Stanford researchers rethink 'natural' habitat for wildlife

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Lonchophylla robusta is one of many bat species found in Panama and Costa Rica, where Stanford scientists studied wildlife populations in agricultural areas. Credit: Matthew Champoux

Protecting wildlife while feeding a world population predicted to reach 9 billion by 2050 will require a holistic approach to conservation that considers human-altered landscapes such as farmland, according to Stanford researchers.

Wildlife and the natural habitat that supports it might be an increasingly scarce commodity in a world where at least three-quarters of the land surface is directly affected by humans and the rest is vulnerable to human-caused impacts such as climate change. But what if altered agricultural landscapes could play vital roles in nurturing wildlife populations while also feeding an ever-growing human population?

A new study, published April 16 in the journal *Nature* and co-authored by three Stanford scientists, finds that a long-accepted theory used to estimate extinction rates, predict ecological risk and make conservation policy recommendations is overly pessimistic. The researchers point to an alternative framework that promises a more effective way of accounting for human-altered landscapes and assessing ecological risks.

Current projections forecast that about half of Earth's plants and animals will go extinct over the next century because of human activities, mostly due to our agricultural methods. "The extinction under way threatens to weaken and even destroy key parts of Earth's life-support systems, upon which economic prosperity and all other aspects of human well-being depend," said co-author Gretchen Daily, the Bing Professor in Environmental Science at Stanford and senior fellow at the Stanford Woods Institute for the Environment.

But that grim future isn't a foregone conclusion.

"Until the next asteroid slams into Earth, the future of all known life hinges on people, more than on any other force," Daily said.

Nature is not an island

Conservationists have long assumed that once natural landscapes are fractured by human development or agriculture, migration corridors for wildlife are broken, blocking access to food, shelter and breeding

grounds. A scholarly theory was developed to estimate the number of species in such fractured landscapes, where patches of forest surrounded by farms resemble islands of natural habitat.

The "equilibrium theory of island biogeography" is a pillar of biological research – its elegant equation to estimate the number of species in a habitat has almost reached the status of a scientific law, according to Chase Mendenhall, a Stanford doctoral student in biology and the study's lead author. The theory drives the default strategy of conserving biodiversity by designating nature reserves. This strategy sees reserves as "islands in an inhospitable sea of human-modified habitats" and doesn't adequately account for biodiversity patterns in many human-dominated landscapes, according to the Stanford study.

"This paper shows that farmland and forest remnants can be more valuable for biodiversity than previously assumed," said Daniel Karp, who earned his PhD in biology at Stanford in 2013 and is currently a NatureNet postdoctoral fellow at the University of California, Berkeley.

"If we're valuing coffee fields and other human-made habitats at zero, we're doing a disservice to ourselves and wildlife," Mendenhall said.

To test the island theory against a more holistic theory of agricultural or countryside biogeography, the researchers turned to bats acutely sensitive to deforestation. The study focused on bat populations within a mosaic of forest fragments and farmland in Costa Rica and on islands in a large lake in Panama. The researchers also did a meta-analysis of 29 studies of more than 700 bat species to bolster and generalize their findings globally.

Island biogeographic theory accurately predicted bats' responses to forest loss on the Panamanian islands system, but didn't come close to accurately forecasting similar responses in the Costa Rican countryside

landscape. For example, the island theory predicted that the Costa Rican coffee plantations would have inadequate habitat to sustain a single species of bat. In reality, plantations in the countryside typically supported 18 bat species, compared to the 23 to 28 supported by tropical forest fragments and nature reserves.

"Conservation opportunities for tropical wildlife are tightly linked to adequate management of these human-modified habitats," said co-author Christoph Meyer, a researcher at the University of Lisbon's Center for Environmental Biology.

Overall, as forest cover disappeared, the rate of species loss was "substantially and significantly higher" in the island ecosystem, and species abundances were "increasingly uneven" compared to the countryside ecosystem, the study found.

The reason for the discrepancies, according to the study's authors, is that island biogeographic theory was originally based on actual islands surrounded by water, and does not account for factors such as a countryside landscape's ability to support more species and slow extinction rates compared to true island ecosystems. Especially in the tropics, island biogeographic theory's application is "distorting our understanding and conservation strategies in agriculture, the enterprise on which the future of biodiversity most critically hinges," the study's authors wrote.

"Not only do more species persist across the 'sea of farmland' than expected by island biogeographic theory, novel yet native species actually thrive there," said co-author Elizabeth Hadly, the Paul S. and Billie Achilles Professor in Environmental Biology at Stanford and senior fellow at the Stanford Woods Institute for the Environment. "This indicates that human-altered landscapes can foster more biological diversity than we anticipated."

A new approach

The fate of much of the world's wildlife is playing out in human-altered landscapes that are increasingly threatened by chemical inputs such as herbicides and pesticides. Biodiversity is not the only loser. People are losing many of nature's benefits such as water purification provided by forests and wetlands and pest control provided by birds and bats.

The study's findings point to the need for new approaches that integrate conservation and food production, to make agricultural lands more hospitable to wildlife by reducing chemical inputs, preserving fragments of forest and other natural habitats and rewarding farmers and ranchers for the benefits that result.

"A theory of countryside biogeography is pivotal to conservation strategy in the agricultural ecosystems that comprise roughly half of the global land surface and are likely to increase even further in the future," the researchers wrote.

Provided by Stanford University