As climate shifts, species will need to relocate, and people may have to help them

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A die-off of California blue oaks (Quercus douglasii) occurred after the extreme drought of 2014, including many of the trees on this hillside in Griswold Hills, southern San Benito County. Credit: Ryan O'Dell, BLM Central Coast Field Office

Climate change is already affecting plants and animals worldwide and is a growing threat to biodiversity, adding a new layer to the existing challenges of habitat loss, invasive species, pollution, and overexploitation.

A new study, published in the April issue of *Biological Conservation*, surveyed the recommendations of scientists for managing biodiversity in the face of climate change, providing a summary of practical guidance and identifying areas in need of further research.

"There is an enormous need to think ahead and be proactive, as well as a growing recognition that we have to act now," said senior author Erika Zavaleta, professor of ecology and evolutionary biology at UC Santa Cruz.

The climatic conditions to which species have adapted are shifting across the geography of a warming planet, leaving plants, animals, and entire ecosystems in danger of being stranded in places where they can no longer survive.

"Climate change is causing a mismatch between where species are now and where the habitat and conditions suitable for them are moving," Zavaleta said. "We need to think about where suitable habitats for different ecological communities will be in the future, and how they can get there."

Climate change is nothing new in the history of our planet, and species have moved and evolved in response to it. But current changes driven by the burning of fossil fuels are happening much faster than past climatic shifts. In addition, the current fragmentation of natural habitats makes it much harder for species to move than it was in the past.

"The need to move is greater while the ability to move is less," Zavaleta

said. "Things are changing, and we need to assist the adaptive responses of the natural world if we don't want to lose both the species and the amenities they provide for people. We depend on natural ecosystems, and helping them adapt is not separate from helping people and communities adapt to climate change."

The new paper updates an earlier survey published in 2009 by Zavaleta and Nicole Heller, then a postdoctoral researcher in Zavaleta's lab. Blair McLaughlin, an assistant professor of ecology at Hampshire College in Massachusetts who earned her Ph.D. in Zavaleta's lab and is currently a visiting scholar at UCSC, led the new analysis and is first author of the paper.

The researchers found that current recommendations have gone beyond conceptual guidance to provide more specific and actionable ideas about strategies to implement for particular ecosystems or species. "There has been a lot more on-the-ground implementation of some of these approaches," Zavaleta said.

Longstanding conservation measures, such as protecting and restoring ecosystems and increasing their connectivity, remain critically important in the context of climate change. To address climate-related challenges in particular, however, three novel strategies have received growing attention in recent years: climate change refugia, assisted migration, and protecting climate-adaptive genetics.

"If you think of a valley oak, with acorns that are carried only a short distance by birds and are only viable in the year they are dropped, you can have connectivity but the trees are not going to move at the same pace as the drying that's happening in parts of their range," Zavaleta explained. "So do we watch their range contract and disappear? Or do we bank them as seedlings in botanical gardens? And what do we need to be learning now about how to put them back out into the landscape

where they can survive?"

Identifying and protecting areas that can serve as a refuge for species threatened by climate change fits easily within the traditional framework of biodiversity conservation. Creating climate change refugia can include habitat restoration efforts, such as restoring woodland streams to raise the water table.

Assisted migration includes "assisted gene flow," which involves moving organisms between populations within a species' existing range to preserve genetic diversity, as well as moving species beyond their historical range. This kind of direct intervention to move threatened species into areas where they could have a better chance of survival in the future is not without controversy, however. Concerns include potential impacts on other organisms after translocation, as well as the possibility of harming the targeted population if translocated individuals do poorly in the new site.

"I feel like the devil is in the details, but I also think translocation has been mischaracterized as an untested strategy, when actually it has been practiced for over a century and probably longer," Zavaleta said. "Forestry, for example, has a long practice of planting trees from a wide range of locations in areas that are being restored. But we do have a lot more to learn, especially for certain animals and species that are not well understood."

Scientists also want to protect the genetic diversity of species, especially genetic variants that might be better adapted to hotter, drier conditions. "These are the very conditions that we are likely to see more of in the future," McLaughlin said. "Preserving the climate-adaptive evolutionary potential of a species before it's lost is critical to make sure we have the genetic resources we need to help species adapt to novel climate futures."

For example, oaks at the southern end of their species' range or that survived a big die-off during a drought might have genetic traits that enhance survival in worsening conditions. Seeds and seedlings from those trees could be protected in a "gene bank" so that those traits are not lost.

McLaughlin currently leads a pilot project to create a gene bank for blue oaks in California, which suffered a pronounced die off in the southern part of their distribution during the last drought.

"We're planting out seedlings from blue oaks that are adapted to hot dry conditions, just so they're banked there in case there are more die offs," she said. "In California, it's become clear that we need to do this now."

More information: B.C. McLaughlin et al, Conservation strategies for the climate crisis: An update on three decades of biodiversity management recommendations from science, *Biological Conservation* (2022). DOI: 10.1016/j.biocon.2022.109497

Nicole E. Heller et al, Biodiversity management in the face of climate change: A review of 22 years of recommendations, *Biological Conservation* (2008). DOI: 10.1016/j.biocon.2008.10.006

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