Tree diseases can help forests: What's bad for a seedling can be good for biodiversity

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A view of Panama's rainforest canopy looking toward the Chagres River and the Caribbean Sea. A new University of Utah study found that plant pathogens or diseases that infect and kill tree seedlings actually help increase the diversity of tree species in the tropical forest. Credit: Erin Spear, University of Utah.

Plant diseases attack trees and crops and can hurt lumber and food production, but University of Utah biologists found that pathogens that

kill tree seedlings actually can make forests more diverse.

While low rainfall has been blamed for a lack of drought-sensitive trees near the Pacific side of the Panama Canal, the new study answers a mystery about what keeps drought-tolerant trees from that area from living along the wetter Caribbean side of the canal. The answer: disease-causing plant pathogens, the researchers report in their study, published online Wednesday, Nov. 12 by the *Journal of Ecology*.

"Because seedlings of disease-sensitive tree species can't survive in the wetter forests and drought-sensitive tree species cannot survive in the drier forests, different tree species inhabit the wetter and drier forests even though they are only 30 miles apart" in Panama, says Phyllis Coley, a senior author of the study and a distinguished professor of biology.

In other words, tree pathogens contribute to the staggering diversity of trees in Panama's tropical forests, she adds.

The study's first author, biology doctoral student Erin Spear, says that is important because "conservation planning and predictions about how tree species distributions may shift with climate change require an understanding of the factors currently influencing where species can and cannot survive."

That is particularly important in tropical forests and other forests that are under elevated threat of deforestation.

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Of Forests and Pathogens

Tropical forests are threatened, and dry tropical forests are even more threatened because sunnier, drier climates are better for growing crops and are favored by people. Some 90 percent of Panama's residents live on the nation's drier Pacific slope.

Forests are essential for feeding and sheltering animals, providing important medicines, storing carbon and water, and reducing erosion by holding soil in place. These functions are influenced by different species inhabiting a forest, so it is essential to understand why certain tree species can survive in certain areas but not others.

Panama's forests also are important economically because tree roots limit how much soil erodes into the Panama Canal, ensuring that huge container ships can pass. Researchers also believe the forests help maintain water levels in the canal because forest soil stores water, slowly releasing it into streams feeding the canal during the dry season.

A healthy seedling of the tree *Castilla elastica* is on the left, while a dying seedling, attacked by a plant pathogen, is on the right. A study in the *Journal of Ecology* by University of Utah biologists shows that such tree diseases, while killing individual seedlings, can increase forest biodiversity. Credit: Erin Spear, University of Utah.

Diversity is high in tropical forests. A 930-square-mile area bordering the Panama Canal has more than 800 tree species. By comparison, about half the state of Rhode Island - or some 610 square miles - is forested, and that area has only 51 tree species.

Part of the reason Panama's forests have more species is because the Pacific end of the canal receives less annual rainfall - about 5.9 feet - than the Caribbean end, where 9.8 feet of rain falls annually.

"While there is considerable evidence that less rain in the drier, Pacific forests means that drought-sensitive tree species can't survive there, it has been unclear what prevents the drought-tolerant species of the drier forests from living in the wetter forests," says University of Utah biology professor Tom Kursar, the study's other senior author. "Our study tackled that unanswered question."

So Spear braved mud, rain, insects and snakes to monitor seedlings of a variety of tree species in the wetter and drier forests of central Panama for pathogen-caused damage and death. Plant pathogens that make plants sick include bacteria, viruses and fungi.

Spear says the researchers' findings suggest that "all seedlings are at a greater risk of being injured and killed by pathogens in the wetter forests than in the drier forests." This could be because the damp environment of the wetter forests helps pathogens survive, and more rainfall helps pathogens move from one seedling to another.

But that's only half the story. Coley says that their study indicates "pathogens are implicated in the absence of the dry-forest tree species from the wetter forests, where they might otherwise be able to live. That is because dry-forest tree species are more likely to die from pathogen

attack than wet-forest species."

Diagnosing Sick Seedlings

Spear collected the seeds for the study by hiking for miles, kayaking in the canal to collect fruit from overhanging branches, and even riding a crane-carried gondola more than 100 feet upward into the forest canopy.

She conducted the study at two forest sites in central Panama: one at the large Metropolitan Natural Park in Panama City on the drier Pacific side, and one on private property in the Santa Rita Ridge area on the wetter Caribbean side. She planted "gardens" of tree seeds - including species typical of wetter and drier forests - in 30 locations at each site. More than 1,000 seeds were planted; 725 of them sprouted.

University of Utah biology doctoral student Erin Spear stands in front of a

150-foot-tall giant rainforest tree, *Ceiba pentandra*, in a Panama forest as she hunts for tree seeds for a study that found seedling-killing diseases actually help increase the diversity of tree species in forests. Credit: Joseph Sertich, Denver Museum of Nature & Science.

Once the seeds were planted, the researchers covered them with wire mesh to protect the seeds and seedlings from being crushed by tree branches or eaten by animals.

Spear visited both sites weekly and took notes on the 725 seedlings. Weekly visits were essential because, diseased seedlings can be dead and decomposing within days.

"We monitored when the seeds germinated, the occurrence of and date when symptoms of pathogen attack were observed, if and when a seedling died, and we ascribed a cause of death," Spear says. Pathogen symptoms included patches of black, dead tissue in the leaves or stem. "In some cases, we could actually see the pathogen growing on the seedling," she says.

Of the 725 seedlings that germinated, 38 percent suffered pathogen-caused damage, including 11 percent of seedlings killed by pathogens.

Compared with seedlings in the drier forest, seedlings in the wetter forest were 74 percent more likely to suffer pathogen-caused damage and 65 percent more likely to be killed by pathogens.

"But what was really striking was that pathogen-caused damage was five times more likely to be lethal for seedlings of dry-forest species than for wet-forest species," suggesting dry- and wet-forest species differ in their ability to halt or slow infection, Spear says.

The researchers next plan to identify specific fungi, bacteria and other pathogens and whether they differ in wetter and drier forests.

During her study at the drier park site in Panama City, Spear discussed her research with tourists and other park visitors.

"I'd emerge from the tangles of vines sweaty, muddy and generally disheveled and people couldn't help but ask what I was doing," Spear recalls. "It was heartening to hear how the forest had touched these very different people."

Provided by University of Utah