When looking at species declines, nuances and long-term data are important

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The scientific process is an iterative and collaborative journey. Research is published, others can weigh in on results, and hypotheses can be corroborated, refuted, or further refined and tested. Though it may seem

like second guessing or even become contentious in some cases, this often overlooked aspect of the scientific method makes science better by continuing to challenge scientific assertions, thereby expanding and deepening our understanding.

An example of this process has been published this month in *Proceedings of the National Academy of Sciences*, in a collaboration between researchers from UConn, Louisiana State University, and the University of Puerto Rico. This new paper is a follow-up to an earlier response published in the same journal in 2018 that told of a collapsing food web and insect declines that were taking place in Puerto Rico, specifically as a result of global warming.

UConn Board of Trustees Distinguished Professor of Ecology and Evolutionary Biology and Executive Director of the Institute of the Environment, Mike Willig, along with his collaborators, have been working in Puerto Rico on long-term ecological research projects for decades, so when the paper came out, they took notice. The team includes lead author Timothy Schowalter and Manoj Pandey of LSU, Steven Presley, also of UConn, and Jess Zimmerman of the University of Puerto Rico.

"When we saw the initial paper and the claims of food web collapse we said, "Well that is news to us!" But perhaps we weren't looking in the right places, or considering all of the possibilities. So we tried to, as science requires, see if the results were replicable or repeatable," Willig says.

Willig explains that as insect populations appear to be on the decline in other areas of the world, the original paper on insect decline in Puerto Rico was among the first to claim declines due to global warming in a tropical setting. Willig and his collaborators decided to take a second look to see if they could corroborate the claims.

"We were not able to arrive at the same conclusions for a variety of reasons. The world is complex and there were a lot of problematic issues with the original research," he says.

Willig says the data that the authors of the initial paper selected and analytical approaches that they used were at the root of the problem. Critically, the original paper did not consider the complexities of the system, notably that Puerto Rico endures frequent hurricanes and tropical storms.

Nuances and long-term data changed the picture when looking at the original paper's hypothesis, says Willig.

"Many studies are like that first study, in which part of the analyses involved two datasets, in this case taken 30 years apart. In contrast, our data looked at 29 years of annual research. Data can be consistent with one hypothesis but that doesn't make it right. Additionally, ecological research projects are often snapshots in time that correspond to the length of a grant, 3-5 years," says Willig. "That's why we're fortunate to have long-term data to disentangle the effects of warming from hurricane impacts and subsequent ecological succession."

Noting the flaws from the first study, the team used this long-term exploration as springboard to look deeper into their data to uncover trends of insect abundance.

"Puerto Rico is a disturbance-mediated environment where there are frequent hurricanes. Ecosystems in these disturbance-mediated environments are predisposed from an evolutionary perspective to be resistant to these storms," says Willig.

After a storm has blown through and brought down trees, the canopy is gone, temperatures on the ground increase, and leaves and other detritus

become food for opportunists. Though a disaster for some species, these post-disturbance conditions lead to the perfect circumstances for a population boom in other species.

"The prediction is that, due to global warming, there will be an increase in the frequency of these high energy storms in the Caribbean. Storms will happen more often so that resident species will be evolving in a world dominated by more frequent hurricanes where habitats will represent early successional stages. The climatic environment and associated plant communities may move outside of tolerance limits of constituent animal species," says Willig.

"We see no species extinction on the site yet," he says, but Willig notes that perhaps the original paper was right for the wrong reasons. Insect declines may not happen directly due to global warming, but an increased hurricane frequency and intensity due to climate change could eventually push species beyond their limits.

"One of the cool things that came out of our study is that the hypothesis from the original food web collapse paper lead us to reanalyze our data in a way that we may not have done as quickly. It jarred us, it accelerated our desire to look at the data from multiple perspectives to try to disentangle the relative importance of warming, hurricanes, and subsequent succession on the abundances of animal species, which is part of the self-correcting process of science. It also forces you to look outside the box and to examine your data to see how you can use it to distinguish between alternative hypotheses," says Willig.

The length of time over which data are collected adds value to those data. Long-term experiments are important for capturing the full story and nuances within a system. Willig likens the situation to regular medical checkups:

"The regular collection of data is important, like having annual checkups with your doctor. You may not be diabetic yet, but your sugar levels may have been gradually increasing over the past 10 years, suggesting that there may be a problem. If you aren't doing regular checkups of the environment we will not have that early warning that environmental problems are on the horizon. It is the same with consistency, you can't fairly examine trends if you don't have comparable data at the same locations over a long term to assess ecosystem health."

Willig stresses this new paper does not deny climate change is impacting insects around the world, but he emphasizes the need for more long-term monitoring of species abundances, and associated climatic and habitat data everywhere, to better understand what is going on in this time of rapid changes:

"What we are saying is that data are inadequate to show that global warming in Puerto Rico had an effect on the flora and fauna on the island, and in fact, we show that other climate change effects related to increasing hurricane frequency and intensity play a dominate role. Without long-term data from throughout the world, we don't know how general our result is compared to that other sites. It is necessary to have a network of sites collecting similar data in similar ways to see if a pattern is general regardless of geographic context."

More information: Timothy D. Schowalter et al. Arthropods are not declining but are responsive to disturbance in the Luquillo Experimental Forest, Puerto Rico, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2002556117

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