Extinction cascading through ecosystems could spell trouble for humans

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Aislyn Keyes, the lead author of the paper. Credit: University of Colorado at Boulder

Humans rely on nature extensively for everything from food production to coastal protection, but those contributions might be more threatened

than previously thought, according to new findings from the University of Colorado Boulder.

This research, out today in *Nature Communications*, looked at three different coastal food webs that include those services provided to humans, or ecosystem services, and found that even if the services themselves aren't directly threatened, they can become threatened when other species around them go extinct—often called secondary extinctions.

With human-induced threats to biodiversity and ecosystems, such as climate change and degradation, on the rise, these findings could have ripple effects not just on our management of the ecosystems themselves, but on conservation science, policy and funding broadly.

"These extinctions can cascade, impacting services, so protecting certain species that are disproportionately contributing to services either by supporting them or directly providing them can potentially help mitigate any indirect threats," said Aislyn Keyes, a Ph.D. student in ecology and evolutionary biology at CU Boulder and the lead author on the paper.

"There's not nearly enough money for conservation, and I think this approach could be a way to better allocate resources to protect multiple species and services."

Ecosystem services can be anything from fish in a fishery to bees or bats pollinating food to grass helping mediate coastline loss. While quite a bit has been studied on these systems, such research tends to focus specifically on the species providing the service. That leaves the ecosystem surrounding it—and the cascading effects they have on each other—largely unknown.

To explore that question, the researchers took concepts and metrics from

network science, insight and knowledge from ecosystem service science, and then combined them with a very well-known research area—food web ecology—merging the fields together in a way not previously explored.

"I think it (this research) is a really cool mesh of all of these different fields," Keyes commented.

Particularly, researchers took three different salt marsh food web datasets collected off the coast of California and Baja California, added their respective ecosystem services to the datasets, and then ran 12 extinction sequences simulations.

They found that food web and ecosystem service responses to extinctions are strongly and positively correlated, meaning what happens to one happens to the other, especially as they pertain to secondary species that support the ecosystem service provider. For those, researchers found that they are integral to maintaining ecosystem services, and if one falls, the ripple effects can be felt throughout the system.

However, they also found that it was not even across the board with services provided by species higher up the food chain (such as a large fish in a fishery) more vulnerable from those secondary extinctions than those lower on the food chain, like plants, with services provided multiple places the most tolerant to extinction.

"A lot of ecosystem service assessments focus on only the species that directly provides the service, but we know that impacts can cascade through an ecosystem, and so we show that these secondary extinctions represent an increased vulnerability for services that hasn't necessarily been considered in previous ecosystem service assessments," Keyes said.

The team next plans to use this research to create an interactive game for K-12 students to play so that they can learn more about ecosystem services. Additionally, they plan to look at whether factors that make food webs more tolerant to extinction extend to services.

"I think it's a really promising way forward for thinking about threats to ecosystem services amidst global change. It highlights that traditional approaches that assess ecosystem services might be missing a lot of this stuff," Keyes said.

"We've opened this box, but what else can we find?"

More information: Aislyn A. Keyes et al, An ecological network approach to predict ecosystem service vulnerability to species losses, *Nature Communications* (2021). DOI: 10.1038/s41467-021-21824-x

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