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SUMMARY

In May 2011, SAD detected 165 square kilometers of deforestation in Legal Amazon. It represented a 72% increase regarding May 2010 when the deforestation totaled 96 square kilometers. From this total 39% occurred in Pará, followed by Mato Grosso (25%) and Rondônia (21%). The rest occurred in Amazonas (12%), Tocantins (2,5%) and Acre (0,1%).

The deforestation accumulated in the period of August 2010 and May 2011, corresponding to the first ten months of the current Deforestation Calendar, has reached 1.435 square kilometers. There was 24% increase regarding the same previous period (August 2009 to May 2010) when the deforestation totaled 1.161 square kilometers.

The degraded forests in Legal Amazon totaled 248 square kilometers in May 2011. From

this total, 42% occurred in Mato Grosso followed by Pará (27%), Rondônia (22%), Amazonas (7%), Tocantins (1,5%), and Acre (0,5%).

The forest degradation accumulated in the period of August 2010 to May 2011 totaled 6.081 square kilometers. Regarding the previous period (August 2009 to May 2010) there was an expressive increase (363%) when the forest degradation totaled 1.312 square kilometers.

In May 2011, the deforestation detected by SAD compromised 2.8 million tons of equivalent CO₂ which represents an increase of 55.6% regarding May 2010. In the accumulated period (August 2010 - May 2011) the deforestation compromised 83.9 million tons of equivalent CO₂ and represented an increase of 10% regarding the previous period (August 2009 to May 2010).

Deforestation Statistics

According to the Imazon's Deforestation Alert System (SAD), the deforestation, (i.e., the total suppression of the forest with soil exposition) in May 2011 at Legal Amazon has reached 165 square

kilometers (Figure 1 and Figure 2). This represented an increase of 72% of deforestation of May 2011 regarding the deforestation detected in May 2010 when the deforestation reached 96 square kilometers.

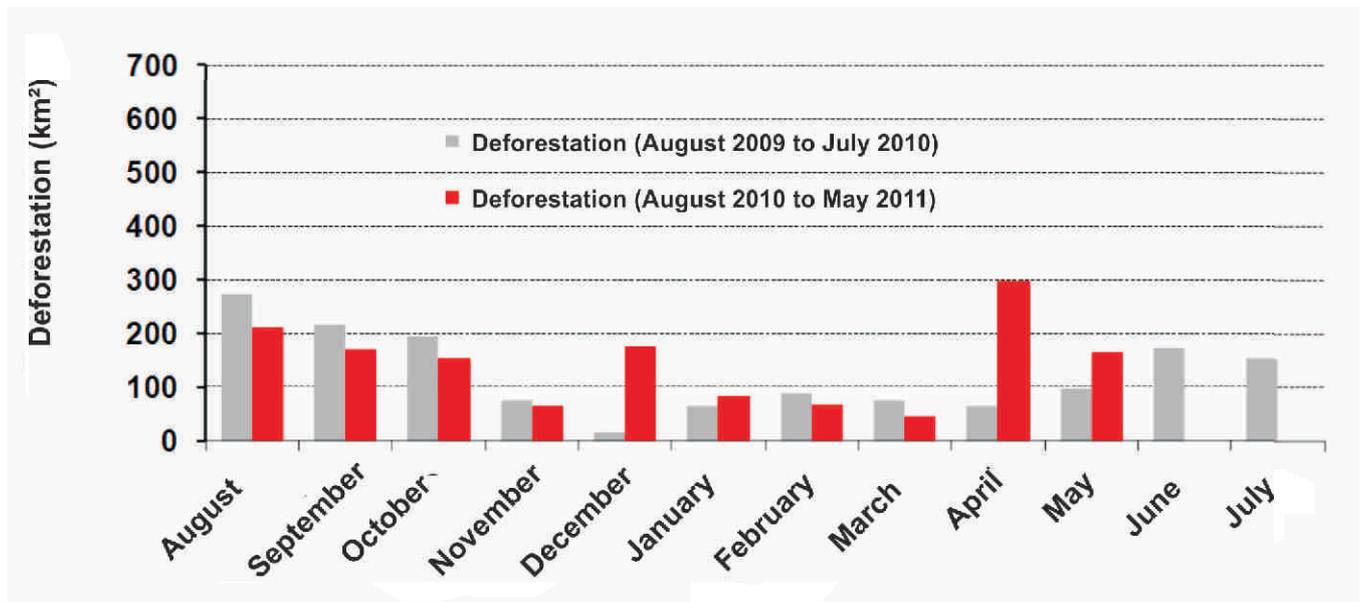


Figure 1. Deforesting from August 2009 to May 2011 in Legal Amazon (Source: Imazon/SAD).

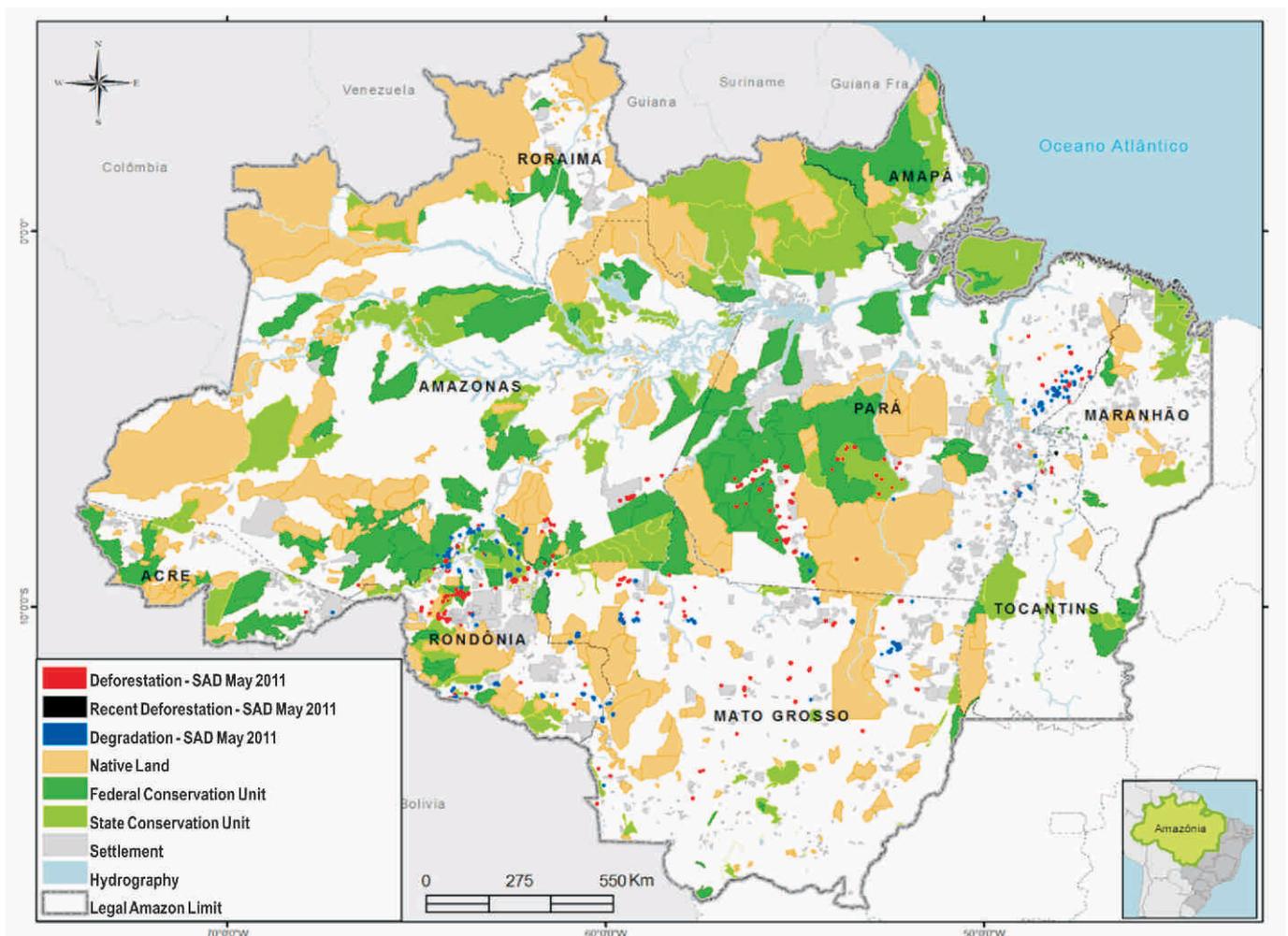


Figure2. Deforesting and Forest Degradation in May 2011 at Legal Amazon (Source: Imazon/ SAD).

The deforestation accumulated in the period of August 2010 to May 2011, corresponding to the first ten months of the official calendar of Deforestation measuring, has reached 1.435 square kilometers. There was 24% increase in the deforestation regarding the same previous period (August 2009 to May 2010) when the

deforestation totaled 1.161 square kilometers.

In May 2011, 39% of deforestation occurred in Pará, followed by Mato Grosso (25%) and Rondônia (21,4%) (Figure 3). The rest of deforestation occurred in Amazonas (12%), Tocantins (2,5%), and Acre (0,5%).

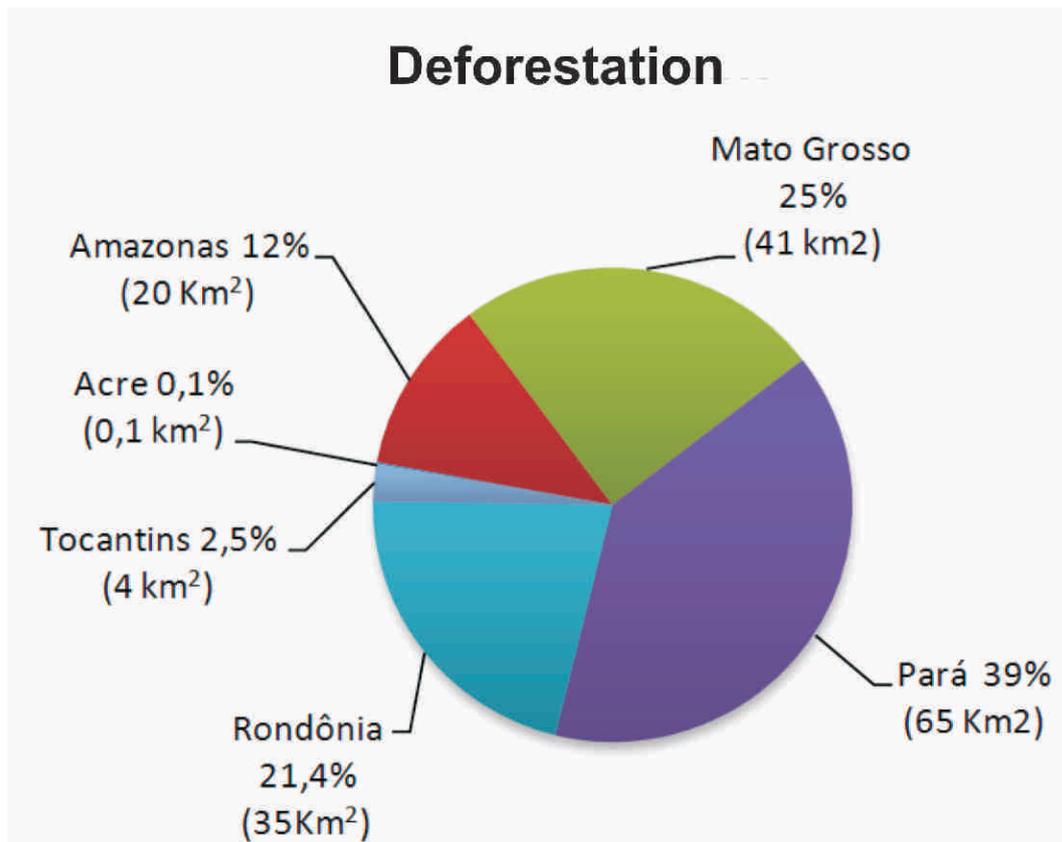


Figure 3. Deforestation (%) in the states of Legal Amazon in May 2011 (Source: Imazon/SAD).

Considering the first ten months of the current deforestation calendar (August 2010 to May 2011), Mato Grosso leads the ranking with 39% of the total deforested in the period. Following is Pará with 24%, followed by Rondônia with 22% and Amazonas with 11%. These four states were responsible for 95% of the deforestation occurred in Legal Amazon in this period. The rest (5%) of deforestation occurred in Acre and Roraima and Tocantins.

There was a 24% increase in the deforestation occurred from August 2010 to May 2011 when

compared to the previous period (August 2009 to May 2010) (Table 1). In relative terms, there was a 800% increase in Tocantins, 131% in Rondônia, 94% in Mato Grosso, 41% in Acre, and 22% in Amazonas. On the other hand, there was a 84% reduction in Roraima and 33% in Pará. In absolute terms, Mato Grosso leads the accumulated deforestation ranking with 55 square kilometers, followed by Pará (339 square kilometers), Rondônia (312 square kilometers), and Amazonas (155 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 Legal Amazon from August 2009 to May 2010 and from August 2010 to May 2011 (Source: Imazon/SAD).

State	August 2009 to May 2010	August 2010 to May 2011	Variation (%)
Acre	39	55	+ 41
Amazonas	127	155	+ 22
Mato Grosso	288	558	+ 94
Pará	507	339	- 33
Rondônia	135	312	+ 131
Roraima	50	8	- 84
Tocantins	1	9	+ 800
Amapá	15	-	-
Total	1.162	1.436	+ 24

* Data from Maranhão were not analyzed.

Forest Degradation

In May 2011, SAD registered 249 square kilometers of degraded forests (intensively explored forests by lumbering and/ or burning activities) (Figures 2 and 4). From the total, 42% of this

degradation occurred in Mato Grosso, followed by Pará (27%), Rondônia (22%), Amazonas (7%), Tocantins (1.5%) and Acre (0.5%).

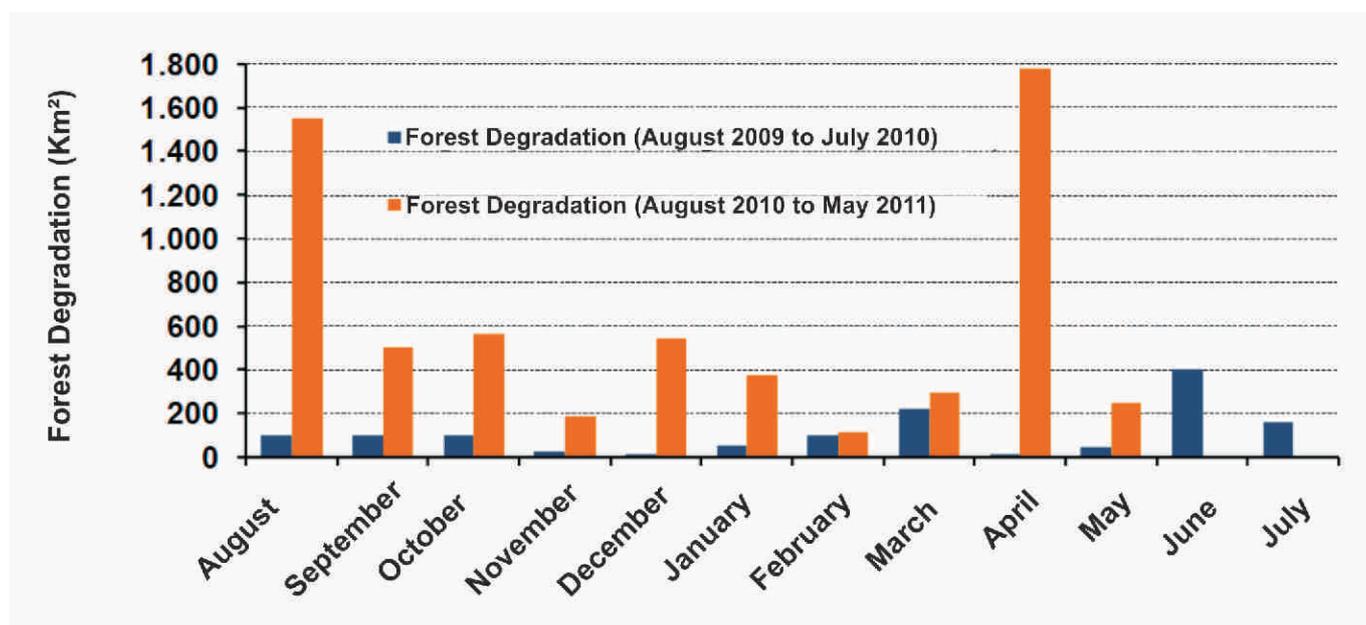


Figure 4. Forest Degradation from August 2009 to May 2011 at Legal Amazon (Source: Imazon/SAD).

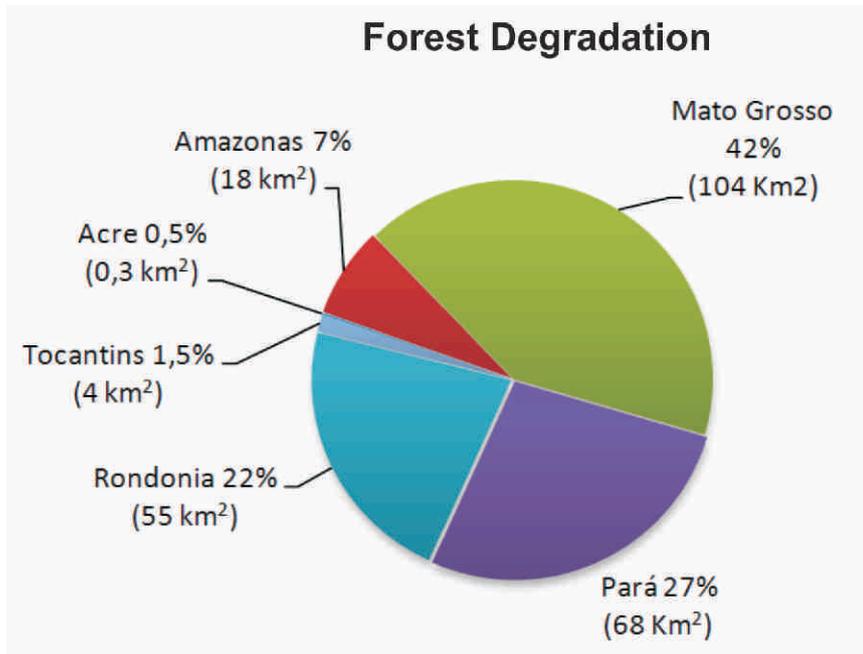


Figure 5. Forest Degradation (%) in the States of Legal Amazon in May 2011 (Source: Imazon/SAD).

The forest degradation accumulated in the period of August 2010 to May 2011, (first ten months of the official calendar of Deforestation measuring) has reached 6.081 square kilometers. This represents an extremely expressive increase of 363% in the forest degradation accumulated in this period (August 2010 to May 2011) regarding the same period of the previous year (August 2009 to May 2010) when the forest degradation totaled 1.312 square kilometers (Table 2).

Tocantins presented in relative terms an expressive increase of 3.000%, however, in absolute terms; the increase was very reduced passing only 1 square kilometer between August 2009 to May 2010 to 30 square kilometers from August 2010 to May 2011.

Other states also contributed for the increase of the forest degradation: Amazonas (+ 592%), Acre (+437), Mato Grosso (+ 409%), Rondônia (+393), and

Pará (+ 221). On the other hand, Roraima presented a reduction of 75% in the forest degradation.

Mato Grosso leads the ranking of forest degradation with 61% of the total in the period of August 2010 to May 2011. Following is Rondônia and Pará with 17% each. These three states were responsible for 94% of the forest degradation in Legal Amazon during this period. The other 6% occurred in Amazonas, Acre, Tocantins and Roraima.

In absolute terms, Mato Grosso also leads the accumulated deforestation ranking with 3.695 square kilometers, followed by Rondônia (1.021 square kilometers), Pará (1021 square kilometers), Amazonas (166 square kilometers), Acre (145 square kilometers), (Tocantins 31 square kilometers) and Roraima (2 square kilometers).

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

Table 2. Evolution of the forest degradation between the States of Legal Amazon from August 2009 to May 2010 and from August 2010 to May 2011 (Source: Imazon/SAD).

State	August 2009 to May 2010	August 2010 to May 2011	Variation (%)
Acre	27	145	+ 437
Amazonas	24	166	+ 592
Mato Grosso	726	3.695	+ 409
Pará	318	1.021	+ 221
Rondônia	207	1.021	+ 393
Roraima	8	2	- 75
Tocantins	1	31	+ 3.000
Amapá	1	-	-
Total	1.312	6.081	+ 363

* Data from Maranhão were not analyzed.

Carbon Affected by the Deforestation

In May 2011, the 165 square kilometers of deforestation detected by SAD in the Legal Amazon compromised 2.8 million tons (with error radius of 303 thousand tons) of carbon. This amount of affected carbon results in 10.3 million tons of equivalent CO² (Figure 6). This represents an increase of 55.6% regarding May 2010 when the affected forest carbon was 1.8 million tons.

The forest carbon compromised by the deforestation in the period of August 2010 to May 2011 (first ten months of the current deforestation calendar) was 22.8 million tons (with error radius of 587 thousand tons), which represented approximately 83.9

million tons of equivalent CO² (Figure 6). Regarding the same period of the previous year (August 2009 to May 2010) there was a 5.7% increase in the amount of carbon compromised by the deforestation. The relative increase (10.1%) of the forest carbon affected by the deforestation in the period of August 2010 to May 2011 regarding the previous period (August 2009 to May 2010) was less than the relative increase of 24% 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.

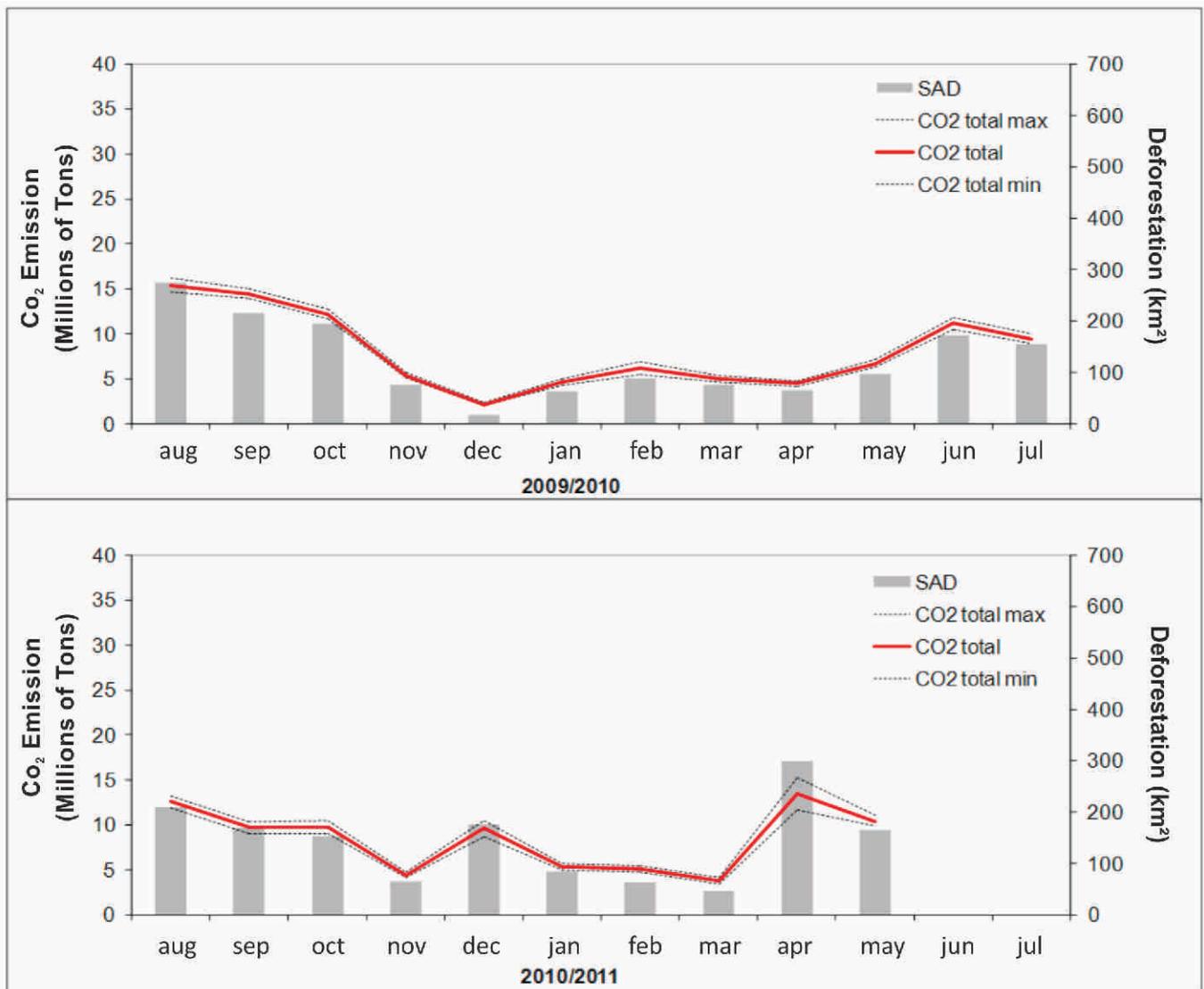


Figure 6. Deforestation and emission of Carbon Dioxide (CO₂) total equivalent from August 2009 to May 2011 in Legal Amazon (Source: Imazon).

Deforestation Geography

Regarding the land situation, in May de 2011, the great majority (65%) of deforestation occurred in private areas or under many stages of ownership. The

rest of the deforestation was registered in Conservation Units (22%), Land Reform Settlements (12%), and Native Lands (1%) (Table 3).

Table 3. Deforestation by land category in May 2011 in Legal Amazon (Source: Imazon/ SAD).

Category	May 2011	
	km ²	%
Land Reform Settlement	19	12
Conservation Units	37	22
Native Lands	1	1
Private, Owned & Abeyance	108	65
Total (km²)	165	100

Land Reform Settlements

SAD registered only 19 square kilometers in the Land Reform Settlements during May 2011. The most affected settlements by the deforestation were

Mãe e Menininha (Altamira, Pará), Rio Juma (Apuí, Amazonas), and Terra Nossa (Altamira, Pará) (Figure 7)



Figure 7. Most deforested Land Reform Settlements in May 2011 at Legal Amazon (Source: Imazon/SAD).

³ It includes private areas (owned or not) and non protected public forests.

Protected Areas

SAD detected 37 square kilometers of deforestation in the Conservation Units (Figure 8). The Conservation Units that suffered deforestation were: APA Triunfo do Xingu (Pará), Flona do Jamanxim (Pará), and Flona de Altamira (Pará). In the case of the

Native Lands, in May 2011 were detected only 1 square kilometer. The deforested Native Lands were Kayabi (Pará), Mekragnoti (Pará), and Karipuna (Rondônia) (Figure 9).

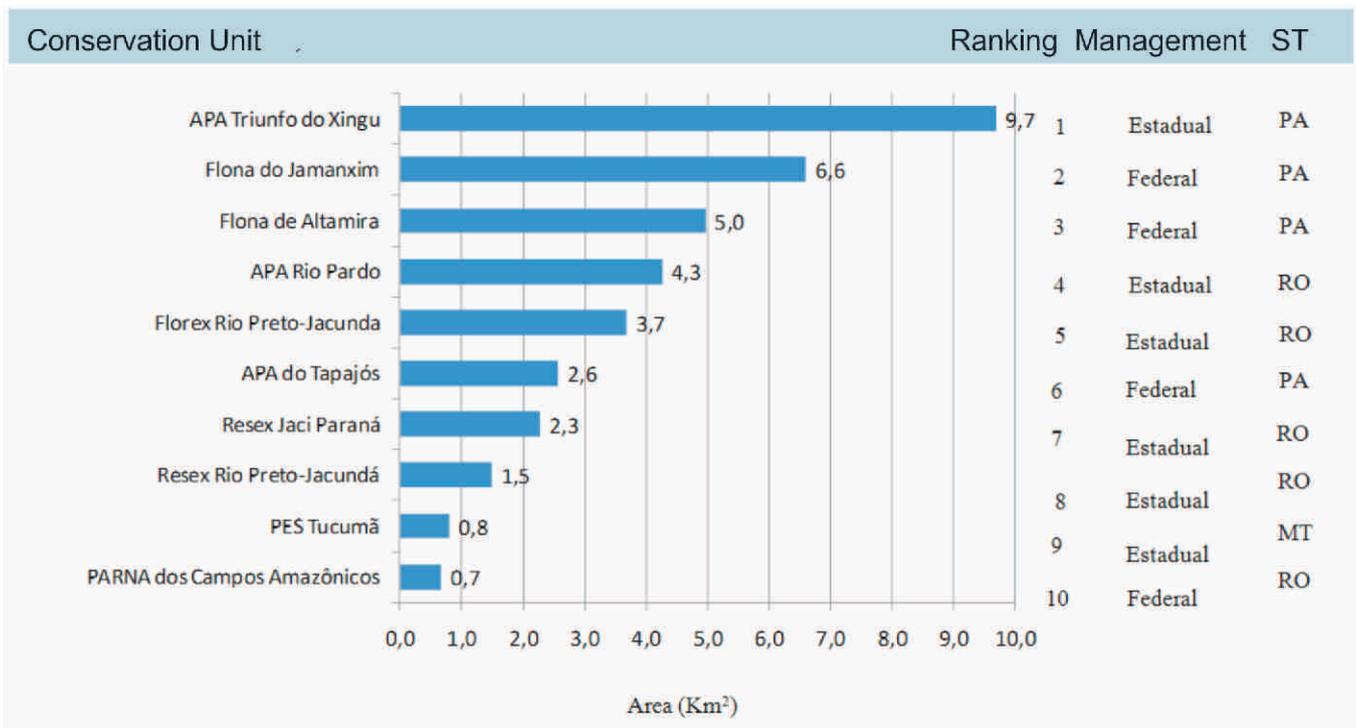


Figure 8. Most deforested Conservation Units at Legal Amazon in May 2011 (Source: Imazon /SAD).



Figure 9. Most deforested Native Lands at Legal Amazon in May 2011 (Source: Imazon /SAD).

Critical Counties

In May 2011, the most deforested counties were: Altamira (Pará), Porto Velho (Rondônia) and

Apuí (Amazonas) (Figures 10 and 11).

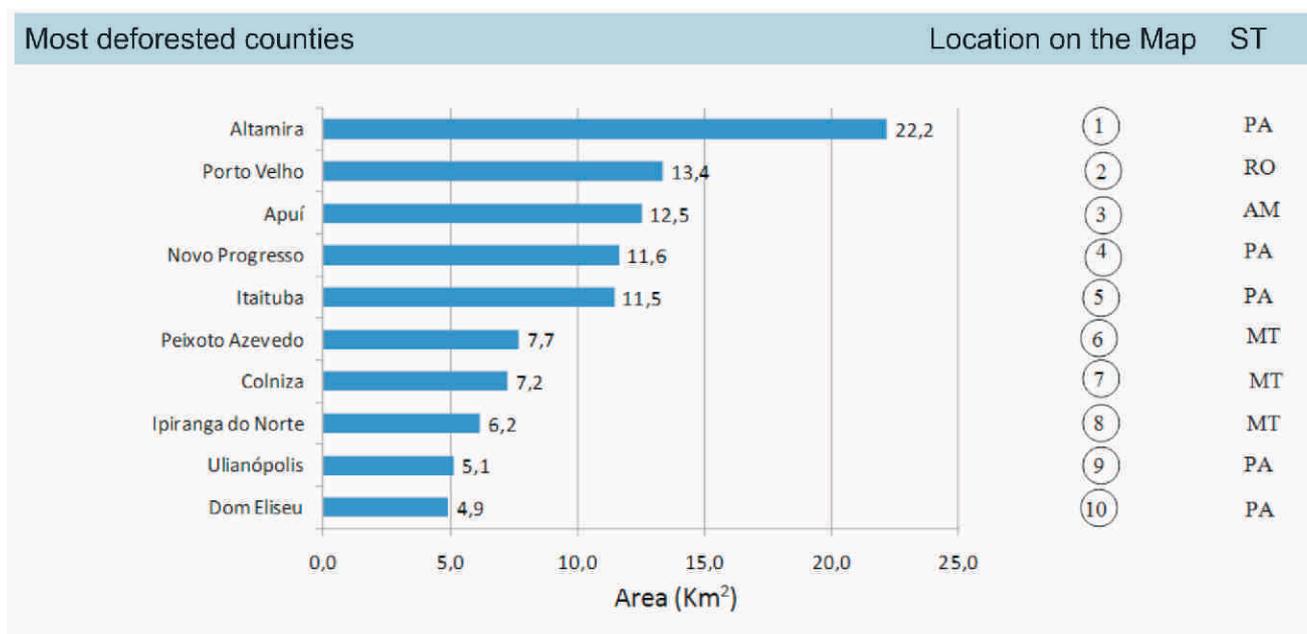


Figure 10. Most deforested counties at Legal Amazon in May 2011 (Source: Imazon /SAD).

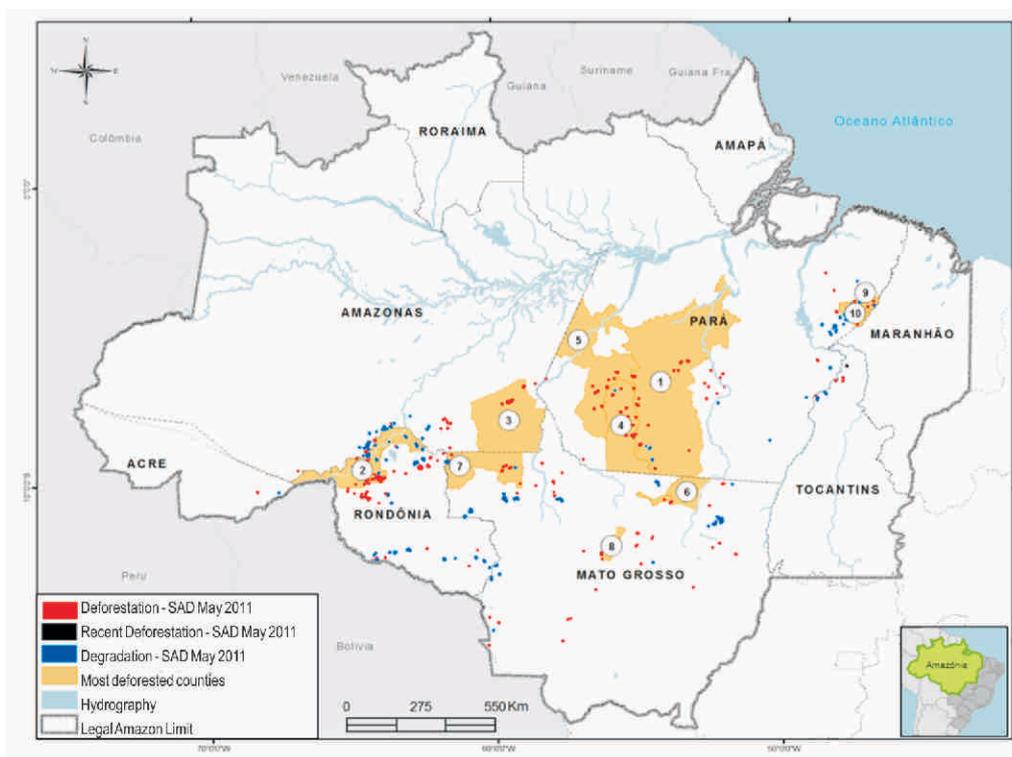


Figure 11. Most deforested counties in May 2011 (Source: Imazon/SAD).

Coverage by clouds and Shade

In May 2011, it was possible to monitor with SAD only 47% of the forest area in Legal Amazon. The other 53% of the territory was covered by clouds, which complicated the monitoring especially in the

central and northern region of Pará, and in the States of Amapá and Roraima which had over 80% of their forest areas covered (Figure 12).

*The part of Maranhão that integrates Legal Amazon was not analyzed

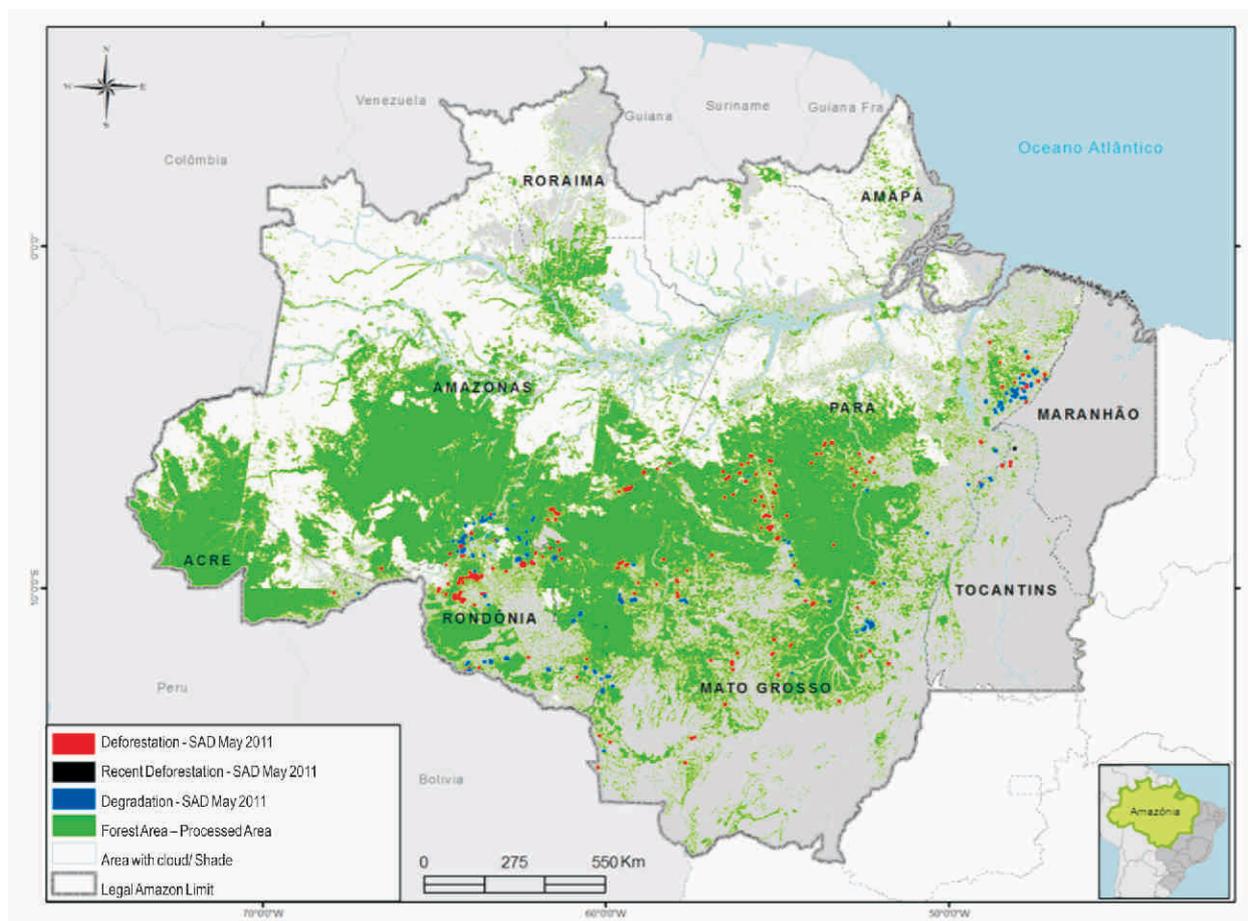


Figure 12. Area with cloud and shade in May 2011 in Legal Amazon

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. The images used are the ones available right after the analyzed month by SAD. All the deforestation polygons detected by SAD are verified using the detailed images. Deforestations smaller than 6.25 hectares, i.e., below SAD's detection capacity, are not included in the statistics, in case they occur in more detailed images. However, if SAD detects false signals of deforestation, they will be removed from the monthly statistics.

In May 2011, 78% of the deforestation detected by SAD was confirmed with the Landsat images (Figure 13). The other 22% were not confirmed due to the great occurrence of clouds in the Landsat and CBERS images available in the period.

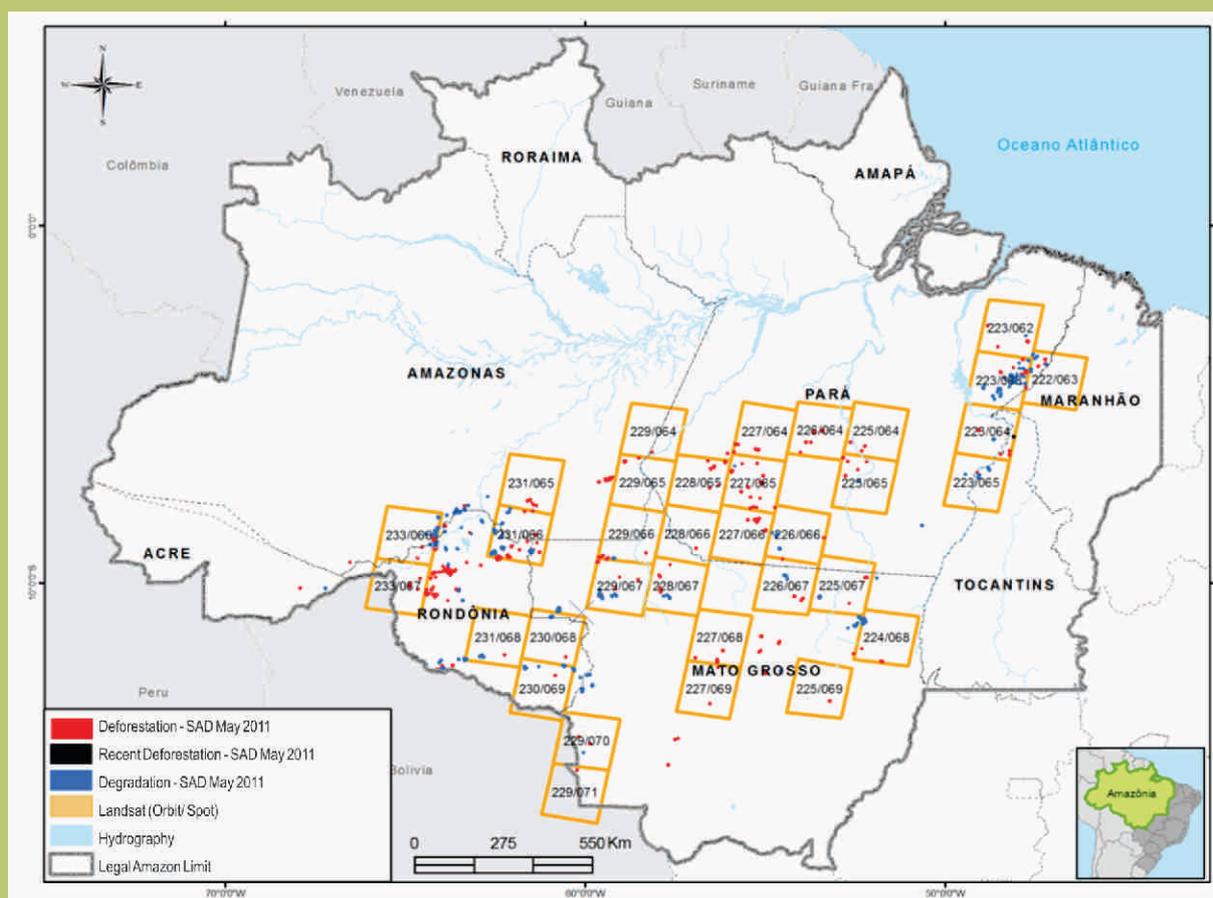


Figure 13. Landsat images used in the validation of the deforestation polygons detected by SAD in May 2011.

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:

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

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

$$\text{VGs} = \text{Vegetation} / (1 - \text{Shade})$$

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 Legal Amazon since April 2008. In this Bulletin, we presented the monthly data generated by SAD from August 2006 to August 2010.

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 Legal 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 below

$$C_t = \sum C(S)_t$$
$$C_t(S) = S_D \times \left[(BVAS - BPF) \times (1 - fc) \times (t = 0) + (BAS_0 \times pd \times e^{(-pd \times t)}) \right]$$
$$BPF = ff * AGLB$$
$$BAS_0 = bf * AGLB$$

Where:

t: time (month)

C_t: Carbon emitted in the month t.

C_t(S): Carbon emitted of a deforested polygon in time t.

S_D: Deforest area.

BVAS: Biomass above the soil of the deforested region S_D.

BPF: Biomass of forest products removed from the forest before the deforestation.

fc: charcoal fraction (3 to 6%).

BAS₀: Biomass below the soil before the deforestation.

pd: monthly decomposition parameter of the biomass below the soil after the deforestation (0.0075).

$pd \times e^{(-pd \times t)}$: 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 CO we applied the value of 3.68.

References:

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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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Data Source:

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

Support

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Fundação Gordon & Betty Moore
Fundo Vale

Partnerships

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Secretaria de Meio Ambiente do Mato Grosso (SEMA)
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Ministério Público Estadual do Amapá
Ministério Público Estadual de Mato Grosso
Instituto Centro de Vida (ICV- Mato Grosso)