Study: Fire in wet area of the Amazon destroys 27% of trees in up to three years

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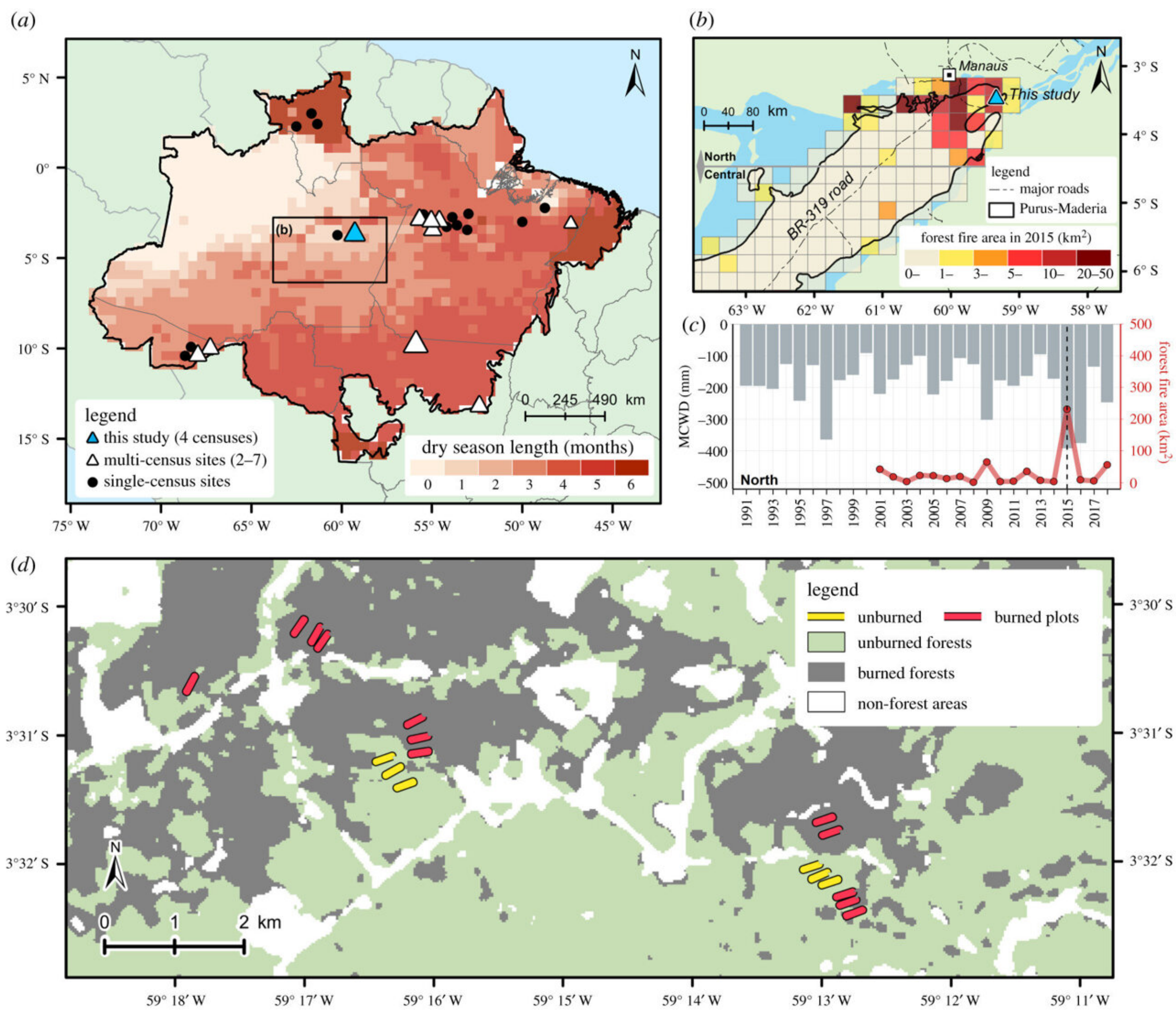

Figure 1. Contextualization of the study area within the Brazilian Amazon and the Purus-Madeira moist forest ecoregion. (a) Rainfall seasonality in the biome [13] and the location of this and other published studies with inventory plots in

burned forests. (b) Gridded map showing the 2015 total burned forest area in part of the ecoregion [30–32]. (c) Yearly burned area (dots) and MCWD (bars) [33]. The dashed line indicates when our field measurements started (2015). (d) Local perspective of our study area, indicated by a blue triangle in (a,b). The 2015 forest fires are mapped in dark gray. Further details for this figure are in the electronic supplementary material, table S1 and text S1. (Online version in color.). Credit: DOI: 10.1098/rspb.2021.0094

Even in the wettest parts of the Amazon, the impact of forest fires, which spread through these areas only during extreme droughts, is sufficient to change the characteristics of the vegetation in the coming decades, although it is not as significant as in other parts of the biome.

According to an innovative study that measured the effects of fire *in situ*, burned forest in a wet area loses 27.3% of its stem density on average. The destruction affects mainly trees of small and medium size. Loss of biomass (stored carbon) in the three years following a fire reaches 12.8%. Mortality is worst in the first two years, and makes way for the growth of native herbaceous bamboo species.

The Amazon region corresponds to 59% of Brazil, with an area of 5 million sq. km., 775 municipalities, 67% of the planet's tropical forest, a third of its trees, and 20% of its freshwater.

It is also the Brazilian biome with the most fires every year since records began, according to the National Space Research Institute (INPE). In 2020, INPE recorded 103,161 fires, the largest number since 2017 (107,439) and the third-largest in the decade. The second-largest number occurred in 2015 (106,438). INPE's forest fire statistics are summarized here.

The 2015 fires, exacerbated by the extreme drought relating to El Niño, were the focus for a study supported by São Paulo Research Foundation—FAPESP via two projects. An article describing the results, including data collected directly in the field, is published in *Proceedings of the Royal Society B: Biological Sciences*.

The study was led by Luiz Eduardo Oliveira e Cruz de Aragão, who heads INPE's Earth Observation and Geoinformatics Division (DIOTG).

"Studying how forests respond to fire in the long run is one of the frontiers of knowledge about the functioning of the Amazon. It's important both to enhance our capacity to model the biome's future and climate interactions, and to provide data for Brazil to report emissions and carbon removal more accurately in the context of policies to reduce emissions from deforestation and forest degradation [REDD+], which can yield financial benefits for the country," Aragão said.

The researchers analyzed burned and unburned areas immediately after the fires that swept through the north of the area between the Purus and Madeira Rivers (central Amazon), and conducted annual surveys to track the demographic drivers of biomass change in the ensuing three years.

The area is located in the municipality of Autazes, some 90 km southeast of Manaus, near the BR-319 highway. The researchers measured trees with a diameter of 10 cm or more, and estimated the extent to which stem growth and tree mortality were influenced by fire intensity (represented by bole char height, an indicator of the length of time a tree bole has been exposed to the flames and high temperatures of a fire), and tree morphology (size and wood density).

Most of the field work was done by Aline Pontes-Lopes, a Ph.D. candidate at INPE, and Camila Silva, a researcher at the Amazon Institute of Environmental Research (IPAM), respectively first and second authors of the article.

"The field data is very valuable. The study included multiple censuses of the same burned area, a type of information that's rare for the Amazon. In particular, field data is rare for tree mortality, growth and local dynamics in rainforest areas generally. The study also analyzed the effects of fire on the wettest parts of the forest, where it's unusual. A great deal of new knowledge about such areas was produced," said Ricardo Dal'Agnol, a researcher at INPE and another co-author of the article.

Dal'Agnol, who is supported by FAPESP via a postdoctoral scholarship, participated in another study published in January showing that water stress, soil fertility and anthropic forest degradation create gaps in the Amazon Rainforest, and influence tree mortality more than any other factors.

Results

"In the burned areas we saw that saplings, small trees and bushes are the first to die, clearing the understory enough for us to walk through the forest and set up the forest inventory plots in 2015. Small and medium trees above all died in two to three years," Pontes-Lopes said. The understory is the layer of trees and shrubs beneath the forest canopy but above the forest floor.

Another important point, she added, is the impact of fire on biomass. According to the study, biomass remained stable throughout the three-year period in the unburned plots but decreased 12.8% in the burned areas.

The impact was especially severe on lianas, which lost 38.6% of their individuals and 38.1% of their biomass. Tree loss was 28% for individual trees and 12.1% for biomass; for palms, the loss was 14.6% for individuals and 27.2% for biomass. The same comparisons for unburned plots showed much smaller losses or no significant change.

The scientists' growth measurements and comparisons of burned with unburned areas showed that trees with lower wood density grew faster in burned areas in a three-year timeframe, and that large trees stored more carbon in burned areas. However, faster growth by these two tree classes did not cause an increase in the forest's total biomass or in wood production, both of which were outpaced by tree mortality due to fire.

According to Pontes-Lopes, other groups are using the data collected in at least four studies. The data has been standardized and posted to ForestPlots.net, a website for researchers, forest scientists and forest communities to share data that will help measure, monitor and understand the world's forests, especially in the tropics.

Future

According to the researchers, continuous monitoring of areas affected by fire at regular intervals (annual or semiannual) is important to improve our understanding of carbon emissions and uptake, the time forest takes to recover to a pre-fire state, and disruption of carbon dynamics by tree mortality due to additional drought and fire events. Future studies should focus on long-term post-fire monitoring to find out whether delayed mortality of large trees occurs on a significant scale in the Amazon, they conclude.

Fire in the Amazon is estimated to cause more than 50% of global greenhouse gas emissions due to land use change. These gases, especially carbon dioxide (CO_2), contribute to the average temperature rise, which could reach 1.5 °C above pre-industrial levels by 2050 if effective measures are not taken soon to mitigate global warming.

The long-term impact of fires in the Amazon is insufficiently quantified, however. An article published last year with Silva as first author showed that more than 70% of the gross emissions resulting from forest fires in a 30-year period were due to tree mortality and decomposition (as distinct from combustion). These emissions were only partially offset by forest growth in the same period. The study also found that net annual emissions peaked four years after forest fires.

Deforestation and forest degradation, in conjunction with climate change, compromise forest carbon stocks. Plant photosynthesis converts light and CO_2 into energy, reducing the amount of CO_2 in the atmosphere. The carbon remains in the biomass until the vegetation burns, or dies and decomposes.

"Without proper land use regulation, the current intention of Brazil's government to pave the BR-319 will increase deforestation in the Purus-Madeira region, increasing ignition sources and the associated risk of large-scale forest dieback," the authors warn.

They recommend two initiatives in support of future decision making to avoid large-scale forest fire in the Amazon: mapping of forest fire risks, and mapping of potential fire impacts based on morphological plant traits. Remote sensing technologies are essential to complement field inventories in developing these initiatives.

"If the effects of fire on the forest are better understood, management of the biome can improve thanks to better fire management policy, which should be decoupled from deforestation reduction policy," Aragão said. "Progress in this matter is crucial to quantify the real impact of human activity on the carbon cycle in the Amazon and find coherent ways of achieving sustainable development for the nation."

More information: Aline Pontes-Lopes et al, Drought-driven wildfire impacts on structure and dynamics in a wet Central Amazonian forest,

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