LIVESCIENCE

# Mysterious Mexican mangrove forest is 'trapped in time' hundreds of miles from the coast

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Scientists have uncovered the origin of a mysterious landlocked mangrove forest in the heart of Mexico's Yucatán Peninsula.

Normally, trees of this species — known as red mangroves, or *Rhizophora mangle* — grow only in salt water, along tropical coastlines. But this forest is located near the San Pedro River in the state of Tabasco, more than 125 miles (200 kilometers) from the nearest ocean. Somehow, these mangroves have adapted to live exclusively in this freshwater environment in southeast Mexico.

Exactly how this ecological enigma came about has baffled scientists. But now, an international, multidisciplinary team of researchers has revealed that this out-of-place ecosystem began growing around 125,000 years ago, when sea levels were much higher and the ocean covered most of the region.

"The most amazing part of this study is that we were able to examine a mangrove ecosystem that has been trapped in time for more than 100,000 years," lead author Octavio Aburto-Oropeza, a marine ecologist at the Scripps Institution of Oceanography at the University of California, San Diego, said in a statement. It was like putting together a "lost world," he added.

**How did it get there?**

Researchers began studying the San Pedro mangrove system only recently, but local people have enjoyed the unique ecosystem for generations.

"I used to fish here and play on these mangroves as a kid, but we never knew precisely how they got there," co-author Carlos Burelo, a botanist at the Juárez Autonomous University of Tabasco in Mexico who grew up near the forest, said in the statement. "That was the driving question that brought the team together."

To find out how this coastal ecosystem ended up marooned so many miles from the coast in an alien environment, the researchers analyzed the DNA in the mangrove trees to see how different they were from other mangrove populations.

The mangroves' "genomes accumulate mutations every generation at a rate of about one in every 300 million letters of the genetic code, which will be passed on to future generations," Richard Nichols, an evolutionary geneticist at Queen Mary University of London who was not involved with the study, told Live Science. "By counting up the number of differences between two genomes it is possible to estimate the number of generations since those two genomes shared an ancestor."

This is one of the most accurate ways to date when two populations became isolated. "If two populations have become isolated from each other, the most recent common ancestors of the individuals from different populations must pre-date the period of isolation," Nichols said.

Based on the number of genetic mutations accumulated in the mangroves' DNA, the team determined that the mangroves have been isolated from the geographically closest coastal mangroves for around 125,000 years. Because global sea levels were much higher 125,000 years ago due to warmer atmospheric temperatures, the researchers suspect that the area was once a coastline.

Therefore, the mangrove forest likely took root while the ocean was higher and managed to survive after it receded to modern-day levels, leaving the coastal ecosystem trapped inland and forcing it to adapt to the freshwater conditions provided by the San Pedro River.

**Changing sea levels**

Global sea levels have risen and fallen many times throughout Earth's history, due, in part, to subtle changes in Earth's orbit around the sun that cause the planet to receive more or less solar radiation, according to the National Oceanic and Atmospheric Administration (NOAA).

During periods in which Earth receives the least amount of radiation, known as glacial maximums or ice ages, the atmospheric temperature drops and ice sheets cover much larger areas in polar regions. When the planet receives the most amount of radiation, known as an interglacial period, the temperature rises and ice sheets melt, releasing more water into the oceans.

The last interglacial period ended around 120,000 years ago, according to NOAA, which lines up with the researchers' theory about the mangrove forest and rising sea levels.

However, previous models did not predict that sea levels at that time would be high enough to cover the mangrove forest — which is currently 30 feet (9 meters) above sea level.

The region surrounding the forest lies so low that a relatively small change in sea level can produce dramatic effects inland, so even though previous models only slightly underestimated the sea level rise, they massively underestimated how much of the region would have been submerged, according to the statement.

Researchers hope that findings could help predict how the region may be impacted by climate change induced sea level rises in the future."Studying these past adaptations will be very important for us to better understand future conditions in a changing climate," Aburto-Oropeza said.

**Ancient relict**

The researchers described the San Pedro River mangrove forest as a "relict," an ecosystem that has survived from an earlier time period. And it wasn't just the mangroves that managed to survive — so did around 100 other species that thrived in or near the ancient ocean, including fish, turtles and plants, according to the statement.

"This discovery is extraordinary," co-author Felipe Zapata, a geneticist at the University of California, Los Angeles, said in the statement. "Not only are the red mangroves here with their origins printed in their DNA, but the whole coastal lagoon ecosystem of the last interglacial has found refuge here."

The researchers are not sure exactly how the mangroves and species that live among them were able to adapt to freshwater conditions, but other researchers can now use the site to investigate these questions. "There is certainly more to discover about how the many species in this ecosystem adapted throughout different environmental conditions over the past 100,000 years," Aburto-Oropeza said.

However, without protected status, the forest could be in danger. In the 1970s, a misguided development plan led large parts of the region to be affected by deforestation, and the mangroves only narrowly avoided destruction. But the forest is still very vulnerable to a similar situation in the future.

"We hope our results convince the government of Tabasco and Mexico's environmental administration of the need to protect this ecosystem," the researchers wrote in their paper. "The story of Pleistocene glacial cycles is written in the DNA of its plants, waiting for scientists to decipher it."

The study was published Oct. 4 in the journal Proceedings of the National Academy of Sciences.

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