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CONSERVATION

Beyond Biodiversity: A New Way of Looking at How Species Interconnect

In a development that has important implications for conservation, scientists are increasingly focusing not just on what species are present in an ecosystem, but on the roles that certain key species play in shaping their environment.

BY JIM ROBBINS · OCTOBER 12, 2017

In 1966, an ecologist at the University of Washington named [Robert Paine](#) removed all the ochre starfish from a short stretch of Pacific shoreline on Washington's Olympic Peninsula. The absence of the predator had a dramatic effect on its ecosystem. In less than a year, a diverse tidal environment collapsed into a monoculture of mussels because the starfish was no longer around to eat them.

By keeping mussel numbers down, the starfish had allowed many other species to thrive, from seaweed to sponges. Paine's research led to the well-known concept of keystone species: The idea that some species in an ecosystem have prevailing traits – in this case preying on mussels – whose importance is far greater than the dominant traits of other species in that ecosystem.

Now, a half-century later, researchers are taking the study of traits much farther, with some scientists concluding that understanding the function of species can tell us more about ecosystems than knowing which species are present – a concept known as functional diversity. This idea is not merely academic, as scientists say that understanding functional diversity can play an important role in shaping conservation programs to enhance biodiversity and preserve or restore ecosystems.

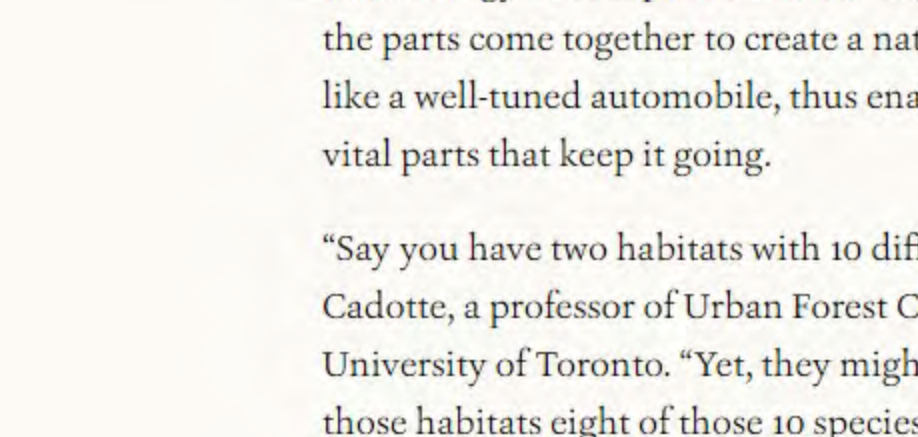
"The trait perspective is very powerful," says Jonathan Lefcheck, a researcher at the [Bigelow Marine Lab](#) in East Boothbay, Maine who studies functional diversity in marine environments. "Some species in an ecosystem are redundant, and some species are very powerful."

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Much about the concept is also unknown. One [case study](#) is taking place along the Mekong River, a 2,700-mile waterway that serves as a vital fishery for millions of people in Southeast Asia. While the fishery is healthy now, widespread changes in the ecosystem – including the proposed construction of numerous dams and the development of riparian forests and wetlands – could mean that key fish species might not be around to carry out important functions, such as keeping prey numbers in check or recycling nutrients.

"There is simply no understanding of how the construction of a dam today, and another five years from now, and another in 10 years – all in the same river basin – will impact the biodiversity and push it past a point of no return, where large scale species extinctions are imminent," said Leo Saenz, director of eco-hydrology for Conservation International.

So a [team of ecologists](#) from Conservation International is trying to determine which roles various species in the Mekong fill that are critical to perpetuating a healthy ecosystem. Those species might be predators like the giant snakehead, which helps control other fish populations so they don't become too numerous, or thick groves of mangrove forests in shallow areas that provide a nursery for a wide variety of fish species. Models can then predict the best way to protect these key species and ensure a healthy river over the long term.



Fishermen on the Mekong River in Laos. Ecologists are trying to determine which fish play critical roles in maintaining the river's ecosystem. SUTHEP KRITSANAVARI/INTERNATIONAL RIVERS

"Ecosystem resilience is an important part of what we aim to maintain, both for the interest of biodiversity conservation and for the maintenance of the ecosystem services that nature provides," says Trond Larsen, a biologist who heads Conservation International's [Rapid Assessment Program](#) for biodiversity.

Some scientists now compare knowing which species are present in an ecosystem to knowing only which parts of a car are present. Functional

trait ecology is a deeper dive into ecosystem dynamics to help understand how the parts come together to create a natural environment that runs smoothly, like a well-tuned automobile, thus enabling a more focused protection of the vital parts that keep it going.

"Say you have two habitats with 10 different species in each," explains Marc Cadotte, a professor of Urban Forest Conservation and Biology at the University of Toronto. "Yet, they might not be comparable at all if in one of those habitats eight of those 10 species are similar and redundant, while in the other habitat, all 10 species are unique from one other. We need alternative measures for biodiversity that tell us something about the niche differences, trait differences, how species are interacting, and how they are using resources. Functional diversity and phylogenetic diversity are meant to capture that."

Phylogenetic diversity refers to species that have few or no close relatives and that are very different from other species, which may mean that they can contribute in very different ways to an ecosystem. Protecting phylogenetic diversity, then, is part of protecting important functions. The distinctive pearl bubble coral is one example, as it provides shelter to shrimp, an important food for the highly endangered hawksbill turtle.

Better understanding these aspects of ecosystems is a game-changer for the conservation of biodiversity. The Indo-West Pacific region, between the east coast of Africa and South Asia, has the highest diversity of life in the world's oceans. But many species there, such as damselfishes and butterfly fishes, have a lot of overlap with other species in terms of traits – somewhat similar body sizes, similar habitats and habits, how and where they school, etc. That means they may have a narrower range of traits that may be important for ecosystem function.

"In the Galapagos, on the other hand, there are fewer species, but each of those species is doing something much different than the others," says Lefcheck, who worked on [research looking at functional diversity](#) there. "If you were prioritizing your conservation efforts, you might focus on the Galapagos. Even though it doesn't have as much biodiversity in the traditional sense, it has a much greater diversity of form and function."

Focusing on species function and evolutionary heritage can narrow the focus on what needs to be protected most urgently.

"Functional diversity is incredibly difficult to determine," says Larsen of Conservation International, "but generating an improved understanding of the relationship between species and their functional diversity is key to understanding and mitigating impacts or threats from development." His organization works to protect tuna and sharks, for example, because these predators help maintain a healthy and balanced ecosystem by keeping numbers of prey from growing too large and by culling the sick and the weak.

In a recent [study](#) in the journal *Nature*, researchers say that focusing on species function and evolutionary heritage can narrow the focus on what needs to be protected most urgently. "Biodiversity conservation has mostly focused on species, but some species may offer much more critical or unique functions or evolutionary heritage than others – something current conservation planning does not readily address," says Walter Jetz, a professor of ecology and evolutionary biology at Yale University.

The researchers noted that 26 percent of the world's bird and mammal species are not included in protected reserves. Focusing on the most important traits and evolutionary heritage of those species would allow conservationists to narrow their protection of critical biodiversity with just a 5 percent increase in protected areas, and would be far less costly than trying to protect them all, the *Nature* study shows.

As traits are better understood in ecosystems, Lefcheck says, it allows tweaking and management of ecosystems for certain outcomes. "You could choose to conserve the species that are very different than others that might lead to changes in the ecosystem that could be considered beneficial," he says. That has potential for fisheries management, for example. "When I tell someone, 'This species has been around for 2.6 million years,' that's very esoteric in a way," says Lefcheck. "But if I can say, 'This large-bodied species produces a lot of biomass, and it can crop down invasive algae, and it plays a high-functioning and critical role in the ecosystem,' you might want to protect species that have that trait."

The benefits of understanding functional diversity can go well beyond ecosystem restoration. In Toronto, for example, green (plant-covered) roofs are required on most new commercial buildings to help cool the city and reduce storm water runoff. A monoculture of grass called sedum is used. In [studies](#), though, Cadotte and colleagues have found that if grass species that are distantly related and dissimilar are used in the mix, they have different traits that provide more shade for the soil and help the roof keep the building cooler. This mix also reduces stormwater runoff by about 20 percent.

The formal study of functional traits can be traced back to the 1990s, when ecologist David Tilman at the University of Minnesota did research on grasslands. He found that those regions with more species [diversity did better during a drought](#), and only a few of the grasses resistant to drought were needed. Later, he and his colleagues discovered that the presence of some grasses with certain traits, such as an ability to fix nitrogen, was more important than overall species diversity.

"Ecology has moved from counting species to accounting for species," says one researcher.

Researchers in Jena, Germany established the [Jena Experiment](#) to follow up on this work. They found that there are plants, such as wild tobacco, that emit "messenger molecules" when they are under assault by herbivores to attract predators from miles away that eat their enemies. This trait not only benefits the tobacco, but other species in the neighboring plant community.

Experts say these findings could also help agriculture rely less on pesticides by understanding the right mix of plants to maximize predator defenses. "Varying the expression of just a few genes in a few individuals can have large protective effects for the whole field," says Meredith Schuman, a researcher on the Jena Experiment at the [Max Planck Institute for Chemical Ecology](#). "It's an economically tenable way to recover the lost benefits of biodiversity for the vast expanses of land that have already been converted from natural, biodiverse habitats into agricultural monocultures."

These new approaches to ecology show how limited the science has been. Many researchers welcome the change. "Ecology has moved from counting species to accounting for species," says Cadotte.



Jim Robbins is a veteran journalist based in Helena, Montana. He has written for the *New York Times*, *Conde Nast Traveler*, and numerous other publications. His latest book, *The Wonder of Birds: What they Tell Us about the World, Ourselves and a Better Future*, is due out in May. [MORE →](#)

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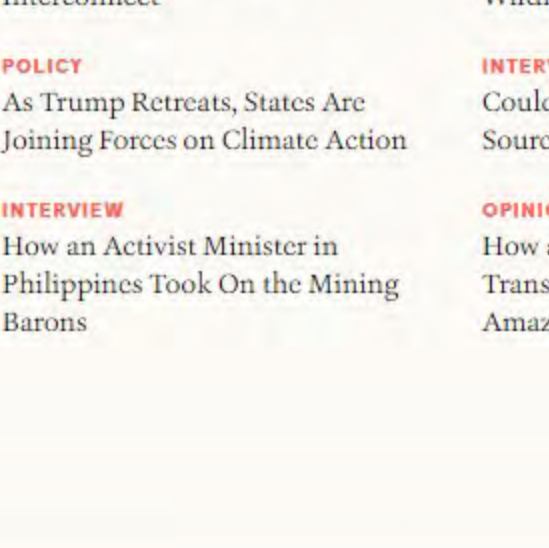
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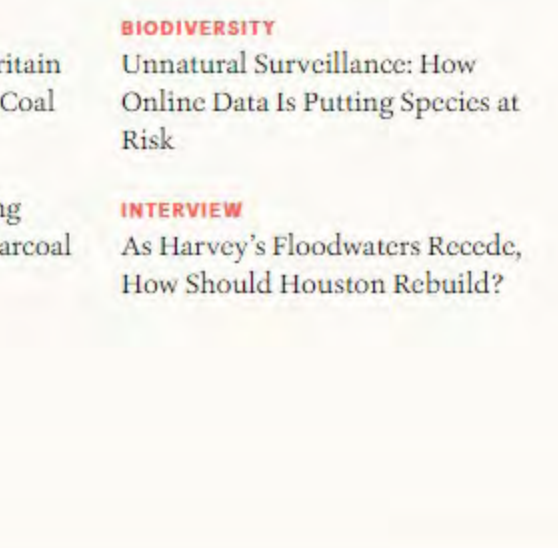
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