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## SUMMARY

In February 2013, 72% of the forest area in Legal Amazon was covered by clouds, mainly in the states of Amapá and Roraima, representing 91% and 90% of the cloud coverage, respectively. This compromised the detection of deforestation and forest degradation on that month by MODIS images used by SAD. Under such conditions, only 45 square kilometers of deforestation were detected in February 2013 in Legal Amazon, what represented a 58% reduction when compared to February 2012 when deforestation summed 107 square kilometers and cloud coverage was 76%.

Accumulated deforestation from August 2012 to February 2013, summed 1,351 square kilometers up, representing a 91% increase compared to the former period [August 2011 to February 2012], when deforestation summed 708 square meters.

In February 2013, a large part of deforestation (78%) occurred in the State of Mato Grosso, followed by Amazonas (12%), Pará (9%), Tocantins (7%), Rondônia (4%), and

Amazonas (2%).

Forest degradation in Legal Amazon summed 50 square meters. Compared to February 2012, when forest degradation summed 95 square km, a 47% reduction was noticed.

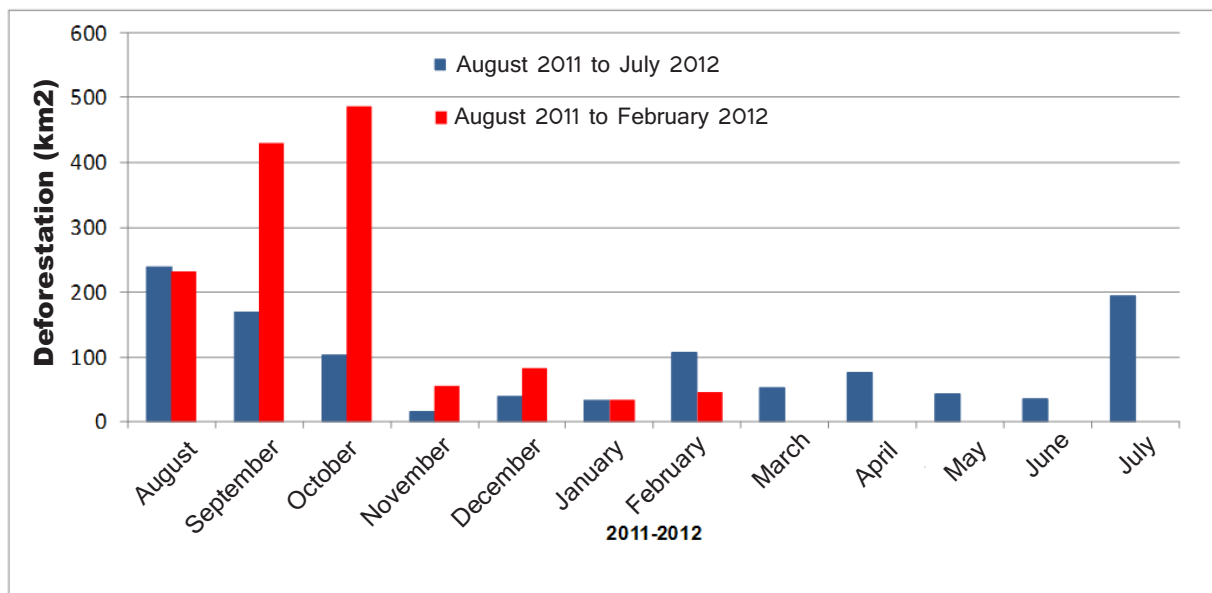
Accumulated deforestation from August 2012 to February 2013, summed 1,091 square kilometers. Compared to the former period [August 2011 to February 2012], when deforestation summed 1433 square meters, a 29% reduction was noticed.

In February 2013, SAD detected a deforestation involving 990 thousand tons of equivalent CO<sub>2</sub>. The accumulated of the period (from August 2012 to February 2013) of equivalent CO<sub>2</sub> issued compromised by deforestation summed 74.5 million tons what represents a 73% increase compared to the former period (august 2012 to February 2012).

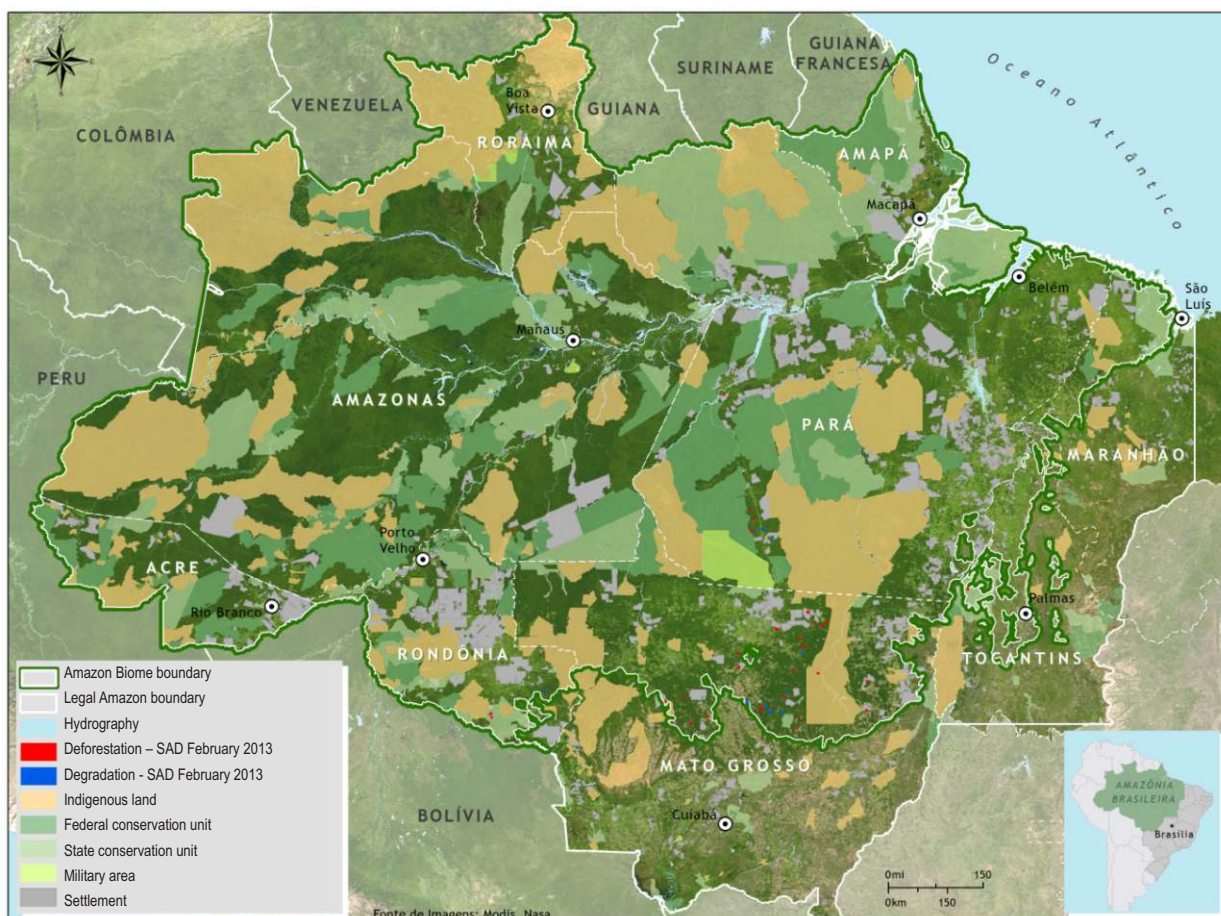
## Deforestation Statistics

According to Imazon's Deforestation Alert System [SAD], deforestation (forest total suppression

for other alternative uses of the soil] has reached 45 square km in February 2013 (Figure 1 and Figure 2).



**Figure 1:** Deforestation from August 2011 to February 2013 in Legal Amazon (Source: Imazon/SAD)

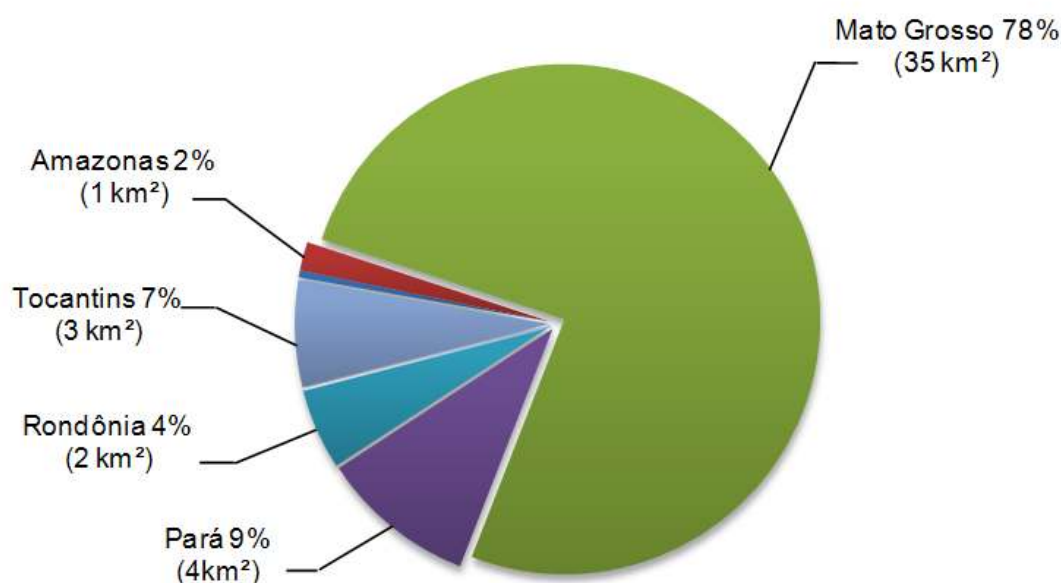


**Figure 2:** Deforestation and Forest Degradation in February 2013 in Legal Amazon (Source: Imazon/SAD).

Accumulated deforestation in the period from August 2012 to February 2013, corresponding to the seven months of the official calendar of deforestation measurement, reached 1,351 square kilometers. A 91% increase of deforestation was observed, compared to the former period [from August 2011 to February 2012], when it reached 708 square kilometers.

In February 2013 most deforestation (78%) occurred in Mato Grosso, followed by Pará (9%), Tocantins (7%), Rondônia (4%), and Amazonas (2%). Because of the massive cloud coverage deforestation could not be detected over Amapá and Roraima in that month.

## Deforestation



**Figure 3:** Percentage of deforestation in the states of Legal Amazon, in February 2013 (Source: Imazon/SAD)

Taking into account the seven months of current deforestation calendar [August 2012 to February 2013], the State of Pará leads the ranking with 48% of the total deforested in the period. Then, Mato Grosso pops up with 25%, followed by Rondônia (13%), and Amazonas (12%). Those four states are accountable for 98% of deforestation occurred in Legal Amazon during that period.

Relatively, a 44% reduction was observed in the State of Acre and a 52% in the State of Roraima.

On the other hand, a 155% increase was observed in Pará, 145% in Amazon, 124% in Tocantins, 69 in Mato Grosso, and 21% in Rondônia.

In absolute terms, the State of Pará leads the ranking of accumulate deforestation with 643 sq. km, followed by Mato Grosso (335 sq. km), Rondônia (172 sq. km), Amazonas (157 sq. km), Tocantins (24 sq. km), Acre (10 sq. km), and Roraima (10 sq. km).

<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 February 2012, and from August 2012 to February 2013 [Source: Imazon/SAD]

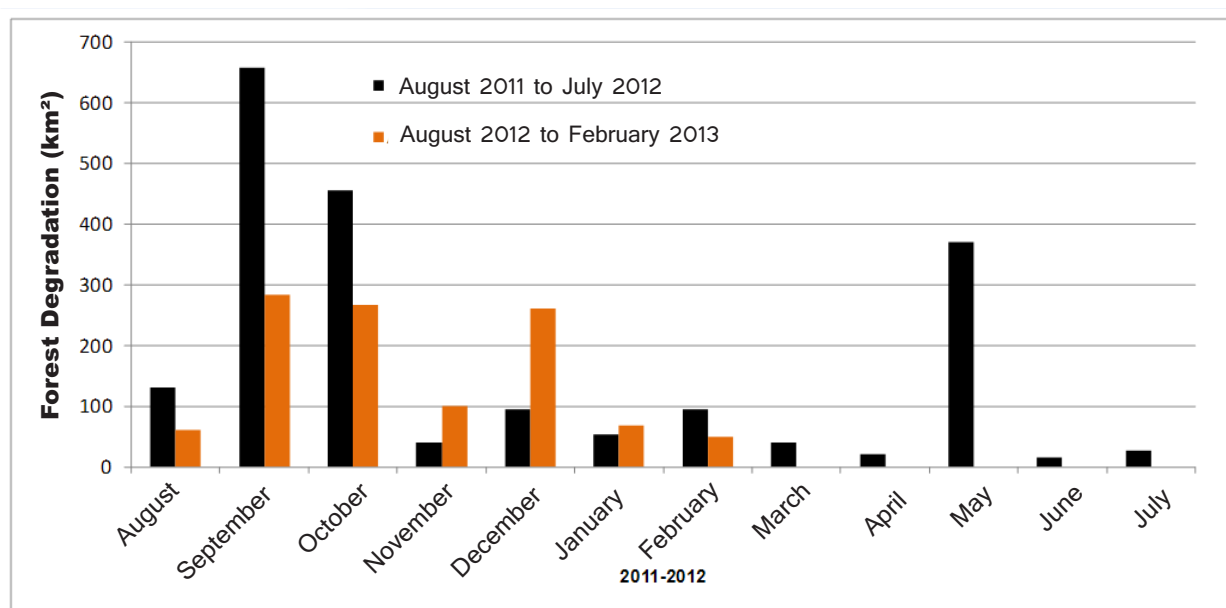
State	August 2011 to February 2012	August 2012 to February 2013	Variation (%)
Pará	253	643	+155
Mato Grosso	198	335	+69
Rondônia	143	172	+21
Amazonas	64	157	+145
Roraima	21	10	-52
Acre	18	10	-44
Tocantins	11	24	+124
Amapá	-	-	-
<b>Total</b>	<b>708</b>	<b>1.351</b>	<b>+91</b>

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

## Forest Degradation

In February 2013 SAD recorded 50 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 February 2013 in Legal Amazon (Source: Imazon/SAD)



Forest degradation accumulated from August 2012 to February 2013<sup>2</sup> reached 1,091 square km.

In absolute terms, Mato Grosso leads the ranking of accumulated forest degradation with 609

square km (56%), followed by the State of Pará with 396 Sq. KM (37%); the remaining (7%) took place in the states of Tocantins (25 square km), and Amazonas (11 square km).

**Table 2:** Evolution of forest degradation across the states of Legal Amazon from August 2011 to February 2012 and from August 2012 to February 2013 (Source: Imazon/SAD).

State	August 2011 to February 2012	August 2012 to February 2013	Variation (%)
Mato Grosso	1.169	609	-48
Pará	232	396	+70
Rondônia	90	49	-45
Amazonas	19	11	-43
Roraima	15	-	-100
Acre	3	-	-100
Tocantins	-	25	-
Amapá	-	-	-
<b>Total</b>	<b>1.433</b>	<b>1091</b>	<b>-29</b>

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

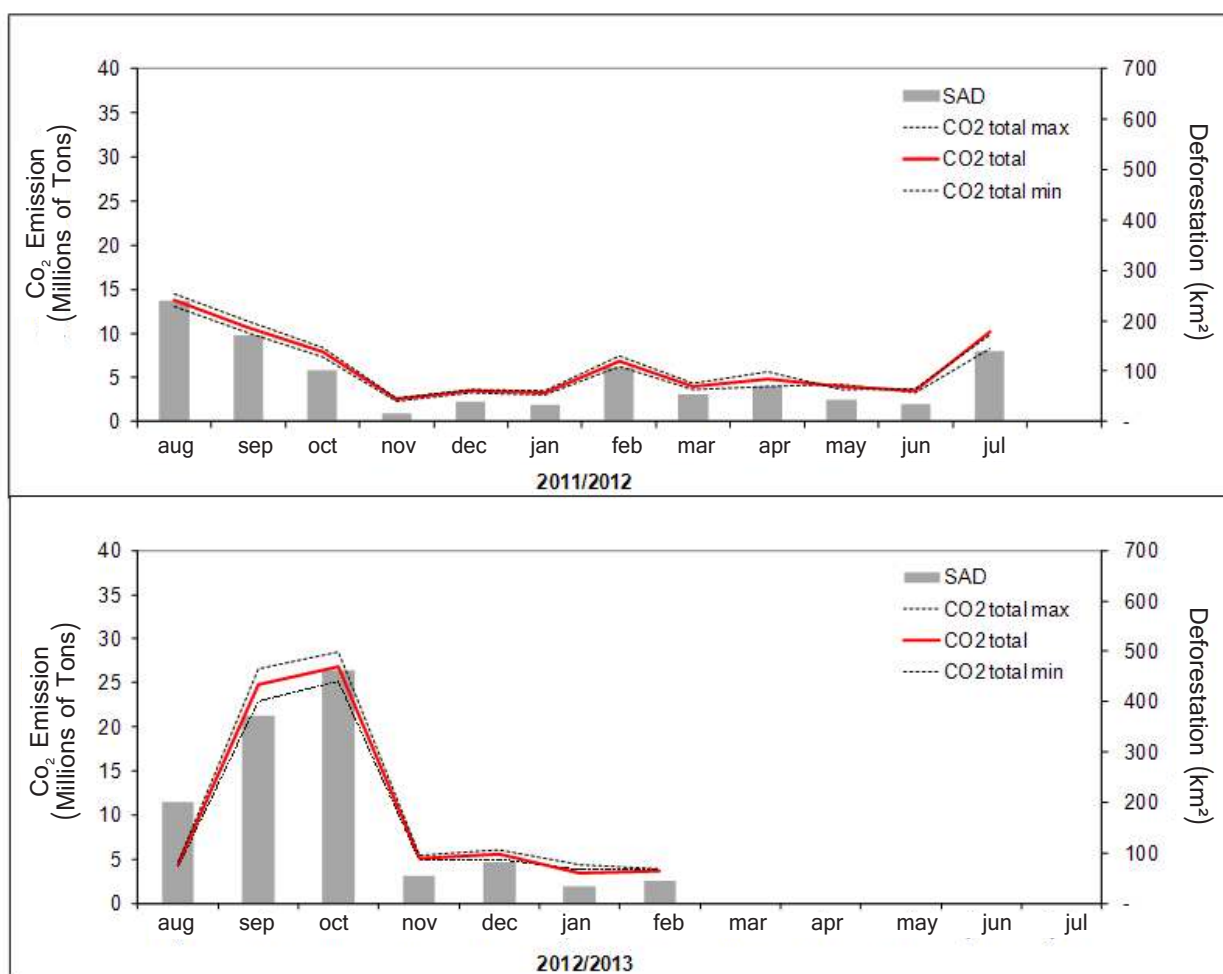
<sup>2</sup> The official calendar of deforestation measurements starts in August and ends in July.

## Carbon Affected by the Deforestation

In February 2013, the 45 square kilometers of deforestation detected by SAD in Legal Amazon endangered 990 thousand tons of carbon (with a margin of error of 283 thousand tons of carbon). This amount of endangered carbon may result in emissions of 3.5 million tons of equivalent CO<sub>2</sub> (Figure 5).

Deforestation-endangered forest carbon in the period from August 2012 to February 2013 was of 18

million tons (with a margin of error of 290 thousand tons), what represented about 74.5 million tons of equivalent CO<sub>2</sub> (Figure 5). Compared to the same period of the former year (August 2011 to February 2012), when endangered forest carbon was of 10.5 million ton, a 74% increase was observed in the quantity of carbon endangered by deforestation.



**Figure 5:** Deforestation and emissions of total equivalent carbon dioxide (CO<sub>2</sub>) from August 2011 to February 2013, in Legal Amazon (Source: Imazon).

## Deforestation Geography

In February 2013, most (82%) of deforestation took place either in private areas or under different stages of ownership. The remaining deforestation was registered

in Land Reform Settlements (10%), Conservation Units (3%), and Indigenous lands (1%) (Table 3).

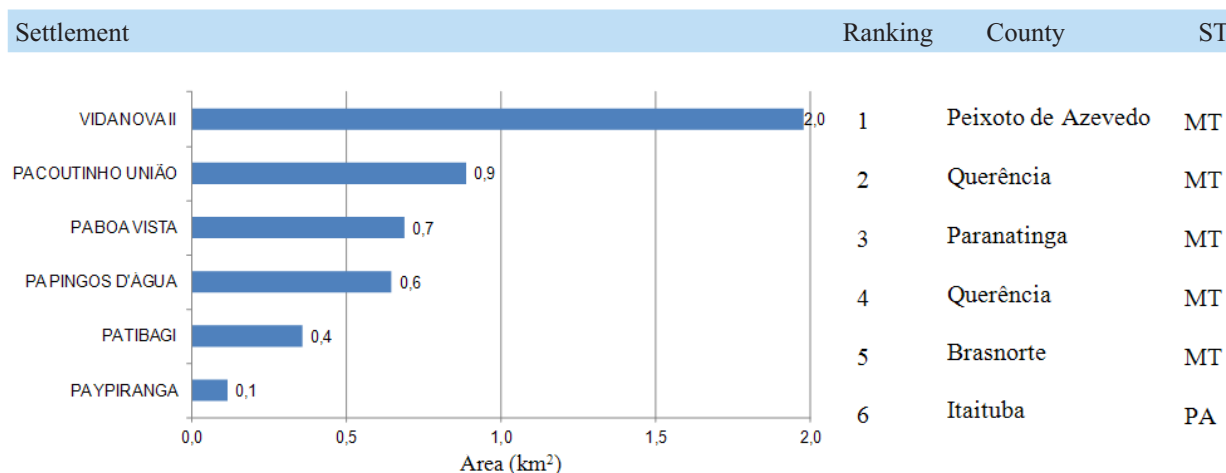
**Table 3:** Deforestation by agrarian category in February 2013, in Legal Amazon (Source: Imazon/SAD).

Category	February 2013	
	km <sup>2</sup>	%
Agrarian Reform Settlement	4,5	10
Conservation Units	3	7
Indigenous Lands	0,5	1
Private, Owned and in Abeyance <sup>3</sup>	37	82
<b>Total (km<sup>2</sup>)</b>	<b>45</b>	<b>100</b>

## Agrarian Reform Settlements

SAD has recorded 4.5 square kilometers of deforestation in Agrarian Reform Settlements in February 2013 (Figure 7). The six settlements affected the most by deforestation were Vida Nova II (Peixoto de Azevedo; Mato Grosso), PA Coutinho

União (Querência, Mato Grosso), Boa Vista (Paranatinga, Mato Grosso), PA Pingos D'Água (Querência, Mato Grosso), PA Tibagi (Brasnorte, Mato Grosso), and PA Ypiranga (Itaituba, Pará)

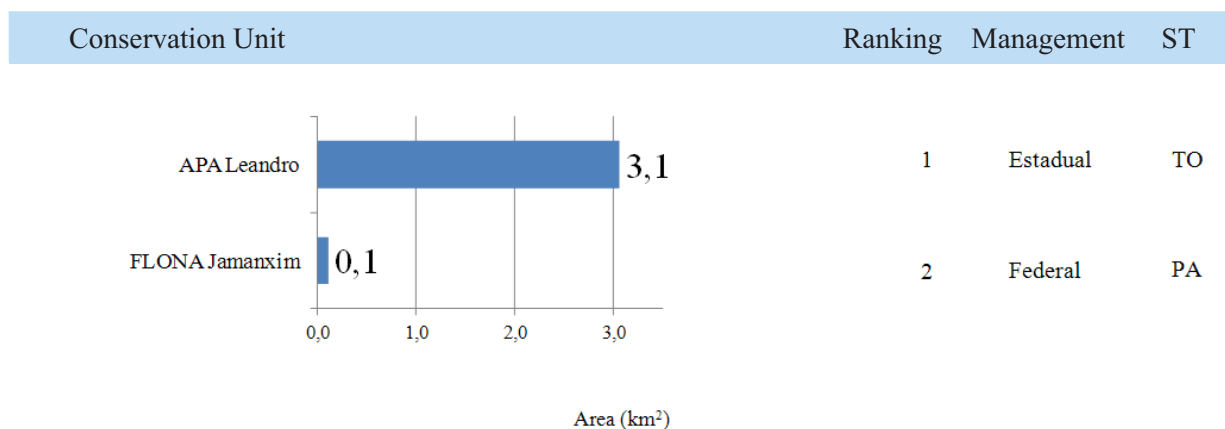


**Figure 6:** Land Reform Settlements deforested the most in February 2013 in Legal Amazon (Source: Imazon/SAD). PA (Settlement Project).

### Protected Areas

In February 2013, because of the cloud coverage, SAD has detected 3 sq. km of deforestation only in APA Leandro (Tocantins), and in Flona

Jamanxim (Pará) (Figure 7). As far as Indigenous Lands is concerned, in February 2013, only 0.5 sq. km were detected in TI Xingu (Mato Grosso).



**Figure 7:** Conservation Unit deforested in Legal Amazon in February 2013 (Source: Imazon/SAD).



## Critical Municipalities

In February 2013 the counties deforested the most were: Itanhangá (Mato Grosso) and Novo

Santo Antônio (Pará) (Figures 9 and 10).

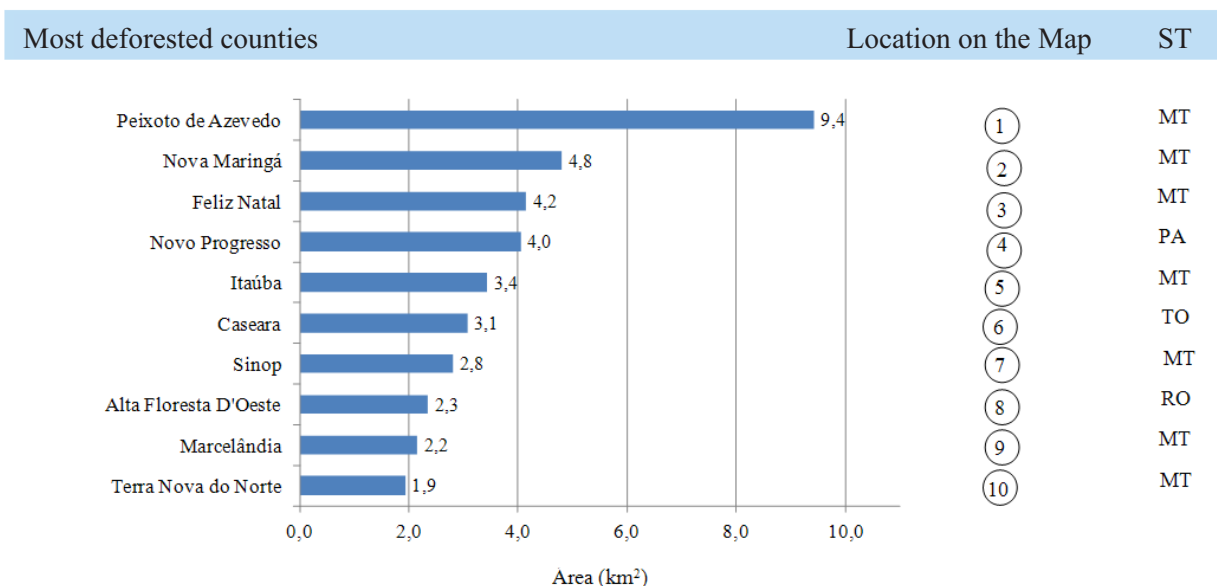


Figure 8: Counties deforested the most in Legal Amazon in February 2013 (Source: Imazon/SAD).

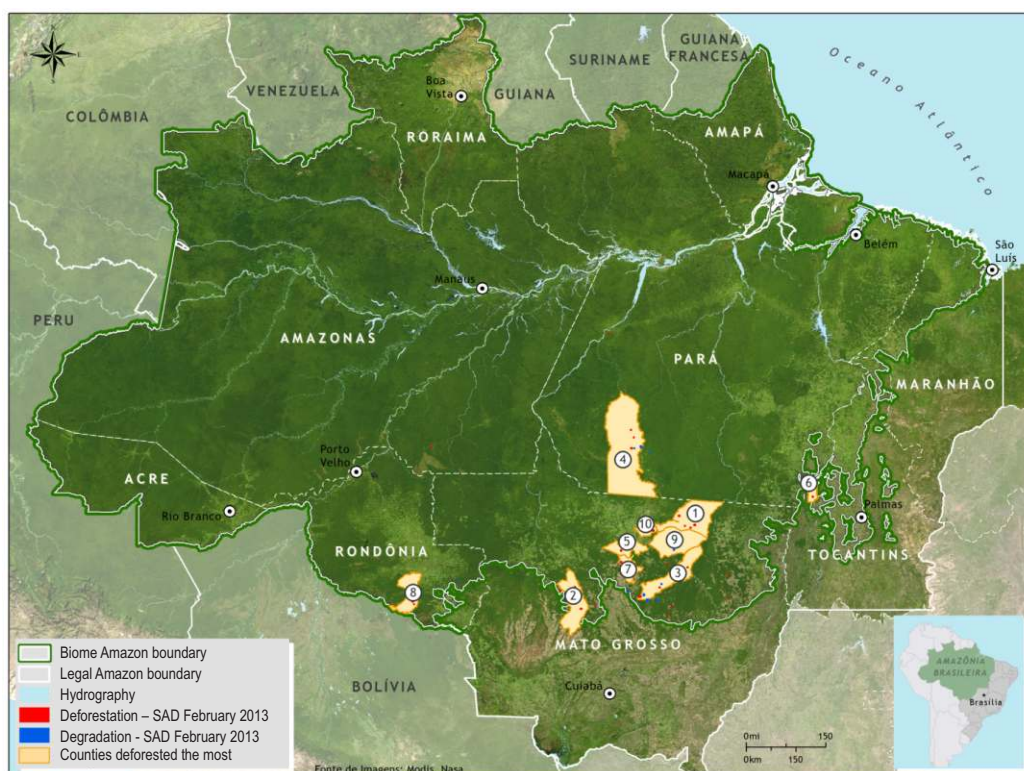


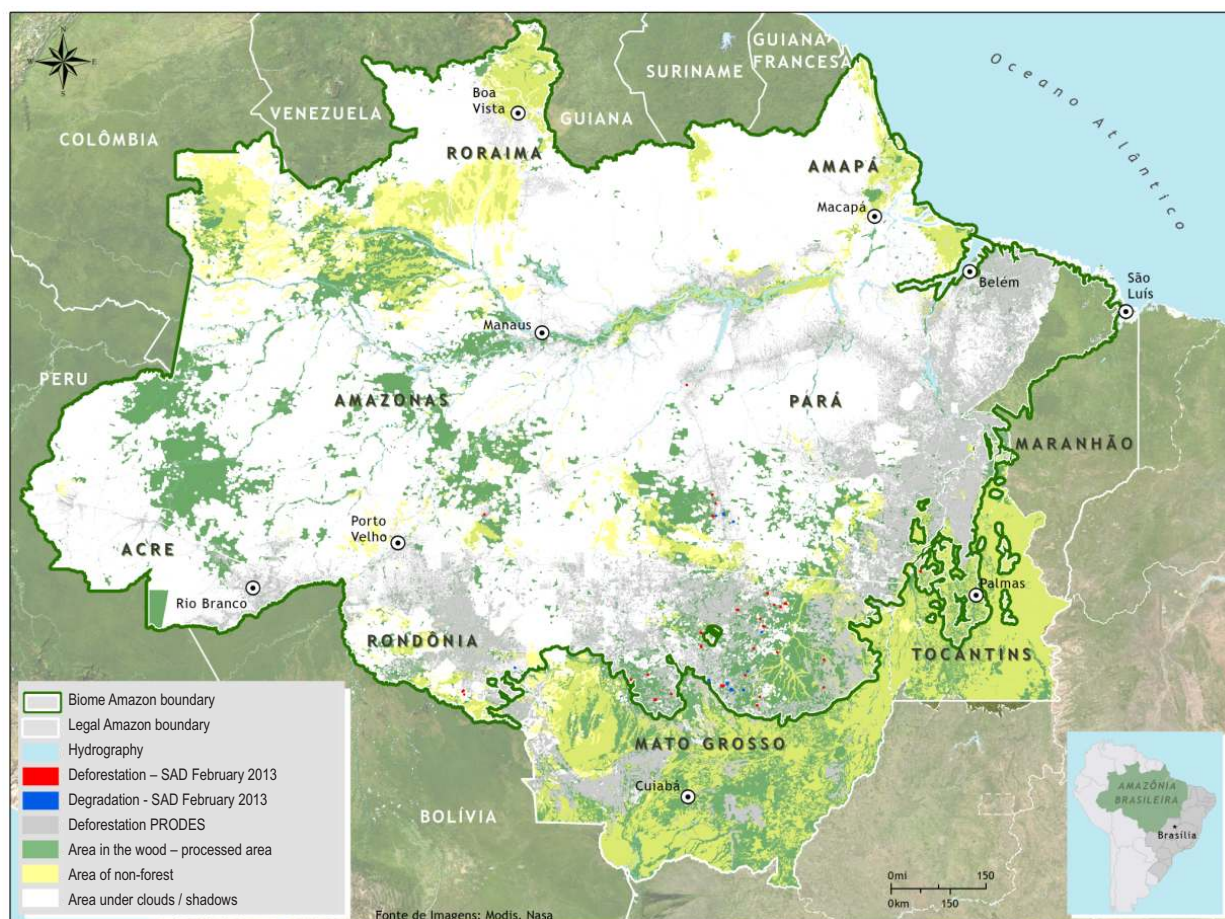
Figure 11: Counties deforested the most in February 2013 (Source: Imazon/SAD).

## Coverage by clouds and Shade

In February 2013, it was possible to monitor, along with SAD, 28% of Legal Amazon forest area. The remaining 72% of forest territory were covered by clouds what hampered the detection of deforesting and forest degradation. The states with larger

coverage were: Amapá (91%), Roraima (90%) and Acre (84%). In virtue of that, data related to both deforestation and forest degradation in February 2013 may be underestimated (Figure 12).

\* Data related to the state of Maranhão, that integrates Legal Amazon, was not analyzed.



**Figure 12:** Area covered by clouds and shadows in February 2013 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.

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<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 ( $\pm 2$  times) of the simulations of carbon affected every month.

To convert carbon values into CO<sub>2</sub> 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/>

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<http://earthengine.google.org/>

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Secretary of State for the Environment Mato Grosso (SEMA)  
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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  
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