Predicting climate impacts on ecosystems will require scientists to widen the lens

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Most research on climate change ecology is limited to the impacts of a single climate variable, such as temperature or water availability, on one trophic level at a time—and often on a single species. For instance, many studies have shown that increasing carbon dioxide levels can increase plant growth.

While such studies can provide important insights, this narrow approach can also be ecologically and climatically unrealistic, according to a new paper by Yale researchers.

Writing in the journal *Trends in Ecology & Evolution*, two Yale scholars make the case that overly simplistic studies or experiments avoid the inherent complexity and interconnectedness of natural systems. As a result, they can yield erroneous climate predictions, they write.

"Most of the climate change ecology research out there has been picking the low-hanging fruit for many years," said Adam Rosenblatt, a postdoctoral fellow at the Yale School of Forestry & Environmental Studies (F&ES) and lead author of the paper. "Often they study the effects of one type of variable. That's obviously useful but it's not realistic because in nature nothing exists in isolation."

The paper was co-authored by Oswald J. Schmitz, the Oastler Professor of Population and Community Ecology at F&ES.

"The tradition in experimental analysis of climate change effects on

ecosystems is to focus on one variable at a time. But this leads to a rather piecemeal and fragmentary picture of ecosystem functioning," said Schmitz. "We propose a more integrative approach. While more complex, it will, nonetheless, help to unveil a more complete and coherent portrait of how real-world climate change will affect ecosystems. "

Specifically, they propose a greater emphasis on scholarship that explores how climate change will affect interactions between all food web components, including direct and indirect effects on predators, herbivores, and plants.

For instance, while some studies examine the effects of, say, rainfall changes on the physiology of animals and plants, the effects of changes to the nutrient content of plants at the bottom of the food web can also have important consequences.

"All of these things are going on simultaneously, so to only look at one side of it is going to miss the fuller picture," Rosenblatt said. "Which means the predictions that we try to make about how food webs and ecosystems are going to respond to climate change won't be as accurate as they could be."

"Our goal is to get people to think in a more realistic way about how climate change will actually affect the ecosystems we rely on."

To illustrate this point, Rosenblatt shared the example of a recent study that showed how warming temperatures in a New England grassland actually increased grasshopper fitness, enhancing the species' reproductive potential. But when Rosenblatt conducted another experiment that combined the effects of warming with drought conditions he found the opposite pattern: the grasshoppers saw decreased fitness.

"Establishing those baseline results under a simple scenario was valuable," he said, "but to take the next step we need larger scale experiments."

Taking that next step, of course, has logistical and economic challenges. In the case of such field experiments, inserting additional variables requires an exponential increase in the number of experimental treatments. For example, if a scientist is looking simply at the effects of warming, they can set up two treatments: warming and non-warming. If they want to simultaneously add the impact of drought to the equation, the number of treatments doubles to account for all four possible variable combinations. Adding a third variable doubles the number of treatments again to eight. And so on.

"The reality is, doing this kind of research is really difficult, so we're not casting blame or saying scientists aren't doing valuable work," Rosenblatt said. "I completely understand why people don't pursue it as much as they pursue the single-factor or single-species research because it's easier to control things and it's less expensive.

"But as a community climate change ecologists need to be thinking about investing the time and money and resources to be able to do this more complex science in addition to the more narrowly focused science."

More information: Adam E. Rosenblatt et al, Climate Change, Nutrition, and Bottom-Up and Top-Down Food Web Processes, *Trends in Ecology & Evolution* (2016). DOI: 10.1016/j.tree.2016.09.009

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