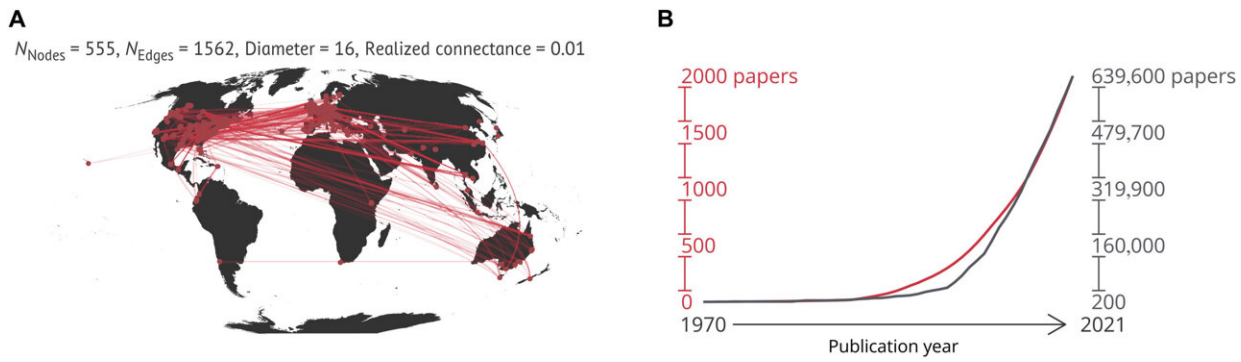
Traditional methods cannot give us the insights we need to understand changing ecosystems, says study

June 22 2023



The study of ecological complexity in space and time. (A) Global network of collaborations including all authors from the articles that referred to "ecological complexity" in their title or keywords (n = 172). Points represent researchers' affiliation addresses, and lines indicate collaboration between authors. (B) Cumulative production (from 1970 to 2021) between articles mentioning "complexity" in their titles and abstracts including all scientific fields (gray line) and, separately, for ecology and environmental sciences, as approximated by the search term "ecological complexity" (red line). Credit: *Science Advances* (2023). DOI: 10.1126/sciadv.abq4207

If we want to face up to the challenges posed by climate change and other global environmental changes, we need to bring complexity science into the mix with ecology and biodiversity conservation.

In a recent study, published in *Science Advances* Dr. Federico Riva, Dr. Caio Graco-Roza and colleagues lay out a path to make this happen, and they're hopeful about the potential for breakthroughs in ecology and conservation biology.

Earth is filled with intricate, complex systems that we're still learning to understand. From the global financial market to the workings of the human brain, and even down to something as seemingly simple as a flock of birds changing direction or fireflies' glowing lights, complex systems are all around us. In fact, Earth itself is a complex system.

While different types of complex systems are generally hard to predict, they share certain commonalities that can help us in understanding them better. This is where complexity science comes in—it's the field of study that looks for the shared principles behind all types of complex systems. It's especially important when it comes to understanding our environment because ecosystems are prime examples of complex systems. And with human activities changing these ecosystems at an unprecedented pace, we need to get a handle on this complexity.

"As scientists, we love to use the word 'complex'", says Dr. Federico Riva, Assistant Professor at VU Amsterdam, "but complexity is a tricky term to pin down. If we're not clear about what we mean by complexity, it can generate confusion, slowing down our efforts to understand how human activities are affecting ecosystems."

But he sees hope in complexity science, saying, "Traditional methods might not be up to the task of studying certain aspects of ecosystems, but complexity science offers a new perspective. We need to make the most of it, which starts with understanding the prerogatives of complex system, and the goals and approaches of complexity science."

To illustrate this point, consider a patch of forest. This ecosystem is a

complex system, made up of not only trees, but also of countless species of animals, insects, and microorganisms, all interacting with each other and with the non-living parts of the environment, like the soil and the climate.

Now imagine that humans start to cut down some of the trees for timber. This perturbation of the system will change not only which trees and animals remain in the forest, but also how these components interact with each other. By exploring the connections among the parts that compose the forest, and more broadly the patterns that might emerge at different organizational levels as this system changes, complexity science could help us predict what timber harvesting means for the forest as a whole.

Dr. Caio Graco-Roza, a postdoctoral fellow at the University of Helsinki, says, "We took a deep dive into environmental science research articles to understand what authors had in mind when they talked about ecological complexity. What we found was that there's a lot of interest around the world in studying complexity in ecology."

However, he adds, "this research isn't always in line with the key principles of complexity science such as nonlinearities, stability, and resilience." But he sees some common ground, especially when it comes to authors framing their work around basic theory, scaling, and macroecology—three paradigms central to complexity science.

As we continue to experience accelerating change in climate and land use, organizing the study of complexity has great potential to increase our understanding of the natural world with novel ideas, techniques, and perspectives.

More information: Federico Riva et al, Toward a cohesive understanding of ecological complexity, *Science Advances* (2023). DOI:

10.1126/sciadv.abq4207