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Lions and Tigers and … Mosquitoes?

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Research by Nick Gotelli, professor of biology, looks to the northern pitcher plant for answers to some critical questions about why major changes in populations occur throughout the food web. *(Photo: Nick Gotelli)*

From razed Venezuelan rain forests to sprawling Vermont subdivisions, habitat loss is a pervasive global problem. As natural terrain shrinks, "top predators" like jaguars and mountain lions often are the first to disappear.

But these wide-ranging charismatic carnivores are not the only ones who feel the squeeze. As habitat is destroyed, a cascade of other changes flows through the food web; populations of not-so-top predators, middle level plant-eaters and scavengers, and plants themselves, undergo a complex series of explosions and declines that can end with an ecosystem in sudden collapse.

While this damaging process has been well described, it has been surprisingly difficult to explain why it happens or to predict how habitat loss will affect particular plant and animal populations. Central to this difficulty has been the question of whether it is the habitat loss itself that leads to the changes in the populations throughout the food web, or the indirect effect of the now-absent top predator.

Rather than studying endangered Siberian tigers for an answer, professor of biology Nicholas Gotelli turned to the northern pitcher plant.

A small and complex food web

These carnivorous bog dwellers found across North America contain a miniature food web in the rainwater that pools at the bottom of their tubular leaves. Here no cats roam. Instead, Wyeomyia mosquito larvae are the top predators. They eat other insects in the water, which in turn feed on yet other invertebrates and bacteria in a complex network that begins with the shredded detritus of unlucky flies and ants that fall into the plant's trapping tube.

As Gotelli recently reported in the open-access journal PLoS Biology, he and his collaborator Aaron Ellison from the Harvard Forest, an ecological research site run by Harvard University, artificially created habitat loss (and gain) by changing the volume of water in individual plants they were studying in Vermont's Moose Bog. They also removed the "top trophic layer" (that is, the mosquito larvae and other predators at the top of the food web) and then watched what happened to the remaining species.

"The goal of this study was to say which kinds of models do a better job predicting the outcome of these changes," Gotelli says. He developed

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A customer methodically flips through the racks at a musty record store, then snatches an album. He checks the vinyl, flips the jacket and pores over the liner notes. "Think about that: When you were taking a chance on a record… you had already read the critic," says Professor John Gennari, author of *Blowin' Hot and Cool: Jazz and Its Critics*.

Trustees Discuss Finances, Facilities Priorities
University trustees began discussion of an updated strategic financial plan and a new strategic capital plan and considered how those two plans will mesh and shape the university's future during the board meetings held Nov. 9-11.

Heart Failure Q+A
Heart failure is the most common diagnosis among Medicare patients, and costs billions annually. Dr. Martin LeWinter of the College of Medicine is leading a major effort to better understand and treat the condition, especially in cases where it is related to diabetes.

several statistical "path models" that each forecast the abundance of midges, mites, flesh flies, rotifers, and protozoans that make up the microscopic watery world at bottom of a pitcher plant. One model focused on the changed volume of water; another on prey availability, like bacteria; and finally, one placed the mosquito larvae in the director's chair as a "keystone" species.

Gotelli says he was surprised that the model with the most predictive power was the keystone model. In this approach, abundances of the other co-dwellers in the pitcher plant were best predicted through mathematical "paths" directly linked to mosquito larvae abundance.

Perhaps more surprising, taking into account the changes in water volume in this keystone model did not make it work better. As Jonathan Shurin wrote in *Nature* in a commentary article about Gotelli's study, "the implication is that the effects of habitat loss on the [pitcher plant] community can be explained entirely as the indirect consequence of its impact on the top predator."

In short, habitat loss may lead to the demise of top predators. But then, if Gotelli's mosquito model is right, the abundance of other creatures down the food chain seems best guessed by looking at their relationship to the top predator and not their amount of remaining habitat.

New evidence at odds with traditional theory

While Gotelli's paper was picked as a "Editor's Choice" in the September 29 edition of *Science*, the implications of his study could rattle some traditional wildlife biologists and land managers. "You can't understand changes in a species you are targeting for conservation by studying it in isolation because at the same time that the target species is changing so are its potential predators and potential prey," Gotelli says. "Simple population models based on only the target species may not do a very good job in protecting that species."

Do the results of this study mean that the population modeling underlying many conservation plans for endangered animals and plants are hopelessly flawed unless they takes a full (and mighty expensive) accounting of the surrounding food web?

"It doesn't mean we necessarily have to measure everything in nature," Gotelli says, "but it may mean we need to expand to consider a couple of other interacting species that may be important to our target species and following those at the same time."

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