

Sanae Hayashi; Carlos Souza Jr.; Márcio Sales & Adalberto Veríssimo (Imazon)

SUMMARY

In February 2012, The Deforestation Alert System (SAD) detected 107 square kilometers of deforestation in Legal Amazon. It represented a 59% increase regarding February 2011 when the deforestation totaled 67 square kilometers.

The deforestation accumulated in the period of August 2011 to February 2012 totaled 708 square kilometers. There was 23% reduction regarding the same previous period (August 2010 to February 2011) when the deforestation totaled 922 square kilometers.

In February 2012, most part (65%) of the deforestation occurred in Mato Grosso. The rest occurred in Rondônia (12%), Amazonas (10%), Roraima and Pará (7% each).

The degraded forests in Legal Amazon totaled 95 square kilometers in February 2012. Comparing to February 2012, there was a 15% reduction, when the forest degradation totaled 112 square kilometers. Most part (70%), occurred in

Mato Grosso, followed by Rondônia (15%), Roraima (9%), Pará (5%), and Amazonas (1%).

The accumulated forest degradation was of 1.528 square kilometers for the period of August 2011 to February 2012. Regarding to the previous period (August 2010 to February 2011), there was a 60% reduction, when the degradation totaled 3.814 square kilometers.

In February 2012, the deforestation detected by SAD compromised 6.6 million tons of equivalent CO₂. In the accumulated period (August 2011 - February 2012) the emissions of equivalent CO₂ related to the deforestation totaled 47 million tons, which represents a reduction of 14% regarding the previous period (August 2010 to February 2011).

It was possible to monitor only 24% of the forest area in Legal Amazon in February 2012 with SAD. The other 76% were covered by clouds which complicated the monitoring in the region.

Deforestation Statistics

According to Imazon's SAD, the deforestation (total suppression of the forest with soil exposition) has reached 107 square kilometers in February 2012

(Figure 1 and Figure 2). This represented a 59% increase in relation to February 2011 when the deforestation reached 67 square kilometers.

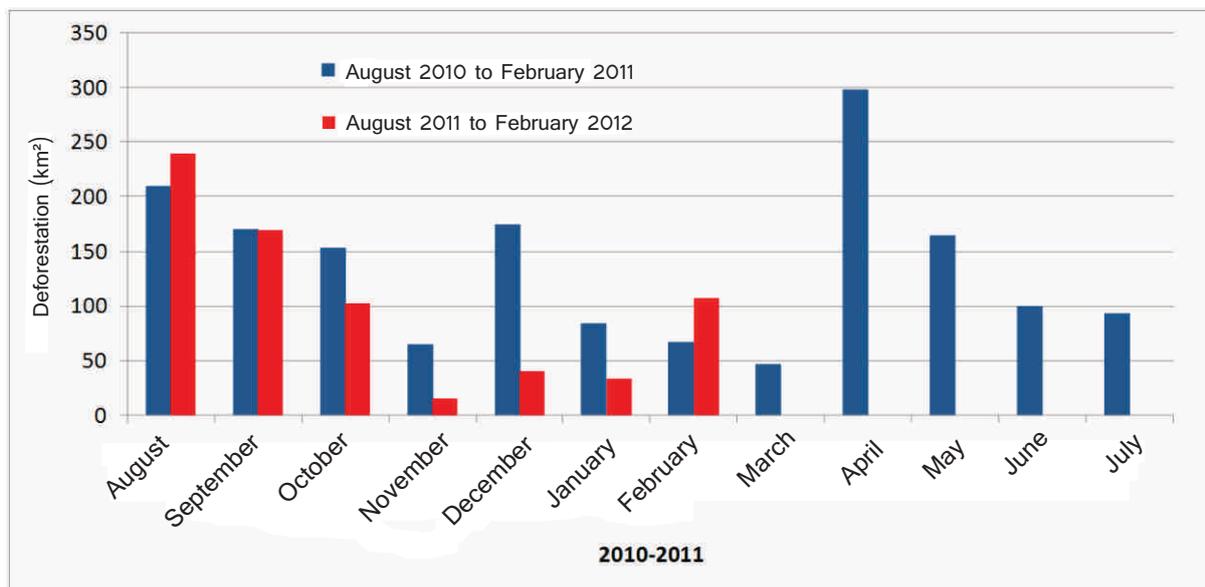


Figure 1. Deforesting from August 2010 to February 2012 in Legal Amazon (Source: Imazon/SAD).

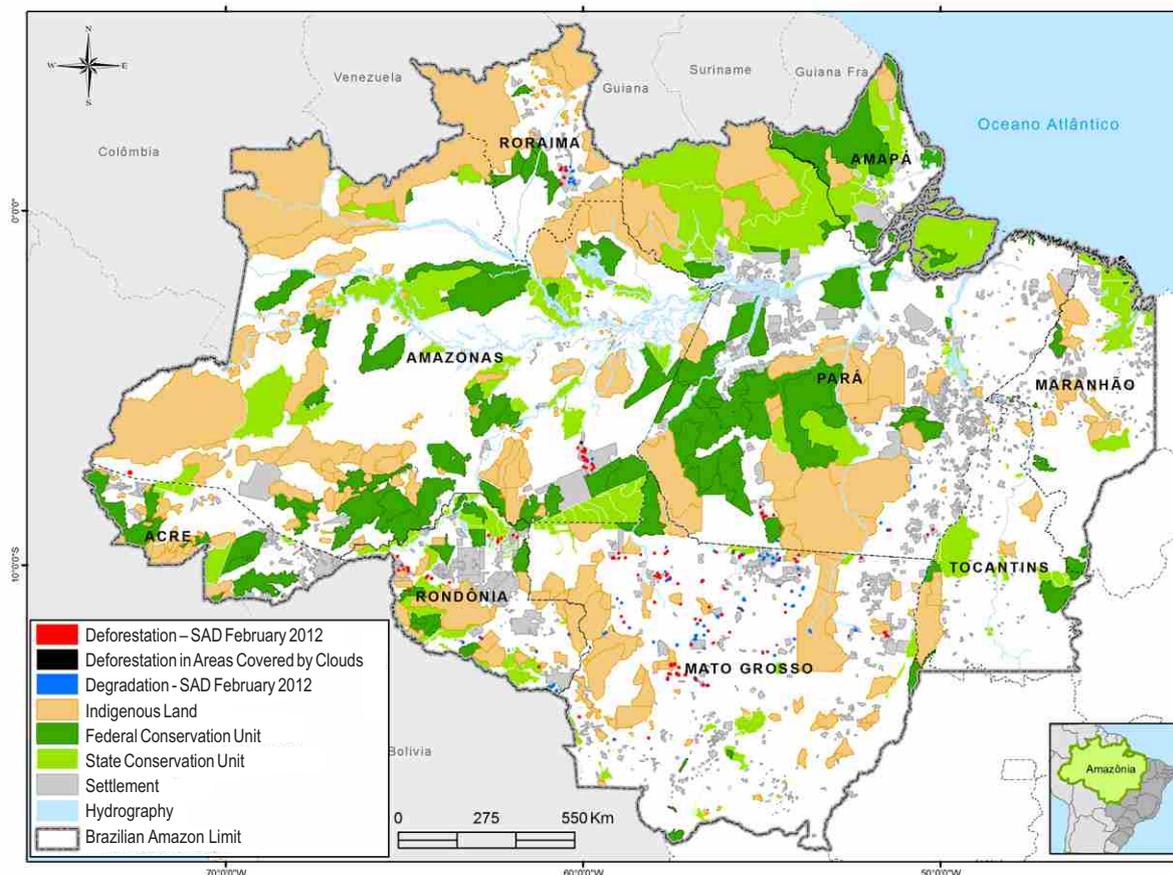


Figure 2. Deforesting and Forest Degradation in February 2012 at Legal Amazon (Source: Imazon/ SAD).

*The Deforestation in Areas Covered by Clouds might have occurred in February 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 February 2012, corresponding to the nine first months of the official calendar of Deforestation measuring, has reached 708 square kilometers. There was a 23% reduction in the deforestation regarding the previous period (August 2010 to February 2011)

when it reached 922 square kilometers.

In February 2012, most part (65%) of the deforestation occurred in Mato Grosso, followed by Rondônia (12%), Amazonas (10%), Roraima (7%) and Pará (5%) (Figure 3).

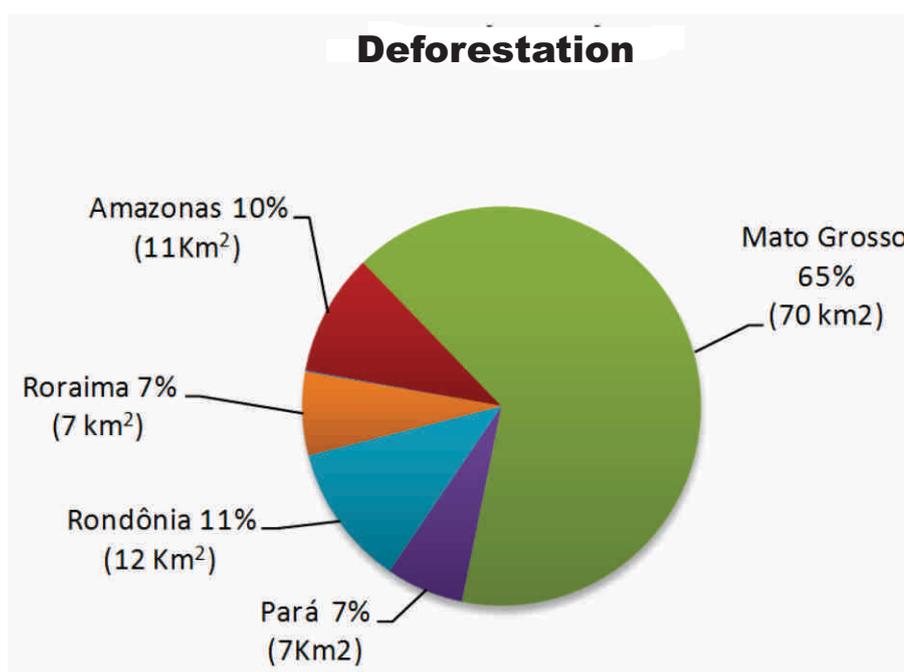


Figure 3. Deforestation (%) in the States of Legal Amazon in February 2012 (Source: Imazon/SAD).

Considering the first seven months of the current deforestation calendar (August 2011 to February 2012), Pará leads the ranking with 36% of the total deforestation. Following is Mato Grosso with 28%, followed by Rondônia with 20% and Amazonas with 9%.

These four states were responsible for 93% of the deforestation occurred in Legal Amazon in this period. The rest (7%) of deforestation occurred in Acre and Roraima and Tocantins and Amapá.

There was a 23% reduction of the deforestation occurred in August 2011 to February 2012 when

compared to the previous period (August 2010 to February 2011) (Table 1). In relative terms, there was a 63% reduction in Acre, 48%, in Amazonas, 36% in Rondônia and 24% in Mato Grosso. On the other hand, there was a 200% increase in Roraima, 120% in Tocantins, 1% in Pará.

In absolute terms, Pará leads the accumulated deforestation ranking with 253 square kilometers, followed by Mato Grosso (198 square kilometers), Rondônia (143 square kilometers), Amazonas (64 square kilometers), Roraima (21 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 Legal Amazon from August 2010 to February 2011 and from August 2011 to February 2012 (Source: Imazon/SAD).

State	August 2010 to February 2011	August 2011 to February 2012	Variation (%)
Acre	49	18	-63
Amazonas	124	64	-48
Mato Grosso	262	198	-24
Pará	251	253	+1
Rondônia	224	143	-36
Roraima	7	21	+200
Tocantins	5	11	+120
Amapá	-	-	-
Total	922	708	-23

*Data from Maranhão were not analyzed.

Forest Degradation

In February 2012, SAD registered 95 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 (February 2011) there

was a 15% reduction when the forest degradation reached 112 square kilometers. In total, most part (70%) of this degradation occurred in Mato Grosso, followed by Rondônia (15%), Roraima (9%), Pará (5%) and Amazonas (1%) (Figure 5).

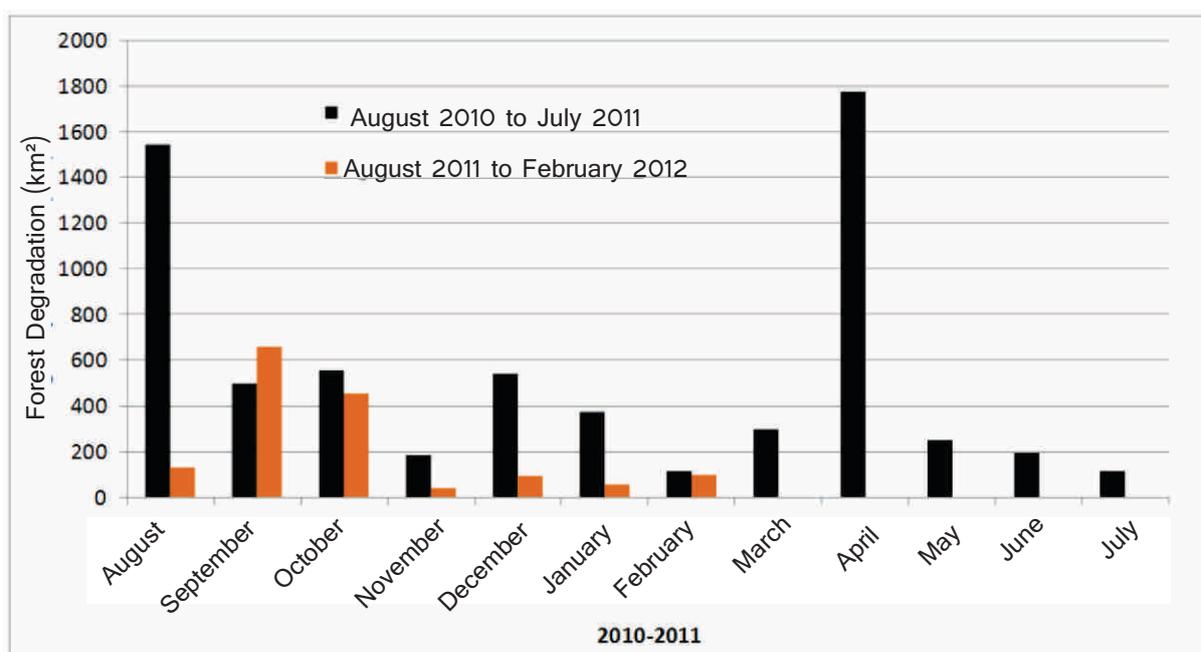


Figure 4. Forest Degradation from August 2010 to February 2012 at Legal Amazon (Source: Imazon/SAD).

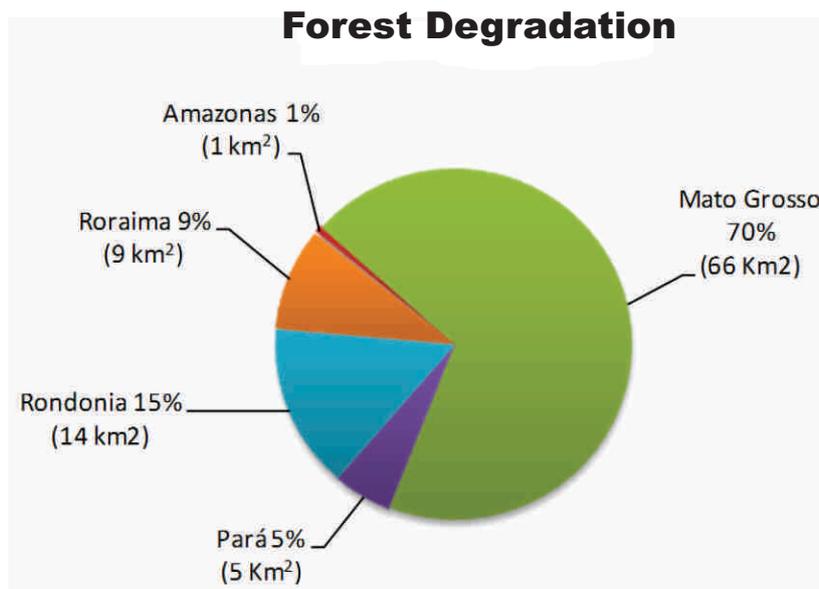


Figure 5. Forest Degradation (%) in the States of Legal Amazon in February 2012 (Source: Imazon/SAD).

The forest degradation accumulated in the period of August 2011 to February 2012 totaled 1.528 square kilometers. This represents a reduction of 60% in the forest degradation accumulated in this period (August 2011 to February 2012) regarding the same previous period (August 2010 to February 2011) when the forest degradation totaled 3.814 square kilometers (Table 2). The largest reductions occurred in Acre (-98%), Amazonas (-87%), Rondônia (-84%) and

Pará (-69%).

In absolute terms, Mato Grosso leads the accumulated deforestation ranking with 1.169 square kilometers (77%), followed by far by Pará with 232 square kilometers (15%), and the rest, Rondônia (90 square kilometers), Amazonas (19 square kilometers), Roraima (15 square kilometers), and Acre (3 square kilometers).

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

State	August 2010 to February 2011	August 2011 to February 2012	Variation (%)
Acre	143	3	-98
Amazonas	141	19	-87
Mato Grosso	2.188	1.169	-47
Pará	745	232	-69
Rondônia	569	90	-84
Roraima	2	15	+650
Tocantins	26	-	-
Amapá	-	-	-
Total	3.814	1.528	-600

*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 February 2012, the 107 square kilometers of deforestation detected by SAD in the Legal Amazon compromised 1.8 million tons (with error radius of 311 thousand tons of carbon). This amount of affected carbon results in 6.6 million tons of equivalent CO₂ (Figure 6).

The forest carbon compromised by the deforestation in the period of August 2011 to January 2012 was of 13 million tons (with error radius of 267 thousand tons), which represented approximately 47 million tons of equivalent CO₂.

(Figure 6). Regarding the same period of the previous year (August 2010 to January 2011) there was a 14% reduction in the amount of carbon compromised by the deforestation. The reduction (14%) of the forest carbon affected by the deforestation in the period of August 2011 to February 2012 regarding the previous period (August 2010 to February 2011) was less than the reduction of 23% 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.

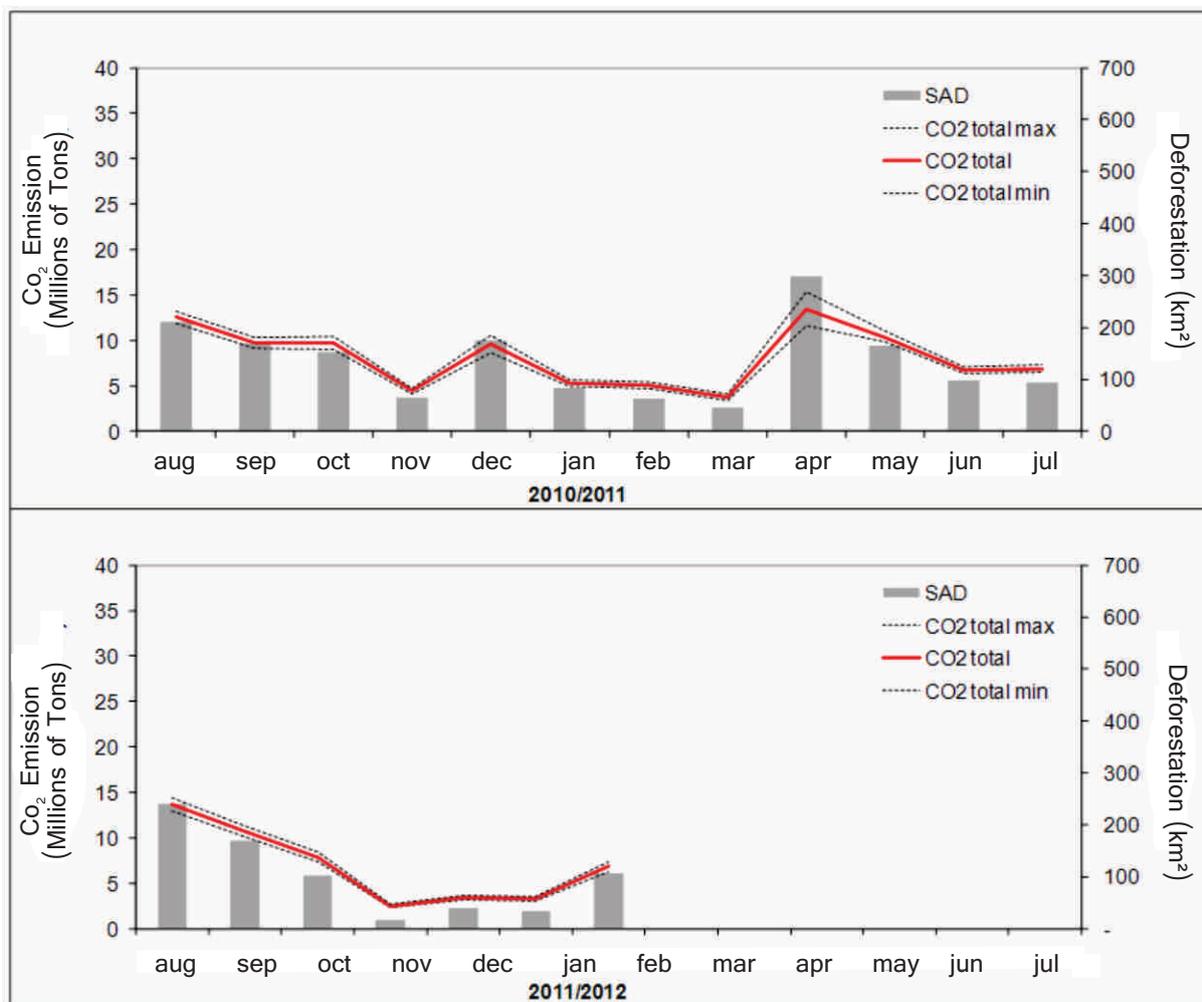


Figure 6. Deforestation and emission of Carbon Dioxide (CO₂) total equivalent from August 2010 to February 2012 in Legal Amazon (Source: Imazon).

Deforestation Geography

In February de 2012, the great majority (66%) of deforestation occurred in private areas or under many stages of ownership. The rest of the deforestation

was registered in Agrarian Reform Settlements (22%), Indigenous Land (9%) and Conservation Units (3%). (Table 3).

Tabela 3. Desmatamento por categoria fundiária em fevereiro de 2012 na Amazônia Legal (Fonte: Imazon/ SAD).

Category	February 2012	
	km ²	%
Agrarian Reform Settlement	23,5	22
Conservation Units	3,5	3
Indigenous Lands	10	9
Private, Owned and in Abeyance ³	70	66
Total (km²)	107	100

Agrarian Reform Settlements

SAD registered 23.5 square kilometers of deforestation in the Agrarian Reform Settlements during February 2012. The most affected settlements

by the deforestation were Anauá (Caracarái; Roraima), Rio Juma (Apuí; Amazonas), and Bordolândia (Alto Boa Vista; Mato Grosso) (Figure 7).



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

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

Protected Areas

SAD detected 3,5 square kilometers of deforestation in the Conservation Units (Figure 8). The Conservation Units that suffered more deforestation were Florex Rio Preto-Jacundá (Rondônia); Resex do Rio Ouro Preto (Rondônia); and Rebio Nascente da Serra do Cachimbo (Pará). In the case of the Indigenous

Lands, in February 2012 only 10 square kilometers of deforestation were detected. The most affected indigenous lands were: Manoki (Mato Grosso), Terena Gleba Iriri (Mato Grosso) and Apiaká-Kayabi (Mato Grosso) (Figure 9).

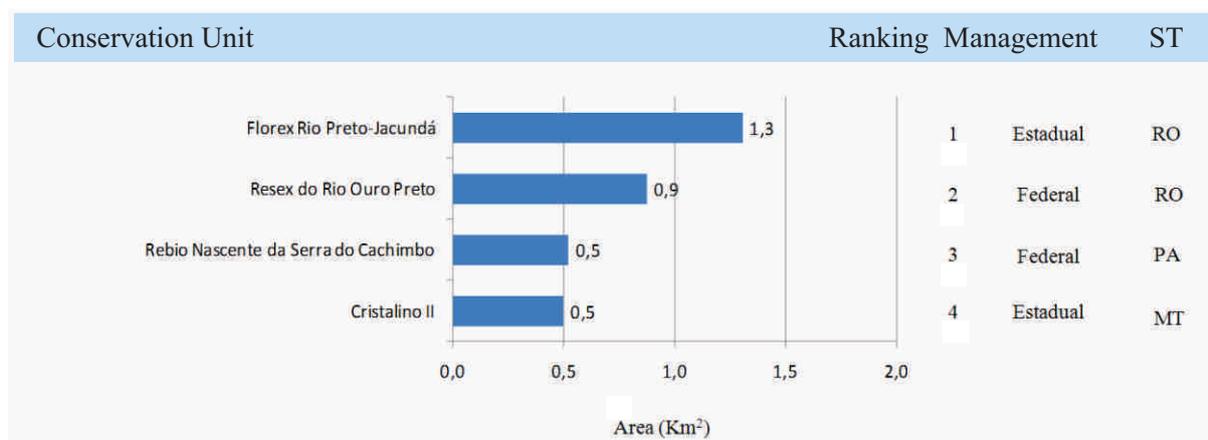


Figure 8. Most deforested Conservation Units in the Brazilian Amazon in February 2012 (Source: Imazon/SAD).

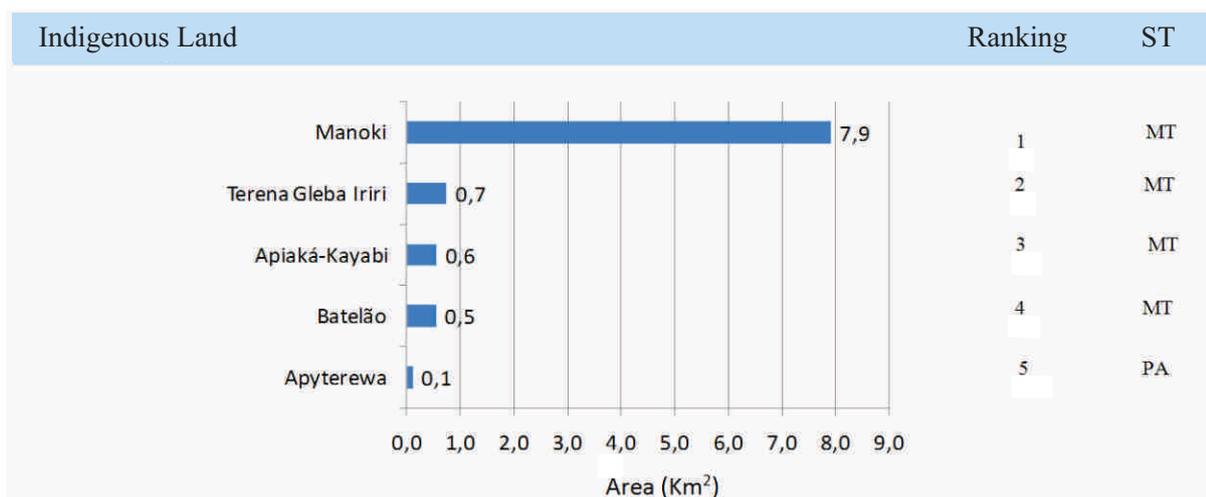


Figure 9. Most deforested Indigenous Lands in the Brazilian Amazon in February 2012 (Source: Imazon/SAD).

Critical Municipalities

In February 2012, the most deforested counties were: Brasnorte (Mato Grosso); Nova

Maringá (Mato Grosso); and São José do Rio Claro (Mato Grosso) (Figures 10 and 11).

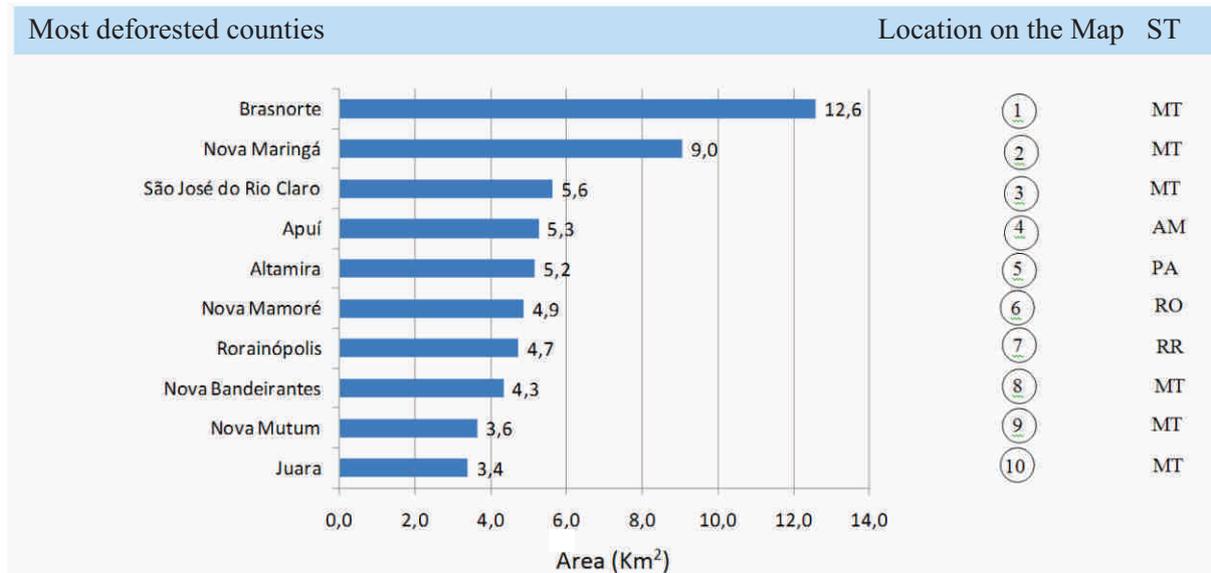


Figure 10. Most deforested counties in the Brazilian Amazon in January 2012 (Source: Imazon/SAD).

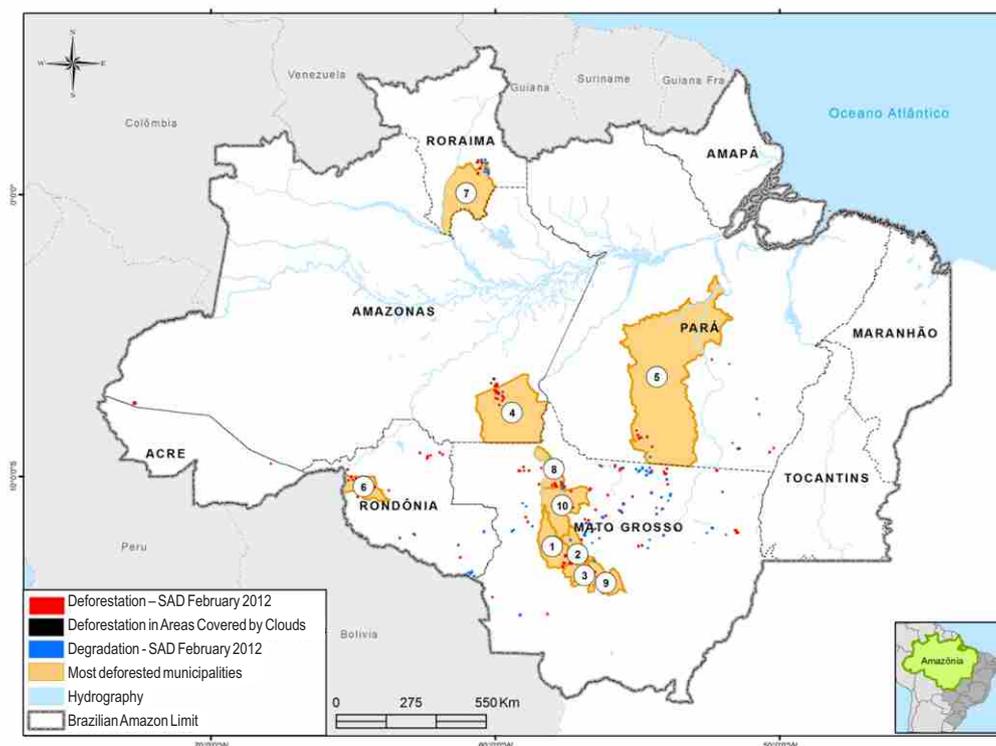


Figure 11. Counties with larger deforested areas in February 2012 (Source: Imazon/SAD).

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

Coverage by clouds and Shade

In February 2012, it was possible to monitor with SAD only 24% of the forest area in the Brazilian Amazon. The other 76% were covered by clouds which made it difficult to detect the deforestation and the forest degradation. The most affected states by the cloud coverage were: Amapá (97%), Pará (91%), Acre (87%), Roraima (75%) and Amazonas (74%). The other states presented less than 50% of their territory

covered by clouds. Because of that, the deforestation and degradation information in February 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 Legal Amazon was not analyzed

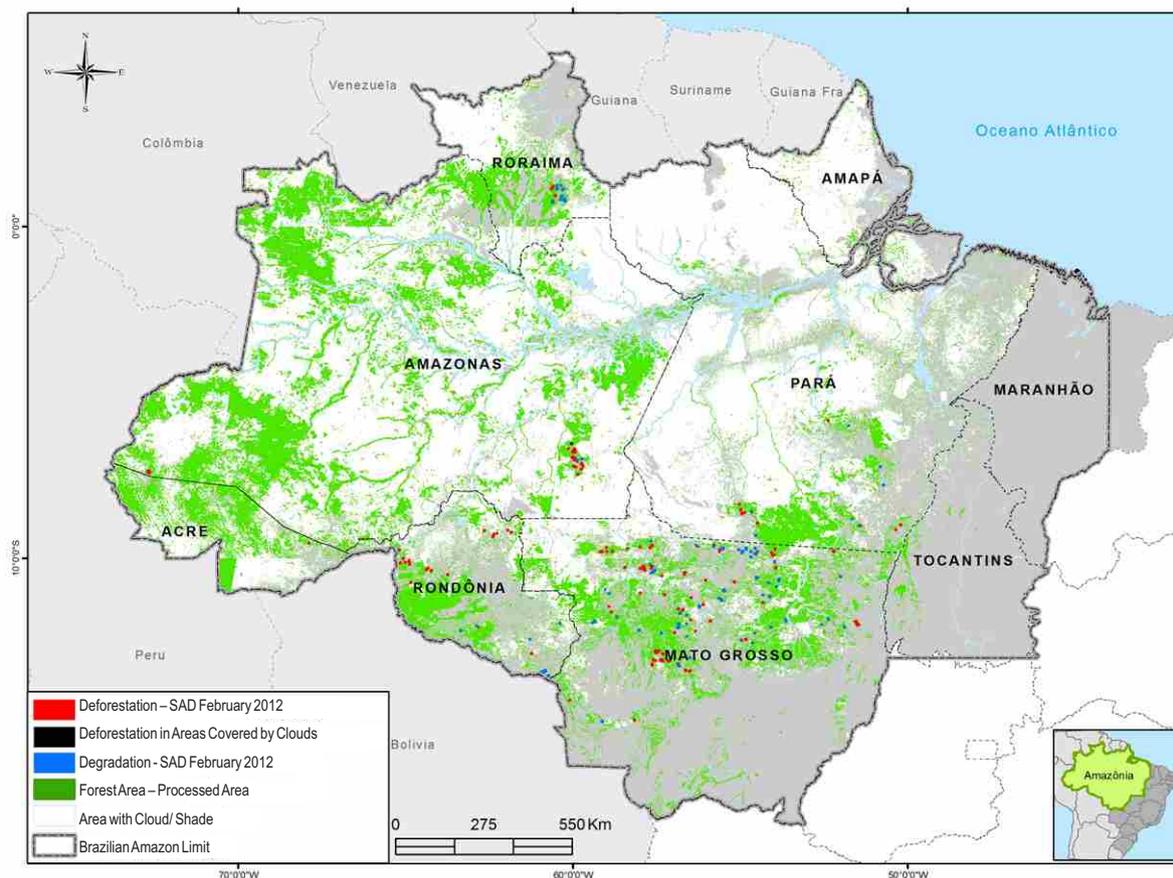


Figure 12. Area with cloud and shade in February 2012 in Legal Amazon

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

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 by pixel mixing, providing the capacity of estimating the abundance of vegetation, soil and Vegetation photosynthetically non active (NPV - Non-Photosynthetic components (Vegetation, Soil and Shade) to calculate the NDFI, with the equation below:

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

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 present the monthly data generated by SAD from August 2006 to February 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 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)

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%).

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 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.

Responsible Team:

General Coordination: Sanae Hayashi, Carlos Souza Jr, e Adalberto Veríssimo (Imazon)

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/>

Support

Fundação David & Lucille Packard through CLUA
(Climate Land Use Aliance)
Fundação Gordon & Betty Moore
Fundo Vale

Partnerships

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