

The hidden emissions: how Amazon wildfires can boost Brazil's CO₂ emissions

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Context

Almost 80% of the native forest cover remains in the Brazilian Amazon (MapBiomas 2021). There is no recognition that a significant part of these forests are continuously being degraded (Matricardi et al. 2020, Silva Junior et al. 2021), which means they are being negatively impacted by direct and indirect anthropogenic activities (e.g. fires, logging, climate change, edge effect). Once degraded, the Amazonian rainforest loses part of their capacity to provide vital function to mankind and over millions of species including its ability to store carbon (Trumbore et al. 2015). The time for forest ecosystems to recover to pre-degradation levels is still uncertain, but it surely is over decadal scales (Silva et al. 2020, Berenguer et al. 2021, Pontes-lobos et al. 2021), meaning standing forest affected by fires act as carbon emitter. This policy brief presents the level of emissions from understory forest wildfires in the Amazon as a way to highlight the urgent need to protect the carbon sink and storage potential, a critical function of the Amazonian rainforests, which has been diminished. Without specific policies, the increase of forest degradation will directly impact Brazil's carbon budget and reinforce global climate change.

Highlights

Since 1985, at least 215,577 km² of native vegetation (forests, savannas and grasslands) in the Brazilian Amazon have burned at least once - 58% of these have burned multiple times.

Almost half of the forest affected by wildfires was deforested by 2020 (49%), leaving 108,470 km² of primary standing forest intensively degraded by fire in the Brazilian Amazon.

Fire-degraded forest store 25% less carbon than undisturbed forests and may act as a carbon source for at least 10 years.

Since 2005, forest wildfires had a net contribution of 21% of CO₂ relative to net deforestation emissions in the last decade

When accounting for both combustion and decomposition emissions, Amazon forest wildfires have emitted up to 1,298 Tg of CO₂ since 1990 - this is equivalent to the mean annual emissions of Japan in the last 15 years.

There are 20,969 km² of burned forests within protected areas, which are degraded and becoming a source of emissions. They released 192 Tg of CO₂ since 1990 - 65% of these emissions derived from post-fire tree mortality and decomposition.

Amazonian forest wildfires represent a significant source of CO₂, which may impact Brazil's commitment in reducing GHG emissions, even in years of low deforestation.

Fire as a driver of forest degradation

Wildfires are one major source of forest degradation. According to MapBiomas Fire (MapBiomas 2021), which mapped 36 years of burned area in Brazil at 30m resolution, since 1985, 215,577 km² of native vegetation (forests, savannas and grasslands) in the Brazilian Amazonian have burned at least once during the last four decades - 58% of these have burned multiple times. Almost half of the forest affected by wildfires during this period (49%) was deforested by 2020, leaving at least 108,470 km² of primary standing primary forest intensively degraded by fire in the Brazilian Amazon. This data already reveals a basic problem. Amazon standing forests should not burn due to its humid characteristics, however human activities promoting land use change and climate change are impacting the ability of Amazon forest to resist to fire (Alencar et al. 2015).

The hidden emissions from degraded burned forests

To understand the consequences of Amazon forest wildfires on the national carbon budget, it is crucial to understand the processes by which fires spread into dense forests, the impacts on different carbon compartments, and the post-fire forest responses (Fig. 1). Forest fires usually affect the understory vegetation in the Amazon, consuming mainly the necromass (i.e. dead trunks and leaves) at the forest floor (Silva et al. 2020). These fires are slow and flames reach low height, causing late mortality of the trees that are usually not resistant to intense temperatures (Brando et al. 2016). Thus, to account for the emissions from a forest affected

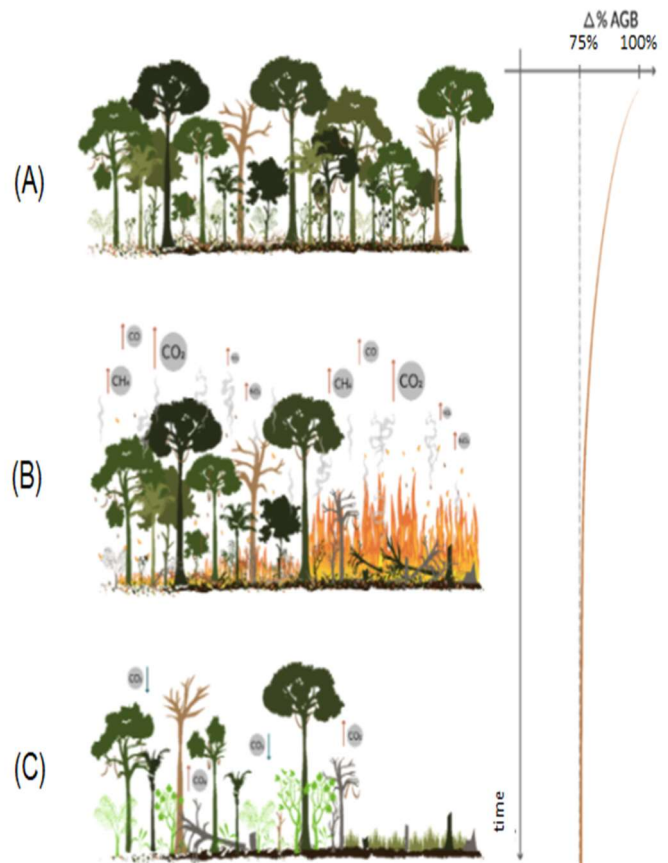


Fig. 1. Process of post-fire biomass reduction (25% decline of above ground biomass (AGB) up to 10 years since fire) and increase in carbon emissions due to understory wildfires, showing the sequential stages (A) primary undisturbed forest, (B) escaping from recent deforested areas affecting the forest understory, (C) resulting forest degradation including the net CO₂ emissions from removals (CO₂ uptake from post-fire regrowth) and late emissions from tree mortality and wood decomposition.

by a wildfire, we calculated the immediate emissions from the combustion of mainly the necromass estimated in burned forest, and added to the estimation of decomposition of post-fire dead trees, accounted as late emissions. An extensive literature review helped to establish the

parameters for trees mortality and net emission factors for both combustion and decomposition.

Implications for Amazon land use change and forest emissions

Fire-degraded forests store 25% less carbon than undisturbed forests and may be a carbon source for at least 10 years. Since 2005, forest wildfires had a net contribution of 21% of CO₂ relative to net deforestation emissions while deforestation rates have reduced during this period, forest wildfires continued to spread over the Amazon, becoming a significant source of CO₂. When accounting for both combustion and decomposition emissions, forest wildfires have emitted up to 1298 Tg of CO₂ since 1990 - this is equivalent to the mean annual emissions of Japan in the last 15 years. From these emissions, the majority (62%) happened in post-fire years (Fig. 2), representing almost two thirds of the emissions of immediate combustion (484 Mt CO₂). These annual distributions of immediate and late

emissions varied over time depending on the climate condition and the level of fire use in the landscape (i.e. deforestation fires and pasture management fires - (Barlow et al. 2020)).

These results are conservative compared with other studies (Aragão et al. 2018, Kruid et al. 2021, Silva Junior et al. 2021), since our results are based on net emissions (i.e. incorporates forest growth). In addition, only primary forest heavily burned were mapped and a portion of the potential fuel material (i.e. fine and gross necromass) were considered. All forest areas that were burned and deforested before 2020 were excluded in the analysis. The net biomass loss (25%) used is conservative for highly fire-degraded forests. Only the decomposition within the time frame (1990-2020), was considered as late emissions (e.g. it does not incorporate future projected committed emissions from fires in the late years of the time frame).

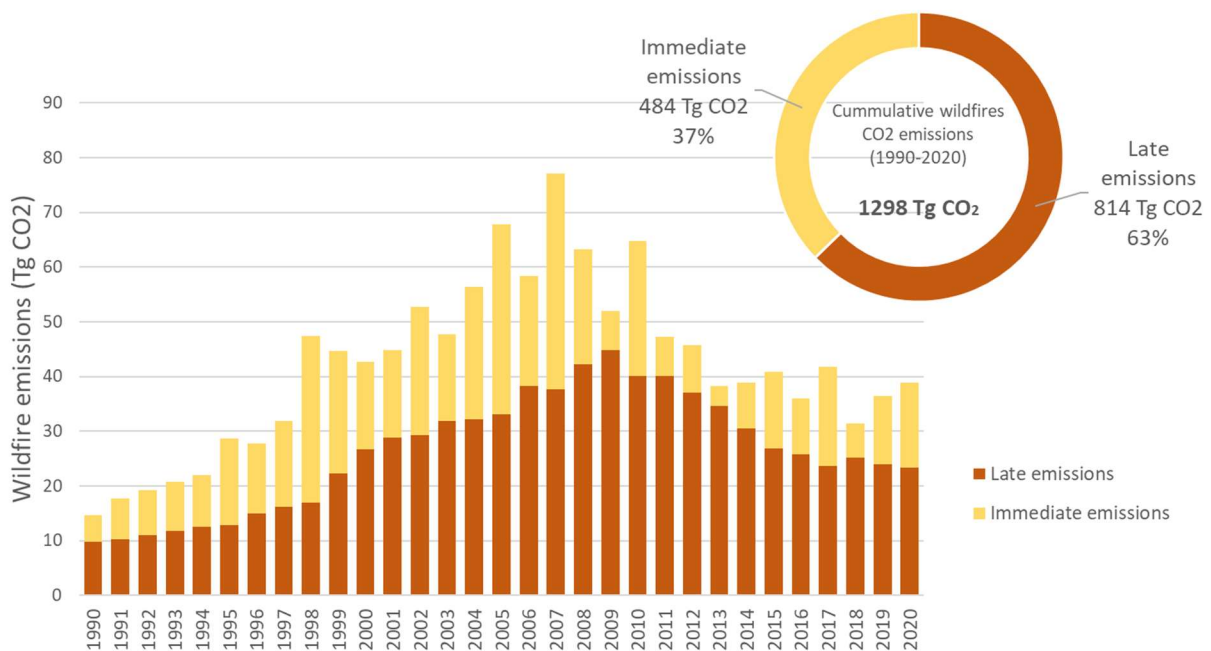


Fig. 2. Annual immediate and late CO₂ emissions from understory forest fires from 1990 to 2020 in the Brazilian Amazon.

Implications for Brazilian carbon budget

The emissions from understory forest fires are not accounted for in the national inventories. In fact, the Brazilian national inventory of GHG emissions not only assumes that all forest areas have good integrity, but also that the Amazon standing forests keep continually up taking carbon from the atmosphere, from forests in managed protected areas (MCTI, 2020). This ends up overestimating the sink role of these forests in the Brazilian carbon budgets. There are 20,969 Km² of burned forests within protected areas/managed areas which are degraded and becoming a source of emissions (Fig. 3). Since 1990, 192 Tg of CO₂ have been released from these areas - 65% of these emissions derived from post-fire tree mortality and decomposition.

The standing forests within protected areas have been affected by fire (and

other degradation drivers). These forests need special protection so they might have a chance to recover their capacity to store and sink carbon. While degraded forests are recovering they should not be accounted for by carbon removal. National inventory methodology needs to be reviewed - there are several parameters to be adjusted if wildfires emissions quantification (e.g. combustion factor, fuel stocks).

Even though we have advanced on carbon accountability of forest degradation by fire, the extent of degraded forests in the Amazon is still uncertain. While few attempts have been made to quantify the extent of specific disturbances (e.g. Matricardi et al. 2020, Mapbiomas Fogo, 2021, DETER/INPE), it is crucial for the government to develop a system that quantifies the multiple types of disturbances, as well as their interaction

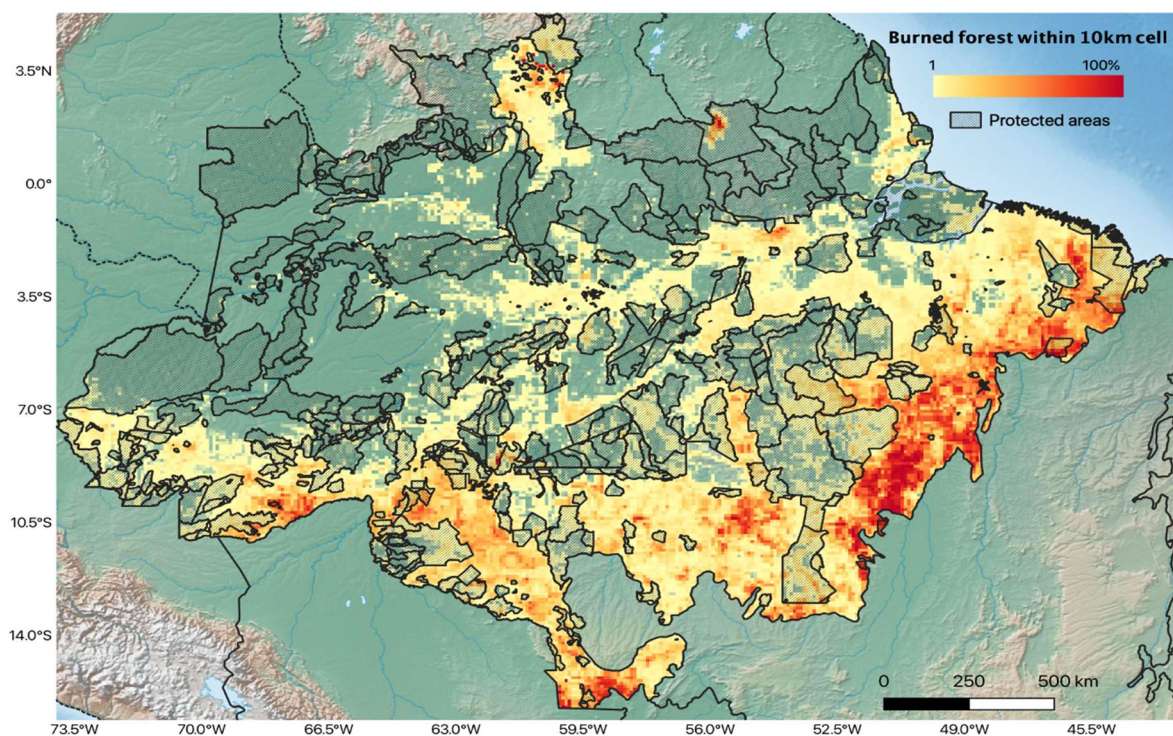


Fig. 3. Concentration of burned forests in the Brazilian Amazon and its protected areas.

on an annual basis and their associated emissions.

Recommendations

There is increasing evidence that forest wildfires are one of the most critical degradation drivers in the Amazon. There are two reasons for that: 1) the high severity of wildfires' impact on rainforests' carbon storage over time; and 2) the challenges to control forest wildfires under increasing deforestation and climate change scenarios. Degraded forests such as forest edges, logged and once burned forests are more vulnerable to repeated fires (Brando et al. 2019).

This policy brief primarily urges the Brazilian Government to create a strategy and support policies to combat forest wildfires by suppressing deforestation. Some of the strategies include: strengthening and promoting articulation of enforcement agencies to apply the law, prosecuting and punishing criminal activities responsible for illegal deforestation. Strategic Enforcement alone can reduce at least half of deforestation in public lands (Alencar et al. 2020). Designating public forests for sustainable conservation to take out the public lands from the illegal land speculation market. Invest in the consolidation of protected areas supporting forest-based economies and circular bioeconomy; providing incentives for private forest conservation (i.e. Forest Code implementation, REDD+, and carbon markets); and engaging the private sector and governments in sustainable production agreements.

Moreover, we need carbon accounting systems to recognize that degraded forests hold less carbon and might not act as carbon sinks. A portion of managed forests (e.g. protected areas)

has been affected by fire and cannot be accounted for only removals. We need to consider that these areas might be emitting due to fire induced degradation processes in order to have the real dimension of forest emissions. Finally, even with low or zero deforestation emissions, we will still have late emissions from forest degradation sending more CO₂ to the atmosphere than absorbing.

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Citation suggestion:

Silva, C., Alencar, A., Pontes, A., Shimbo, J., Silva, W. 2021. The hidden emissions: how Amazon wildfires can boost Brazil's CO₂ emissions. Policy Brief. Instituto de Pesquisa Ambiental da Amazônia, Brasília, DF. Available at: www.ipam.org.br.