Diversified farming practices might preserve evolutionary diversity of wildlife

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The Fiery-billed Aracari (Pteroglossus frantzii) declines in intensive monocultures but thrives in forest reserves and diversified farms. Credit: Daniel Karp

As humans transform the planet to meet our needs, all sorts of wildlife continue to be pushed aside, including many species that play key roles in Earth's life-support systems. In particular, the transformation of forests into agricultural lands has dramatically reduced biodiversity around the world.

A new study by scientists at Stanford and the University of California, Berkeley, in this week's issue of *Science* shows that evolutionarily distinct species suffer most heavily in intensively farmed areas. They also found, however, that an extraordinary amount of evolutionary history is sustained in diversified farming systems, which outlines a strategy for balancing agricultural activity and conservation efforts.

"This work is urgent, because humanity is driving about half of all known life to extinction, mostly through agricultural activities to support our vast numbers and meat-rich diets," said Gretchen Daily, the Bing Professor in Environmental Science at Stanford and senior author on the paper. "How are we restructuring the tree of life? What are the implications for people? And what can we do to harmonize farming with nature?"

Calculating evolutionary history

The findings arise from a 12-year research project conducted by Stanford scientists at the intersections of farms and jungles in Costa Rica. Much of the research has focused on how farming practices can impact biodiversity, and has gone so far as to establish the economic value of pest-eating birds and crop-pollinating bees.

The researchers have developed an extraordinarily detailed data set to show human impacts on phylogenetic diversity, a measure of the evolutionary history embodied in wildlife – in this case, birds.

For example, an area inhabited by two species of blackbirds that diverged only a couple of million years ago would have relatively low phylogenetic diversity. The tinamou – a speckled, football-shaped flightless bird – diverged from blackbirds about 100 million years ago, and if it moved into the blackbird's habitat, the phylogenetic diversity of that area would increase significantly.

"If you have an area with lots of closely related species, you won't have a lot of phylogenetic diversity," said co-lead author Luke Frishkoff, a biology doctoral student at Stanford. "The further apart species are on the evolutionary tree, the more phylogenetic diversity your system represents."

The biologists counted almost 120,000 birds, hailing from nearly 500 species, in three different types of habitats in Costa Rica: untouched forest reserves; farmlands with multiple crops and small patches of forest; and intensive farmlands consisting of single crops, such as sugar cane or pineapple, with no adjoining forest areas. They then analyzed the species spread across those types of places and calculated phylogenetic diversity in each.

The findings were bad and good. Not surprisingly, the diversified farmlands supported on average 300 million years of evolutionary history fewer than forests. But they retained an astonishing 600 million more years of evolutionary history than the single crop farms.

"The loss of habitat to agriculture is the primary driver of diversity loss globally, but we hadn't known until now how agriculture affected diversity in an evolutionary context," said study co-lead author Daniel Karp, who began working on this project while he was a doctoral student at Stanford and has continued it as a research fellow at UC Berkeley. "We found that forests outperform agriculture when it comes to supporting a larger range of species that are more distantly related."

But the fact that diversified farms conserve much more phylogenetic diversity than intensive agriculture is encouraging.

"It shows how important it is for biodiversity conservation to surround protected areas with productive forms of diversified agriculture, whenever possible," said co-author Claire Kremen, a professor of environmental science, policy and management at UC Berkeley.

Saving a species

The authors trace the decline of phylogenetic diversity in farmland to the fact that evolutionarily distinct species tend to require niche habitats for survival, and these are often wiped out in developed lands.

While sparrows are adept at finding shelter in farmlands and are happy to eat a variety of seeds found in those areas, the tinamou and other evolutionarily distinct species are highly dependent on jungle habitats and have very specific needs such as diet that can only be met in those environments.

The researchers also outline a theory that human agriculture is simply tipping the scale in favor of species that trace their origin to similar conditions.

"Natural savannahs share some of the characteristics of diversified agriculture," Frishkoff said. "We find some evidence that birds that evolved in those types of habitats, such as blackbirds and sparrows, are doing better in those habitats today."

Preserving biodiversity and phylogenetic history is critical for both healthy ecosystems and prosperous farms, Frishkoff and Karp said. Different species specialize in keeping different pest insects under control, in pollinating the many flowering trees and other plants in tropical landscapes, and then in dispersing their seeds.

"Having just sparrows in an ecosystem is like investing only in technology stocks: If the bubble bursts, you lose," Frishkoff said. "You want to have a truly diversified ecosystem, with an array of species each contributing different benefits. This work really highlights the need to preserve native tropical forest, and whenever possible to make agricultural systems as wildlife friendly as possible. Even relatively modest increases in vegetation on farms can support diverse lineages of birds."

More information: "Neotropical agriculture reduces phylogenetic diversity and favors closely related birds," by L.O. Frishkoff et al. www.sciencemag.org/lookup/doi/ … 1126/science.1254610

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