Amazon in the firetrap: Deforestation and warming lock rainforest in dry and damaged grassland state

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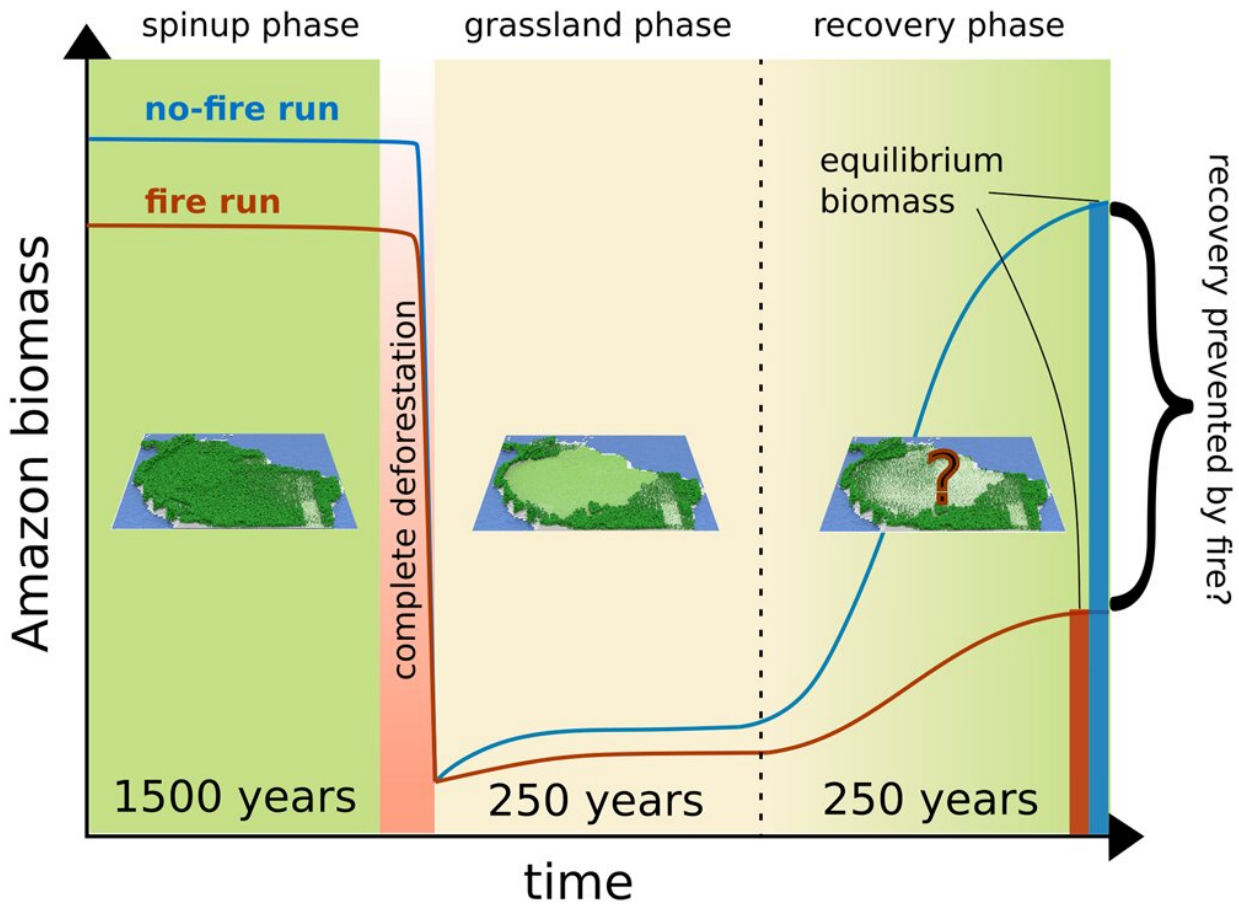

Conceptual experimental design for testing the influence of fire on the Amazon regrowth potential. After bringing climate and vegetation into equilibrium over 1,500 years under historical atmospheric CO_2 concentrations (spin-up phase), for two model set-ups (with and without fire), all trees in the Amazon region are removed and only grass can grow for 250 simulation years (grassland phase). It is

followed by another 250 simulation years where trees are allowed to grow again (recovery phase). At the end of the last simulation phase, the relative difference in biomass between the model set-ups is taken, which denotes the role of fire in preventing forest recovery (illustrated by red vs. blue bar). The whole simulation is performed multiple times from the grassland phase onwards under different constant atmospheric CO_2 concentrations to assess the influence of climate and CO_2 fertilization on forest recovery. Credit: *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00911-5

Global warming and drastic deforestation could dry out the Amazon rainforest faster and enforce the risk of keeping it downright fire-trapped. A new study published in *Communications Earth & Environment* shows that fire can be a decisive factor for a potential tipping of the Amazon rainforest, as it is capable of locking large parts of the Amazon in a treeless state. While naturally not occurring in rainforests, fire can play an increasing role once the forest is damaged, thinned or completely lost, up to a status where fire is the dominating driver of the ecosystem.

"It turns out, fire is the important factor for locking the Amazon in a grassland state, preventing 56%–86% of the Amazon from regrowing, depending on the strength of climate change," lead author Markus Dr.üke from the Potsdam Institute for Climate Impact Research (PIK) explains. "We know that reversing the Amazon forest loss becomes increasingly harder the more forest is lost, and our study shows that fire puts another lever onto this coherence."

Usually, the trees of the Amazon transport enormous amounts of water back to the atmosphere, which they originally received as rain. This water can form new rain locally or downwind in a process called moisture recycling basically forming "flying rivers," not only stabilizing the Amazon as whole but also enabling it to extent into regions that would be too dry without this process.

This coherence is the main reason why the Amazon is considered a tipping element of the Earth system. Global warming and deforestation can damage these flying rivers leading to a self-reinforcing feedback of forest loss. The new study now underlines how fire dynamics help to push and lock the Amazon towards and in a savanna-like or treeless state.

Fire plays key role in irreversible transition

In contrast, in simulations without fire, the forest was able to recover over a longer time period of within 250 years, which emphasizes the important role of fire for the irreversibility of tropical deforestation.

"For the first time, it has been possible to calculate the feedbacks between fire, rainforest and climate in a process-based manner using the Earth system model POEM (Potsdam Earth Model)", adds co-author Kirsten Thonicke, Deputy Head of Research Department on Earth System Analysis and Working Group Leader on Ecosystem in Transitions at PIK.

"Our results highlight the need to keep the Earth system within stable boundaries and limit climate change as well as tropical deforestation in order to prevent the tropical forest from crossing an irreversible fire-controlled tipping point," she concludes.

More information: Markus Drüke et al, Fire may prevent future Amazon forest recovery after large-scale deforestation, *Communications Earth & Environment* (2023). DOI: 10.1038/s43247-023-00911-5

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