NASA surveys hurricane damage to Puerto Rico's forests

July 11 2018, by Samson Reiny

On April 25, 2018, the G-LiHT team captured this aerial image of El Yunque National Forest. Credit: NASA

On Sept. 20, 2017, Hurricane Maria barreled across Puerto Rico with winds of up to 155 miles per hour and battering rain that flooded towns, knocked out communications networks and destroyed the power grid. In the rugged central mountains and the lush northeast, Maria unleashed its fury as fierce winds completely defoliated the tropical forests and broke and uprooted trees. Heavy rainfall triggered thousands of landslides that mowed over swaths of steep mountainsides.

In April a team of NASA scientists traveled to Puerto Rico with airborne instrumentation to survey damages from Hurricane Maria to the island's forests.

"From the air, the scope of the hurricane's damages was startling," said NASA Earth scientist Bruce Cook, who led the campaign. "The dense, interlocking canopies that blanketed the island before the storm were reduced to a tangle of downed trees and isolated survivors, stripped of their branches."

NASA's Earth-observing satellites monitor the world's forests to detect seasonal changes in vegetation cover or abrupt forest losses from deforestation, but at spatial and time scales that are too coarse to see changes. To get a more detailed look, NASA flew an airborne instrument called Goddard's Lidar, Hyperspectral and Thermal Imager, or G-LiHT. From the belly of a small aircraft flying one thousand feet above the trees, G-LiHT collected multiple measurements of forests across the island, including high-resolution photographs, surface temperatures and the heights and structure of the vegetation.

The U.S. Forest Service, the U.S. Fish and Wildlife Service, the Federal Emergency Management Agency and NASA provided funding for the airborne campaign.

The team flew many of the same tracks with G-LiHT as it had in the spring of 2017, months before Hurricane Maria made landfall, as part of a study of how tropical forests regrow on abandoned agricultural land. The before-and-after comparison shows forests across the island still reeling from the hurricane's impact.

Using lidar, a ranging system that fires 600,000 laser pulses per second, the team measured changes in the height and structure of the Puerto Rican forests. The damage is palpable. Forests near the city of Arecibo on the northern side of the island grow on limestone hills with little soil to stabilize trees. As a result, the hurricane snapped or uprooted 60 percent of the trees there. In the northeast, on the slopes of El Yunque National Forest, the hurricane trimmed the forests, reducing their

average height by one-third.

Data from G-LiHT is not only being used to capture the condition of the island's forests; it is an important research tool for scientists who are tracking how the forests are changing as they recover from such a major event.

"[Hurricane] Maria pressed the reset button on many of the different processes that develop forests over time," said Doug Morton, an Earth scientist at NASA's Goddard Spaceflight Center and G-LiHT co-investigator. "Now we're watching a lot of those processes in fast-forward speeds as large areas of the island are recovering, with surviving trees and new seedlings basking in full sunlight."

Among the areas that the team flew over extensively was El Yunque National Forest, which Hurricane Maria struck at full force. The U.S. Forest Service manages El Yunque, a tropical rainforest, as well as its designated research plots, which were established in the late 1930s. University and government scientists perform all manner of research, including measuring individual trees to track their growth, counting flowers and seeds to monitor reproduction, and analyzing soil samples to track the nutrients needed for plant growth.

One important assessment of a tree's health is its crown, which comprises the overall shape of a treetop, with its branches, stems and leaves. Hurricane winds can heavily damage tree crowns and drastically reduce the number of leaves for creating energy through photosynthesis.

"Just seven months after the storm, surviving trees are flushing new leaves and regrowing branches in order to regain their ability to harvest sunlight through photosynthesis," Morton said, while also noting that the survival of damaged trees in the years ahead is an open question.

While it's difficult to assess tree crowns in detail from the ground, from the air G-LiHT's lidar instrument can derive the shape and structure of all of the trees in its flight path. The airborne campaign over Puerto Rico was extensive enough to provide information on the structure and composition of the overall forest canopy, opening up a range of research possibilities.

"Severe storms like Maria will favor some species and destroy others," said Maria Uriarte, an ecologist at Columbia University who has studied El Yunque National Forest for 15 years and is working with the NASA team to validate flight data with ground observations. "Plot level studies tell us how this plays out in a small area but the damage at any particular place depends on proximity to the storm's track, topography, soils and the characteristics of each forest patch. This makes it hard to generalize to other forests in the island."

But with G-LiHT data scientists can study the storm impacts over a much larger area, Uriarte continued. "What's really exciting is that we can ask a completely different set of questions," she said. "Why does one area have more damage than others? What species are being affected the most across the island?"

Understanding the state of the forest canopy also has far-reaching implications for the rest of the ecosystem, as tree cover is critical to the survival of many species. For example, birds such as the native Iguaca parrot use the canopy to hide from predator hawks. The canopy also creates a cooler, humid environment that is conducive to the growth of tree seedlings and lizards and frogs that inhabit the forest floor. Streams that are cooled by the dense shade also make them habitable for a wide diversity of other organisms.

Yet by that same token, other plants and animals that were once at a disadvantage are now benefiting from changes brought about by the loss

of canopy.

"Some lizards live in the canopy, where they thrive in drier, more sunlit conditions," said herpetologist Neftali Ríos-López, an associate professor at the University of Puerto Rico-Humacao Campus. "Because of the hurricane those drier conditions that were once exclusive to the canopy are now extended down to the forest floor. As a result, those animals are better adapted to those conditions and have started displacing and substituting animals that are adapted to the once cooler conditions."

"Who are the winners and losers in this new environment? That's an important question in all of this," said NASA's Doug Morton. During the airborne campaign, he spent several days in the research plots of El Yunque taking three-dimensional images of the forest floor to complement the data from G-LiHT. He said it's clear that the palms, which weathered the hurricane winds better than other broad-leafed trees, are among the current beneficiaries of the now sun-drenched forest. And that's not a bad thing.

"Palm trees are going to form a major component of the canopy of this forest for the next decade or more, and in some ways they'll help to facilitate the recovery of the rest of this forest," Morton said. "Palms provide a little bit of shade and protection for the flora and fauna that are recolonizing the area. That's encouraging."

The implications of this research extend beyond the forest ecosystem, both in time and space, said Grizelle Gonzalez, a research ecologist with the U.S. Forest Service and project lead for the research plots in El Yunque. As an example, she pointed out that the hurricane caused the mountain streams to flood and fill with sediment that ultimately flowed into the ocean. Sediment can negatively impact the quality of the drinking water as well as the coral communities that fisheries depend on

for both subsistence and commerce.

"It's beautiful to see that so many federal agencies came together to collaborate on this important work because forests play a key role in everything from biodiversity and the economy to public health," Gonzalez said.

G-LiHT data also has global implications. In July, the team heads to Alaska to continue surveying the vast forestland in the state's interior to better understand the impacts of accelerated Arctic warming on boreal forests, which, in turn, play a key role in cooling Earth's climate by sequestering carbon from the atmosphere. "G-LiHT allows us to collect research data at the scale of individual trees across broad landscapes," Morton said. "Forests from Alaska to Puerto Rico are constantly changing in response to climate warming and disturbances such as fire and hurricanes."

Provided by NASA's Goddard Space Flight Center

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