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## SUMMARY

In December 2012, most part (56%) of the Legal Amazon forest area was covered by clouds. In these conditions 82 square km of deforestation were detected in the Legal Amazon. This represented a 107% increase compared to December 2011 when deforestation summed 40 square kilometers for a cloud covering of 76%.

In December 2012, most part of deforestation (57%) occurred in the State of Mato Grosso, and then of Pará (27%), Rondônia (10%) and Amazonas (6%).

Accumulated deforestation from August 2012 to December 2012 summed 1.288 square kilometers up. A 127% increase was observed compared to the former period [August 2011 to December 2011], when deforestation summed 568 square kilometers.

Degraded forests in Legal Amazon summed 261

square km in December 2012. Compared to December 2011, when the forest degradation summed 94 square kilometers, an increase of 178% was observed.

Accumulated forest degradation in the period (August 2012 to December 2012) summed 972 square kilometers. Compared to the former period (August 2012 to December 2011), when forest degradation summed 3325 square kilometers, a 71% reduction was noticed.

In December 2012, SAD detected a deforestation involving 5,5 million tons of equivalent CO<sub>2</sub>. For the accumulation of the period (from August 2012 to December 2012) the compromised equivalent CO<sub>2</sub> emissions summed 66,5 million tons representing a 27% increase compared to the former period (August 2011 to December 2011).

## Deforestation Statistics

According to SAD, the deforestation (forest total suppression for other alternative uses of the soil]

has reached 82 square km in December 2012.

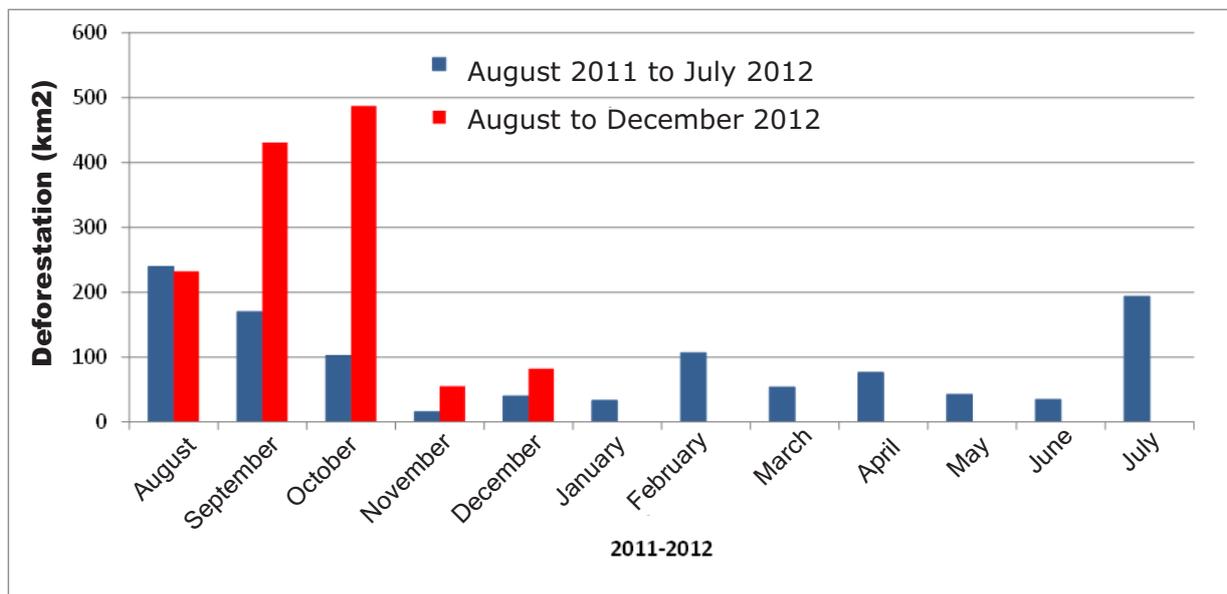


Figure 1: Deforestation from August 2011 to December 2012 in Legal Amazon (Source: Imazon/SAD)

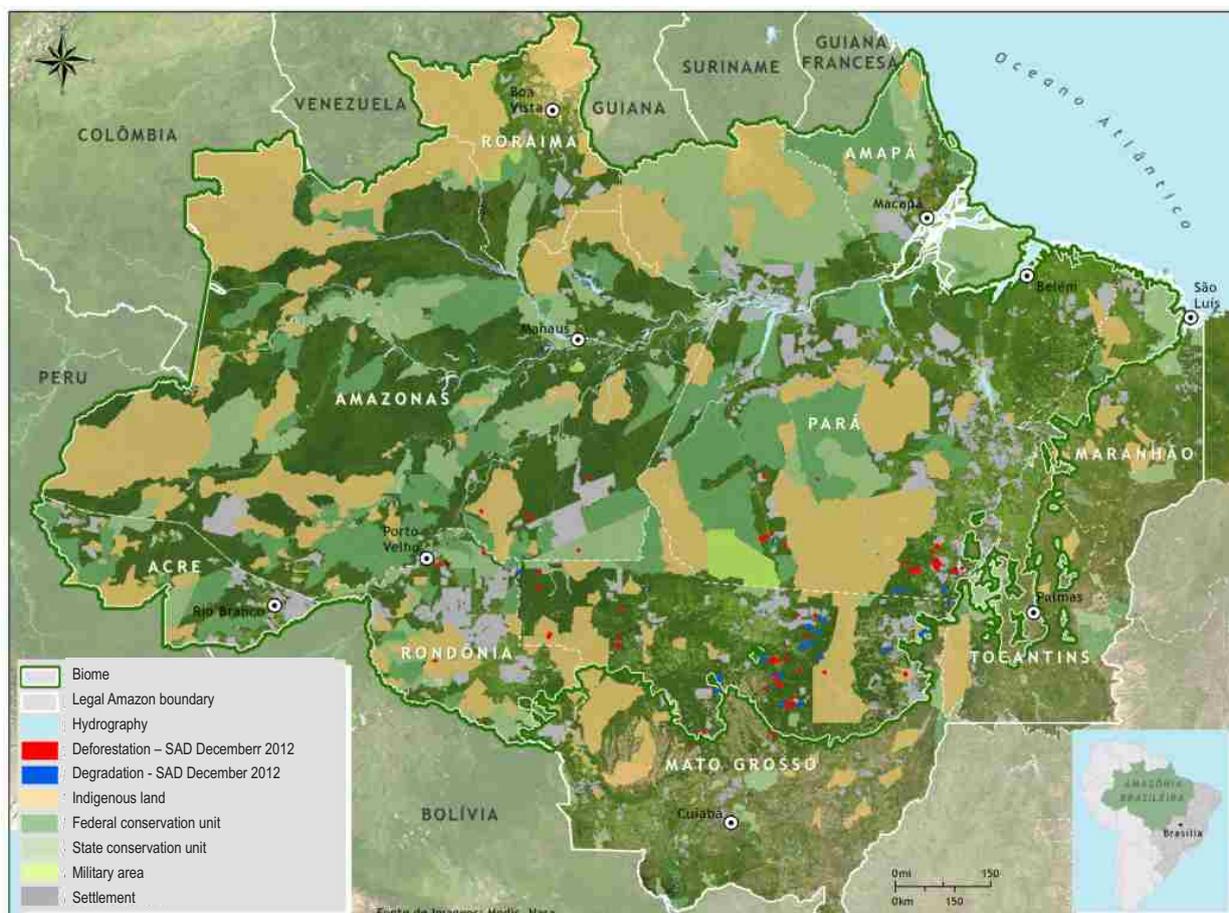


Figure 2: Deforestation and Forest Degradation in December 2012 in Legal Amazon (Source: Imazon/SAD).

Accumulated deforestation in the period from August 2011 to December 2012, corresponding to five months of the official calendar of deforestation measurement, reached 1,288 square kilometers. A 127% increase of deforestation was observed, compared to the former period [from August 2011 to December 2011], when it reached 567 square kilometers.

In December 2012, most part (57%) of the deforestation occurred in the State of Mato Grosso then in Pará (27%), Rondônia (10%) and Amazonas (6%). It was not possible to detect the deforestation in Acre and Amapá due to the high cloud covering during the month.

### Deforestation

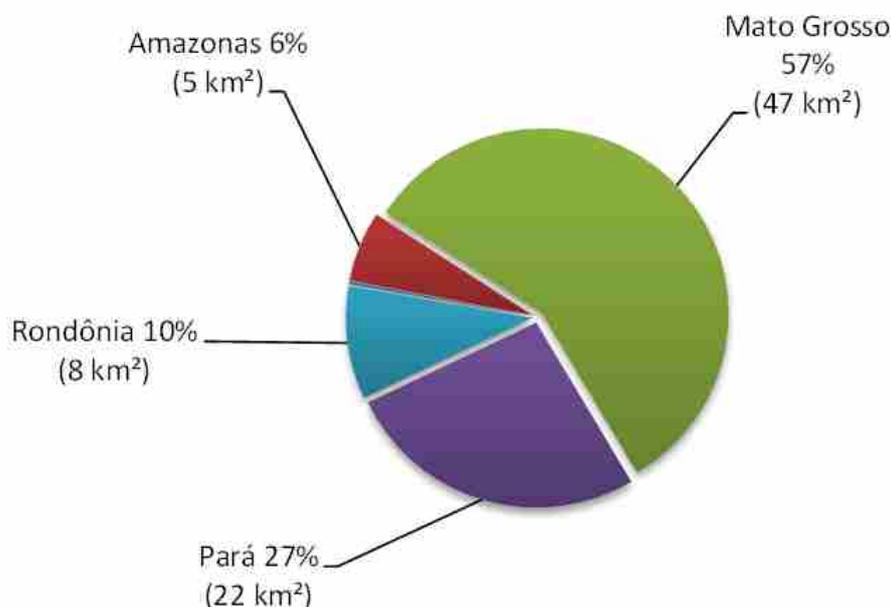


Figure 3: Percentage of deforestation in the states of Legal Amazon, in December 2012 (Source: Imazon/SAD)

Taking into account the accumulated deforestation during the five months of the current deforestation calendar [August 2012 to December 2012], the State of Pará leads the ranking with 49% of the deforested total. Then come Mato Grosso with 23%, followed by Rondônia with 13% and Amazonas with 12%. Those four states are accountable for 97% of deforestation occurred in Legal Amazon during that period.

Relatively, a 49% reduction was observed in

the State of Roraima, and a 43% in the State of Acre. On the other hand, a 200% increase was observed in Amazonas, 176% in the State of Pará, 138% in Mato Grosso, 96% in Tocantins, and 40% in Rondônia.

In absolute terms, Pará leads the ranking of accumulated deforestation with 635 square kilometers, followed by Mato Grosso (296 square km), Rondônia (167 square km) and Amazonas (152 square km) (Table 1).

<sup>1</sup> The official calendar of deforestation measurements starts in August and ends in July

**Table 1:** Deforestation evolution across the states of Legal Amazon from August 2011 to December 2011, and from August 2012 to December 2012 [Source: Imazon/SAD]

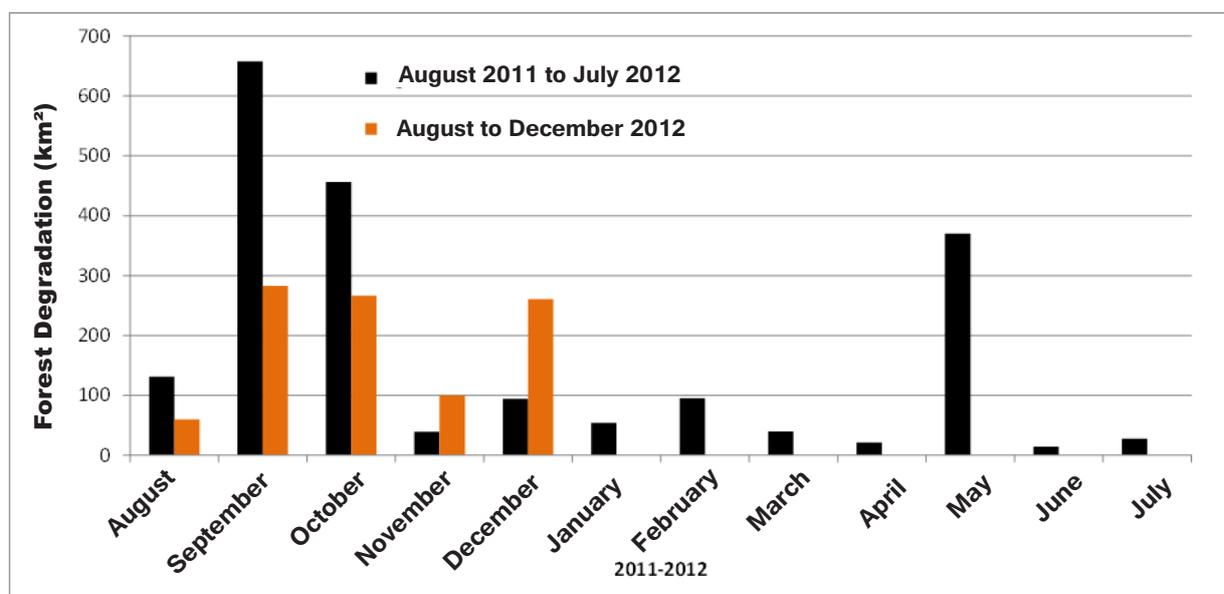
State	August 2011 to December 2011	August 2012 to December 2012	Variation (%)
Pará	230	635	+176
Mato Grosso	125	296	+138
Rondônia	120	167	+40
Amazonas	51	152	+199
Roraima	14	7	-46
Acre	17	10	-43
Tocantins	11	21	+98
Amapá	-	-	-
<b>Total</b>	<b>568</b>	<b>1.288</b>	<b>+127</b>

\* Data from the State of Maranhão has not been analyzed.

## Forest Degradation

In December 2012, SAD recorded 261 square km of degraded forests (forests that are extremely

exploited by wood activities and/or burnings) (Figures 2 and 4).



**Figure 4:** Forest degradation from August 2011 to December 2012 in Legal Amazon (Source: Imazon/SAD)

The forest degradation accumulated on the period from August 2012 to December 2012 reached 972 square km.

In absolute terms, Mato Grosso leads the ranking of accumulated forest degradation with 503 square km (46%), followed by the State of Pará with

386 square km (40%). The remaining (8%) took place in the states of Rondônia (48 square km), Tocantins (25 square km), and Amazonas (10 square km).

**Table 2:** Evolution of forest degradation across the states of Legal Amazon in August 2011 to December 2011 and from August 2012 to December 2012 (Source: Imazon/SAD).

State	August 2011 to December 2011	August 2012 to December 2012	Variation (%)
Mato Grosso	1819	503	-72
Pará	733	386	-47
Rondônia	471	48	-90
Amazonas	134	10	-93
Roraima	2	-	-100
Acre	143	-	-100
Tocantins	24	25	-
Amapá	-	-	-
<b>Total</b>	<b>3.325</b>	<b>711</b>	<b>-71</b>

\* Data from the state of Maranhão was not analyzed.

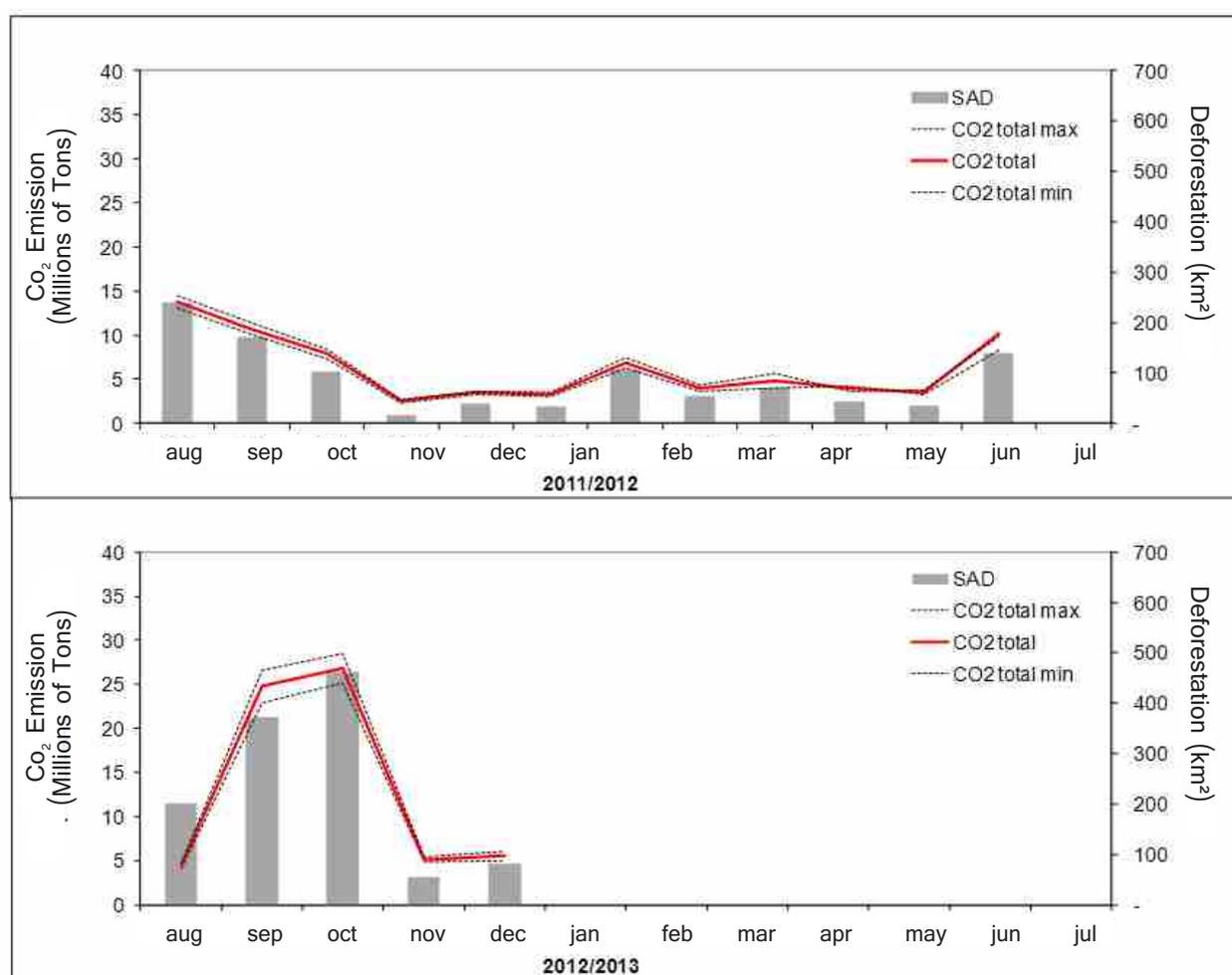
<sup>2</sup> The official calendar of deforestation measurements starts in August and ends in July

### Carbon Affected by the Deforestation

In December 2012, the 82 square kilometers of deforestation detected by SAD in Legal Amazon endangered 1,6 million tons of carbon (with a margin of error of 506 thousand tons). This amount of endangered carbon may result in emissions of 5.5 million tons of equivalent CO<sub>2</sub> (Figure 6).

Deforestation-endangered forest carbon in the period from August 2012 to December 2012 was of 18 million tons (with a margin of error of 431 thousand

tons), what represented about 66,5 million tons of equivalent CO<sub>2</sub> (Figure 6). Compared to the same period of the former year (August 2011 to December 2011), when endangered forest carbon was of 10.4 million ton, a 76% increase was observed in the quantity of carbon endangered by deforestation.



**Figure 6:** Deforestation and emissions of total equivalent carbon dioxide (CO<sub>2</sub>) from August 2011 to December 2012, in Legal Amazon (Source: Imazon).

## Deforestation Geography

In December 2012, most (71%) of deforestation took place either in private areas or under different stages of ownership. The remaining

deforestation was registered in Conservation Units (2%), Indigenous lands (3%) and Land Reform Settlements (10%) (Table 3).

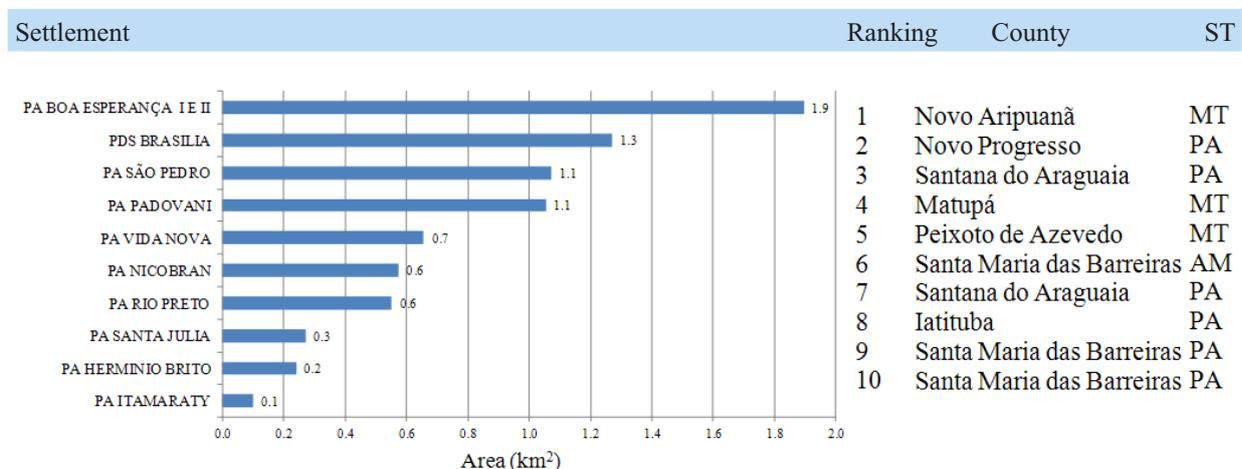
**Table 3:** Deforestation by agrarian category in December 2012, in Legal Amazon (Source: Imazon/SAD).

Category	December 2012	
	km <sup>2</sup>	%
Agrarian Reform Settlement	8	10
Conservation Units	1,5	2
Indigenous Lands	14	17
Private, Owned and in Abeyance <sup>3</sup>	58,5	71
<b>Total (km<sup>2</sup>)</b>	<b>82</b>	<b>100</b>

## Agrarian Reform Settlements

SAD has recorded 8 square kilometers of deforestation in Agrarian Reform Settlements in December 2012 (Figure 7). The 10 settlements affected the most by deforestation were PA Boa Esperança I e II (Novo Aripuanã; Mato Grosso), PA PDS Brasília (Novo Progresso, Pará), PA São Pedro (Santana do Araguaia, Pará), PA Padovani (Matupá,

Mato Grosso), PA Vida Nova (Peixoto de Azevedo, Mato Grosso), PA Nicobran (Santa Maria das Barreiras, Pará), PA Rio Preto (Santana do Araguaia, Pará), PA Santa Julia (Itaituba, Pará), PA Hermínio Brito (Santa Maria das Barreiras, Pará) and PA Itamaraty (Santa Maria das Barreiras, Pará).



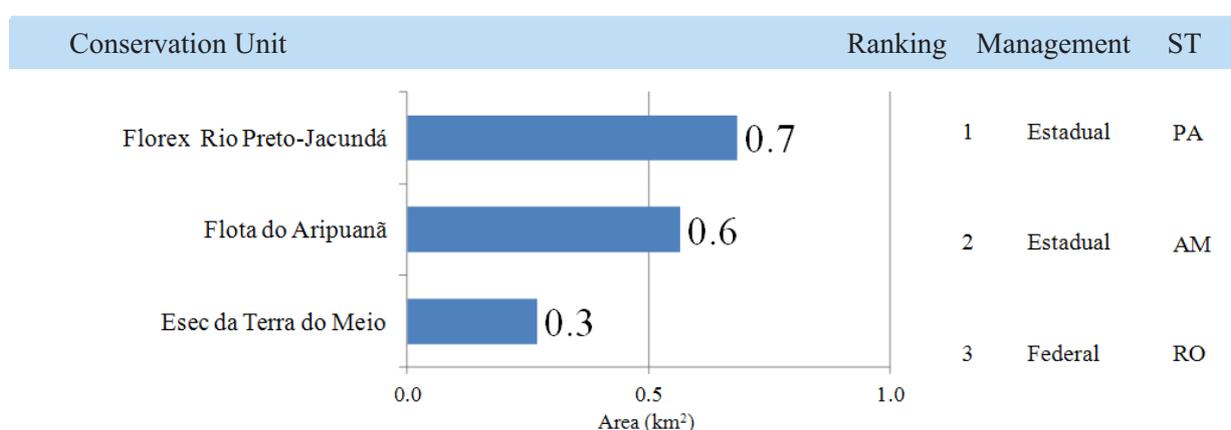
**Figure 7:** Agrarian Reform Settlements deforested the most in December 2012 in Legal Amazon (Source: Imazon/SAD).

<sup>3</sup> It includes private areas (titled or not) and unprotected public forests.

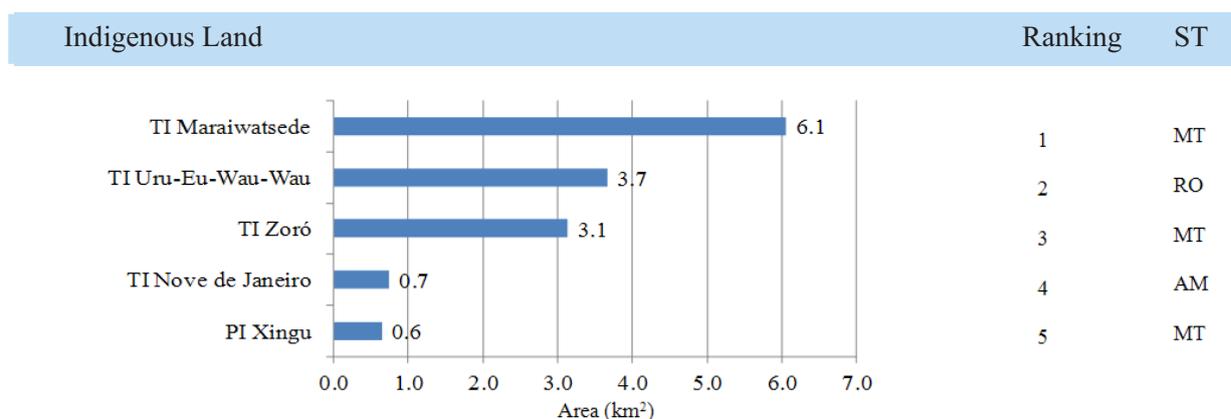
### Protected Areas

In the month of December, due to the high clouds covering, SAD has detected 1,5 square km of deforestation only in the Florex Rio Preto-Jacundá (Rondônia), Flota do Aripuanã (Amazonas) and in the Esec da Terra do Meio (Pará) (Figure 8). As far as

Indigenous Lands are concerned, in December 2012 a deforestation of 14 square km was identified in the Lands of Maraiwatsede (Mato Grosso), Uru-Eu-Wau-Wau (Rondônia), Zoró (Mato Grosso), Nove de Janeiro (Amazonas) and PI Xingu (Mato Grosso) (Figure 9).



**Figure 8:** Conservation Unit deforested in Legal Amazon in December 2012 (Source: Imazon/SAD).



**Figure 9:** Deforested Indigenous lands in Legal Amazon in December 2012 (Source: Imazon/SAD).

## Critical Municipalities

In December 2012 the counties deforested the most were: Santa Carmem (Mato Grosso) and Cumaru

do Norte (Pará) (Figures 10 and 11).

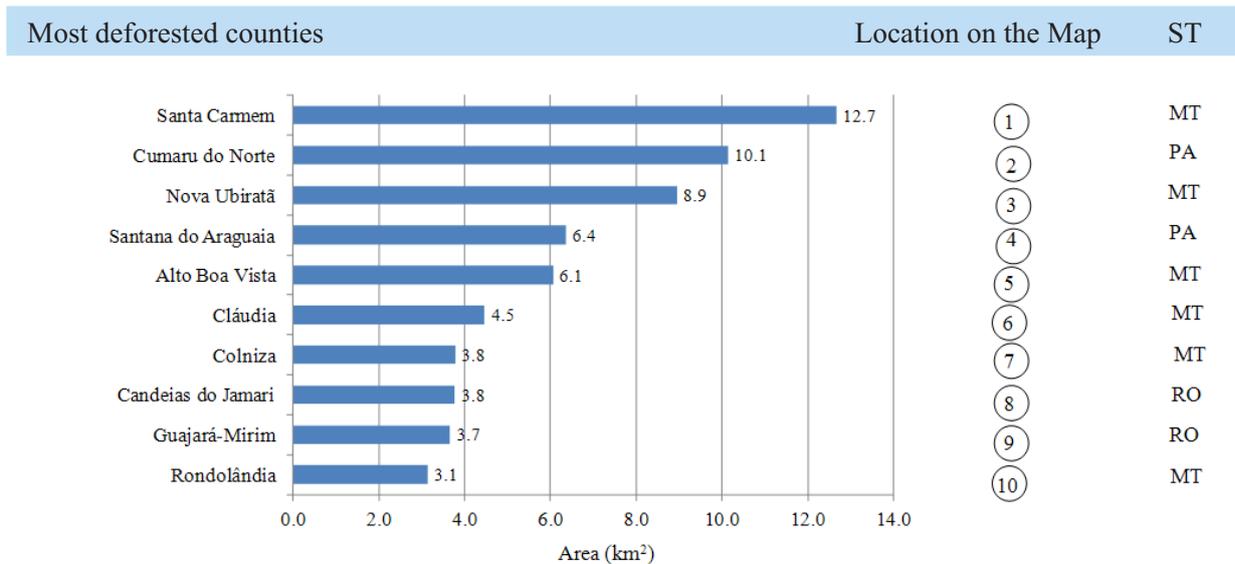


Figure 10: Counties deforested the most in Legal Amazon in December 2012 (Source: Imazon/SAD).

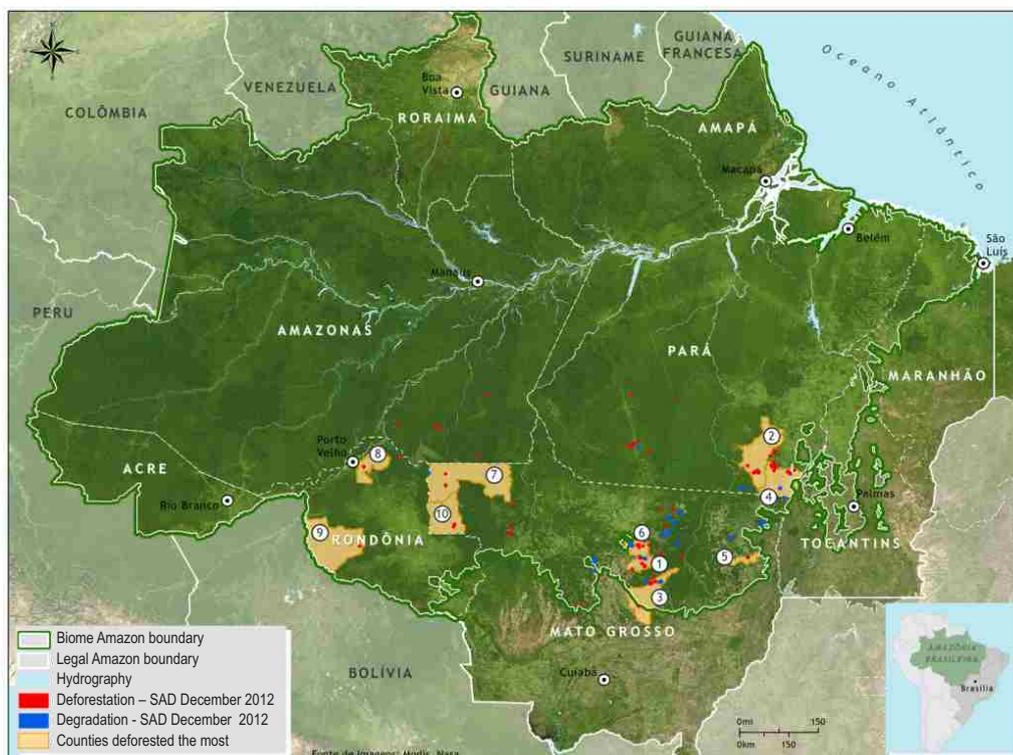


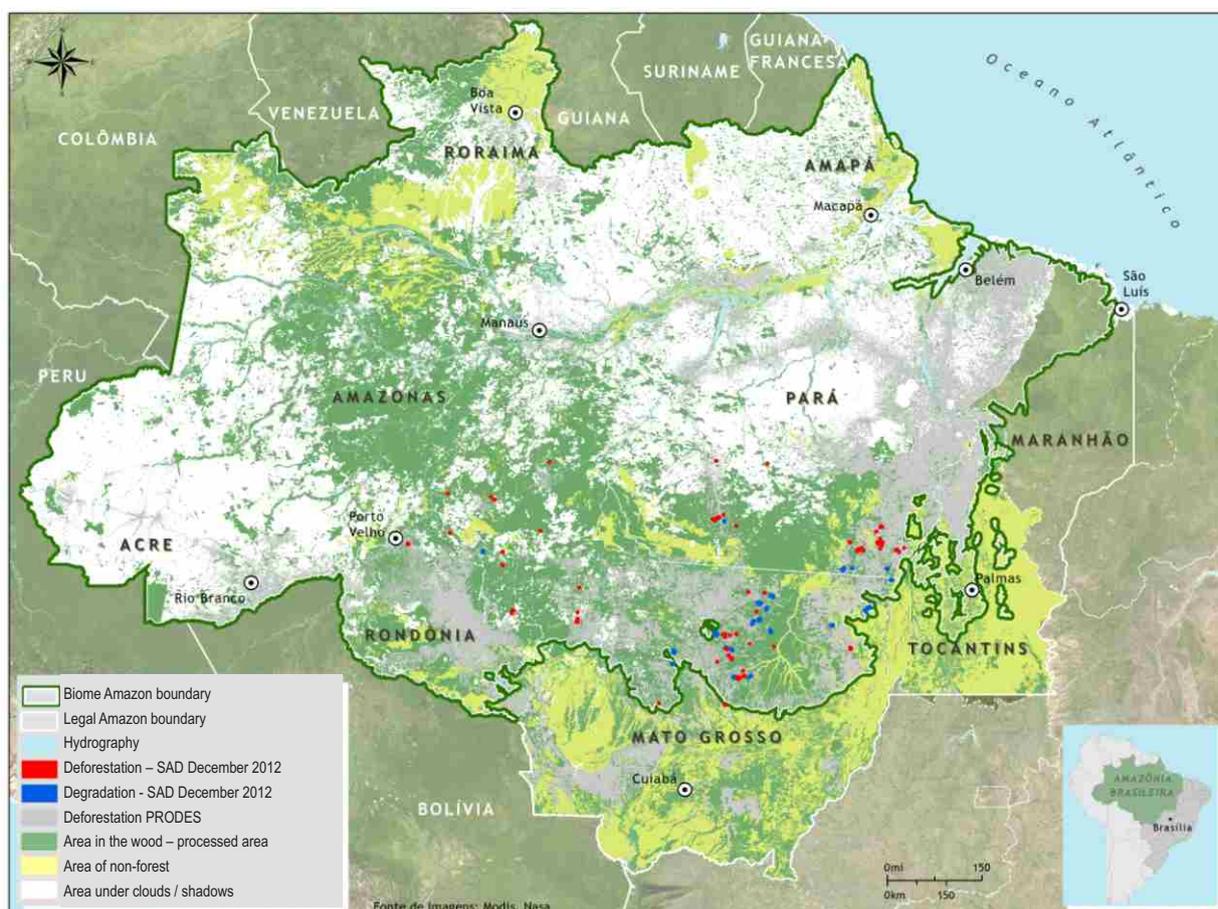
Figure 11: Counties deforested the most in December 2012 (Source: Imazon/SAD).

### Coverage by clouds and Shade

In December 2012, it was possible to monitor, along with SAD, 44% of Legal Amazon forest area. The remaining 56% of forest territory were covered by clouds what hampered the detection of deforesting and forest degradation.

The states with larger clouds coverage were: Acre (100%), Amapá (79%), Pará (76%) e Roraima (62%). In virtue of that, data related to both deforestation and forest degradation in December 2012 may be underestimated (Figure 12).

\* The part of the state of Maranhão, that integrates Legal Amazon, was not analyzed.



**Figure 12:** Area covered by clouds and shadows in December 2012 in Legal Amazon

### Google SAD-EE

Since June 2012 the detection of alerts of deforestation and forest degradation has been carried out in the Google's Earth Engine – EE – platform, with the new version: SAD EE. This system was developed in

collaboration with Google and uses the same process already used by SAD, with MODIS' reflectance images, in order to generate alerts of deforestation and forest degradation.

## Table I: SAD 3.0

Since August 2009, SAD has been introducing some news. First, we created a graphical interface to integrate all image processing programs used in SAD. Second, we started computing deforestation in areas that were covered by clouds in the previous months, under a new class. Finally, deforestation and degradation are detected with pairs of NDFI images in a change detection algorithm. The main method remains the same as SAD 2, as described here below.

SAD generates a temporal mosaic of daily MODIS images of MOD09GQ and MOD09GA products to filter the clouds. Afterwards, we used a technique of different spectral resolution band merge, i.e., pixels of different sizes. In that case, we changed the 500 meter 5-band scale of MODIS to 250 meters. This allowed to enhance the spectral model of pixel mixture, thus supplying ability to estimate the abundance of vegetation, soils and non-active photo-synthetically vegetation (NPV, for Non-Photosynthetic, in English) components (vegetation, soil and Shadow) so to be able to calculate the NDFI with the following equation:

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

Where VG is the standardized component of vegetation for shadow given by:

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

NDFI ranges from -1 (pixel with 100% of exposed soil) to 1 (pixel with >90% with forest vegetation). Thus, we could have a continuous image showing the transition from deforested areas, crossing the degraded forests, reaching the forest with no warning signs of disturbance.

Detection of both deforestation and degradation was shown this month with the difference of NDFI images related to the consecutive months. Hence, a reduction in NDFI values ranging from -200 to -50 indicates possibly cleared areas, and a reduction ranging from -49 to -20 indicates signs of degradation.

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

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

### Table II: Carbon affected by deforestation

Since January 2010 we have been reporting the estimates of carbon endangered (i.e., of forest carbon subject to emissions due to burnings and decomposition of forest biomass residues) arising from the deforestation detected by SAD in Legal Amazon.

Carbon estimates are generated based on the combination of SAD deforestation maps and simulations of spatial distribution of biomass for Amazonia. We have developed a model of estimates of carbon emissions based on stochastic simulation (Morton et al, in prep.), named Carbon Emission Simulator (CES). We generated 1000 simulations of biomass spatial distribution in Amazon using a geo-statistic model (Sales et al., 2007), and transformed such biomass simulations in C stocks using biomass conversion factors for C – as stated in 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<sub>t</sub>: Carbon emitted in the month t.

C<sub>t</sub>(S): Carbon emitted of a deforested polygon in time t.

S<sub>D</sub>: Deforest area.

BVAS: Biomass above the soil of the deforested region S<sub>D</sub>.

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

fc: charcoal fraction (3 to 6%).

BAS<sub>0</sub>: 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.

In order to apply CES model using data from SAD, we considered only the carbon endangered by deforestation, i.e., the fraction of forest biomass consisting of carbon (50%) subject to instantaneous issuances due to burnings of forests by deforesting and/or the future decomposition of the remaining forest biomass. Furthermore, we have adapted the CES model so to be able to estimate – on monthly basis - the forest carbon endangered by deforestation. Finally, simulations have allowed us to estimate the uncertainty of carbon endangered, represented by the standard deviation (± 2 times) of the simulations of carbon affected every month.

To convert carbon values into CO2 equivalent, we applied a 3.68 value.

#### References:

D.C. Morton<sup>1</sup>, M.H. Sales<sup>2</sup>, C.M. Souza, Jr.<sup>2</sup>, B. Griscom<sup>3</sup>. Baseline Carbon Emissions from Deforestation and Forest Degradation: A REDD case study in Mato Grosso, Brazil – undergoing preparation.

Sales, M.H. et al., 2007 - Improving spatial distribution estimation of forest biomass with geo-statistics: A case study for Rondônia, Brazil. *Ecological Modeling*, 205(1-2), 221-230.

## Responsible Team:

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## Data Source:

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

## Thanks:

Google Earth Engine Team  
<http://earthengine.google.org/>

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Secretary of State for the Environment of Pará (EMS)  
Secretary of State for the Environment Mato Grosso (SEMA)  
Federal Public Attorney's office of the Pará  
State Public Attorney's office of the Pará  
State Public Attorney's office of the Roraima  
State Public Attorney's office of the Amapá  
State Public Attorney's office of the Mato Grosso  
Instituto Centro de Vida (ICV- Mato Grosso)