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This model gives us the best look yet at how Amazon forests will react to climate change

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Figuring out how the Amazon will respond to climate change is a big priority for scientists, given its high biodiversity, valuable natural resources and ability to store massive amounts of carbon in its forests. But according to new research, we've been going about it all wrong.

Scientists generally use models to predict how forests will respond to environmental change. Now, a new paper suggests that the models used to study the Amazon until now aren't very accurate. The authors have introduced a new model that they say gives us the best look so far at how these tropical forests respond to changes in climate.

The problem with the old models is that they don't reflect the diversity present in Amazon forests, said Paul Moorcroft, a biology professor at Harvard University and senior author of the new paper, which was published Monday in Proceedings of the National Academy of Sciences. In any given tract of land, there are likely to be many species of trees present, each of which reacts to environmental changes in a different way. However, instead of representing each tree individually, the older models tend to combine all of their properties to produce one "average" type of tree, which they then use to represent each plant in the area.

This strategy means every tree in the model will react to any given change in the exact same way, given th... all have the same properties. The outcome is a “binary response,” Moorcroft said. Either a climatic shift produces no response, or it produces the same response in every tree. This means previous models have often predicted long periods of time during which the Amazon remains unchanged, even while climate change progresses. Then, eventually, a tipping point is reached, and all the trees in the model die off at once.

It’s obviously not a realistic scenario — which is why Moorcroft and a group of other researchers decided to apply a different type of model, which Moorcroft helped create, to the Amazon. The new model, called the Ecosystem Demography Biosphere model, allows scientists to take individual plants’ responses to climate change into account.

“What this model does is it captures the diversity and heterogeneity of the system,” said Scott Saleska, an ecology professor at the University of Arizona who was not involved in this particular study. The result is a much more realistic response to climatic changes, in which some plants are more sensitive to environmental stressors than others. This means some trees will start to die off right away as temperatures rise and water becomes more limited, but overall the forest as a whole persists much longer than previous models have predicted — and certainly doesn’t all die off at one time.

“You get a much more graded response to any difference in the climate,” Moorcroft said. In this study, the researchers took a look at what will happen in the Amazon as the climate gets drier. Different regions of the Amazon already vary in the length of their dry seasons, but climate projections for the Amazon basin suggest that many parts of the region are likely to become drier in the future.

In general, the model predicted that as the dry season lengthens, forests will start to lose biomass and transition gradually into savannah-like states, with smaller scrubbier trees. The severity of a forest’s response, however, depends on certain factors.

The types of trees present in an area, and their ability to withstand water stress, is one obvious influence on how a landscape will change. “The conclusions highlight the need to consider and understand the different strategies* employed by rainforest species for tolerating drought conditions,” said Rosie Fisher, a scientist at the National Center for Atmospheric Research, in an email to The Post. “Some safety conscious plants devote more resources to acquiring water during droughts. Other, less conservative plants, devote more to growing faster and shading their competitors. The ecosystem model* used here can represent which of these different strategies are successful in different conditions, both in the present day and in the future."

The model also demonstrated that soil type is another important factor.

"The reason the soil type comes into play is that the amount of water stress [in a region] is not just influenced by how much rainfall comes into the ecosystem, but also how much of that rainfall is held by the soil," Moorcroft said. "Different kinds of soils have different hydrologic properties, different capacities to hold water." For instance, the results suggested that regions with high clay content would be more sensitive to changes in climate.

And, Moorcroft added, regions that already have longer dry seasons are likely to be more vulnerable to change, since they're already more water-stressed than other areas. "Somewhere that's very wet, the dry season could lengthen but the ecosystem will likely survive because there's a lot of extra water available," Moorcroft said.

It's important to note that the model likely still isn't giving us a perfect picture of what the future will look like. There are many other factors important to a forest's resilience that could be included in future simulations, said Saleska, such as higher atmospheric concentrations of carbon dioxide or deforestation and other land use changes.

For the time being, the model is "a demonstration of the kinds of things that we need to incorporate in order get these answers," Saleska said.

But as future simulations become more accurate, they're also likely to become more important to policymakers making decisions about which regions of the Amazon to prioritize for conservation. Knowing which regions are most vulnerable and which are likely to thrive on their own is useful in this way.

"Let's say land use managers and policymakers say we have enough resources to save 50 percent of the forest," Saleska said. "Which 50 percent should we save? Under limited resources, or needing to prioritize, these models could be used as a tool to say which ones we should save."

And this could be a boon for forests outside the Amazon — even forests outside the tropics, altogether — as well, Saleska pointed out. The problems with the old Amazon models represent "a problem across the board in terms of trying to predict vegetation responses to climate change," he said. So the Ecosystem Demography model could be applied to other regions of the world in order to get a better sense of how global forests will respond to climate change.

In fact, Moorcroft noted that he's already taken an interest in exploring the climate sensitivity of forests in California, which have been enduring record-breaking drought for three years now.

Whether it's California, the Amazon, or other parts of the world entirely, having the most accurate understanding of natural ecosystems and their responses to environmental shifts will be crucial to scientists and policymakers as they continue to make decisions on how to prepare for future climate change. According to Saleska, the improvement of the models used in these processes is a clear step in the right direction.

"They say, 'the whole is greater than the sum of the parts,'" Saleska said. "This model is saying all we need to do to get to the whole is add up all the parts right."

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