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SUMMARY

In March 2012, The Deforestation Alert System (SAD) detected 53 square kilometers of deforestation in the Brazilian Amazon. It represented a 15% increase regarding March 2011 when the deforestation totaled 46 square kilometers. In March 2012, it was possible to monitor with SAD only 26% of the forest area in the Brazilian Amazon.

The deforestation accumulated in the period of August 2011 to March 2012 totaled 760 square kilometers. There was a 22% reduction regarding the same previous period (August 2010 to March 2011) when the deforestation totaled 969 square kilometers.

In March 2012, most part (60%) of the deforestation occurred in Mato Grosso. Following is Pará with 25% and Rondônia with 9%. The rest (6%) occurred in Amazonas, Roraima and Acre. However, it was possible to monitor only 26% of the forest area of the Amazon and, therefore, the deforestation information in this month may be underestimated.

The degraded forests in the Brazilian Amazon totaled 40 square kilometers in March 2012. In relation to March 2011, when the forest degradation totaled 298 square kilometers, there was a reduction of 87%. Most part (67%), occurred in Mato Grosso, followed by Amazonas (15%), Rondônia (10%), and Pará (7%).

The forest degradation accumulated in the period (August 2011 to march 2012) totaled 1.568 square kilometers. There was a 2010 reduction of 62% regarding the same previous period (August 2010 to March 2011) when the deforestation totaled 4.111 square kilometers.

In March 2012, the deforestation detected by SAD compromised 3.6 million tons of equivalent CO2. In the accumulated period (August 2011 - March 2012) the emissions of equivalent CO2 related to the deforestation totaled 51 million tons, which represents a reduction of 13% regarding the previous period (August 2010 to March 2011).

Deforestation Statistics

According to Imazon's SAD, the deforestation (total suppression of the forest with soil exposition) has reached 53 square kilometers in March 2012 (Figure 1 and Figure 2). This represented a 15% increase in relation to March 2011 when the deforestation reached 46 square kilometers.

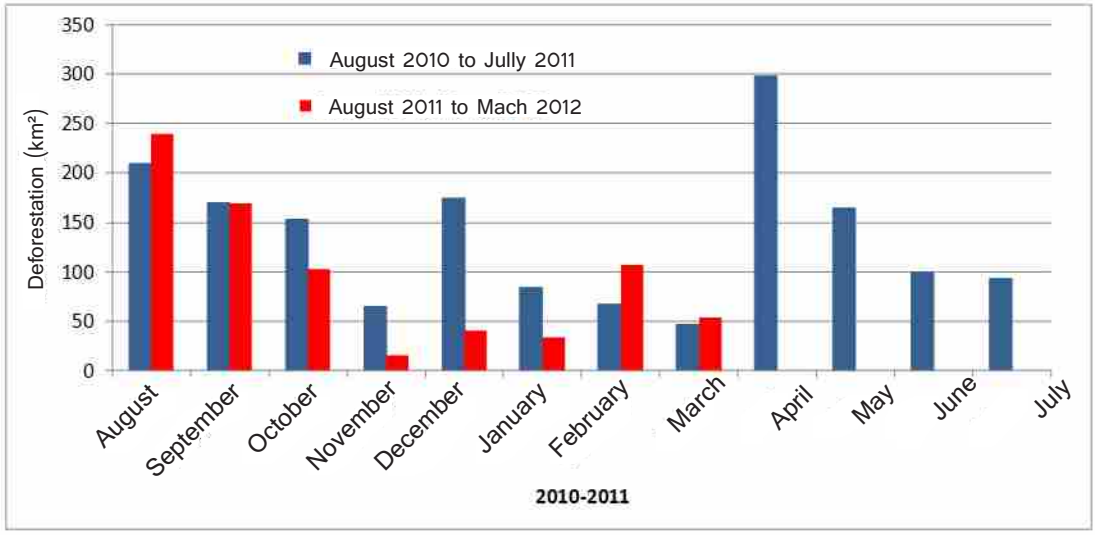

Figure 1. Deforestation from August 2010 to March 2012 in the Brazilian Amazon (Source: Imazon/SAD).

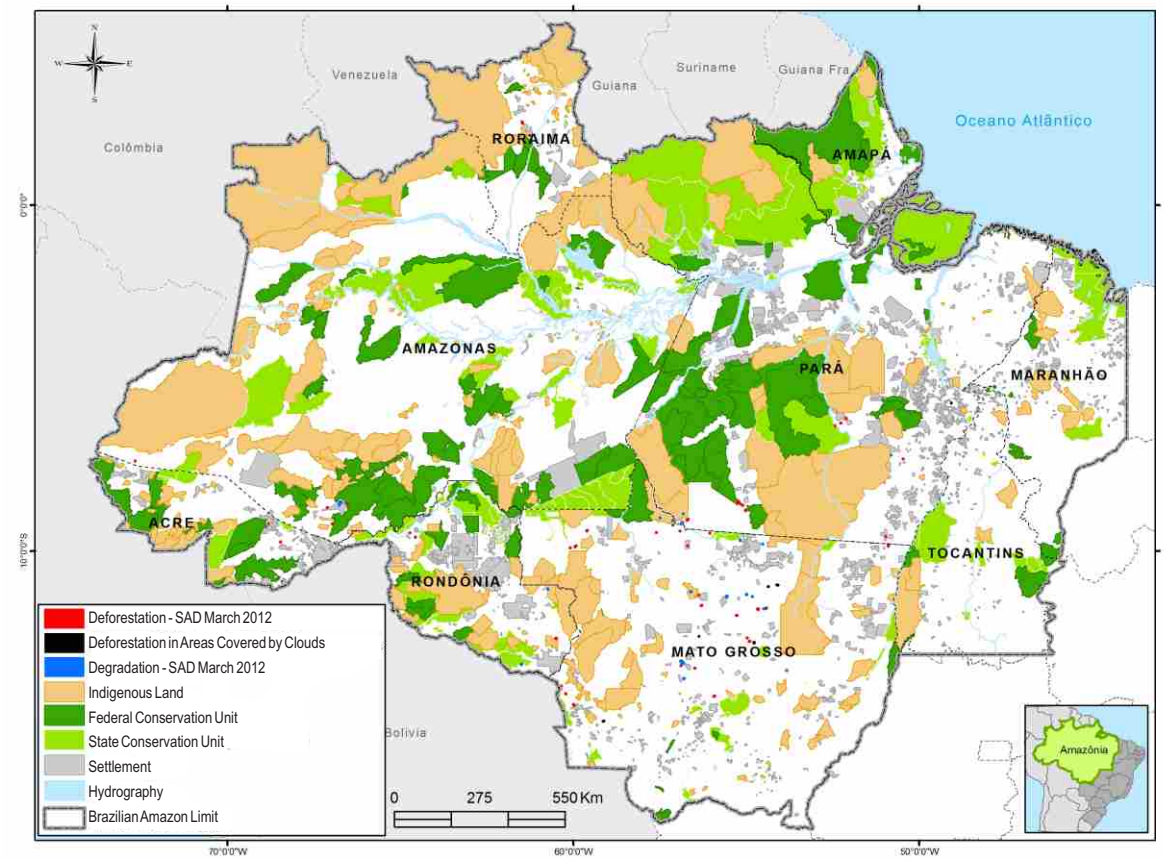

Figure2. Deforestation and Forest Degradation in March 2012 in the Brazilian Amazon (Source: Imazon/ SAD).

*The deforestation in the Areas Covered by Clouds might have occurred in March or previous months, however, it was only possible to detect it now, when there were no clouds over the region.

The deforestation accumulated in the period of August 2011 to March 2012, corresponding to the eight first months of the official calendar of Deforestation measuring, has reached 760 square kilometers. There was a 22% reduction in the deforestation regarding the previous period (August 2010 to March 2011) when it reached 969 square kilometers.

In March 2012, most part (60%) of the deforestation occurred in Mato Grosso, followed by Pará (25%), Rondônia (9%), Amazonas (2%), Roraima (2%) and Acre (2%) (Figure 3).

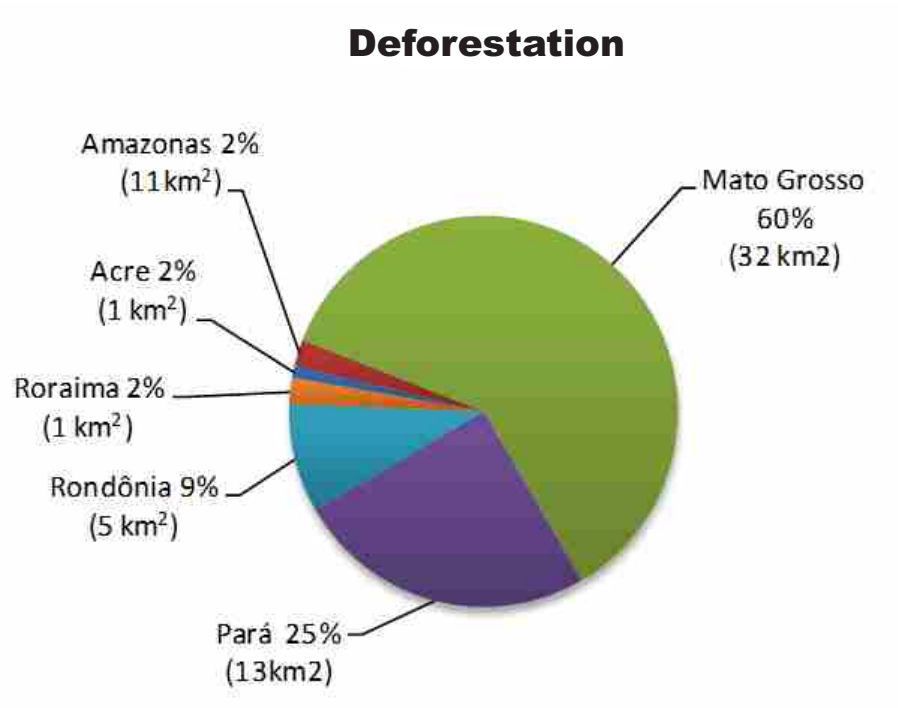

Figure 3. Deforestation (%) in the states of the Brazilian Amazon in March 2012 (Source: Imazon/SAD).

Considering the first eight months of the current deforestation calendar (August 2011 to March 2012), Pará leads the ranking with 35% of the total deforestation. Following is Mato Grosso with 30%, followed by Rondônia with 19% and Amazonas with 9%. These four states were responsible for 93% of the deforestation occurred in the Brazilian Amazon in this period. The rest (7%) of deforestation occurred in Acre and Roraima and Tocantins and Amapá.

There was a 22% reduction of the deforestation occurred in August 2011 to March 2012 when compared to the previous period (August 2010 to March 2011) (Table 1). In relative terms, there was a 63% reduction in Acre, 48% in Amazonas, 42% in Rondônia and 16% in Mato Grosso. On the other hand, there was a 175% increase in Roraima, 120% in Tocantins, 6% in Pará.

In absolute terms, Pará leads the accumulated deforestation ranking with 266 square kilometers, followed by Mato Grosso (230 square kilometers), Rondônia (148 square kilometers), Amazonas (65 square kilometers), Roraima (22 square kilometers), Acre (18 square kilometers) and Tocantins (11 square kilometers).

[1] The official deforestation measuring calendar begins in August and ends in July.

Table 1. Evolution of the deforestation between the States of the Brazilian Amazon from August 2010 to March 2011 and from August 2011 to March 2012 (Source: Imazon/SAD).

State	August 2010 to Mach 2011	August 2011 to March 2012	Variation (%)
Acre	49	18	-63
Amazonas	126	65	-48
Mato Grosso	273	230	-16
Pará	252	266	+6
Rondônia	256	148	-42
Roraima	8	22	+175
Tocantins	5	11	+120
Amapá	-	-	-
Total	**969**	**760**	**-22**

* Data from Maranhão were not analyzed.

Forest Degradation

In March 2012, SAD registered 40 square kilometers of degraded forests (intensely explored forests by lumbering and or/ burning activities) (Figures 2 and 4). Regarding the same period of the previous year (March 2011) there was a 87% reduction when the forest degradation reached 298 square kilometers. In total, most part (67%) of this degradation occurred in Mato Grosso, followed by Amazonas (15%), Rondônia (10%), and Pará (5%) (Figure 5).

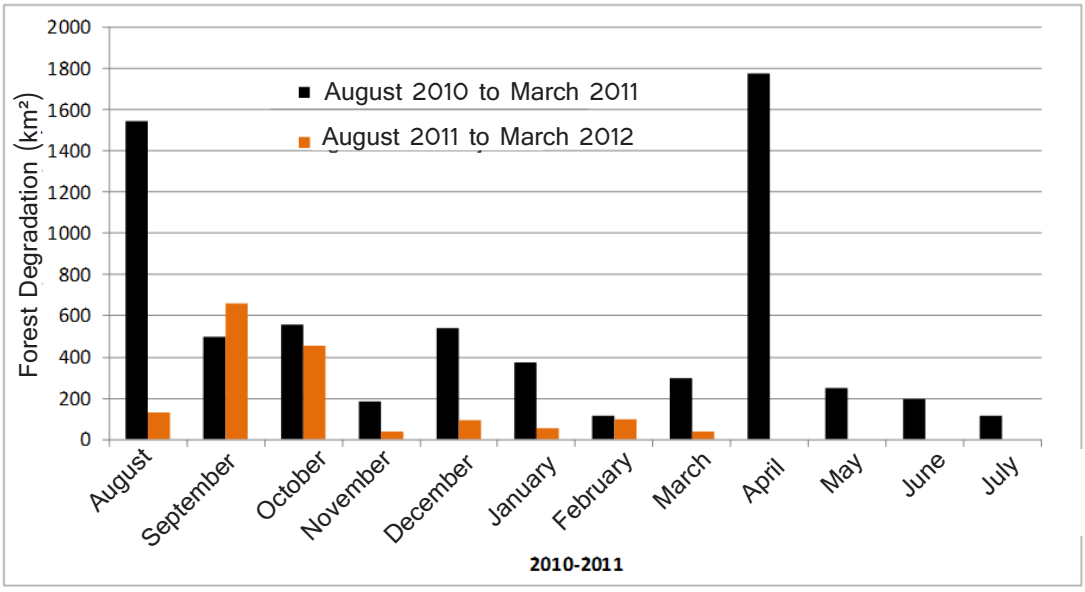

Figure 4. Forest Degradation from August 2010 to March 2012 at the Brazilian Amazon (Source: Imazon/SAD).

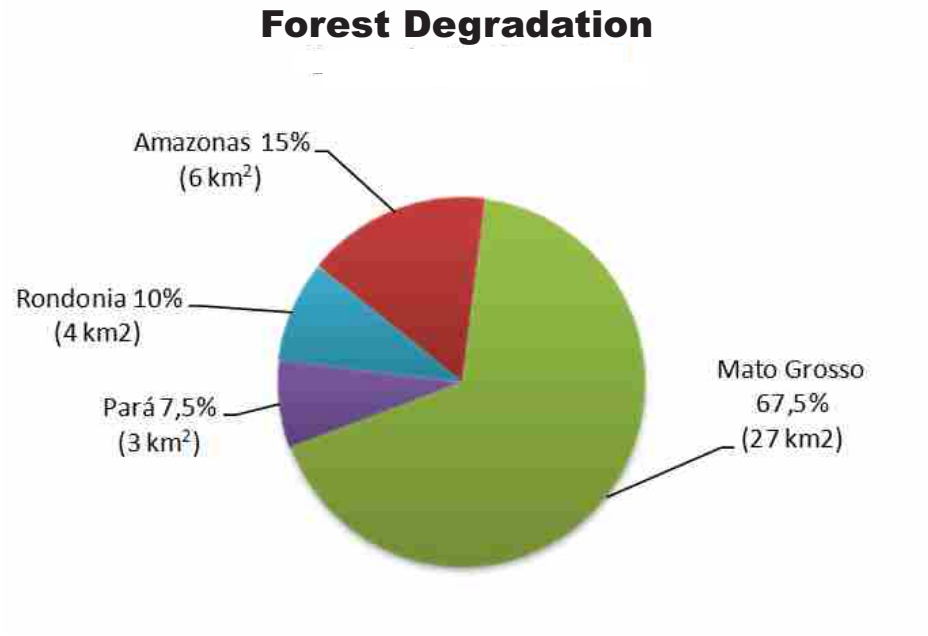

Figure 5. Forest Degradation (%) in the States of the Brazilian Amazon in March 2012 (Source: Imazon/SAD).

The forest degradation accumulated in the period of August 2011 to March 2012 totaled 1.568 square kilometers. This represents a reduction of 62% in the forest degradation accumulated in this period (August 2011 to March 2012) regarding the same previous period (August 2010 to March 2011) when the forest degradation totaled 4.111 square kilometers (Table 2). The largest reductions occurred in Acre (-98%), Rondônia (-86%), Amazonas (-82%), Pará (-68%) and Mato Grosso (-68%).

In absolute terms, Mato Grosso leads the accumulated deforestation ranking with 1.196 square kilometers (76%), followed by far by Pará with 235 square kilometers (15%). The rest (9%) occurred in Rondônia (93 square kilometers), Amazonas (26 square kilometers), Roraima (15 square kilometers), and Acre (3 square kilometers).

Table 2. Evolution of the forest degradation among the States of the Brazilian Amazon from August 2010 to March 2011 and from August 2011 to March 2012 (Source: Imazon/SAD).

State	August 2010 to March 2011	August 2011 to March 2012	Variation (%)
Acre	143	3	-98
Amazonas	141	26	-82
Mato Grosso	2.404	1.196	-50
Pará	754	235	-68
Rondônia	650	93	-86
Roraima	2	15	+650
Tocantins	26	-	-
Amapá	-	-	-
Total	**4.111**	**1.568**	**-62**

* Data from Maranhão were not analyzed.

[2] The official deforestation measuring calendar begins in August and ends in July.

Carbon Affected by the Deforestation

In March 2012, the 53 square kilometers of deforestation detected by SAD in the Brazilian Amazon compromised 1 million tons of carbon (with error radius of 311 thousand tons of carbon). This amount of affected carbon results in 3.6 million tons of equivalent CO^2 (Figure 6).

The forest carbon compromised by the deforestation in the period of August 2011 to March 2012 was of 14 million tons (with error radius of 289 thousand tons), which represented approximately 51 million tons of equivalent CO^2 (Figure 6). Regarding the same period of the previous year (August 2010 to March 2011) there was a 13% reduction in the amount of carbon compromised by the deforestation.

The reduction (13%) of the forest carbon affected by the deforestation in the period of August 2011 to March 2012 regarding the previous period (August 2010 to March 2011) was less than the reduction of 22% of the deforestation detected by SAD during the same period. This suggests that the deforestation this year is occurring in areas with less stocks of forest carbon.

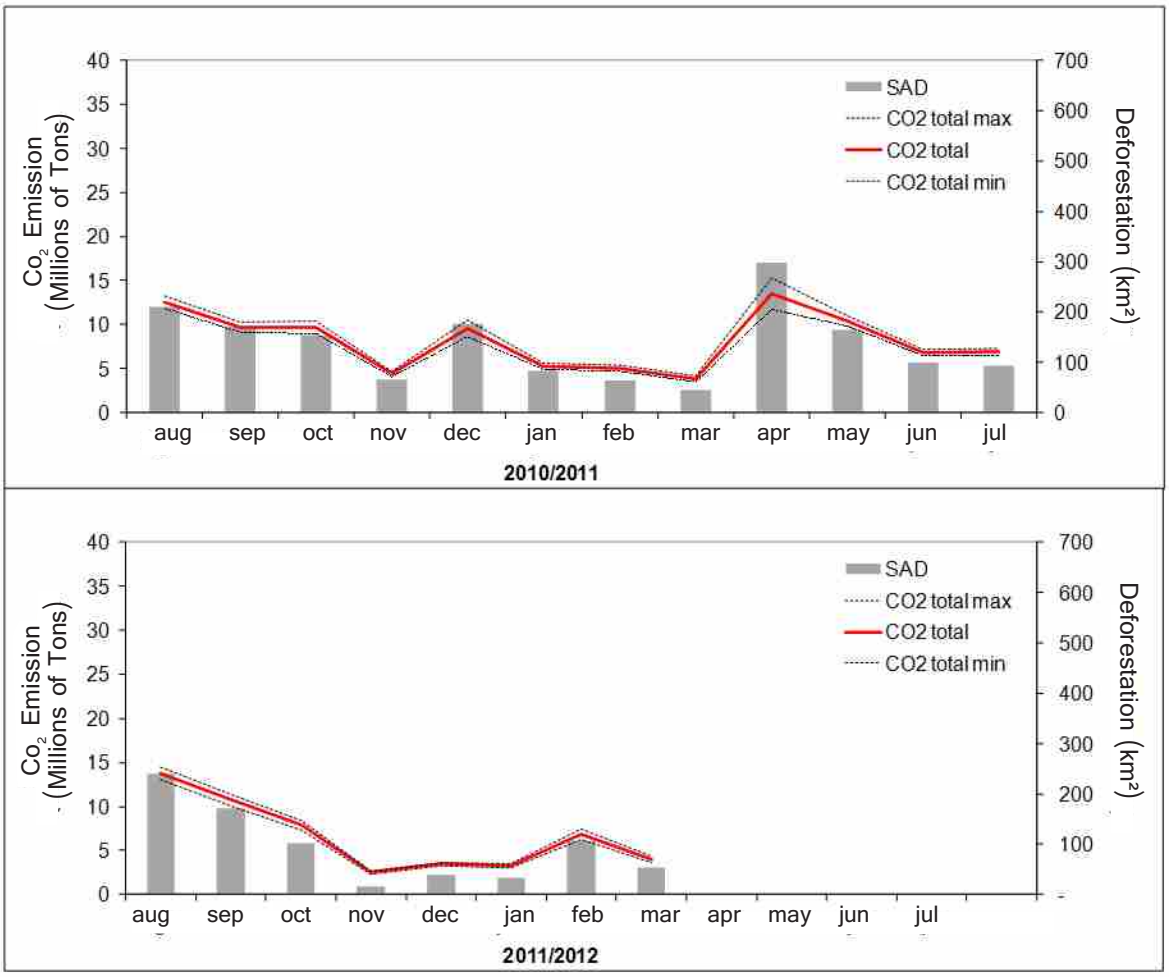

Figure 6. Deforestation and emission of Carbon Dioxide (CO^2) total equivalent from August 2010 to March 2011 in the Brazilian Amazon (Source: Imazon).

Deforestation Geography

In March de 2012, the great majority (94%) of deforestation occurred in private areas or under many stages of ownership. The rest of the deforestation was registered in Conservation Units (3%), Agrarian Reform Settlements (2%) and Indigenous Lands (1%). (Table 3).

Table 3. Deforestation by land category in March 2012 in the Brazilian Amazon (Source: Imazon/ SAD).

Category	March 2012	
	km²	%
Agrarian Reform Settlement	1	2
Conservation Units	1,5	3
Indigenous Lands	0,5	1
Private, Owned and in Abeyance[3]	50	94
Total (km²)	53	100

Agrarian Reform Settlements

SAD registered only one square kilometer of deforestation in the Agrarian Reform Settlements during March 2012. The most affected settlements were Marcedes Bens I and II (Tabaporã; Mato Grosso), São Pedro (Paranaíta; Mato Grosso), and Japão (Iracema; Roraima) (Figure 7).

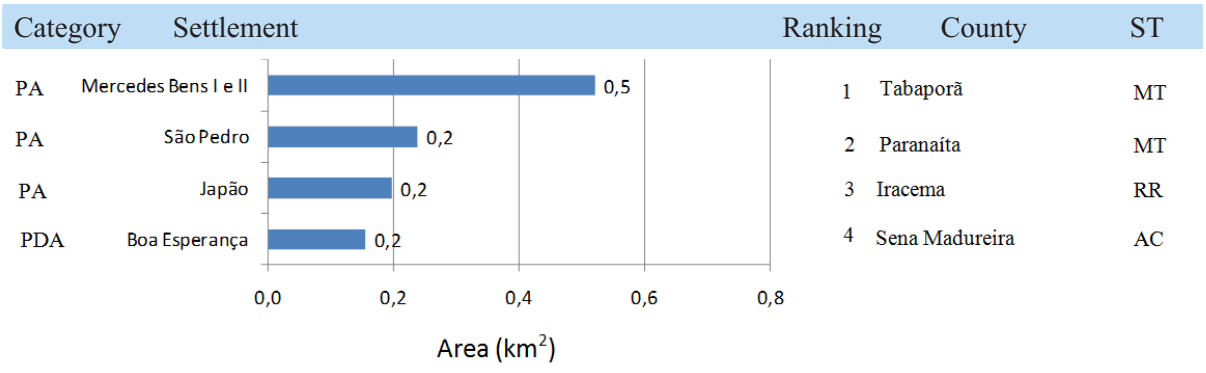

Figure 7. Most deforested Agrarian Reform Settlements in February 2012 at the Brazilian Amazon (Source: Imazon/SAD). PA (Settlement Project).

[3] Includes private areas (owned or not) and non protected public forests

Protected Areas

SAD detected 1.5 square kilometers of deforestation in the Conservation Unit (Figure 8). The Conservation Units that suffered deforestation was APA Triunfo do Xingu (Pará). In the case of the Indigenous Lands, in March 2012 less than 1 square kilometer was detected in the Indigenous land of Tubarão/Latundê (Rondônia) (Figure 9).

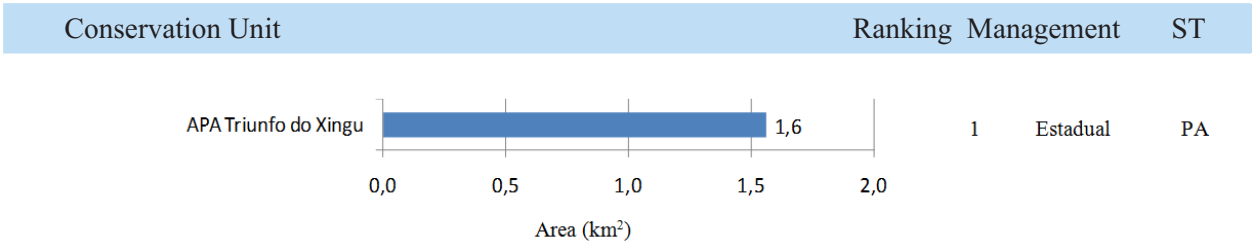

Figure 8. Most deforested Conservation Units at the Brazilian Amazon in March 2012 (Source: Imazon/SAD).

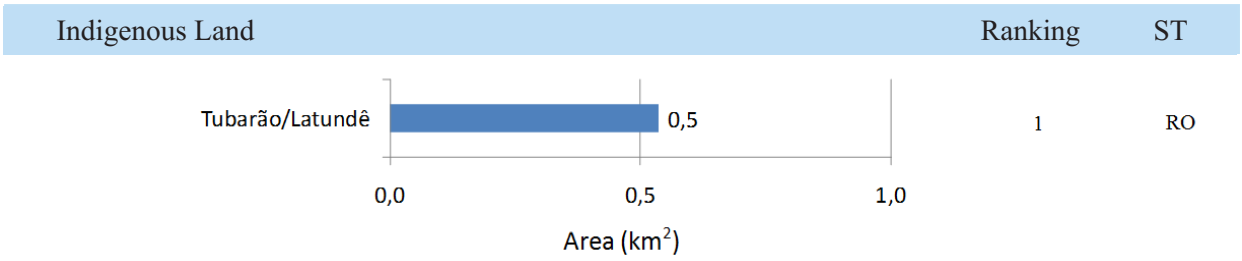

Figure 9. Most deforested Indigenous Lands in the Brazilian Amazon in March 2012 (Source: Imazon/SAD).

Critical Municipalities

In March 2012, the most deforested counties were: União do Sul (Mato Grosso); Jacareacanga (Pará); and Vilhena (Rondônia) (Figure 10 and 11).

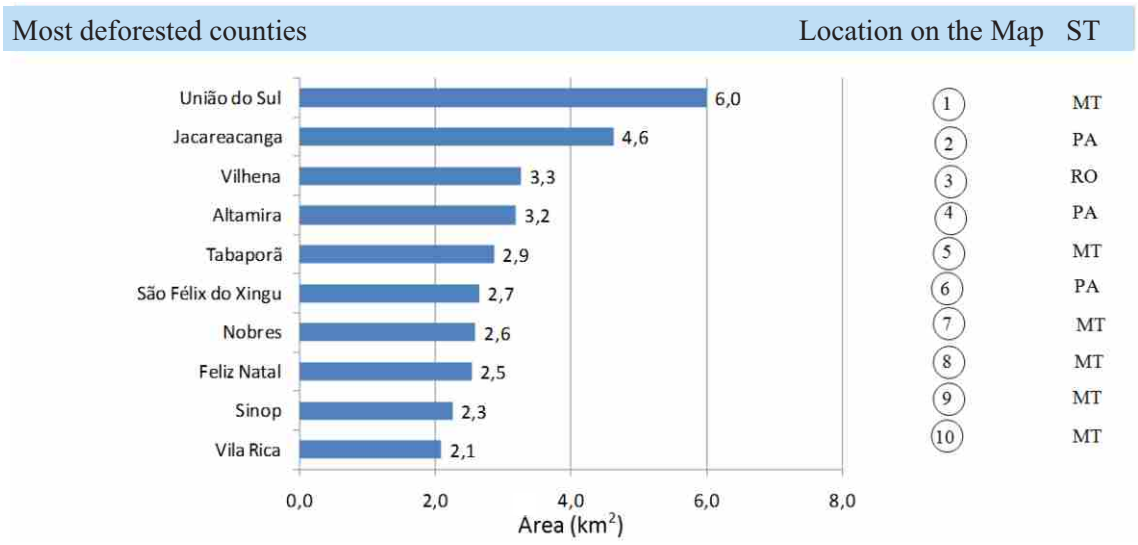

Figure 10. Most deforested municipalities in the Brazilian Amazon in March 2012 (Source: Imazon/SAD).

* The deforestation in the Areas Covered by Clouds might have occurred in March or previous months, however, it was only possible to detect it now, when there were no clouds over the region.

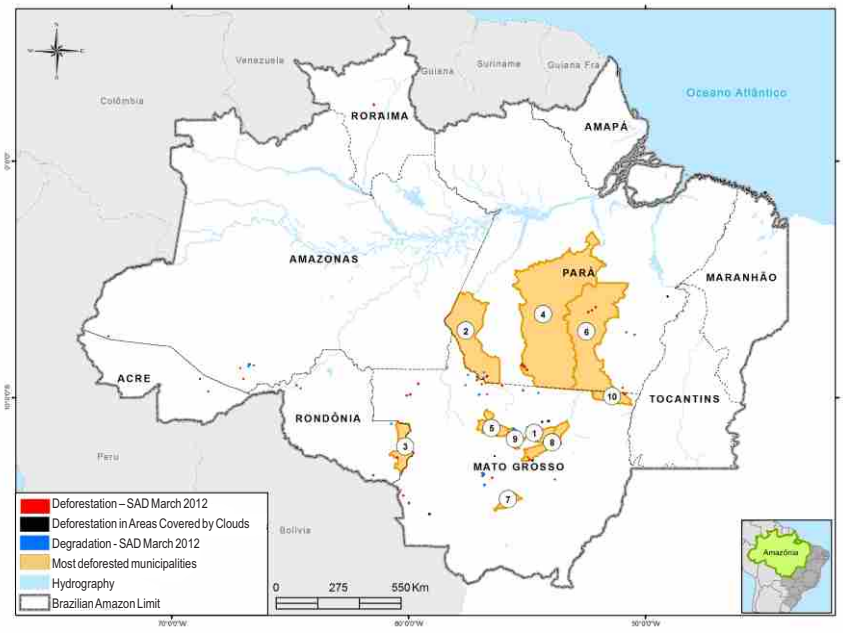

Figure 11. Counties with larger deforested areas in March 2012 (Source: Imazon/SAD).

Coverage by clouds and Shade

In March 2012, it was possible to monitor with SAD only 26% of the forest area in the Brazilian Amazon. The other 74% were covered by clouds which made it difficult to detect the deforestation and the forest degradation. The states with most coverage by clouds were (98%), Pará (84%), Amazonas (76%) and Rondônia (72%). The other states presented less than 60% of their territory covered by clouds. Because of that, the deforestation and degradation information in March 2012 may be underestimated. (Figure 12). The period from December to March is characterized by a rainy period in the Amazon region, thus the monitoring of deforestation through satellite images becomes difficult.

* The part of Maranhão that integrates the Brazilian Amazon was not analyzed.

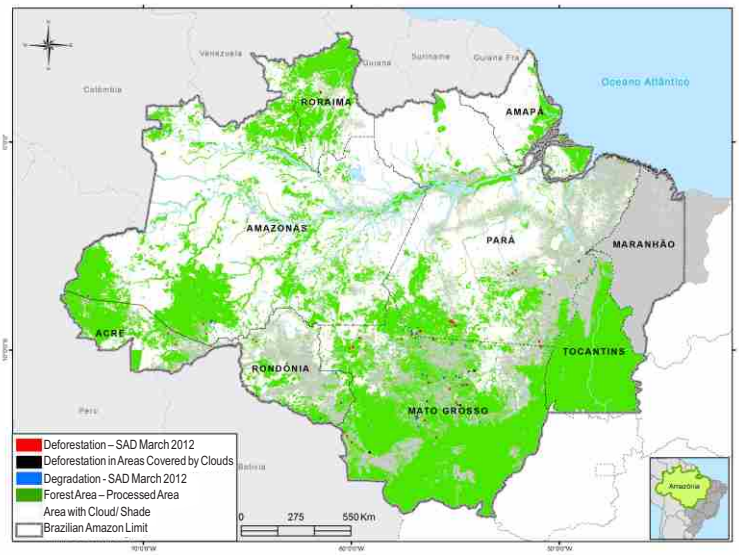

Figure 12. Area with cloud and shade in March 2012 in the Brazilian Amazon

*The deforestation in the Areas Covered by Clouds might have occurred in March or previous months, however, it was only possible to detect it now, when there were no clouds over the region.

Validation of the SAD data using Landsat and Cbers images

The data from SAD are validated with CBERS and Landsat images (thinner spatial resolution) available by the Instituto Nacional de Pesquisas Espaciais (Inpe) – National Institute for Space Research. In November 2011, it was not possible to confirm with the Landsat images the deforestation detected due to the great occurrence of clouds in the Landsat and CBERS images available in the period.

Frame I: SAD 3.0

Since August 2009, SAD presented some new features. First we created a graphic interface to integrate all the image processing programs used with SAD. Second, we started to compute the deforestation in areas that were covered by clouds in the previous months in a new class. Last, the deforestation and the degradation are detected with pairs of NDFI images in a change detection algorithm. The main methodology remains the same as SAD 2 as described below.

SAD generates the temporal mosaic of daily MODIS images of the products MOD09GQ and MOD09GA for the filtering of the clouds. Next, we use a fusion technique of different spectral resolution bands, i.e., with pixels of different sizes. In this case we changed the scale of 5 bands with 500 meter pixels of the MODIS for 250 meters. This allowed the improvement of the spectral model of pixel mixing, providing the capacity of estimating the abundance of vegetation, soil and Vegetation photosintetically non active (NPV - Non-Photosynthetic components (Vegetation, Soil and Shade) to calculate the NDFI, with the equation below:

$$NDFI = \frac{(VGs - (NPV + Soil)}{(VGs + NPV + Soil)}$$

Where VGs is the vegetation component normalized for shade given by:

$$VGs = Vegetation/(1 - Shade)$$

The NDFI varies from -1 (pixel with 100% of exposed soil) to 1 (pixel with > 90% of forest vegetation). This way, we start having a continuous image that shows the transition of deforested areas, going through degraded forests, until we reach the forests without signs of disturbance.

The deforestation and degradation detection spent this month with the difference of NDFI images of the consecutive months. This way, there is a reduction of the NDFI values between -200 and -50 indicating the areas possibly deforested and between -49 and -20 with signs of degradation.

SAD 3.0 Beta is compatible with its previous versions (SAD 1.0 and 2.0), because the threshold of deforestation detection was calibrated to generate the same type of answer obtained by the previous method.

SAD is already operational in the State of Mato Grosso since August 2006 and at the Brazilian Amazon since April 2008. In this Bulletin, we present the monthly data generated by SAD from August 2006 to november 2012.

Frame II: Carbon Affected by the Deforestation

Since January 2010 we report the estimates of the compromised carbon (i.e., forest carbon subject to the emission due to the burning and the decomposition of residues in the forest biomass) resulting from the detected deforestation by SAD in the Brazilian Amazon.

The carbon estimates are generated based on the combination of SAD's deforestation maps with simulation of the spatial distribution of biomass to the Amazon. We developed an estimate model of carbon emissions, as base in a stochastic simulation (Morton et al, in prep.), denominated Carbon Emission Simulator (CES). We generate 1000 simulations of spatial distribution of biomass in the Amazon using a geostatistic model (Sales et al., 2007), and transform these simulation of biomass in stocks of C using conversion factors of biomass for C from the literature, according to the formula bellow:

$$C_t = \sum C(S)_t$$

$$C_t(S) = S_D \times \left[(BVAS - BPF) \times (1 - fc) \times (t == 0) + \left(BAS_0 \times pd \times e^{(-pd \times t)} \right) \right]$$

$$BPF = ff * AGLB$$

$$BAS_0 = bf * AGLB$$

where:
t: time (month)
Ct: Carbon emitted in the month t.
$C_t(S)$: Carbon emitted of a deforested polygon in time t.
SD: Deforest area.
BVAS: Biomass above the soil of the deforested region SD.
BPF: Biomass of forest products removed from the forest before the deforestation.
fc: charcoal fraction (3 to 6%).
BAS_0: Biomass below the soil before the deforestation.
pd: monthly decomposition parameter of the biomass below the soil after the deforestation (0.0075).
$pd \times e^{(-pdxe)}$: monthly decomposition rate of the biomass below the soil after the deforestation.

For the application of the CES model using SAD's data, we considered only the carbon compromised by the deforestation, i.e., the fraction of forest biomass composed by carbon (50%) subject to instantaneous emissions due to forest burnings by the deforestation and/ or future decomposition of the remaining forest biomass. In addition, we adapted the CES model to estimate the forest carbon compromised by the deforestation in monthly scale. Lastly, the simulation allowed to estimate the uncertainty of the compromised carbon, represented by the standard deviation (+/- 2 times) from the simulation of carbon affected in each month.

For the conversion of carbon values to equivalent CO2 we applied the value of 3.68.

References:

D.C. Morton1, M.H. Sales2, C.M. Souza, Jr.2, B. Griscom3. Baseline Carbon Emissions from Deforestation and Forest Degradation: A REDD case study in Mato Grosso, Brazil. In preparation.
Sales, M.H. et al., 2007. Improving spatial distribution estimation of forest biomass with geostatistics: A case study for Rondônia, Brazil. *Ecological Modelling*, 205(1-2), 221-230.

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Team: Marcio Sales (Modeling and statistics), Rodney Salomão, Amintas Brandão Jr., João Victor (Geoprocessing) e Bruno Oliveira (Communication)

Data Source:
The deforestation statistics are generated from SAD's data (Imazon);
INPE data- Deforestation (PRODES)
http://www.obt.inpe.br/prodes/

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