Satellite data analysis suggests Amazon rainforest is losing resilience

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The Amazon rainforest is likely losing resilience, data analysis from high-resolution satellite images suggests. This is due to stress from a combination of logging and burning—the influence of human-caused

climate change is not clearly determinable so far, but will likely matter greatly in the future. For about three-quarters of the forest, the ability to recover from perturbation has been decreasing since the early 2000s, which scientists see as a warning sign. The new evidence is derived from advanced statistical analysis of satellite data of changes in vegetation biomass and productivity.

"Reduced resilience—the ability to recover from perturbations like droughts or fires—can mean an increased risk of dieback of the Amazon rainforest. That we see such a resilience loss in observations is worrying," says Niklas Boers from the Potsdam Institute for Climate Impact Research and the Technical University of Munich, who conducted the study jointly with researchers from the University of Exeter, UK.

"The Amazon rainforest is home to a unique host of biodiversity, strongly influences rainfall all over South America by way of its enormous evapotranspiration, and stores huge amounts of carbon that could be released as greenhouse gases in the case of even partial dieback, in turn contributing to further global warming," Boers explains. "This is why the rainforest is of global relevance."

When the tipping point itself will be observable, 'it would likely be too late'

The Amazon is considered a potential tipping element in the Earth system and a number of studies revealed its vulnerability. "However, computer simulation studies of its future yield quite a range of results," says Boers. "We've therefore been looking into specific observational data for signs of resilience changes during the last decades. We see continuously decreasing rainforest resilience since the early 2000s, but we cannot tell when a potential transition from rainforest to savanna

might happen. When it will be observable, it would likely be too late to stop it." The research is part of the project "Tipping Points in the Earth System" (TiPES).

The team from the Potsdam Institute for Climate Impact Research and the Global Systems Institute of the University of Exeter used stability indicators that had previously been applied to the Greenland ice sheet and the Atlantic overturning circulation. These statistical indicators aim at predicting the approach of a system towards an abrupt change by identifying a critical slowing down of the system's dynamics (for instance, its reaction to weather variability). The analysis of two satellite data sets, representing biomass and the greenness of the forest, revealed a critical slowing down. This critical slowing down can be seen as a weakening of the restoring forces that usually bring the system back to its equilibrium after perturbations.

'A system might seem stable if one is considering only its mean state'

"While a system might seem stable if one is considering only its mean state, taking a closer look at the data with innovative statistical methods can reveal resilience loss," says Chris Boulton from the University of Exeter's Global Systems Institute. "Previous studies based on computer simulations indicated that large parts of the Amazon can be committed to dieback before showing a strong change in the mean state. Our observational analysis now shows that in many areas destabilization indeed seems to be underway already."

To try and determine causes for the loss of resilience that the scientists found in the data, they explored the relation to rainfall in a given area in the Amazon, culminating in three "once in a century" drought events in the region. Drier areas turn out to be more at risk than wetter ones. "This

is alarming, as the IPCC models project an overall drying of the Amazon region in response to anthropogenic global warming," says Boers. Another factor is the distance of an area to roads and settlements from where people can access the forest. The data confirms that areas close to human land-use are more threatened.

"Our novel analysis of empirical data brings additional evidence to the worries about the forest's resilience, especially in the near future," says Tim Lenton, Director of the Global Systems Institute. "It confirms that strongly limiting the logging, but also limiting global greenhouse gas emissions, is necessary to safeguard the Amazon."

The results of this study are published in *Nature Climate Change*.

More information: Chris Boulton, Pronounced loss of Amazon rainforest resilience since the early 2000s, *Nature Climate Change* (2022). DOI: 10.1038/s41558-022-01287-8.
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