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Social and ecological drivers of the fire regimes in the Brazilian Amazon

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Between 2004 and 2012, deforestation rates in the Brazilian Amazon decreased by ~ 80% after the implementation of a program to reduce deforestation. During this period, **forest degradation**, mainly driven by wildfires and logging, become **the main source of above ground biomass losses** over the region. This is partially explained by feedback between **deforestation**, **forest degradation**, **climate** and **fire regimes**. Moreover, a weakening of environmental protection led to a surge of deforestation since 2012. For understanding better the social and ecological drivers of fires regimes in the region, a spatio-temporal model with data from 2003 and 2019 will be created.

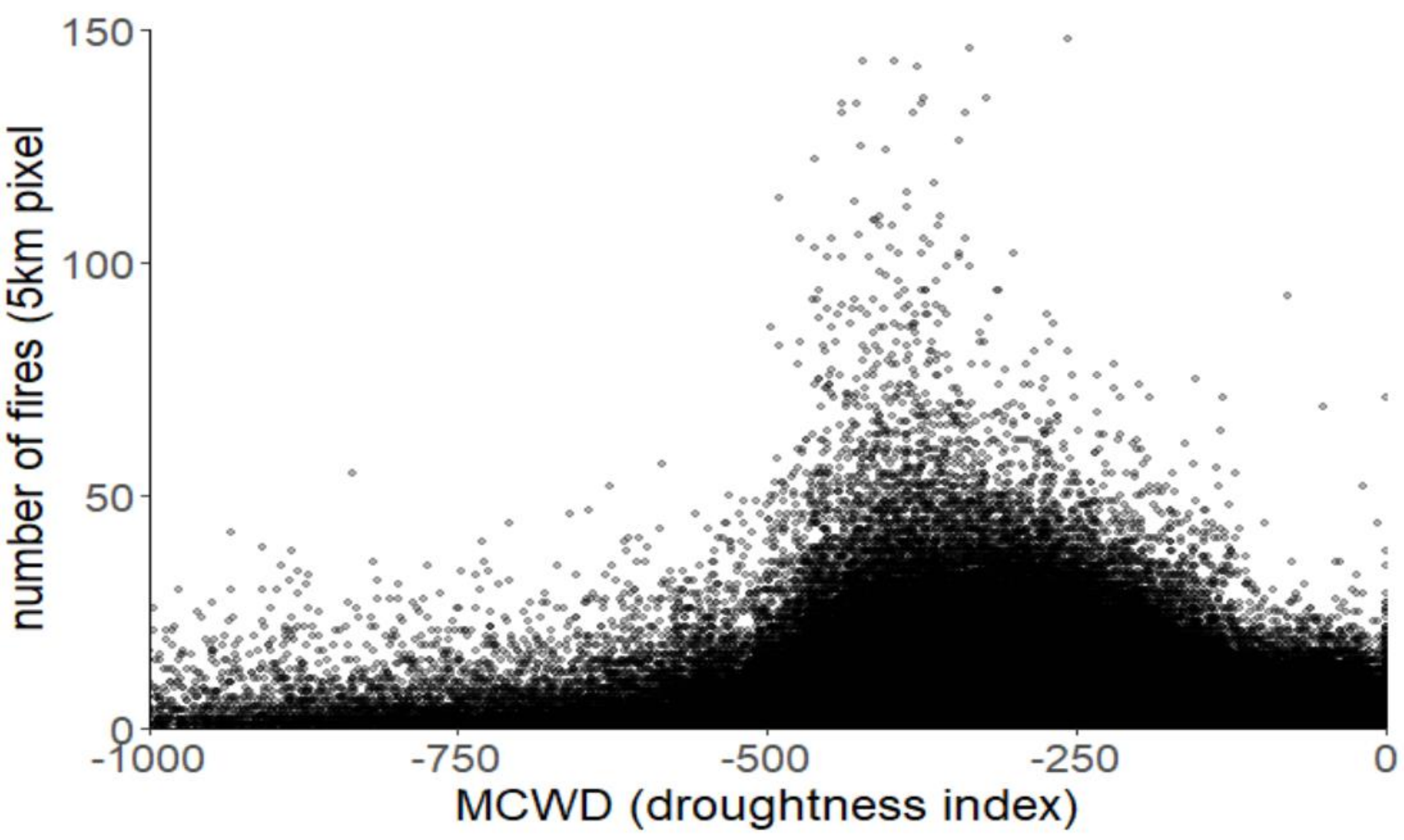

Figure 1. *Number of fires detected by MODIS on 5km pixels according to the Maximum cumulated Water Deficit, an index of droughtness, in the Brazilian Amazon*

Classification AF

Fires in the Brazilian Amazon can broadly be classified in 3 categories (figure 2):

- **Fires for deforestation:** land clearings for creating new pastures and cropland are made by cutting trees and set fire during the dry seasons
- **Fires for agricultural maintenance:** fires lite during the dry seasons to burn regrowing vegetation on pasture and cropland, increasing productivity on the short term
- **Forest fires:** when two previous types of fires are conducted close to forest edges, they can escape in nearby forest (especially during drought) and burn over large areas.

Annual land cover maps have been used to classify fires observed by MODIS sensors according to dominant land use. Deforestation maps will be used to improve the classification of the fires. Relatives importance of drivers for the three fires types will be analysed. This is critical to articulate efforts aiming at fighting deforestation and fire hazard from agricultural burnings.

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Cumulative Impact of Fires on Rainforest

In normal conditions, rainforests are resistant to fire due to their high level of humidity. However, human pressures degrade the ecosystem, affecting canopy structure and micro-climatic conditions, and create frequent ignition points on forest edges. Likelihood of forest fires resulting from agricultural fires depends both on the ecosystem integrity, climatic conditions and fire-control measure taken by landholders. Tree mortality resulting from the wildfires are increasing dead biomass available for burning, leading to increasingly intense and damaging fires. Damage to the canopy also favours the invasion by exotic grasses, promoting frequent burning.

Changing Governance Context

After 2004, the Brazilian government adopted an ambitious plan to halt deforestation relying on: (i)improving satellite monitoring of deforestation for law enforcement, (ii) planification of land use through the delimitation of protected areas and enforcement of the forest code on private land, (iii) encouraging sustainable farming systems. Private actors also signed a moratorium to clean their supply chain of soy and beef from deforested areas. These initiatives succeeded to reduce drastically the deforestation rate between 2004 and 2012, but were less efficient to limit number of fires. These policies change have met resistance from political interests linked to agribusiness and extractive industries, leading to a weakening of these environmental policies since 2012 through downsizing or degazettement of protected areas, successive legislative change and budget slashing. This resulted in an increase of deforestation rate and number of fires between 2015 and 2020.

Drivers of the fire regimes

Based on literature review of the drivers of deforestation and fires regimes in the Amazon and complementary interviews with local stakeholders, we determined 6 types of drivers that will be included in our model:

- **Climatic:** periodic drought resulting from EL-Nino and AMO events put under stress large part of the Amazonian forest, resulting in a surge of wildfires (Figure 1).
- **Agricultural expansion:** Ranching and crop cultivation rely on frequent use of fire, both for land clearing and field maintenance.
- **Infrastructure and migration:** road network , mining and governmental programs determine the repartition of the population in the region and subsequent pressure on forest
- **Ecosystem integrity:** forest degradation and fragmentation increase vulnerability of the forest to wildfires
- **Environmental policies:** reduce pressure on the ecosystems and discourage from the use of fires
- **Land conflicts:** increase deforestation rates and fires to prove productive use of the land and gain land rights

Methods

30 potential variables have been identified for assessing the relative influence of the 6 types of drivers of fire regimes. After a preliminary work to understand potential co-dependency between the variables, **spatio-temporal Bayesian models** will be created using R-INLA package. This approach account for spatial and temporal auto-correlation that might result from the exclusion of important variables from the model. After variables selection and fine-tuning, final model will inform us on the impact of different variables on fire regimes over the Basin.

Next Steps

Large scale modelling exercise could be helpful for capturing general patterns but are limited when it comes to explaining the fine-scale dynamics at play. Thus, two complementary research activities will be conducted to build on the results of this exercise:

- Fieldwork to understand change in fire management practices of local communities and impact of environmental policies
- Analysis of forest areas which burned several times, to assess cumulative impact on the fire intensity, canopy structure and tree mortality.

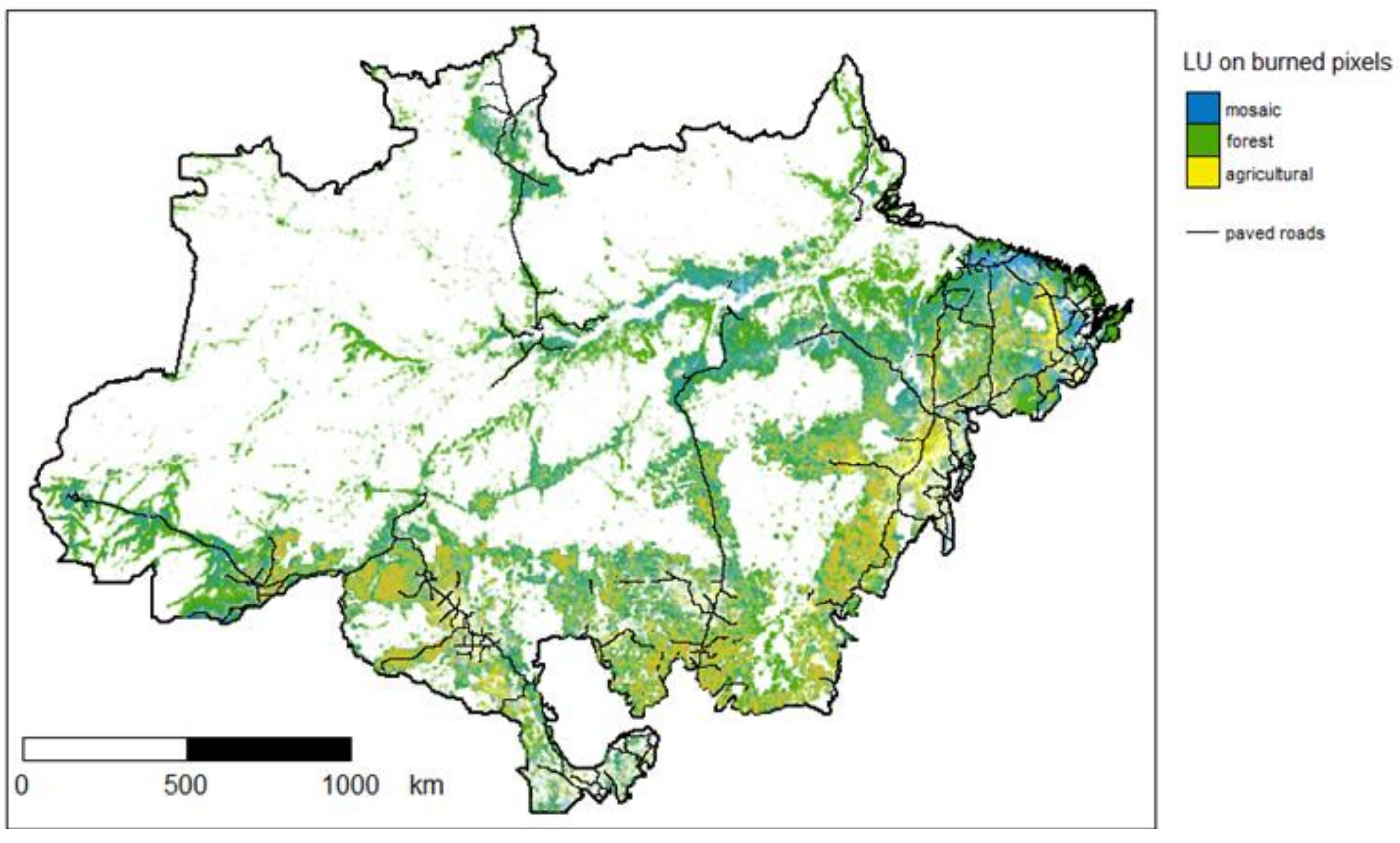

Figure 2. *Map of the fires observed over the 2003-2019 period in the Brazilian Amazon according to land-use map. Fires on mosaic are related to deforestation fires.*