DECORRELATION BETWEEN FOREST FIRE AND DEFORESTATION IN RONDONIA

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ABSTRACT

Carbon emissions from tropical countries are largely associated with changes in land use and land cover (LULCC), especially those related to direct conversion of old-growth forests into pastures or croplands through forest clearing and burning. Based on this process, the Brazilian proposal for reducing CO_2 emissions has largely focused on curbing illegal deforestation rates. However, despite the reduction of deforestation rate and consequent reduction in the reported emissions linked to deforestation, there are evidences that carbon emission associated to fire incidence in human modified regions (without deforestation) have not decrease in the same period. Considering this scenario, our objective here was to test if areas affected by forest fires in Rondônia state between 2007 and 2015 are subsequently clear-cut through deforestation. The results showed that a considerable part of the affected area was burned at least 2 times during the studied period, with some forests burning up to seven times. In addition, the annual variability of forest fires and deforestation for the same place and same period were uncorrelated (R^2=0.01).

***Key words* —** Forest Fire, Deforestation, Amazonia, Rondônia

1. INTROUCTION

Brazil has been a proactive player in the discussions and actions that involve Global Climate Changes. Brazil was one of the first developing countries to voluntarily commit to reduce greenhouse gas emissions, specially from land use and land cover change. According to the first (2013), second (2014) and third (2016) editions of the Annual Estimates of Greenhouse Gas Emissions in Brazil and the first (2004), second (2010) and third (2016) editions of the National Communication of Brazil to the United Nations Framework Convention on Climate Change (UNFCCC), on average 51% of our emissions are related to deforestation of tropical forests. Usually, carbon emissions from tropical countries are largely associated with the complete conversion of old-growth forests into pastures or croplands through a forest clearing and burning procedure [1],[2],[3].

To tackle this problem, the Brazilian proposal to reduce carbon emissions is almost entirely based on reduction of deforestation. However, despite the reduction of deforestation rate and consequent reduction in the reported emissons linked to deforestation, studies [4],[5],[6] have shown that carbon emissions associated to fire incidence not associated to deforestation have increased in human modified regions during the same period.

To provide a comprehensive understanding of the fate of burned forests, here we aim to analyze the spatial and temporal relationships between forest fire and deforestation between 2007 and 2015 for the State of Rondônia, Brazil.

2. MATERIAL AND METHODS

2.1 Study Area

Our study covers the entire State of Rondônia, located in the Southwest flank of the Brazilian Legal Amazon (figure 1). Despite the great dynamics in land use and land cover changes, 51% of the State is still covered by old-growth tropical forest. This balance between the presence of forest and the pressures induced by economic activities associated to agriculture and livestock can potentially favor fire occurrence and, therefore, was critical for selection of the study case.

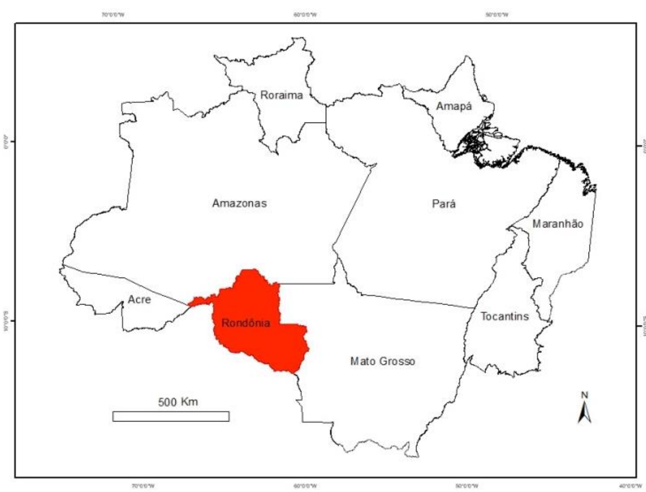

Figure 1. States of the Brazilian Legal Amazon with the location of Rondônia state in red.

2.2 Mapping of Burned Areas

The annual burned area maps were produced based on daily surface reflectance products (MOD09GA and MOD09GQ) and 8 day surface reflectance products (MOD09Q1 and MOD09A1), from MODIS data set. The metodology used consisted of applying a segmentation procedure followed by an unsurpevised classification over the shade fraction image that contains the relevant information for mapping burned areas in forests.

2.3 Mapping deforestation

The annual deforestation data used was obtained from the INPE/PRODES (Assessment of Deforestation in Brazilian Amazonia) database [7]. The PRODES program uses satellite images with spatial resolutions ranging from 20 to 30 meters, that provides a minimum mapped area of 0.0625 km^2 or 6.25 ha, to quantify only the complete conversion of old-growth forests into agricultural uses.

2.4 Burned forest sizes and overall extent

Originally, the burned area maps do not distinguish different types of land use and cover classes. To calculate the area of burned forest and to assure that only forest areas were included in the analysis, we only considered burned scars that were superimposed on the forested area mapped by PRODES (figure 2). Then, the number and the size of individual forest fire polygons per year were used to generate annual forest burned area data.

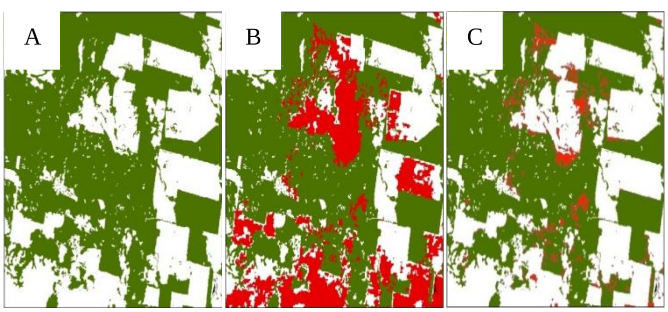

Figure 02. Extraction of forest fire polygons. A) Green - Area of forest B) Red - General Burned area and C) Red - Only Forest Burned area

2.5 Relationship between burned forest and deforestation

Here we calculated how much of the forest burned area was suppressed by deforestation in the following years after fire until 2015. To do so, we calculated the instersection between the forest fire polygons from a starting year and those of deforestation of the following years. The forest fire polygons of year 1 (e.g. 2007) were superimposed on the deforestation polygons of the following years (2008-2015), one by one separately (figure 3).

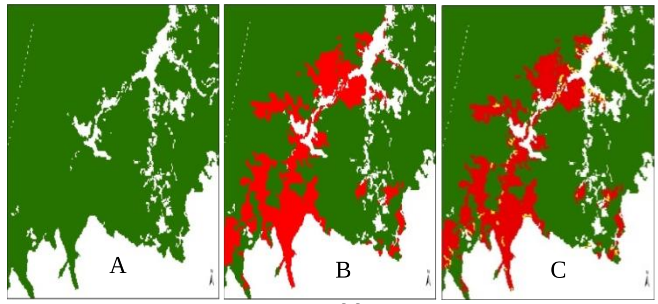

Figure 03. A) Green - Area of forest 2007, B) Red - Burned forest 2007 and C) Yellow - Deforested areas between 2007 – 2015.

3. RESULTS

3.1 Burned forest size and overall extent.

During the study period, an area of about 4755 km^2 of primary forest were burned taking into account all reburned areas and around 3757 km^2 of primary forest (around 20% of the remaining forest) was burnt (without reburns). More than half of the area, around 52 %, burned in drought years (2007, 2010 and 2015) as shown in figure 04.

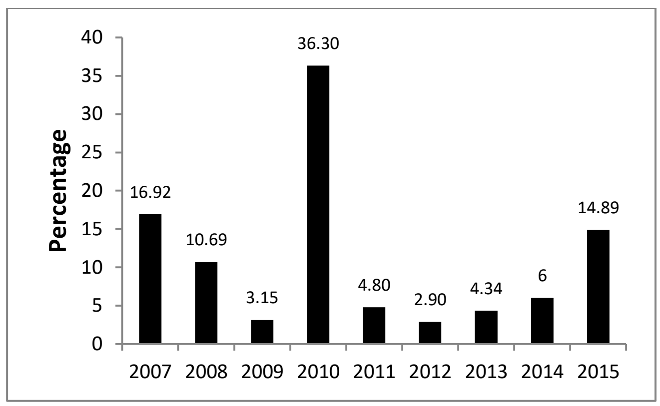

Figure 04. Proportion of Burned Forest per year between 2007-2015

In addition, we calculated how many times the area burned during the study period. We found that 78.5 % of the area burned once, 15.26% burned twice and 6.25 % burned from 3 to 9 times. Figure 05 shows the State of Rondonia with the remaining forests in green and the forest burned once in red, twice in black and from 3 to 9 time in yellow.

3.2 Relation between Burned Forest and Deforestation

Between 2007 and 2015 about 4755 km^2 of forest were burned while 7650 km^2 were deforested. This suggests a close relationship between forest fires and deforestation in the period. However, when the spatially explicit data of forest fire and deforestation from same period are compared, we observed that these factors are unrelated for the same period and space. The following table (table 01) shows the percentage of forest burned in a given year and deforested in subsequent years from 2007 to 2015.

Table 1. Proportion of forest burned in a given year and deforested in subsequent years

	% Def 08	% Def 09	% Def 10	% Def 11	% Def 12	% Def 13	% Def 14	% Def 15
Fire 2007	10.52	2.22	2.23	3.07	2.25	2.63	1.91	1.88
Fire 2008		5.63	3.43	4.67	3.05	4.61	2,17	2.46
Fire 2009			8.39	3.84	3.11	5.25	3,47	2.75
Fire 2010				6.89	5.55	5.06	2,09	2.14
Fire 2011					8.22	9.91	3,13	2.46
Fire 2012						19.55	2,95	3.58
Fire 2013							12.30	4.79
Fire 2014								12.78

It is clear that only a small part of what was burned in each year was deforested in the following years. In addition, the annual variability of forest fires and deforestation was uncorrelated (R^2=0.01). This results are in agreement with the results obtained by [6], which was one of the first studies to show the fate of burned forest for the entire Amazon

4. CONCLUSIONS

Deforestation of tropical forests is considered one of the major sources of greenhouse gas emissions [1], [8], [9], [10], [11]. Nevertheless, emissions from forest degradation remain poorly studied and consequently is one of the main sources of uncertainties for the global carbon cycle .[12], [13], [14].

Deforestation rate is largely used as a single source of information for quantification of CO_2 emissions from land cover change in regional [15] or global [16] carbon emission inventories [3].

However, the magnitude of forest degradation and the long-term fate of degraded forests remain poorly studied and consequently are not explicitly treated in emission reports. The lack of systematic data is therefore critical for effectively report these quantities.

Finally, we conclude that on average around 23±5% of the forests that burned in a given year are subsequently deforested. Therefore, emissions from the remaining 77% of degraded forest should be included in the emissions calculation from land use change in Amazonia as forest

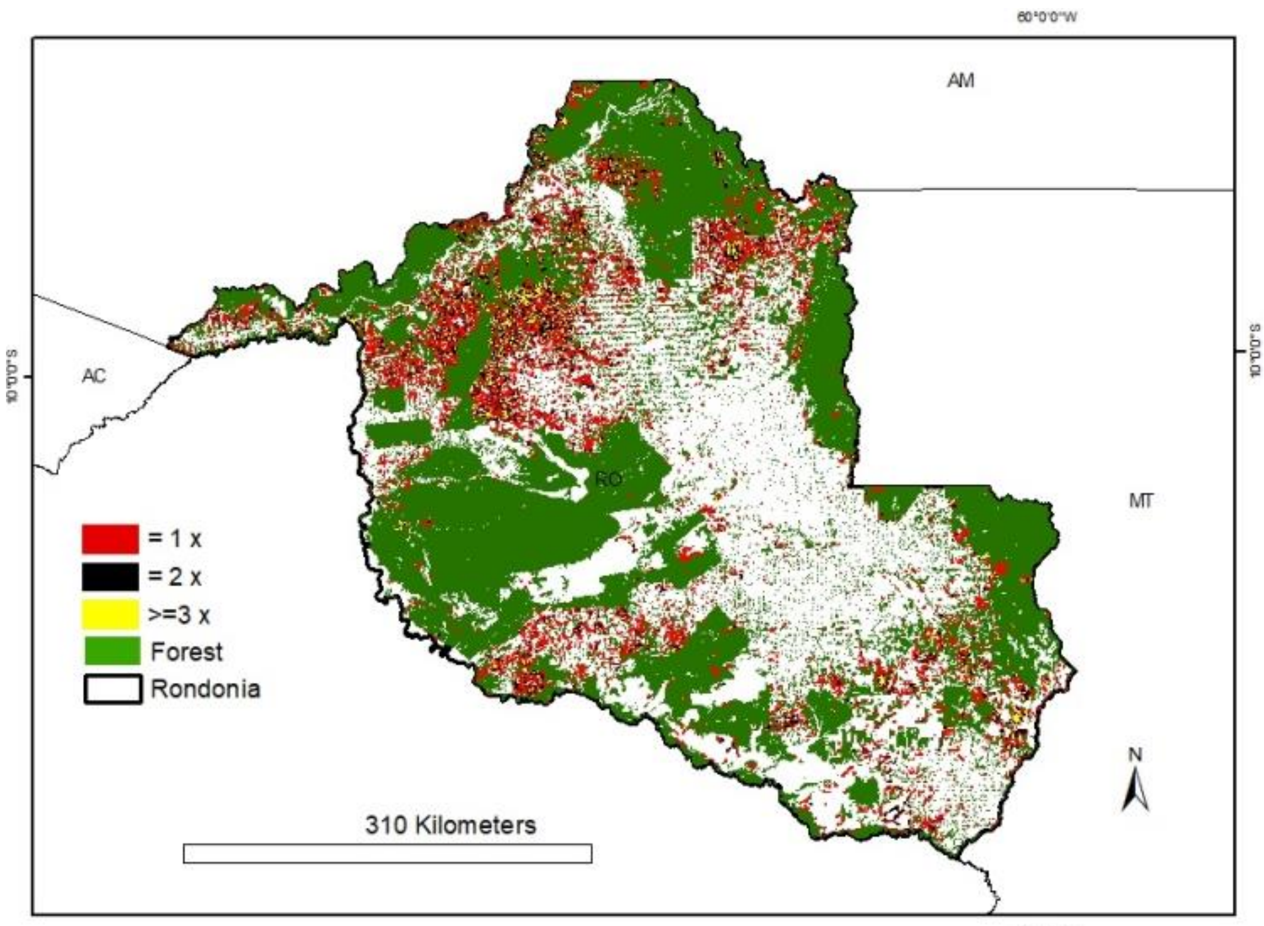

Figure 05. Map of fire recurrence. Unburned forests are in green and forests once, twice and more than 3 times burned are in red, black and yellow, respectively

degradation.

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