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SUMMARY

In April 2013, half (55%) of the forest area in Brazilian Amazon was covered by clouds, this situation compromised the deforestation and degradation detection via MODIS images used by SAD system, mainly in the States of Roraima, Amapá and Pará which presented 90%, 77% and 75% of clouds coverage respectively. Under these conditions, it was possible to detect 140 square kilometers of deforestation in Brazilian Amazon. It represented an increase of 84% in comparison to April 2012, when the deforestation totaled 76 square kilometers and the clouds coverage totaled 74%.

The accumulated deforestation for the period from April 2012 to April 2013 totaled 1,570 square kilometers. There was an increase of 88% in relation to the previous year (August 2011 to April 2012) when the deforestation totaled 836 square kilometers.

In April 2013, the most part of deforestation (73%) occurred in Mato Grosso, followed by Rondônia (19%), Amazonas (6%), Pará (1%) and Roraima (1%).

Degraded forests in Brazilian Amazon totaled 83 square kilometers in April 2013. In comparison to April 2012, when the forest degradation totaled 40 square kilometers, there was an increase of 107%.

The accumulated deforestation for the period (August 2012 to April 2013) reached 1,219 square kilometers. In comparison to the previous year (August 2011 to April 2012), when the deforestation totaled 1,589 square kilometers, there was a reduction of 23%.

In April 2013, the deforestation detected by SAD compromised 2,5 millions tons of equivalent CO2. For the accumulated period (August 2012 to April 2013) the emissions of equivalent CO2 compromised by the deforestation totaled 88 millions of tons, which represents an increase of 55% in comparison to the previous year (August 2011 to April 2012).

Deforestation Statistics

According to SAD, the deforestation (total forest suppression for other alternative soil purposes) has reached 140 square kilometers in April 2013. (Figure 1 and 2).

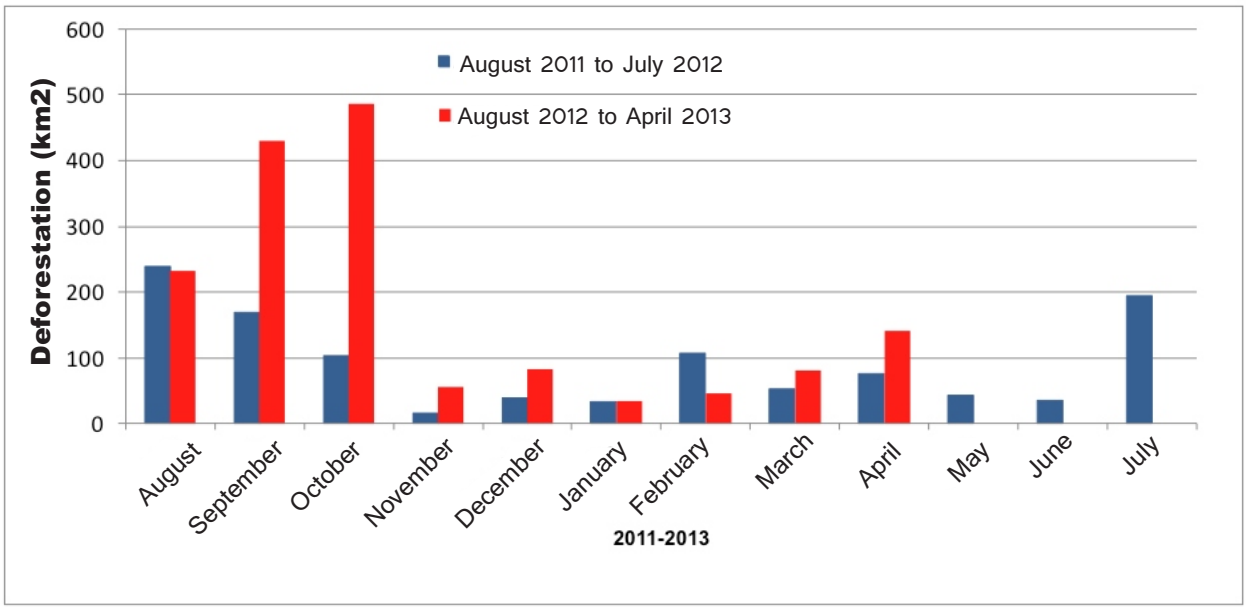

Figure 1. Deforestation in Brazilian Amazon from August 2011 to April 2013 (Source: Imazon/SAD).

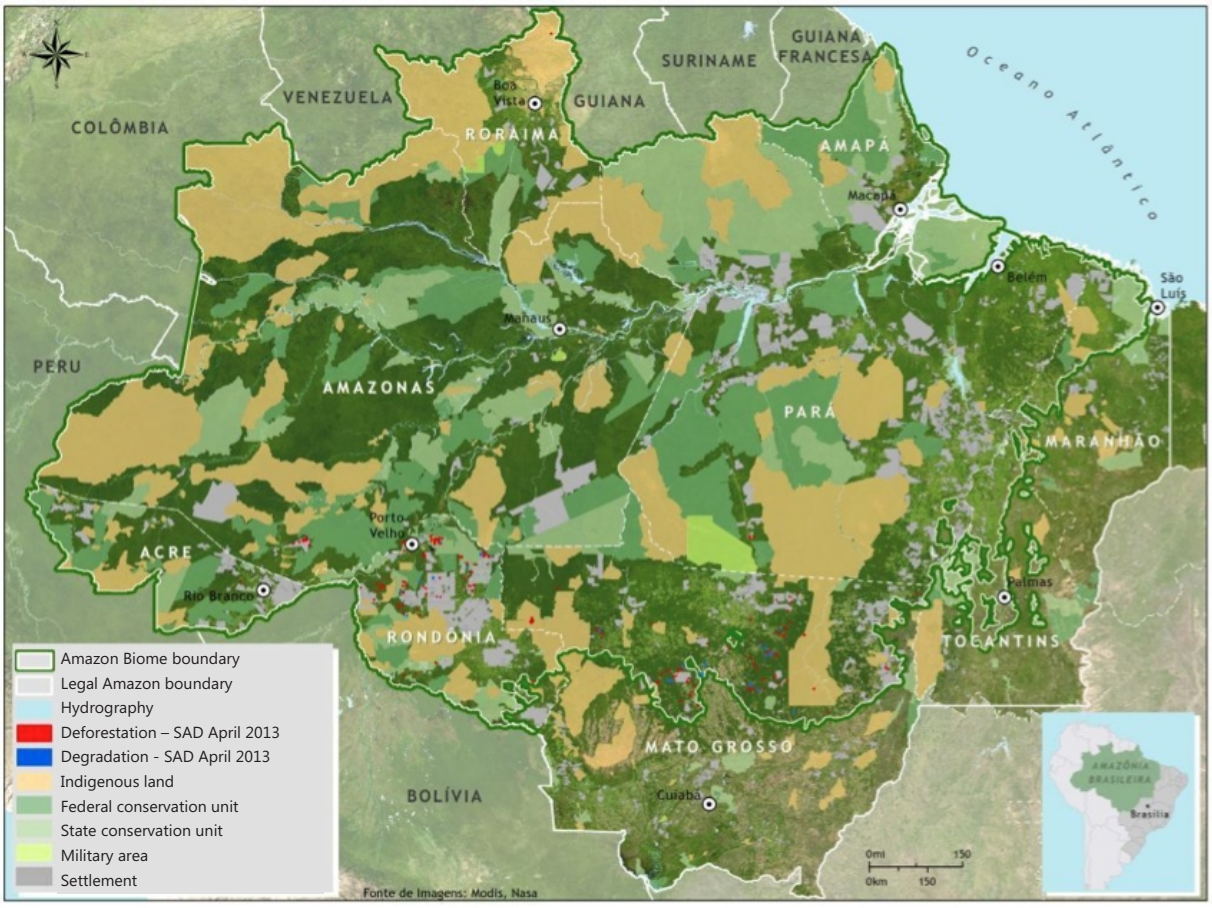

Figure 2. Deforestation and forest degradation in Brazilian Amazon as April 2013 (Source: Imazon/SAD).

The accumulated deforestation for the period from August 2012 to April 2013, corresponding to the nine months of the official calendar year for measuring the deforestation, reached 1,569 square kilometers. There was an increase of 84% of deforestation in comparison to the same period in the previous year (August 2011 to April 2012) when it reached 836 square kilometers.

In April 2013, the most part of deforestation (73%) occurred in Mato Grosso, followed by Rondônia (19%), Amazonas (6%), Pará (1%) and Roraima (1%).

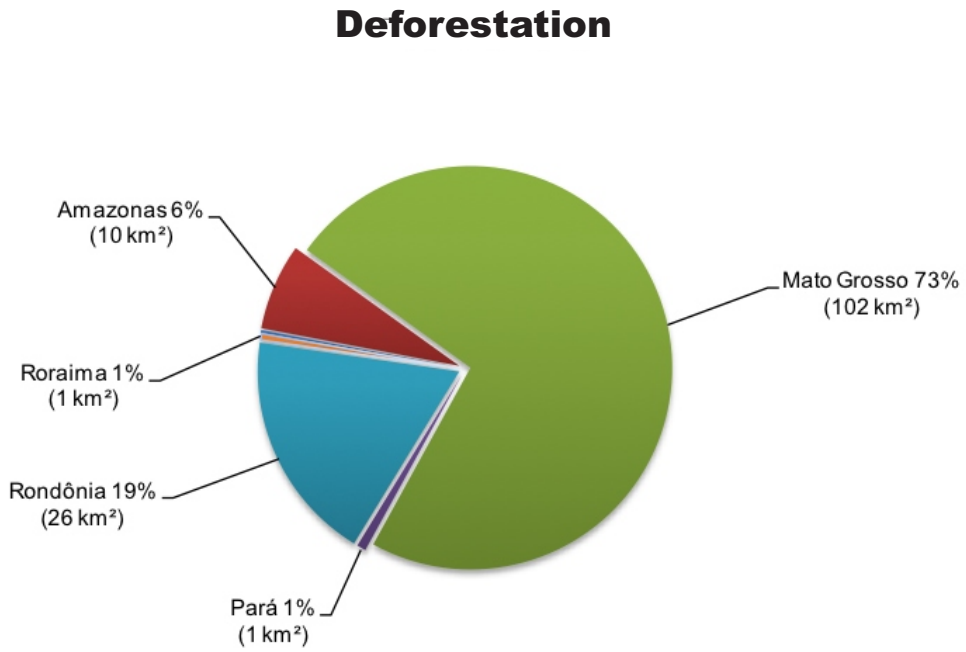

Figure 3. Level of deforestation in the States of Brazilian Amazon in April 2013 (Source: Imazon/SAD).

Considering the accumulated deforestation in the current official calendar year for measuring it (From August 2012 to April 2013), Pará leads the ranking with 41% of the total deforested nature. Followed by Mato Grosso (31%), Rondônia (14%), and Amazonas (11%). These four mentioned states were responsible for 97% of the deforestation in Brazilian Amazon in this period.

In relative terms, there was a reduction of 31% in Acre and 44% in Roraima. On the other hand, there was an increase in Pará (+139%), Amazonas (+145%), Tocantins (+111%), Mato Grosso (+72%) and in Rondônia (37%).

In absolute terms, Pará leads the rank of accumulated deforestation with 651 square kilometers, followed by Mato Grosso (481 square kilometers), Rondônia (220 square kilometers), Amazonas (168 square kilometers), Tocantins (24 square kilometers), Acre (13 square kilometers) and Roraima (13 square kilometers).

[1] The official calendar of deforestation measurements starts in August and ends in July

Table 1. Deforestation evolution among the states of Brazilian Amazon from August 2011 to April 2012 and August 2012 to April 2013 (Source: Imazon/SAD).

State	August 2011 to April 2012	August 2012 to April 2013	Variation (%)
Pará	273	651	+139
Mato Grosso	280	481	+72
Rondônia	161	220	+37
Amazonas	69	168	+145
Roraima	23	13	-44
Acre	19	13	-31
Tocantins	11	24	+111
Amapá	-	-	-
Total	**836**	**1.570**	**+88**

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

Forest Degradation

In April 2013, SAD registered 83 square kilometers in degraded forests (highly explored forests by burning and/or lumbering activities) (Figure 2 and 4).

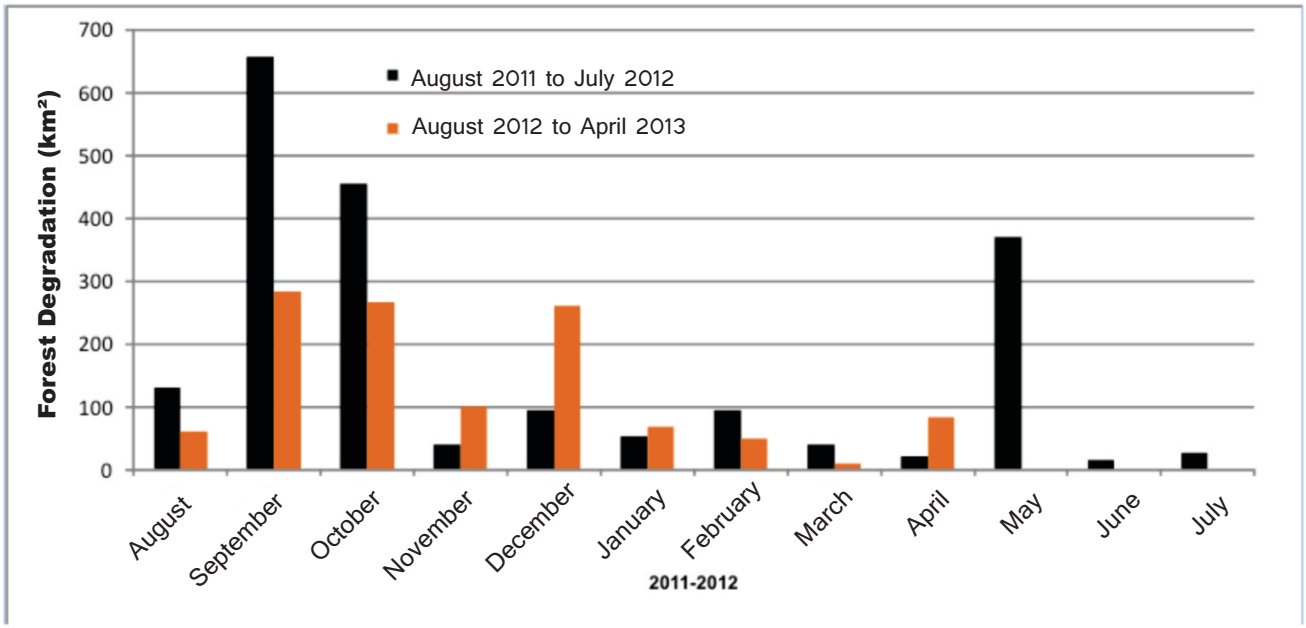

Figure 4. Forest degradation in Brazilian Amazon from August 2011 to April 2013 (Source: Imazon/SAD).

Accumulated forest degradation for the period from August 2012 to April 2013 affected 1,219 square kilometers.

In absolute terms, Mato Grosso leads the rank of forest degradation with 680 square kilometers (56%), followed by Pará with 398 square kilometers (33%). The rest (11%) occurred in Rondônia (97 square kilometers), Tocantins (25 square kilometers) and Amazonas (11 square kilometers).

Table 2. Evolution of forest degradation in the states of Brazilian Amazon from August 2011 to April 2012 and from August 2012 to April 2013 (Source: Imazon/SAD).

State	August 2011 to April 2012	August 2012 to April 2013	Variation (%)
Mato Grosso	1.217	680	-44
Pará	235	398	+69
Rondônia	93	97	4
Amazonas	26	11	-58
Roraima	15	5	-67
Acre	3	3	-
Tocantins	-	25	-
Amapá	-	-	-
Total	**1.589**	**1.219**	**-23**

* Data from the state of Maranhão was not analyzed.

[2] The official calendar of deforestation measurements starts in August and ends in July.

Carbon Affected by the Deforestation

In April 2013, the 140 square kilometers of deforestation detected by SAD in Brazilian Amazon compromised 2,5 million tons of carbon (with margin of error of 860 thousand tons of carbon). This amount of affected carbon results in 9 million tons of equivalent CO2, (Picture 6).

The forest carbon compromised by the deforestation for the period from August 2012 to April 2013, totaled 24 million tons (with margin of error of 853 thousand tons), which represented 88 million tons of equivalent CO2 (Picture 6). In relation to the same period in the previous year (August 2010 to April 2011) when the compromised forest carbon totaled 15 million tons there was an increase of 55% in the amount of carbon compromised by the deforestation.

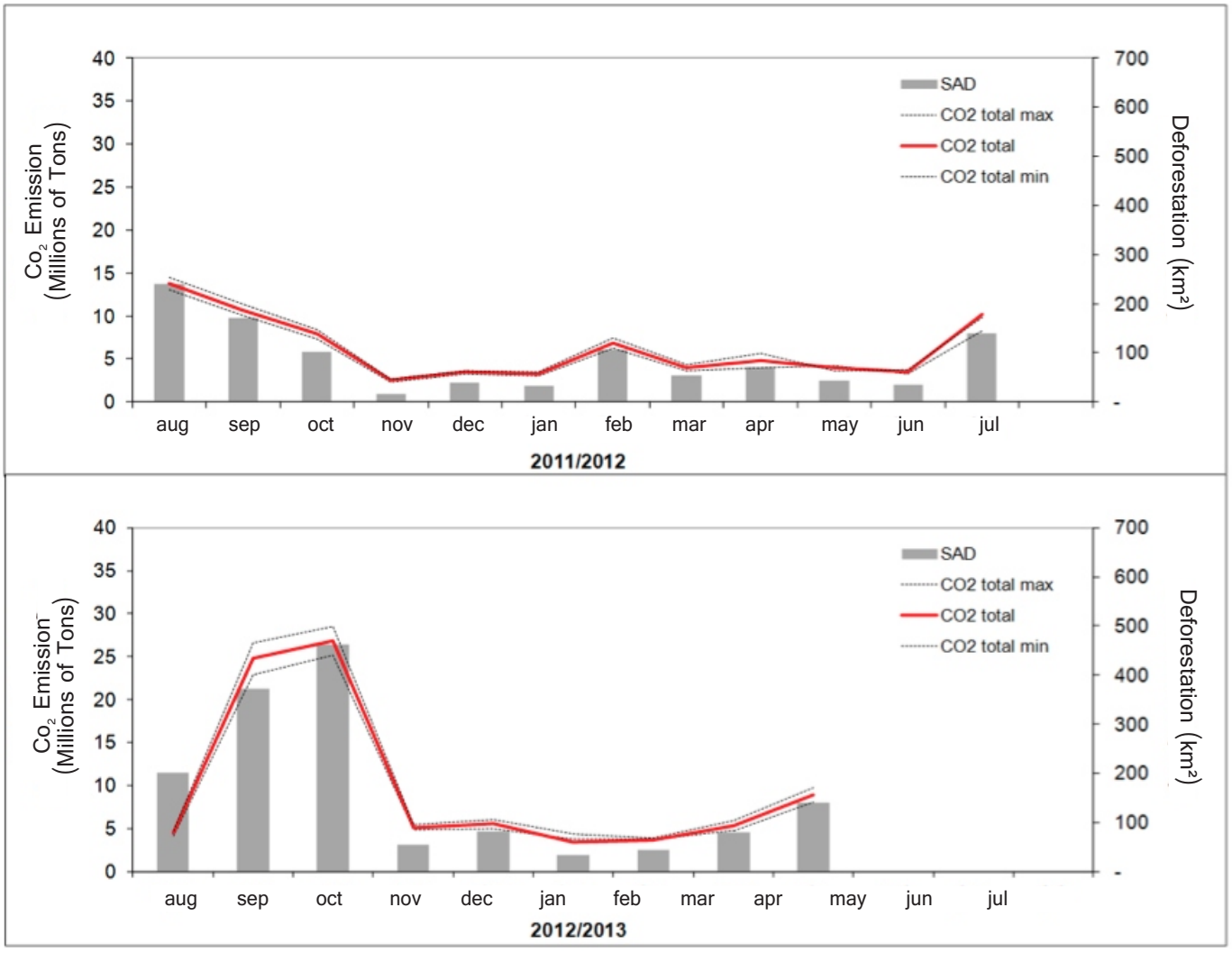

Figure 5. Deforestation and emissions of total equivalent carbon dioxide (CO2) from August 2012 to April 2013 in Brazilian Amazon (Source: Imazon).

Deforestation Geography

In April 2013, most part (61%) of deforestation occurred in private areas or under several kinds of possessions. The rest of deforestation was recorded as Settlements of Land Reformation (9%), Conservation Units (7%) and Indigenous Land (23%) (Table 3).

Table 3. Deforestation set on agrarian category in April 2013 in Brazilian Amazon (Source: Imazon/SAD).

Category	April 2013	
	km²	%
Agrarian Reform Settlement	13	9
Conservation Units	10	7
Indigenous Lands	32	21
Private, Owned and in Abeyance³	85	61
Total (km²)	**140**	**100**

Agrarian Reform Settlements

SAD has recorded 13 square kilometers of deforestation in the Settlements of Land Reformation in April 2013 (Picture 6). The most affected Settlements were SP Monte (Lábrea; Amazonas), SP Lajes (Machadinho D'Oeste, Rondônia) and SDP Mãe Menininha (Altamira, Pará).

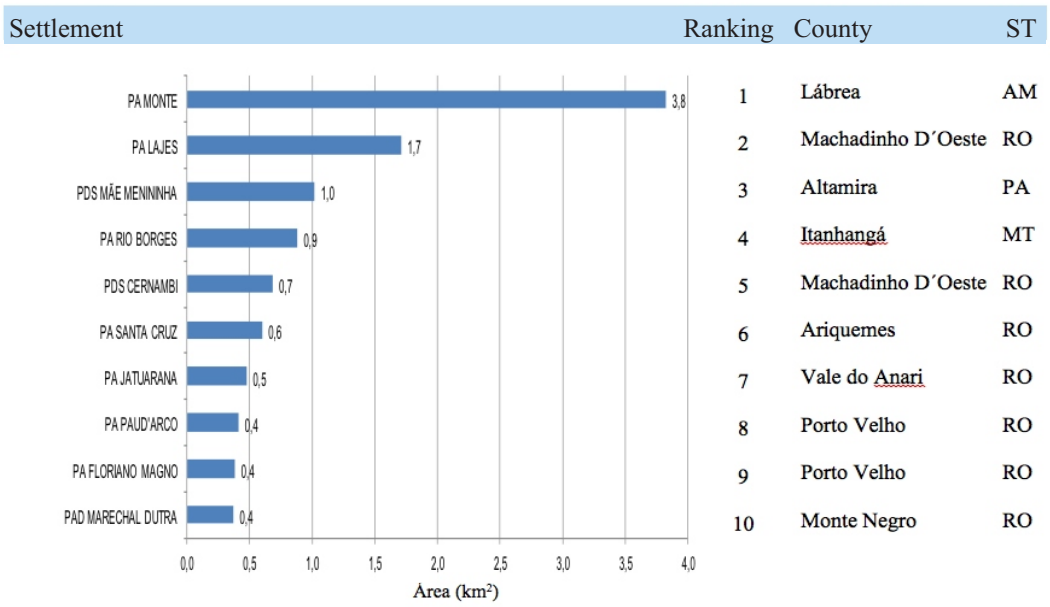

Figure 6. Settlement of Land Reformation deforested in April 2013 in Brazilian Amazon (Source: Imazon/SAD).

Áreas Protegidas

In April 2013, SAD detected 10 square kilometers of deforestation in the conservation units: Florex Rio Preto – Jacundá, Resex Jaci Paraná and Florsul do Rio Vermelho (C), all of them in Rondônia (Figure 7).

Conservation Unit	Ranking	Management	ST
FLOREX Rio Preto-Jacundá	1	Estadual	RO
RESEX Jaci Paraná	2	Estadual	RO
FLORSU do Rio Vermelho (C)	3	Estadual	RO

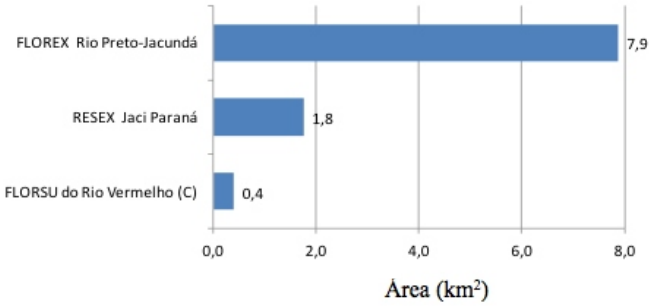

Figura 7. Unidades de Conservação desmatadas na Amazônia Legal em abril de 2013 (Fonte: Imazon /SAD).

Indigenous Land

In April 2013, SAD detected 23 square kilometers of deforestation inside the Indigenous Land Florex Zoró (MT), Parque do Xingu (MT) and in Raposa Serra do Sol (RR) (Figure 8).

Indigenous Land	Ranking	ST
TI Zoró	1	MT
PI Xingu	2	MT
TI Raposa Serra do Sol	3	RR

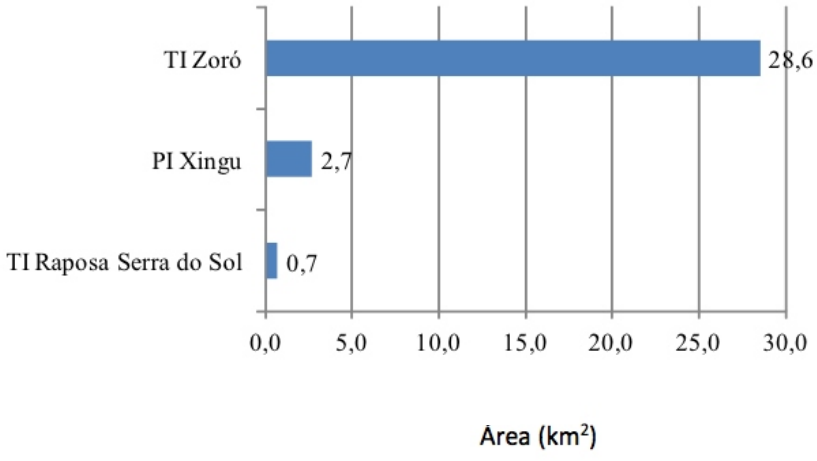

Figure 8. Indigenous Land deforested in Brazilian Amazon as April 2013 (Source: Imazon/SAD).

Critical Municipalities

In April 2013, the most deforested municipalities were: Rondolândia (Mato Grosso) and Porto Velho (Rondônia) (Figure 9 and 10).

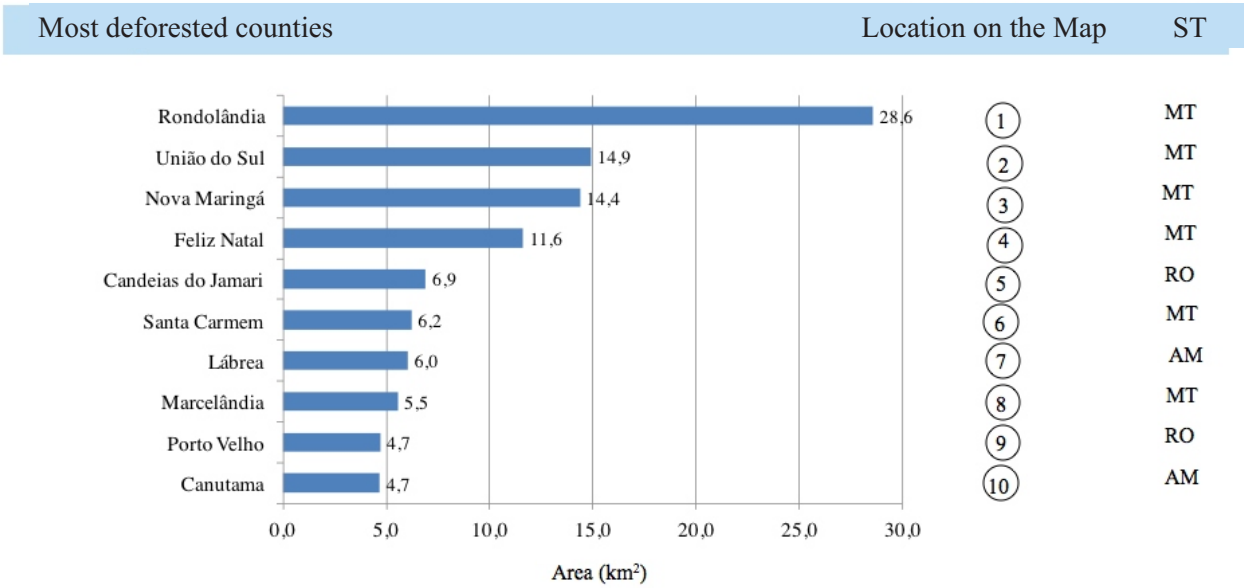

Figure 9. Most deforested municipalities in Brazilian Amazon as April 2013 (Source: Imazon/SAD).

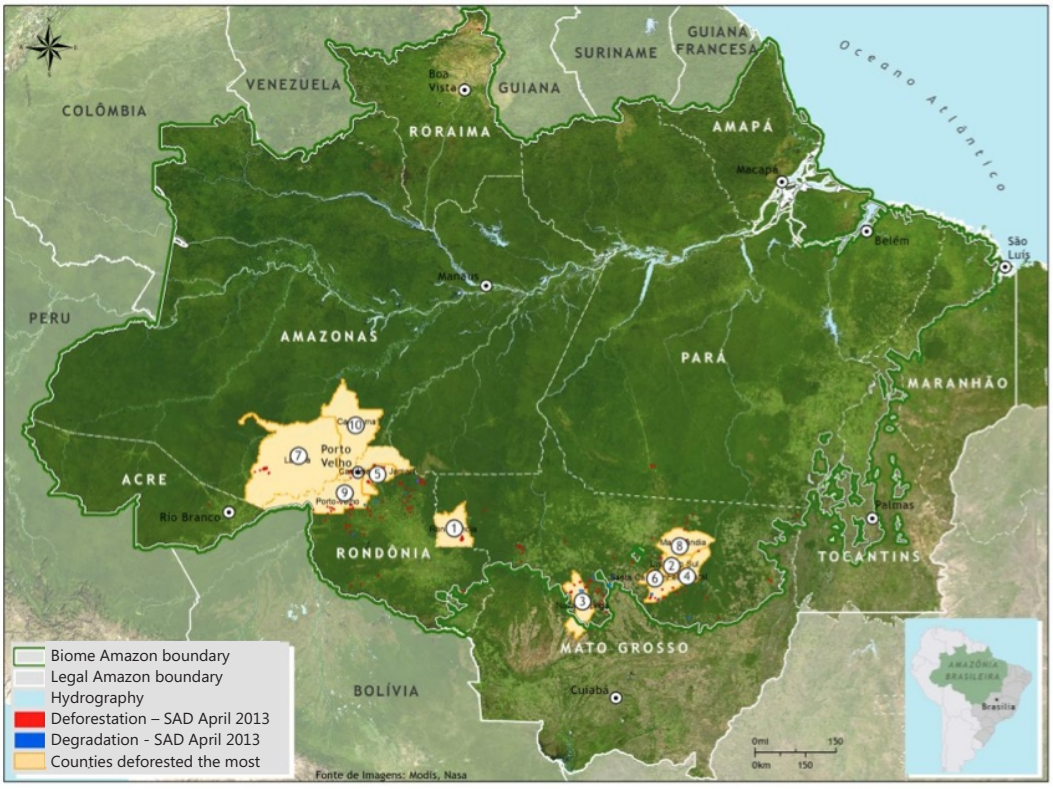

Figure10. Most deforested municipalities as April 2013 (Source: Imazon/Sad).

Coverage by clouds and Shade

In April 2013, it was only possible to monitor, with SAD, 45% of the forest area in Brazilian Amazon. The other 55% of forest land were covered by clouds, which made the detection of the deforestation and degradation more difficult. The States that presented a higher coverage of clouds were: Roraima (90%), Amapá (77%) and Pará (75%). Due to this fact, the data on the deforestation and forest degradation may be underestimated as April 2013. (Figure 11).

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

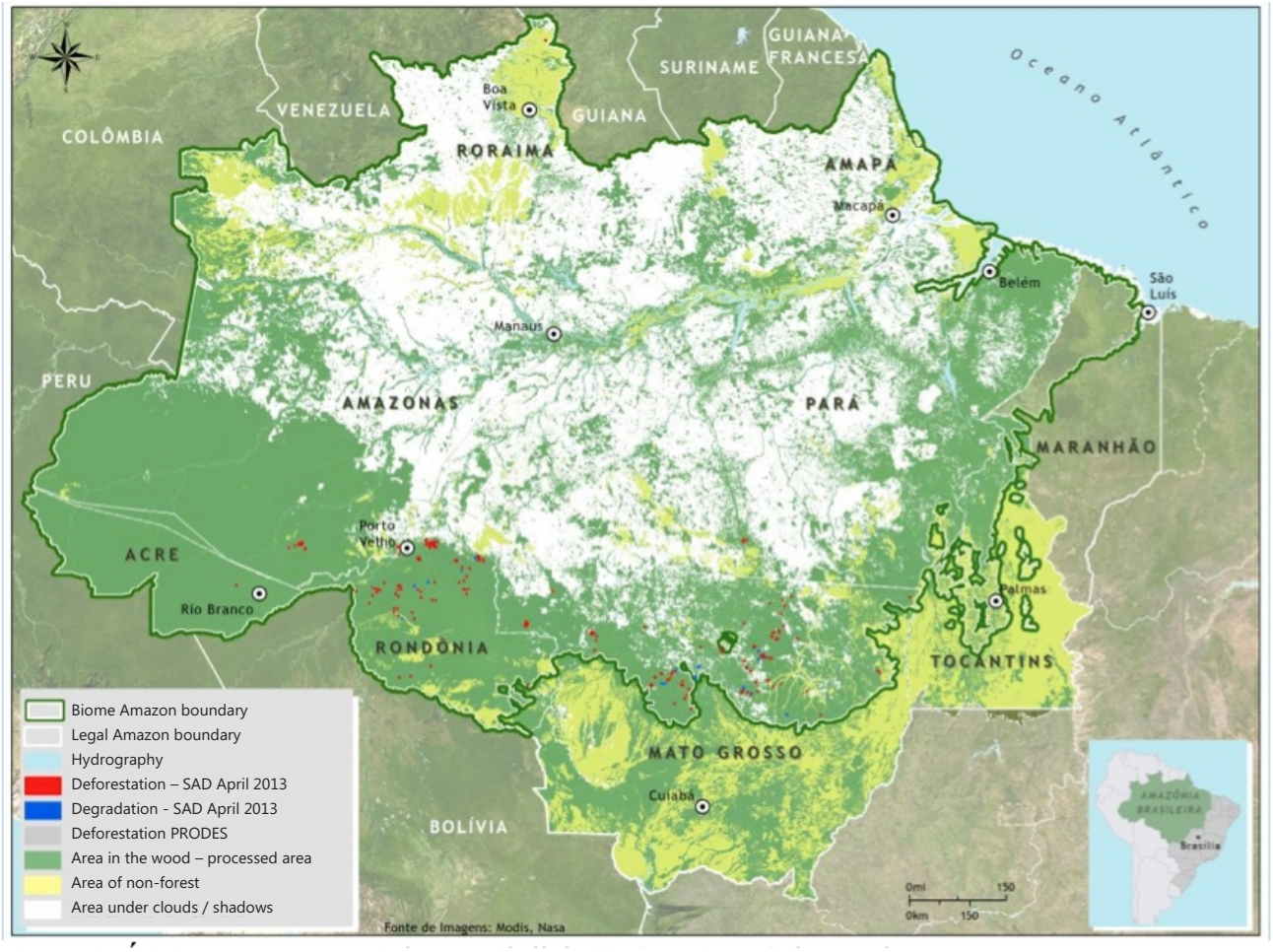

Figure 11. Area covered by shade and clouds as April 2013 in Brazilian Amazon.

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:

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

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

$$VGs = Vegetation / (1 - Shadow)$$

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 develop 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:

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

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

$$BPF = ff * AGLB$$

$$BAS_0 = bf * AGLB$$

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%).
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.

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:

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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.

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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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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
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