Stanford University Global Climate and Energy Project.

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