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Tropical forests can take the heat, study finds. Dryness? Not so much

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The Biosphere 2 project, run by the University of Arizona, maintains a replica of a humid tropical forest inside a glass dome in the middle of the desert outside Tucson. Inside, trees rise to a height of 17 meters (55 feet) amid artificially controlled climatic conditions. In this environment, scientists have analyzed just how resilient forests are under extreme temperature scenarios. The results, which may help inform fundamental strategies for the preservation of tropical forests in a changing climate, are published in a new study in the journal Nature Plants.

For the experiment, the temperature inside the dome was cranked up to 40° Celsius (104° Fahrenheit). That's 6°C (10.8°F) higher than the maximum temperature regularly recorded in the Amazon currently, and consistent with projections for global warming by the year 2100 if greenhouse gas emissions continue at their current pace. The research was carried out by scientists from across the U.S. and several institutions in Brazil, including the Brazilian Agricultural Research Corporation (Embrapa), the Federal University of Western Pará (UFOPA), the National Institute of Amazonian Research (INPA) and the University of São Paulo (USP).

In a glass dome, scientists reproduced the environment of the humid rainforest in the middle of the Arizona desert. Image courtesy of Marielle N. Smith.

To measure the vegetation's sensitivity to the climate scenario projected for the end of the century, the researchers looked at the photosynthesis capacity of the plants under increased temperatures. Up to 38°C (100°F), which is 10°C (18°F) warmer than the average temperature in tropical forests today, the trees continued to photosynthesize.

But the reactions observed were associated with a condition that was only possible to achieve because of the controlled nature of the environment in Biosphere 2. As the temperature was increased, the humidity in the air remained stable: water vapor was artificially inserted and was

trapped beneath the glass dome. Such conditions could never be replicated in a natural environment.

The study shows that one of the main threats to forest ecosystems is not only a warmer world, but also a drier climate. Study lead author Marielle Smith, a rainforest ecologist at the University of Arizona, said plants in tropical regions have evolved with little temperature variability, which can cause them to be most vulnerable to climate change. “As much as the laboratory conditions are artificial, the results are extremely useful for those who model climate forecasts. With that, the estimates for the future may be more assertive,” she said.

In tropical forests, in general, the hotter the climate, the drier the air. During photosynthesis, plants open and close their stomata, the tiny pores in their leaves, to absorb carbon dioxide, which is essential for photosynthesis. The longer the stomata are open, the more CO2 is absorbed. But if the air is drier, they lose a greater volume of water through these open pores, which forces the plants to regulate their absorption of CO2 in line with their water loss.

Brazilian researchers from various institutions participated in the study, which analyzed the effects of climate change on plant photosynthesis. Image courtesy of Chris Richards/University of Arizona.

Study co-author Tyeen Taylor, also from the University of Arizona, said another possible effect is greater absorption of CO2 by plants, because of the higher concentration of the greenhouse gas in the atmosphere. “In this scenario, plants will maintain the quality of photosynthesis while losing less water,” he said.

Marcos Costa, a professor of agricultural engineering at Brazil’s Federal University of Viçosa (UFV), who was not involved in the Biosphere 2 study, said its findings add to a growing body of research on the resilience of forests. “Biosphere 2 has its limitations, but the conclusions are in line with previous studies,” he said.

He added that “the main threat to the forest is the action of mankind and not only the increase in temperature, as a reflection of a global phenomenon. Deforestation and degradation will create the conditions for plants not to be able to perform photosynthesis in the ideal way, which compromises the maintenance of the system as a whole,” Costa said.

Smith agreed that although the findings showed a high degree of resilience in forests to rising temperatures, “the research does not mean that we can relax in relation to protecting forests.”

“There are other threats that were not analyzed in the article, such as the effect of droughts, deforestation and fires. We don’t know if all conditions will be ideal for the resilience mechanism to work,” Smith said.

Paulo Artaxo, a physicist at USP, who was not involved in the study, said understanding the survival limits of tropical forests, whether in terms of temperature or rainfall levels, is strategically important in devising policies to mitigate the effects of climate change.

“In the field, it is impossible to heat an area of the Amazon by 4°C or 6°C. The results help to understand the effects which are impossible to replicate in nature today,” he said.

He also highlighted the difference between the composition of Biosphere 2, with a few hundred species of trees, and the Amazon rainforest, which has the greatest plant biodiversity on the planet. With due care in interpreting the scalability of application of the results, Artaxo said, studies of this type are important tools for understanding the transformations on the planet.

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