New view of species interactions offers clues to preserve threatened ecosystems

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A blue magpie (Urocissa ornate), native to the rainforests of Sri Lanka, was photographed near the Sinharaja Forest Reserve, a World Heritage site that was part a new study of ecosystem diversity by UC San Diego evolutionary biologist Professor Wills and his colleagues. Credit: Christopher Wills, UC San Diego

As the health of ecosystems in regions around the globe declines due to a

variety of rising threats, scientists continue to seek clues to help prevent future collapses.

A new analysis by scientists from around the world, led by a researcher at the University of California San Diego, is furthering science's understanding of species interactions and how diversity contributes to the preservation of ecosystem health.

A coalition of 49 researchers examined a deep well of data describing tree species in forests located across a broad range of countries, ecosystems and latitudes. Information about the 16 forest diversity plots in Panama, China, Sri Lanka, Puerto Rico and other locations—many in remote, inaccessible areas—had been collected by hundreds of scientists and students over decades.

Lead researcher Christopher Wills, an evolutionary biologist and professor emeritus in the UC San Diego Division of Biological Sciences, says the new study addresses large questions about these complex ecosystems—made up of trees, animals, insects and even bacteria and viruses—and how such stunning diversity is maintained to support the health of the forest.

The new analysis, believed to be the most detailed study of such an enormous set of ecological data, is published in the journal *PLOS Computational Biology*.

Mora excelsa trees with giant buttresses form a prominent part of the pristine rainforest of Guyana. Credit: Christopher Wills, UC San Diego

"Observational and experimental evidence shows that all ecosystems are characterized by strong interactions between and among their many species. These webs of interactions can be important contributors to the preservation of ecosystem diversity," said Wills.

The authors note, however, that many of these interactions—including those involving microscopic pathogens and the chemical defenses mounted by their prey—are not easy to identify and analyze in ecosystems that feature tens to hundreds of millions of inhabitants.

The researchers employed a detailed computational tool to extract hidden details from the forest census data. Their new "equal-area-annulus" method identifies pairs and groups of tree species that show unusually high or low levels of between-species interactions affecting their recruitment, mortality and growth. The authors found, unexpectedly, that closely-related pairs of tree species in a forest often interact weakly with each other, while distantly-related pairs can often interact with surprising strength. Such new information enables the design of further fieldwork and experiments to identify the many other species of organisms that have the potential to influence these interactions. These studies will in turn pave a path to understanding the roles of these webs of interactions in ecosystem stability.

Most of the thousands of significant interactions that the new analysis revealed were of types that give advantages to the tree species if they are rare. The advantages disappear, however, when those species become

common. Some well-studied examples of such disappearing advantages involve diseases of certain species of tree. These specialized diseases are less likely to spread when their host trees are rare, and more likely to spread when the hosts are plentiful. Such interaction patterns can help to maintain many different host tree species simultaneously in an ecosystem.

At Manu Park in Peru, ants are seen fiercely protecting a young Cecropia tree. Such mutually beneficial interactions are an essential part of ecosystem diversity. Credit: Christopher Wills, UC San Diego

"We explored how our method can be used to identify the between-species interactions that play the largest roles in the

maintenance of ecosystems and their diversity," said Wills. "The interplay we have found between and among species helps to explain how the numerous species in these complex ecosystems can buffer the ecosystems against environmental changes, enabling the ecosystems themselves to survive."

Moving forward, the scientists plan to continue using the data to help tease out specific influences that are essential to ecosystem health.

"We want to show how we can maintain the diversity of the planet at the same time as we are preserving ecosystems that will aid our own survival," said Wills.

More information: Christopher Wills et al, Interactions between all pairs of neighboring trees in 16 forests worldwide reveal details of unique ecological processes in each forest, and provide windows into their evolutionary histories, *PLOS Computational Biology* (2021). DOI: 10.1371/journal.pcbi.1008853

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