Tending Nature's Garden

How flora and fauna structure tropical forests

By ELIZABETH PENNISI

Sunrise in a tropical forest is never quiet. Monkeys bicker over breakfast. Birds clamor for the attention of mates. Insects chirp and twang as they go about their morning business.

If plants made noises, they would contribute to the din. Instead, inaudibly, neighboring trees bicker about sharing sunlight. Colorful canopy blossoms clamor for the attention of pollinators. Roots tussle over water. A sapling groans because a fungal infection is girdling its trunk.

For almost 3 centuries, biologists from temperate lands have tried to tune in to these silent tiffs. Often, the diversity of the tropics has stymied them.

The forests these biologists are familiar with have a tenth as many species per acre, and winter's cold tends to silence the flora for months at a time. "[Coming to the tropics] completely shatters everything you thought you knew and everything you thought was true," says Catherine Potvin, an ecologist at McGill University in Montreal. "We have acquired knowledge about how northern systems work, and yet we have no clue as to what's going on here [in the tropics]."

"It's much more difficult, much more complex, much more stochastic."

For years, these travelers have appreciated all too well the diversity and dynamic nature of these green paradises. But they have been unable to glean why or how these conditions come about. Yet just as zoologists have managed to attach meaning to animal chatter and from that figure out predictable patterns of behavior, botanists and ecologists have started to distinguish patterns of tropical plant "behavior."

"What biologists are looking for are ways competition is ameliorated so all these species can coexist," explains S. Joseph Wright, a tropical ecologist at the Smithsonian Tropical Research Institute (STRI) in Balboa, Panama. Do plants jostle each other to get and keep a place in the sun? Or do they let animals or other organisms control their fates?

Wright and others find that seemingly random events — weather, predators, pathogens — can dictate which trees sprout or survive at any given time. They also help ensure that no one species outcompetes all the rest.

Because each plant differs in how it harnesses the available resources — be they water, light, pollinators, even seed dispersers — each does better or worse in certain conditions. Researchers have begun to sense that these differences lead to complex patterns.

As conditions change, so does an individual species' fitness. Over time, one type of tree may give way to another, and the mix of species — that is, the community structure — shifts.

To tease apart the complexity, scientists typically begin by concentrating on a particular aspect of these communities. "I'm interested in how microorganisms affect community structure," explains STRI plant pathologist Gregory S. Gilbert. A botanical epidemiologist of sorts, he is examining the distribution and survival of a common tropical tree, *Ocotea whitei,* that grows in ravines and on wet slopes in Central and South America. He works on Barro Colorado Island, a tropical reserve in Panama. There, "this species has lost about half its population in the last 10 years. And there is no sign of [the loss] slowing down," he says.


Gilbert/Smithsonian

A *fungal infection led to this canker on* Octea whitei *and threatens to make the species rare in this Panamian forest.*

A fungus is to blame, and Gilbert suspects that the fungus has always existed on the island, infecting a few isolated trees. When it gets into a tree, it settles below the bark, where it destroys inner tissue. Cankers develop on the trunk, sometimes encircling the tree but rarely killing it.

The current devastation may have its roots in the early 1980s, when a record dry year followed an extremely wet one, Gilbert speculates. First, extra moisture provided optimal conditions for the fungus' spread. Then, because the fungus makes the tree less able to transport water, the drought — caused the following year by an El Niño — created "incredible stress as far as the tree is concerned," he explains. "The tree is already a slope specialist — it has to grow where it is moist most of the time. When drought hits, the [trees] can't handle it."

For his studies, Gilbert checked both young and old trees for cankers. He determined the distances between young trees and the nearest adult *O. whitei,* noting, too, their fungal status. He then examined the distances between young *O. whitei* and adults of a canopy tree that does not get this disease. Finally, he compared his observations about the distribution of infected trees with data about dead *O. whitei* collected in surveys done in 1982, 1985, and 1990 (SN: 6/4/94, p.362).

More than the usual number of juvenile *O. whitei* die or become sick when they sprout within 20 meters of an adult, say Gilbert, ecologist Stephen P. Hubbell of Princeton University, and Robin B. Foster, a botanist at STRI and the Field Museum of Natural History in Chicago. In contrast, more than the expected number of young trees thrived when they existed over 30 meters away from an adult of the same species, these scientists report in the current OECOLOGIA.

"If you go away from the mother trees, [you can see that] they have a much better chance of surviving and a much better chance of being healthy," says Gilbert.

Even more intriguing is how this fungus seems to have singled out *O. whitei.* Nine of the 10 tree species on the island in the same family as *O. whitei* develop the cankers. But far fewer individuals of the other species become infected, and the one that seems immune is increasing in number.

What's more, *O. whitei's* cousin, *Beilschmiedia,* seems to protect its neighbors as well as itself from the fungus. When Gilbert examined the distribution of small *O. whitei* trees, he discovered that those growing close to an adult *Beilschmiedia* are more likely to be healthy, irrespective of whether they are also close to a sick adult *O. whitei.*

He concludes that this fungus is helping restructure the island's forest. His data add weight to the notion that, in the tropics, individuals of a species do better farther away from each other. This tendency helps create the mosaic of different species that contributes to the high diversity observed, he notes.

"The neat thing is that up until now, the studies in the tropics of the impact of diseases on tree spacing or on population dynamics have been done almost entirely on the level of seedlings, and the studies, of course, were done in a matter of weeks," Gilbert points out. "What we've been able to do extends that and shows that diseases can have an impact [on species distribution] for many, many years; they can affect trees that have [already] put a tremendous amount of effort into growing."

Wright does not see the dramatic — or traumatic — change that Gilbert witnesses. He focuses on more subtle controls on plant populations. Nonetheless, Wright, too, has begun to perceive patterns of change, some of which run counter to what others had thought about tropical flora.

"One thing that's sort of been intuitive dogma is that once a tree gets its place in the sun, it controls it and is not displaced," Wright says. "But I've watched trees being encroached upon tremendously by their neighbors. The zones of contact between the tree crowns aren't stable; one tree crown is overtopping another."

To get to work, Wright rides a steel cage that hangs from a construction crane. In this way, he can get 38 meters into the air, right up to the tops of the tallest trees. "The vast majority of the action is out on the tips of branches," he points out. "If you look at the way the trees are built, the leaves and the reproductive organs are all out in the sun, at the tips."

He finds that the youngest leaves — the most energetic photosynthesizers — are farthest out. As they age and are nibbled on by insects, they lose this prominence, both functionally and spatially — the tip elongates and adds another set of leaves. Certain shrubs follow this pattern, but not deciduous trees common in the northeastern United States, he notes.

From monitoring those tips, Wright has learned that the plant often fuels flower production with the half-dozen or so leaves closest to the bud. They harness sunlight daily for this new growth.

In the tropics, many plants shed their leaves, produce a flush, and then flower, says McGill's Potvin, who works in the crane's cage alongside Wright. Up north, flowering tends to precede leaf development, as if to announce an end to the winter dormancy. She and Wright suspect that because the tropics lack a cold season, where respiration drops and insect pests are inactive, the trees there can't afford to store the reserves they produce for reproduction. "If the plant had a storage organ, somebody would find it and eat it," Wright jokes.

At one time, researchers thought tropical trees underwent this growth spurt during rainy seasons and dropped leaves during the hot, dry months to avoid water stress. But Wright has evidence that light, not water availability, guides growth in many species and, in turn, helps restructure tropical forests.

"A lot of that dogma about the role of seasons and of water stress in controlling this is just wrong," he says. "If you look at the data, most of the flowering is in the dry season."

There are fewer clouds during that time, resulting in more sun for plant growth. Each week for 208 weeks, Wright's group looked for new leaves and flowers on trees in a particular study site on Barro Colorado Island. There, sunlight for photosynthesis increases by almost 50 percent during the dry season, and many of the species take advantage of that extra energy. In the forest within the crane's reach, several of the most common species increased their leaf area by 20 to 60 percent at the beginning of the dry season rather than losing leaves, as predicted. Data from six other forests also indicate that most trees have evolved to leaf out and flower when the sun is strongest, Wright and Carel P. van Schaik reported in the January AMERICAN NATURALIST.

"These plants are not tied to the seasonality of water but to the seasonality of radiation," Wright concludes. These deep-rooted species represent one extreme along a continuum in terms of their rooting depths, he explains. Shallow-rooted plants represent the other extreme, with many species lying in between. Most likely, observations of trees with shallow roots had led to the current dogma.

Pennisi

***W**ith a construction crane stationed in the middle of a forest study plot, biologists can monitor the canopy leaves and blossoms up close (insert).*

For example, some of the trees that now make up the canopy under the crane do drop their leaves when the rain stops. They got their start before the Canal Zone was established, when much of the land was pasture. At that time, their roots competed only with the very shallow roots of grasses for the ground's water. They didn't tolerate dry months very well, but that scarcely mattered because no other trees competed with their leaves for light.

Now, life is very different. Many of the trees that have begun to grow up around the early settlers have invested in deep root systems. The deeper the roots, the longer the tree can avoid stress caused by lack of water and the longer into the dry season it can be productive. These well-rooted species only make matters worse for a tree with shallow roots, since they compete for that tree's water and force it to drop its leaves ever earlier in the season. "The competition with the other trees has made its timing [of active growth] all wrong," Wright says of one such aging giant.

In the meantime, the deep-rooted plants use the dry months to gain inches that will one day enable them to challenge other species for a place in the sun. Over time, the canopy's shape and makeup change as these opportunists reach up, block more and more of the older trees' sun, and make room for themselves.

"They make hay when the sun shines, almost literally," Wright says. □