Clarifying Amazonia's burning crisis

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Main text

Recent fires in the Amazon have attracted much political and media attention, but it still remains unclear what has been burning. This is crucial to understanding impacts and identifying solutions. There are three broad types of fire in the Amazon (Fig 1a). First, there are deforestation fires – the process of clearing primary forest which starts with the vegetation being felled and left to dry. Fire is then used to prepare the area for agriculture. Second, there are fires in areas that have been previously cleared. For example, cattle ranchers use fire to rid pastures of weeds, and smallholders, indigenous and traditional peoples use fire in farm-fallow systems. Not all fires in previously cleared lands are intentional – some escape beyond intended limits. Third, fires can invade standing forests, either for the first time when flames are mostly restricted to the understorey, or as repeated events, resulting in more intense fires.

Different types of fire have different drivers (Fig. 1a). While weak governance may lead to more deforestation fires (Fonseca et al. 2019), climate change makes forests hotter and drier, thus more likely to sustain escaped fires (Brando et al. 2019). Different fire types also have different impacts. For example, uncontrolled fires in open lands can kill livestock and destroy crops and farm infrastructure, while even low intensity forest fires can kill up to 50% of the trees and reduce the value of the forests for local people (e.g. Barlow et al. 2012). In contrast, farm-fallow fires are essential for the food security and livelihoods of some of the Amazon’s poorest people (Carmenta et al. 2013). A failure to distinguish between different fire types has contributed to the uncertainty surrounding the recent Amazonian fires, and has important implications for policy responses.

We evaluate the Brazilian government's claims that the Amazon fire situation in August 2019 was 'normal' and 'below the historical average' by assessing the longer-term trends in active fires and annual deforestation and more recent month-by-month deforestation trends. The number of active fires in August in 2019 was nearly three times higher than in 2018 and the highest since 2010 (Fig 1b). There is strong evidence this increase in fire was linked to deforestation. To examine this, we first estimate 2019 deforestation as the numbers from the Brazilian PRODES system for measuring annual deforestation are yet to be published. The area of deforestation detected by PRODES runs from August to July each year and is, on average, 1.54 higher than near-real-time DETER-b measure of deforestation. Using this conversion factors suggests that >10,000 km^2 of forest were lost in the period between Aug-2018 and July-2019, which would make it the highest annual loss since 2008 (Fig 1b). These annual trends are mirrored by a sharp increase in monthly deforestation detected by DETER-b – deforestation in July 2019 was almost four times the average from the same period in 2016-18 (Fig 1c).

The marked upturn in both active fire counts and deforestation (Fig 1b) in 2019 therefore refute suggestions that August 2019 was a 'normal' month in the Amazon (Fig 1b). Moreover, the increase in fires has occurred in the absence of a strong drought, which can be a strong predictor of fire occurrence (Aragão et al. 2018). The important role of deforestation-related fires were consistent with media footage of large-scale fires in deforested areas, while the enormous plumes of smoke that reached high into the atmosphere can only be explained by the combustion of large amounts of biomass. The unusual nature of 2019 was also emphasized by exceptionally high fire counts in some protected areas, such as Jamanxim National Forest where active fires increased by 355% from 2018 to 2019, 44% above the long-term average (BDQueimadas 2019).

Some key uncertainties remain. Despite the large-scale fires seen in August 2019, there was a 35% drop in active fires in September, and it is unclear to what extent rainfall or the recent two-month fire moratoria declared by President Bolsonaro has contributed to this. Crucially, it is also unclear what will happen when the ban is lifted. The figures from DETER-b suggest deforestation remained well above average in September, despite the moratoria (Fig. 1c). Moreover, over the last 20 years, 65% of annual fire detections occur from September to December, which is the peak of the dry season for much of the Amazon. Given the essential role of fire in clearing felled vegetation, these recently deforested areas are very likely to burn in the near future.

Another uncertainty relates to the extent of forest fires. These are rarely detected by active fire counts – for example, active fire counts during the 2015 *El Niño* were unexceptional, even though forest fires burned 1 million ha in the Santarém region (Withey et al. 2018) and affected many other areas of the Amazon in one of the strongest El Niño-mediated droughts on record (Jimenez et al 2016). However, weekly mapping in August 2019 has already revealed 8,500 ha of forest fires in the frontier region of Brazil and Peru (Sonaira Silva *pers. comm*.) despite the lack of an unusual drought in 2019.

Managing Amazonian fires requires understanding what is burning, what drives contagion and extent, and how different drivers combine to make the Amazon more flammable (Fig. 1a). Tackling deforestation is key – forest clearance is a major source of ignition, and augments the flammability of remaining forests by increasing edge density, raising regional temperatures and reducing rainfall. Brazil's successful deforestation action plan of 2004-2012 (see Fig. 1b) provides a clear blueprint for action, but is contrary to the current government's approach of undermining forest monitoring and cutting resources for law enforcement.

Fires on previously cleared lands provide many of the ignition sources for forest fires (Fig 1a). Some of these risks could be reduced by phasing them out. For example, incentives and capacity building can encourage fire-free cattle ranching, which can also return higher yields than extensive fire-based approaches to pasture management. Finding equitable alternatives to the traditional fire-dependent agriculture practiced by smallholders is more challenging. "Technological spillover" has enabled some smallholders to access tractors from capitalised landholders, but this could have perverse outcomes for sustainable land use, crop choices that affect regional food security, and even social justice. Where alternatives are not practical or socially desirable, policies need to support the politically and economically marginalized land users to develop farming practices adapted to changing environmental conditions.

Preventing forest fires will also require action to prevent illegal logging operations, as microclimatic changes make logged forests more flammable (Uhl & Kauffman1990). Near-real-time monitoring and forecasting of drought intensity and fire risk would also help, especially if linked to responsive and capable local fire brigades. Global climate change is also a key driver of change in the Amazonian system, increasing both dry season lengths and temperatures (Brando et al. 2019). Maintaining the climate change mitigation potential of the Amazon is therefore itself dependent on reducing greenhouse gas emissions across the world.

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Figure 1. a) An overview of fire types, drivers, and their positive feedbacks on fire prevalence. Fire types are shaded by the three broad classes of fire in the Amazon: Deforestation (dark grey), fires on previously cleared lands (grey), and forest fires (light grey). Deforestation and agricultural fires are intentional, while uncontrolled fires are either started accidentally or through malevolent intent. **b)** Annual deforestation (August-July, following PRODES from Terrabrasilis, 2019; yellow) and active fire counts (January-August, matching the pre-Moratoria period in 2019). Deforestation in 2019 (orange) was estimated based on DETER-b (Terrabrasilis, 2019). Active fire counts are from BDQueimadas. Years with extreme droughts are shown with an asterisk. **c)** Monthly deforestation detected by DETER-b for the period April-September, comparing 2019 (red) with the mean ± SD from 2016-18 (blue). The vertical dashed line represents the onset of the fire moratoria.