Amazon rainforest may be more resilient to deforestation than previously thought

May 30 2017

Uncontacted indigenous tribe in the brazilian state of Acre. Credit: Gleilson Miranda / Governo do Acre / Wikipedia

The Amazon forest stores about half of the global tropical forest carbon and accounts for about a quarter of carbon absorption from the atmosphere by global forests each year. As a result, large losses of Amazonian forest cover could make global climate change worse.

In the past, researchers have found that a large part of the Amazon forest is susceptible to a tipping point. The tell-tale sign is satellite data showing areas of savannah and rainforest coexisting under the same environmental conditions. Theories from nonlinear dynamics would then suggest that both states are alternative stable outcomes. This so-called bistability means that shocks such as forest clearance or drought could lead to a dramatic increase of fire occurrence and tip an area of rainforest into savannah. Areas that have experienced this transition would then remain locked into this savannah state until large enough increases of rainfall and release of human pressures allow forests to regrow faster than they are lost by intermittent fires.

Bert Wuyts, a fourth year PhD student in the Bristol Centre for Complexity Sciences and lead author on the paper, said: "I decided to take a fresh look at the data and a very different picture emerged when I controlled for seasonality and took out all the data points from satellite images that represented locations that had been subjected to human influence. Suddenly the property of bistability disappeared almost completely."

Bert, who made this discovery in the first year of his PhD, thought it seemed most puzzling, so he teamed up with Professor Alan Champneys, a theorist in the Department of Engineering Mathematics, and Dr Jo House, an expert on land use change from the School of Geographical Sciences. For the past two years they have been examining these findings rigorously.

Alan Champneys, Professor of Applied Non-linear Mathematics, added: "When I first agreed to co-supervise Bert's PhD, I was worried that I had no expertise in the mathematics required to study the observed effects in the satellite data. Fortunately Bert is a superbly independent student and Jo was on hand as a field expert.

"Little did I realise though that the key to understanding Bert's observations was the same pattern formation theory I have used extensively before. To me this shows the power of interdisciplinary collaboration and also the ubiquity of mathematics and data science in explaining seemingly unrelated phenomena."

Previous research appears to have failed to take into account spatial interaction and edge effects between neighbouring zones, typically through naturally occurring forest fires. Taking such terms into account leads to reaction-diffusion theory, used widely in predicting the formation of spatial patterns within physics and chemistry. According to the theory, there should be a distinct boundary between forest and savannah predictable from climate and soils.

The key was to recognise that proximity to human cultivations acts as a third determining factor. Forests closer to human cultivations are subject to logging and erosion by fires originating from the open cultivated areas. This causes a shift of the forest-savanna boundary towards wetter areas.

The good news is that as long as there is some forest left, deforestation will not lock currently forested areas into a savannah state. This means that recovery of the forest in deforested areas should happen as soon as these areas are released from human pressures. Nevertheless, there exists a second mechanism that could lead to bistability of Amazonian forest cover, which was not taken into account in this research.

Previous research has shown via simulations that the Amazon forest can have a positive effect on regional rainfall. Through this mechanism, forest loss may lead to decreased rainfall causing further forest loss.

Whether climate change or deforestation may still permanently transform the Amazon forest into a savannah depends on the importance of this second mechanism and is subject of further research.

More information: 'Amazonian forest-savanna bistability and human impact' by Bert Wuyts, Alan R. Champneys and Joanna I. House in *Nature Communications*, 2017.

Provided by University of Bristol