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## SUMMARY

In December 2011, most part (76 %) of the forest area of the Brazilian Amazon was covered by clouds. This compromised the detection of the deforestation and forest degradation for this month through the images of the MODIS used by SAD. Under these conditions only 40 km² of deforestation were detected in December 2011 in the Brazilian Amazon

From the 40 km² of deforestation detected in December 2011, 24 square kilometers (60%) occurred in Mato Grosso, 4 square kilometers (15%) in Pará, 5.5.square kilometers (14%) in Rondônia, 2.5 square kilometers (6%) in Roraima and 2 square kilometers (5%) in Amazonas.

The deforestation accumulated in the period of August 2011 to December 2011, corresponding to the five first months of the current Deforestation Calendar, has reached 568 square kilometers. There was 26% reduction regarding the same previous period (August 2010 to December 2010) when the deforestation totaled 772 square kilometers.

The degraded forests in the Brazilian Amazon totaled only 94 square kilometers in December 2011. Most part (92%) occurred in Mato Grosso followed by far by Pará (6%), and Amazonas (2%).

The forest degradation accumulated in the period of August 2011 to December 2011 totaled 1.380 square kilometers. Regarding the previous period (August 2010 to December 2010) there was a reduction of 59%, when the forest degradation totaled 3.326 square kilometers.

In December 2011, the deforestation detected by SAD compromised 3.4 million tons of equivalent CO2. In the accumulated period (August 2011 - December 2011) the emissions of equivalent CO2 related to the deforestation totaled 38 million tons which represents a reduction of 16.6% regarding the previous period (August 2010 to December 2010).


# Deforestation Statistics

The deforestation detection (total suppression of the forest with soil exposition) performed by the Deforestation Alert System (SAD) from Imazon was compromised by the coverage of clouds in December 2011. Approximately 76% of the forest are from the Brazilian Amazon was covered by clouds in the MODIS images used by SAD. This way, only 40 square kilometers of deforestation were detected in December 2011 in the Brazilian Amazon (Figure 1 and Figure 2).

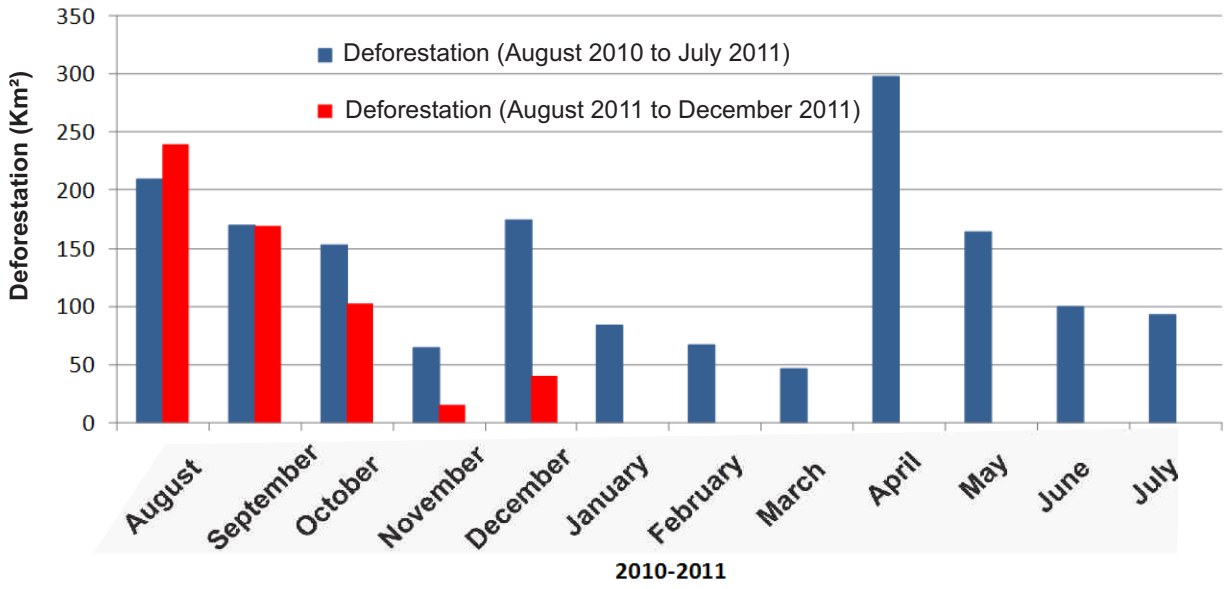


**Figure 1.** Deforesting from August 2010 to December 2011 in the Brazilian Amazon (Source: Imazon/SAD).

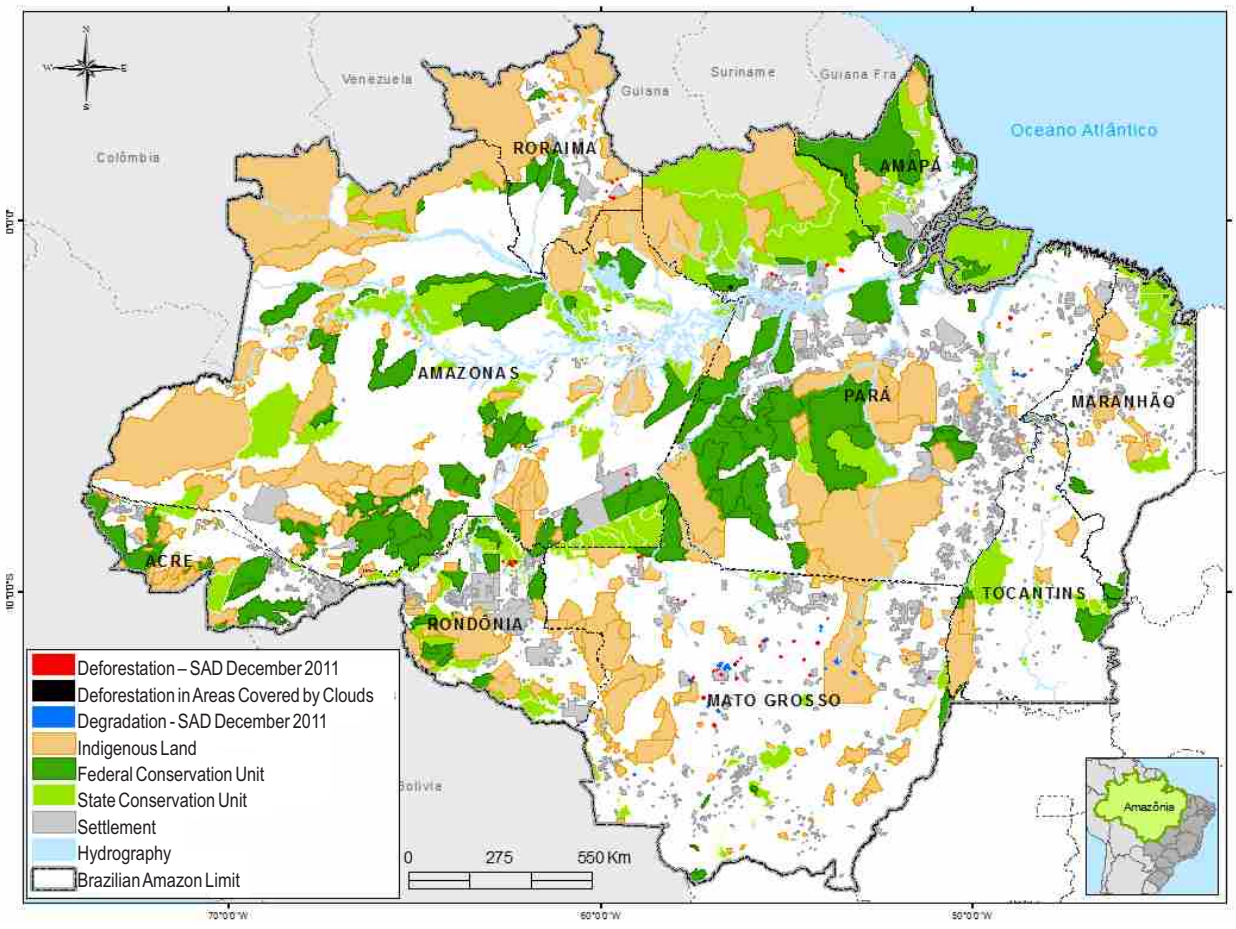


**Figure2.** Deforesting and Forest Degradation in December 2011 at the Brazilian Amazon (Source: Imazon/ SAD).

*The recent deforestation might have occurred in June or previous months, however, it was only possible to detect it now, when there were no clouds over the region. havia nuvens sobre a região.

The deforestation accumulated in the period of August 2011 to December 2011, corresponding to the first five months of the official calendar of Deforestation measuring, has reached 568 square kilometers. There was a 26% reduction in the deforestation regarding the previous period (August 2010 to December 2010) when it reached 772 square kilometers.

In December 2011, Mato Grosso led with 60% of deforestation, followed by Pará (15%) Mato Grosso (14%), Roraima (6%) and Amazonas (5%) (Figure 3).

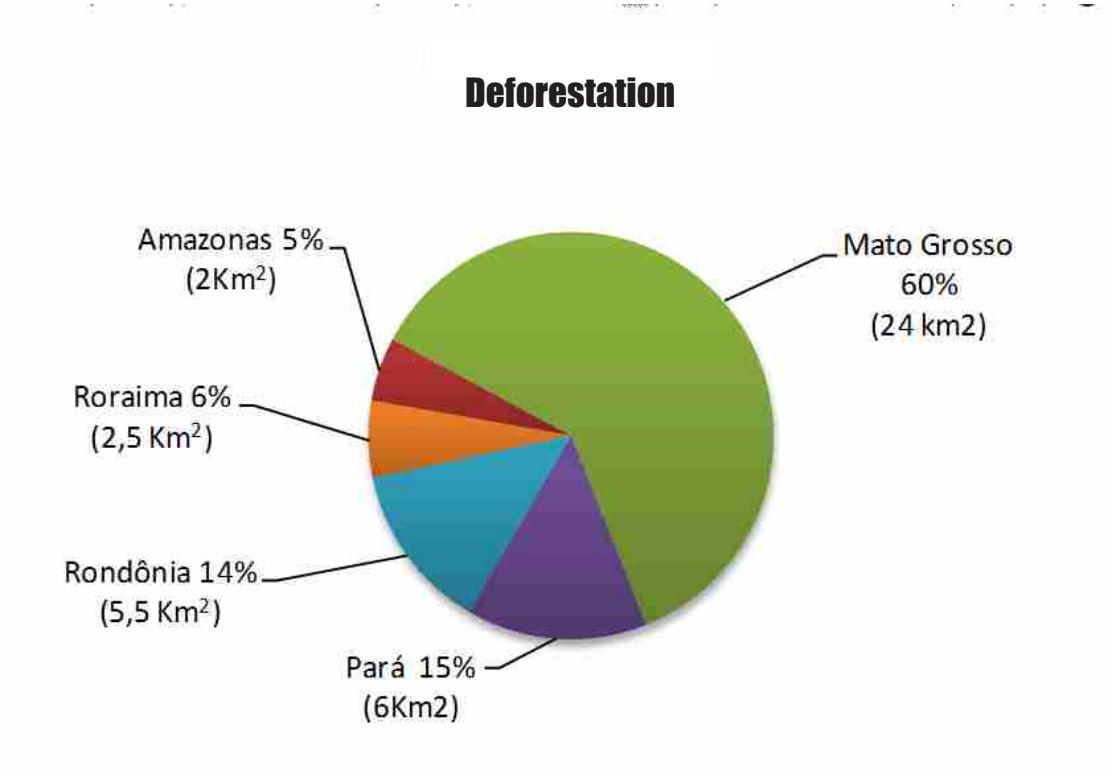


**Figure 3.** Deforestation (%) in the states of the Brazilian Amazon in December 2011 (Source: Imazon/SAD).

Considering the first five months of the current deforestation calendar[1] (August 2011 to December 2011), The state of Pará leads the ranking with 40% of the total deforested in the period. Following is Mato Grosso with 22%, followed by Rondônia with 21% 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 26% reduction of the deforestation occurred in August 2011 to December 2011 when compared to the previous period (August 2010 to December 2010) (Table 1). In relative terms, there was a 65% reduction in Acre, 56%, in Amazonas, and 40% in Mato Grosso. On the other hand, there was a 250% increase in Roraima, 175% in Tocantins, 6% in Pará.

In absolute terms, Pará leads the accumulated deforestation ranking with 230 square kilometers, followed by Mato Grosso (125 square kilometers), Rondônia (120 square kilometers), Amazonas (51 square kilometers), Acre (17 square kilometers), Roraima (14 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 December 2010 and from August 2011 to December 2011 (Source: Imazon/SAD).

| State | August 2010 to December 2010 | August 2011 to December 2011 | Variation (%) |
|---|---|---|---|
| Acre | 49 | 17 | -65 |
| Amazonas | 116 | 51 | -56 |
| Mato Grosso | 209 | 125 | -40 |
| Pará | 216 | 230 | +6 |
| Rondônia | 174 | 120 | -31 |
| Roraima | 4 | 14 | +250 |
| Tocantins | 4 | 11 | +175 |
| Amapá | | | - |
| **Total** | **772** | **568** | **-26** |

* Data from Maranhão were not analyzed.

# Forest Degradation

In December 2011, SAD registered 94 square kilometers of degraded forests (forest intensely explored by lumbering activities and or/ burning) (Figures 2 and 4). The monitoring of forest degradation was compromised due to the great coverage of clouds in the MODIS in December 2011 (76% of the forest area of the Brazilian Amazon).

From the 94 square kilometers of degraded forests detected by SAD in December 2011, the majority (92%) occurred in Mato Grosso followed by far by Pará 6%, and Amazonas (2%) (Figure 5).

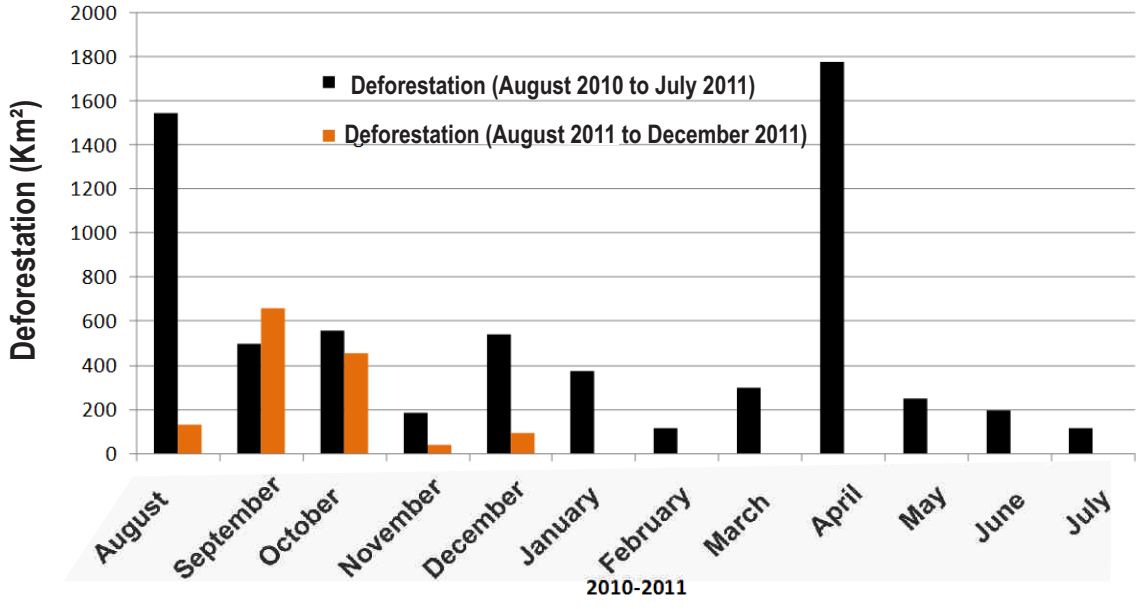


**Figure 4.** Forest Degradation from August 2010 to December 2011 at the Brazilian Amazon (Source: Imazon/SAD).

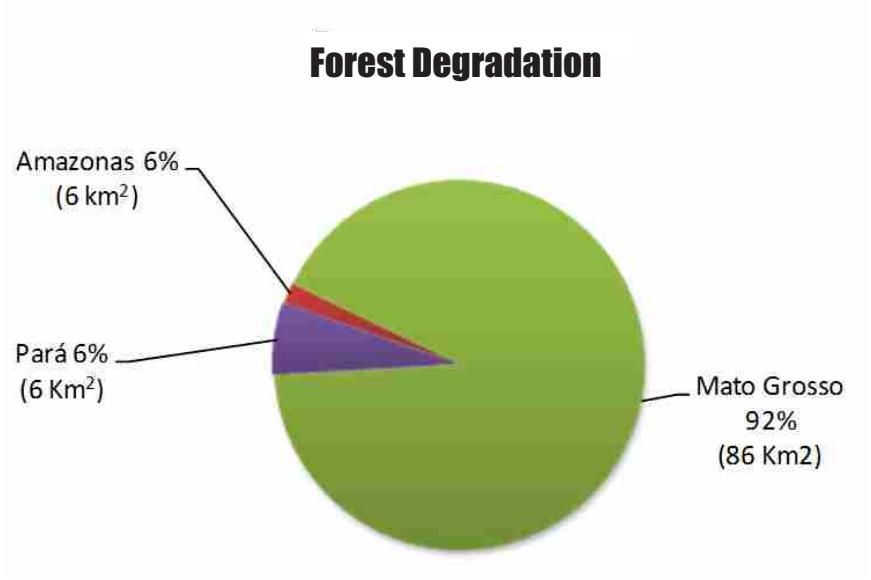


**Figure 5.** Forest Degradation (%) in the States of the Brazilian Amazon in December 2011 (Source: Imazon/SAD).

The forest degradation accumulated in the period of August 2011 to December 2011 totaled 1,380 square kilometers. This represents a reduction of 59% in the forest degradation accumulated in this period (August 2011 to December 2011) regarding the same previous period (August 2010 to December 2010) when the forest degradation totaled 3.326 square kilometers (Table 2).

Acre presented a 98% reduction in the forest degradation between August 2011 and December 2011 compared to August 2010 to December 2010. The reductions were more expressive in Amazonas (-86%), Rondônia (-85%) and Pará (-73%).

Mato Grosso leads the ranking of forest degradation with 78% of the total in the period of August 2011 to December 2011. Following comes Pará with 14%. These two states were responsible for 93% of the forest degradation in the Brazilian Amazon during this period. The rest (7%) occurred in Rondônia and Amazonas.

In absolute terms, Mato Grosso also leads the accumulated deforestation ranking with 1.081 square kilometers, followed by far by Pará (200 square kilometers), Rondônia (71 square kilometers), Amazonas (19 square kilometers), Roraima (6 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 December 2010 and from August 2011 to December

| State | August 2010 to December 2010 | August 2011 to December 2011 | Variation (%) |
|---|---|---|---|
| Acre | 143 | 3 | -98 |
| Amazonas | 134 | 19 | -86 |
| Mato Grosso | 1.819 | 1.081 | -41 |
| Pará | 733 | 22 | -73 |
| Rondônia | 471 | 71 | -85 |
| Roraima | 200 | 6 | +200 |
| Tocantins | 24 | - | - |
| Amapá | - | - | - |
| **Total** | **3.326** | **1.380** | **-59** |

* 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 December 2011, the 40 square kilometers of deforestation detected by SAD in the Brazilian Amazon compromised 940 thousand tons (with error radius of 126 thousand tons of carbon). This amount of affected carbon results in 3.4 million tons of equivalent $CO^2$ (Figure 6).

The forest carbon compromised by the deforestation in the period of August 2010 to December 2011 was 10.4 million tons (with error radius of 210 thousand tons), which represented approximately 38 million tons of equivalent $CO^2$ (Figure 6). Regarding the same period of the previous year (August 2009 to December 2010) there was a 16.6% reduction in the amount of carbon compromised by the deforestation.

The reduction (16,6%) of the forest carbon affected by the deforestation in the period of August 2011 to December 2011 regarding the previous period (August 2010 to December 2011) was less than the reduction of 26% 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.

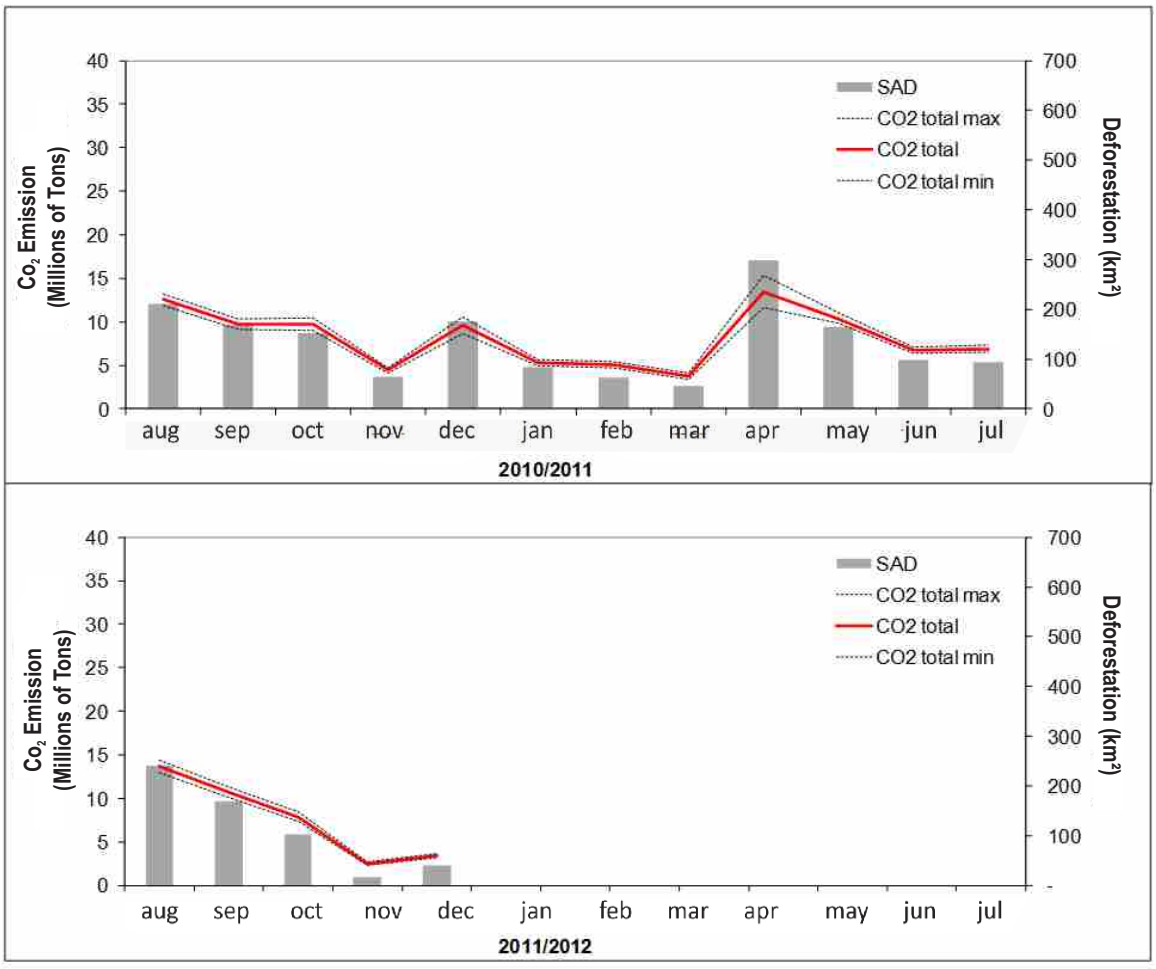


**Figure 6.** Deforestation and emission of Carbon Dioxide ($CO^2$) total equivalent from August 2010 to December 2011 in the Brazilian Amazon (Source: Imazon).

# Deforestation Geography

Regarding the land situation, in December de 2011, the great majority (71%) of deforestation occurred in private areas or under many stages of ownership. The rest of the deforestation was registered in Agrarian Reform Settlements (16.5%), Conservation Units (11.5%) and Indigenous Lands (1.5%) (Table 3).

**Table 3.** Deforestation by land category in December 2011 at the Brazilian Amazon (Source: Imzaon/ SAD).

| Category | December 2011 | |
|---|---|---|
| | km² | % |
| Agrarian Reform Settlement | 6,5 | 16,5 |
| Conservation Units | 4,5 | 11,5 |
| Indigenous Lands | 0,5 | 1 |
| Private, Owned and in abeyance[3] | 28,5 | 71 |
| Total (km²) | 40 | 100 |

# Agrarian Reform Settlements

SAD registered 6,5 square kilometers of deforestation in the Agrarian Reform Settlements during December 2011. The most affected settlements by the deforestation were Rio Juma (Apuí; Amazonas), Santo Antonio da Mata Azul (Novo Santo Antonio; Mato Grosso), and Jatapu (Caroebe; Roraima). (Figure 7).

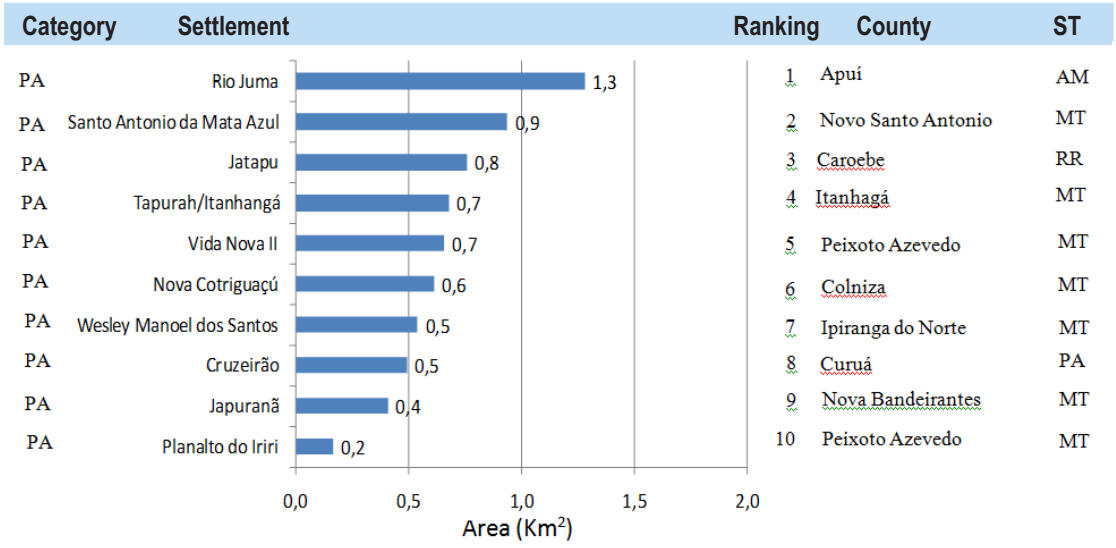


**Figure 7.** Most deforested Agrarian Reform Settlements in December 2011 at the Brazilian Amazon (Source: Imazon/SAD).

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

# Protected Areas

SAD detected 11,5 square kilometers of deforestation in the Conservation Units (Figure 8). The Conservation Units that suffered deforestation were Flores Rio Preto-Jacundá (Rondônia), Flona de Saracá-Taquera (Pará), and Flota do Paru (Pará). In the case of the Indigenous Lands, in December 2011 less than 1 square kilometer was detected in the Indigenous land of Manoki (Figure 9).

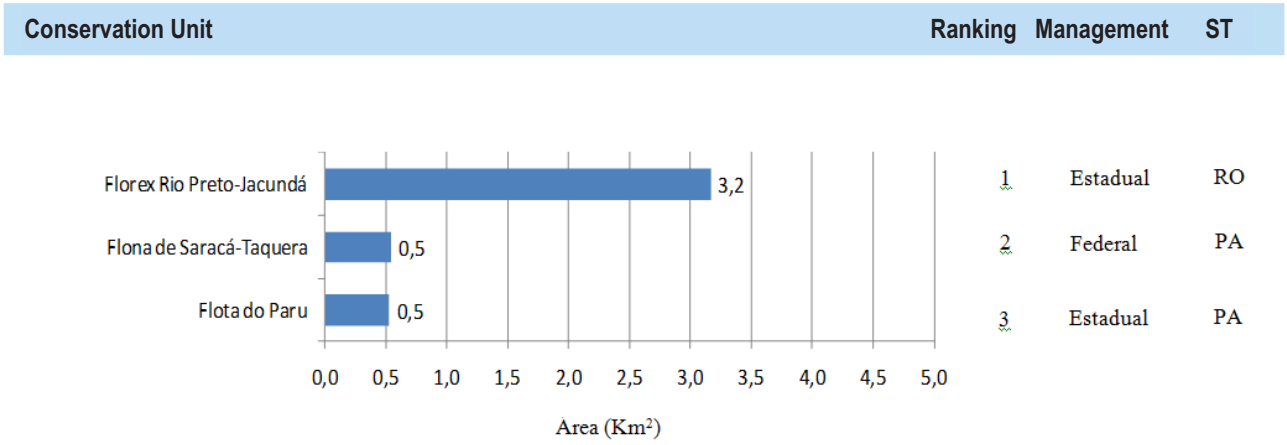


**Figure 8.** Most deforested Conservation Units at the Brazilian Amazon in December 2011 (Source: Imazon/SAD).

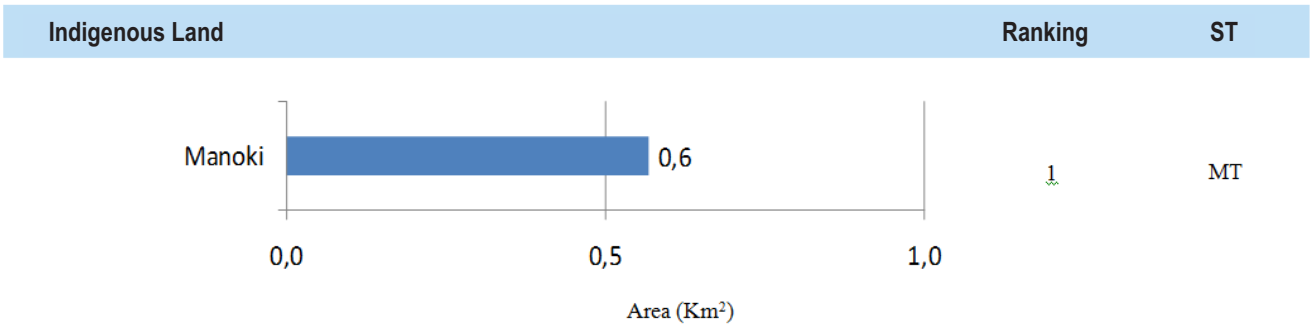


**Figure 9.** Most deforested Indigenous Lands at the Brazilian Amazon in December 2011 (Source: Imazon/SAD).

# Critical Municipalities

In December 2011, the most affected municipalities were União do Sul (Mato Grosso), Cujubim (Rondônia), Itanhagá (Mato Grosso) (Figure 10 and 11).

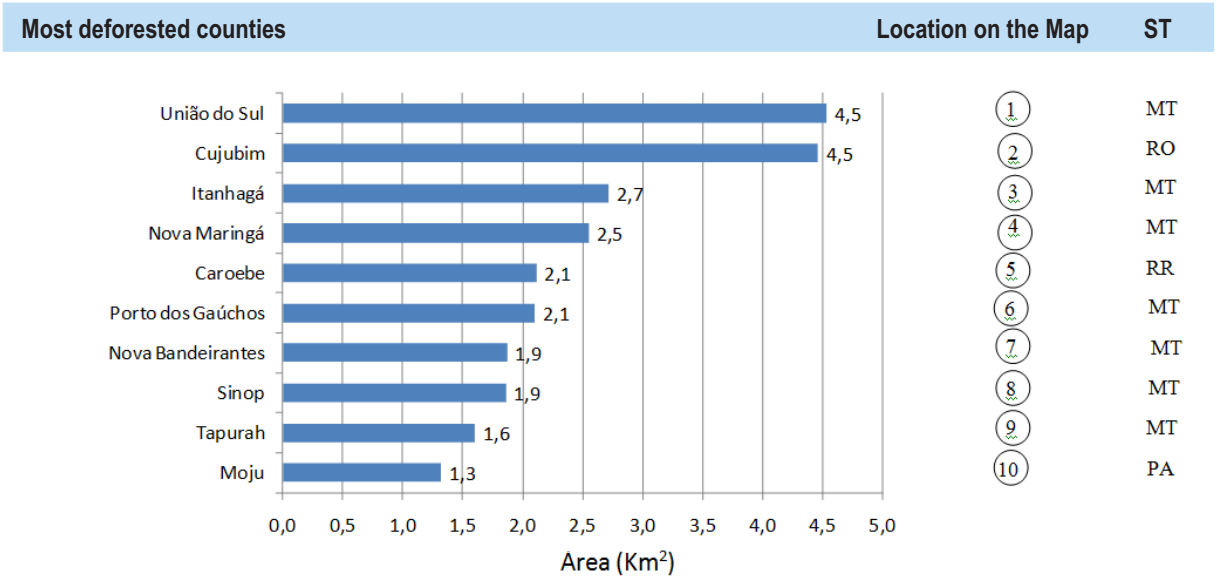


**Figure 10.** Most deforested counties at the Brazilian Amazon in December 2011 (Source: Imazon/SAD).

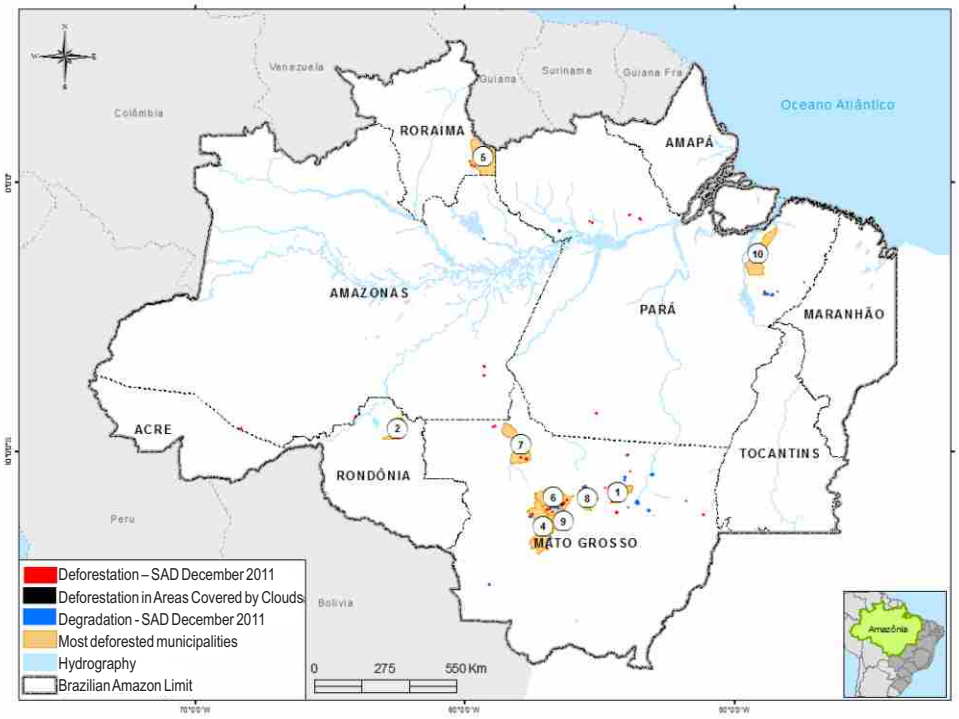


**Figure 11.** Most deforested counties in December 2011 (Source: Imazon/SAD).

# Coverage by clouds and Shade

In December 2011, 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. Most part of the States of the Brazilian Amazon had over 65% of their areas covered by clouds: Acre (90%), Rondônia (88%), Roraima (83%), Amazonas (79%), Amapá (76%), Pará (68%), and Mato Grosso (65%). Because of that, the deforestation and degradation information in December 2011 may be underestimated. (Figure 12).

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

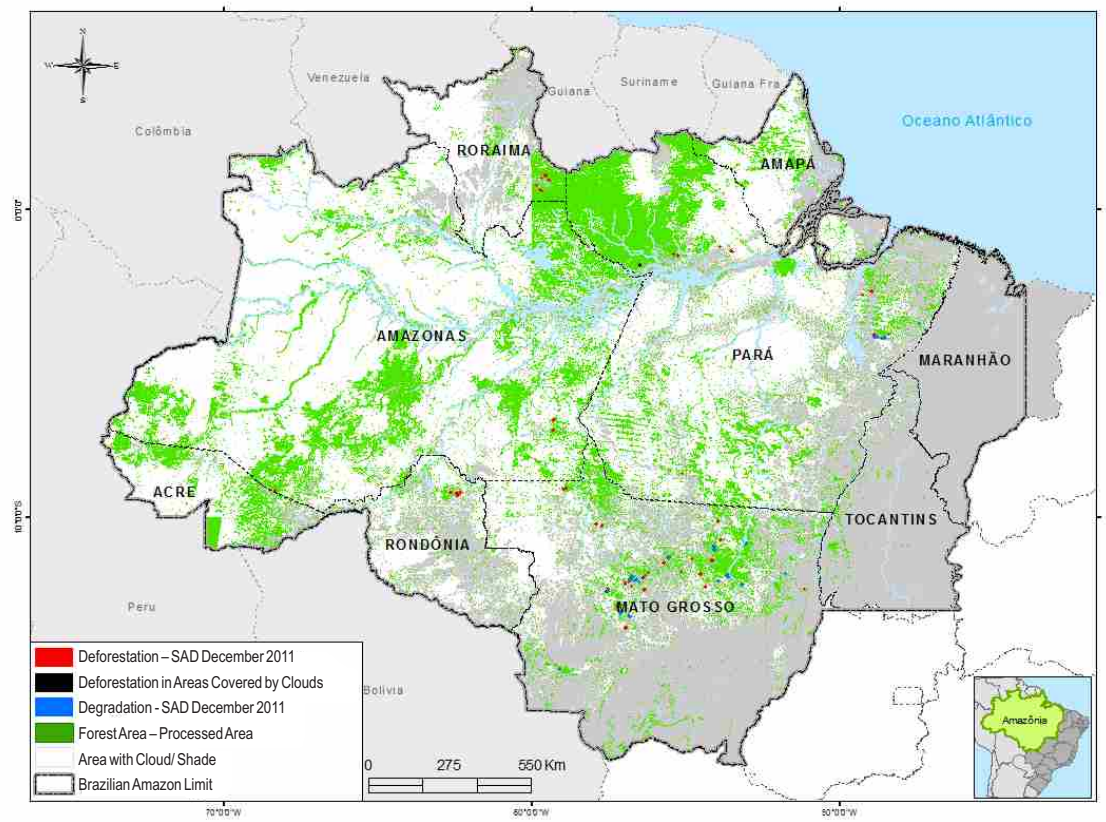


**Figure 12.** Area with cloud and shade in December 2011 in the Brazilian Amazon

The deforestation in areas covered by clouds might have occurred in December 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 December 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 an 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 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 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 below:

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

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

$$BPF = ff * AGLB$$

$$BAS_0 = bf * AGLB$$

where:

t: time (month)

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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**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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**Partnerships**
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