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SUMMARY

In March 2013, most part of forest region in Brazilian Amazon (60%) was covered by clouds, which compromised the forest degradation and deforestation detection via MODIS images used by SAD. Under these conditions, it was possible to detect only 80 square kilometers of deforestation in Brazilian Amazon. It represented an increase of 50% in comparison to March 2012, when the deforestation totaled 53 square kilometers and the clouds coverage totaled 74%.

The accumulated deforestation for the period from August 2012 to March 2013 totaled 1.430 square kilometers. There was an increase of 88% in comparison to the previous year (August 2011 to March 2012) when the deforestation totaled 760 square kilometers.

In March 2013, most part (56%) occurred in Mato Grosso, followed by Rondônia (28%), Pará (9%), Roraima (3%), Acre (2%) and Amazonas (2%).

The deforested area in Brazilian Amazon totaled only 9 square kilometers in March 2013. In comparison to March 2012, when the deforestation totaled 40 square kilometers, there was a reduction of 90%.
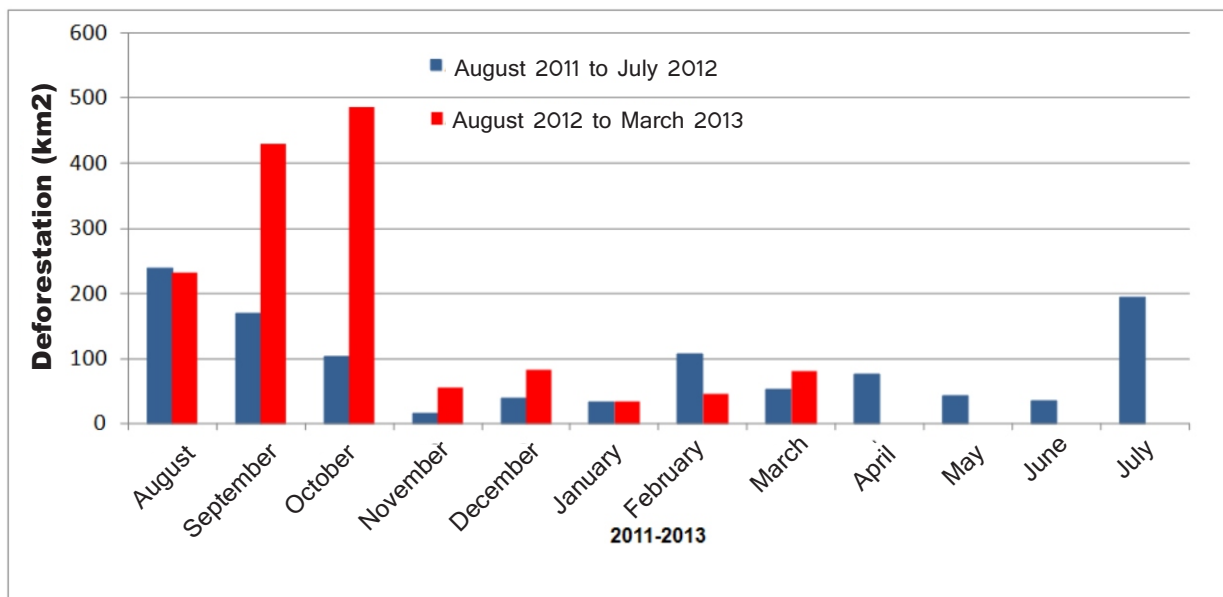
The forest degradation for the period (August 2012 to March 2013) reached 1.100 square kilometers. In relation to the previous year (August 2011 to March 2012), when the degradation totaled 1,568 square kilometers, there was a reduction of 30%.

In March 2013, the deforestation detected by SAD compromised 1,5 million tons of equivalent CO_2. For the accumulated period (August 2012 to March 2013) the emissions of equivalent CO_2 compromised by the deforestation totaled 79 million tons, which represents an increase of 38% in comparison to the previous year (August 2011 to March 2012).
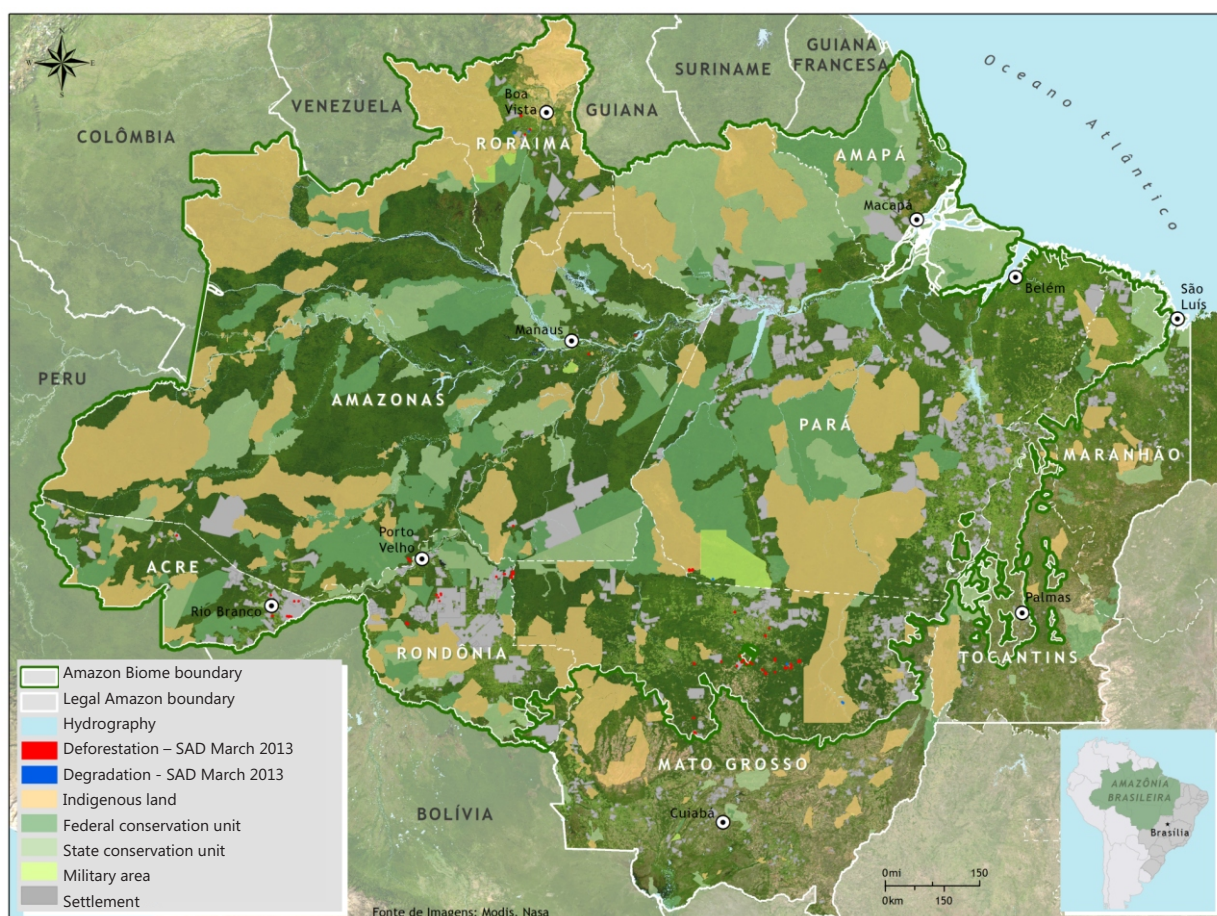
Deforestation Statistics

According to SAD, the deforestation (total forest suppression to other alternative purposes for the soil) reached 80 square kilometers in March 2013 (Figure 1 and 2).

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


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

The accumulated deforestation for the period from August 2012 to March 2013, corresponding to the eight months of the official calendar year for measuring the deforestation, reached 1,430 square kilometers. There was an increase of 88% of deforestation in comparison to the previous year (August 2011 to March 2012) when it reached 760 square kilometers.

In March 2013, most part (56%) of deforestation occurred in Mato Grosso, followed by Rondônia (28%), Pará (9%), Roraima (3%), Acre (2%) and Amazonas (2%).

Deforestation
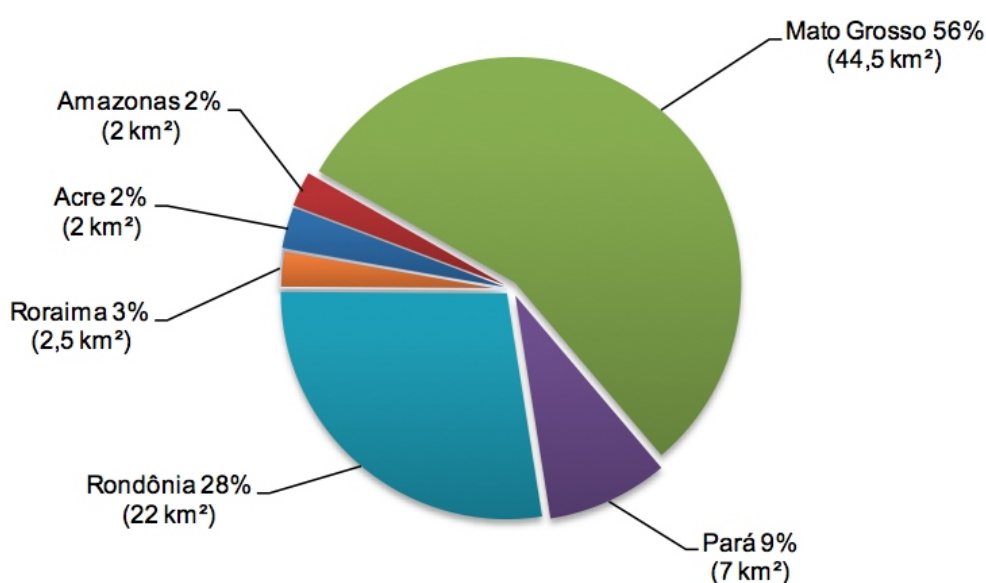
Figure 3. Percentage of deforestation In the States of Brazilian Amazon in March 2013 (Source: Imazon/SAD).

Considering the accumulated deforestation for the eight months in current official year for measuring the deforestation (August 2012 to March 2013), Pará leads the ranking with 45% of the total deforested area. Followed by Mato Grosso with 27%, Rondônia with 14% and Amazonas with 11%. These four mentioned states were responsible for 97% of deforestation occurring in Brazilian Amazon for this period.

In relative terms, there was a reduction of 33% in Acre and 44% in Roraima. On the other hand, there was an increase in Pará (+144%), Amazonas (+143%), Tocantins (+126%), Mato Grosso (+65%) and in Rondônia (31%).

In absolute terms, Pará leads the ranking of accumulated deforestation with 650 square kilometers, followed by Mato Grosso (379 square kilometers), Rondônia (194 square kilometers), Amazonas (159 square kilometers), Tocantins **(square kilometers)**, Acre (12 square kilometers) and Roraima (12 square kilometers).

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[1] The official calendar year for measuring deforestation starts in August and ends in July..

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

State	August 2011 to February 2012	August 2012 to February 2013	Variation (%)
Pará	266	650	+144
Mato Grosso	230	379	+65
Rondônia	148	194	+31
Amazonas	65	159	+143
Roraima	22	12	+31
Acre	18	12	-33
Tocantins	11	24	+126
Amapá	-	-	-
Total	**760**	**1.430**	**+88**

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

Forest Degradation

In March 2013, SAD recorded 9 square kilometers of deforested area (forests highly explored by lumbering and/or burning activities). (Figure 2 and 4).
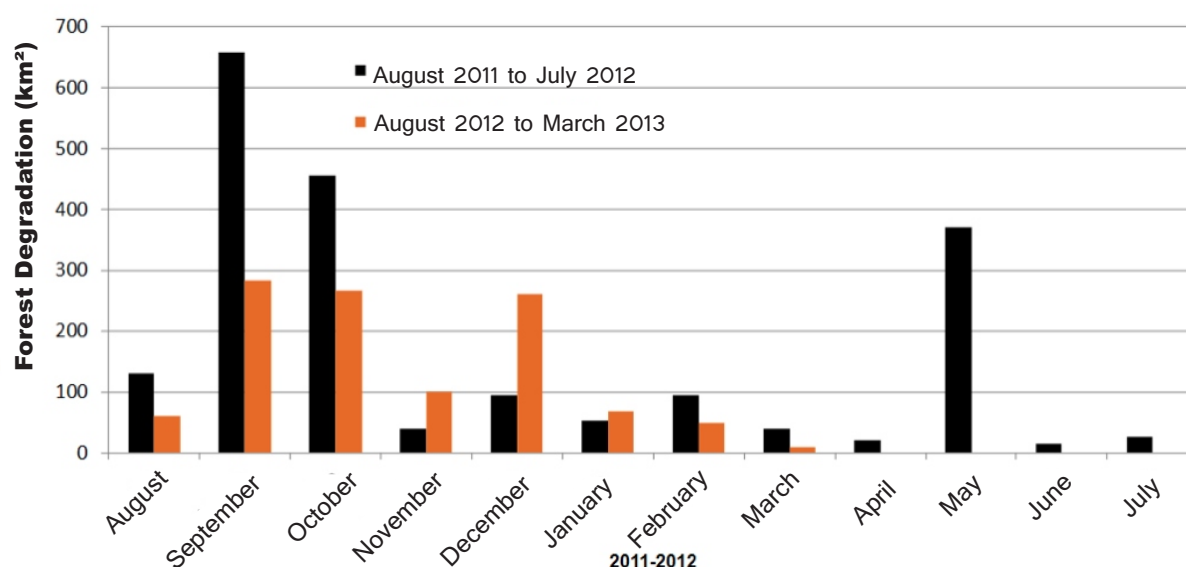
Figure 4. Forest degradation from August 2011 to March 2013 in Brazilian Amazon (Source: Imazon/SAD).

The accumulated forest degradation for the period from August 2012 to March 2013 reached 1.100 square kilometers.

In absolute terms, Mato Grosso leads the ranking of accumulated forest degradation with 612 square kilometers (56%), followed by Pará with 397 square kilometers (36%). The other 8% occurred in Rondônia (50 square kilometers), Tocantins (25 square kilometers) and Amazonas (11 square kilometers).

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

State	August 2011 to March 2012	August 2012 to March 2013	Variation (%)
Mato Grosso	1.196	612	-49
Pará	235	397	+69
Rondônia	93	50	-46
Amazonas	26	11	-57
Roraima	15	5	-69
Acre	3	-	-100
Tocantins	-	25	-
Amapá	-	-	-
Total	**1.568**	**1100**	**-30**

* 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 March 2013, the 80 square kilometers of deforestation detected by SAD in Brazilian Amazon compromised 1.5 million tons of carbon (with margin of error of 605 thousand of carbon). This amount of affected carbon results in 5 million tons of equivalent CO_2 (Picture 6).

Forest carbon compromised by the deforestation for the period from August 2011 to March 2012, resulted 21 million tons (with margin of error of 984 thousand tons), which represented approximately 79 million tons of equivalent CO_2 (Picture 6). In comparison to the same period in the previous year (August 2010 to March 2011) when the compromised forest carbon totaled 14 million tons, there was an increase of 38% in the amount of carbon compromised by the deforestation.
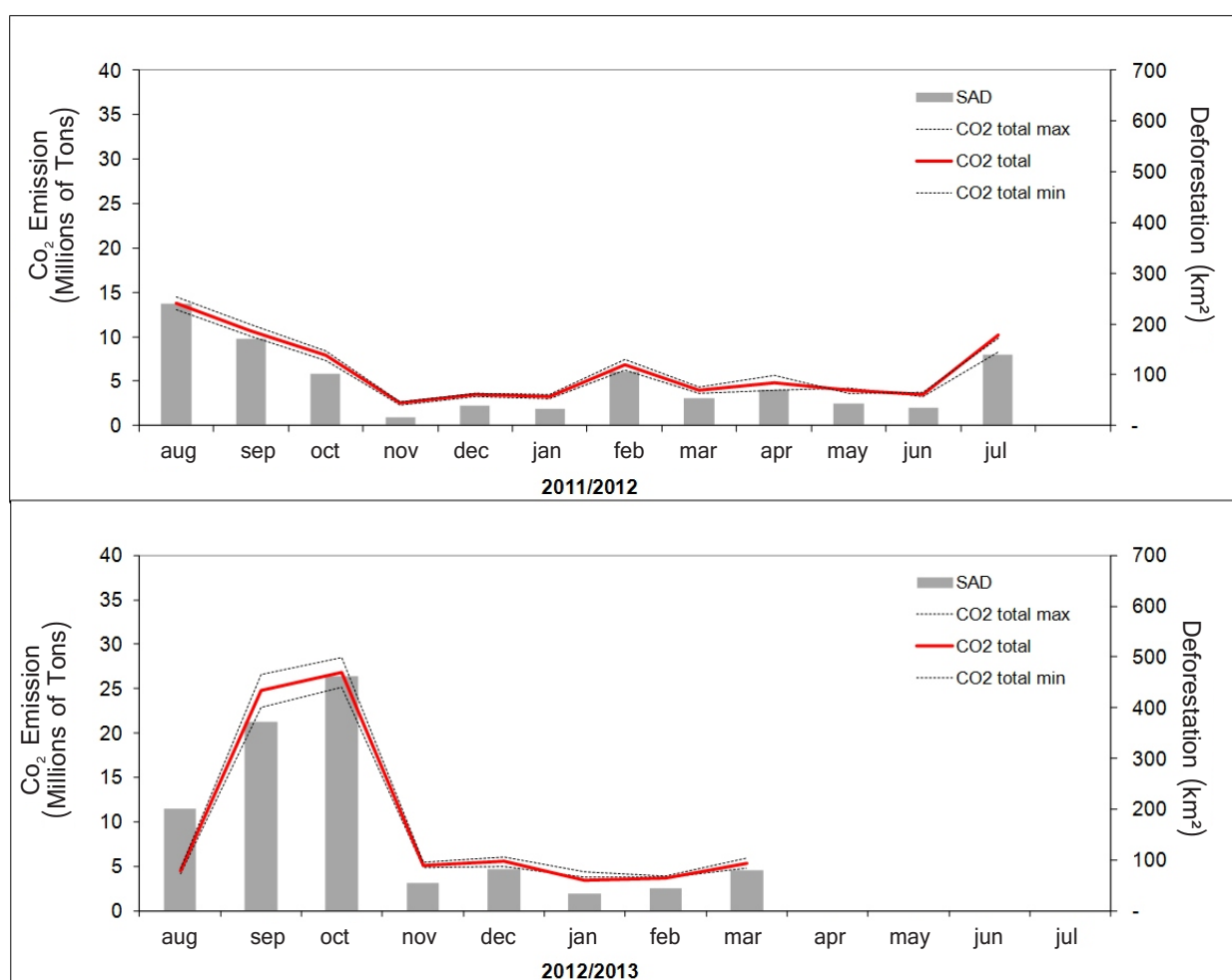
Figure 5. Deforestation and total of equivalent Carbon Dioxide emissions from August 2011 to March 2013 in Brazilian Amazon (Source: Imazon).

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Deforestation Geography

In March 2013, most part (86%) of deforestation occurred in private areas or under many stages of possessions. The rest of deforestation was recorded in Settlements of Land Reformation (6%) and Indigenous Land (8%) (Table 3).

Table 3. Deforestation set on agrarian category in March 2013 in Brazilian Amazon (Source: Imazon/SAD).
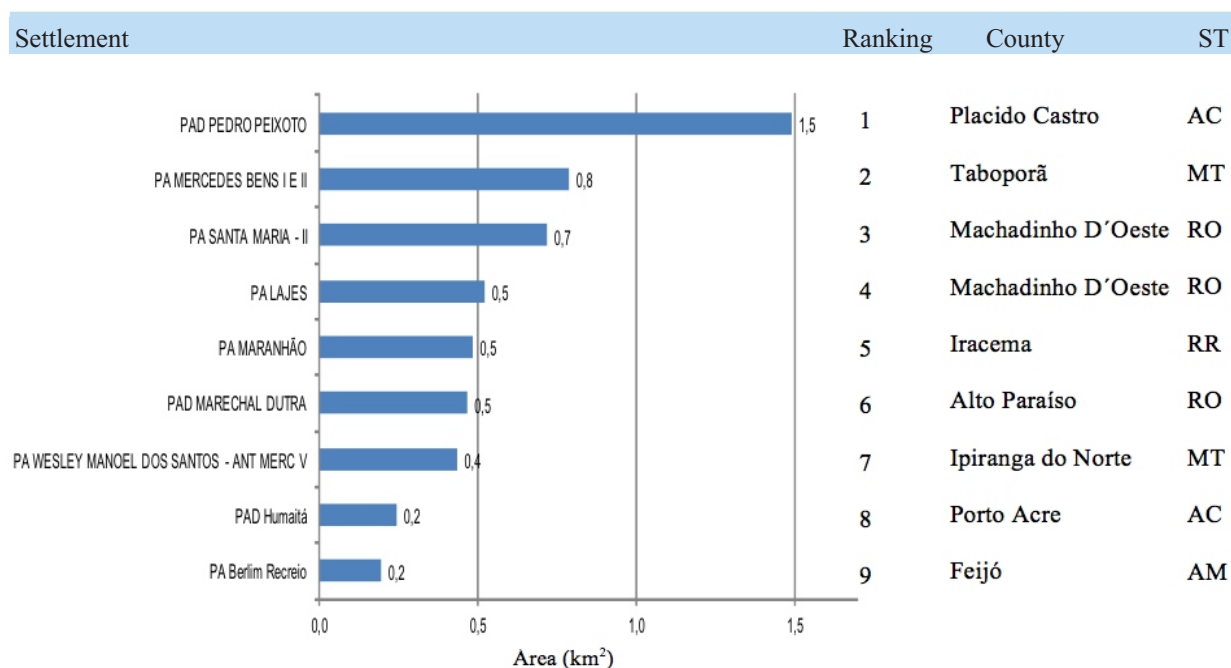
Category	March 2013	
	km²	%
Agrarian Reform Settlement	5	6
Conservation Units	0	0
Indigenous Lands	6	8
Private, Owned and in Abeyance[3]	69	86
Total (km²)	80	100

Settlements of Land Reformation

SAD recorded 5 square kilometers of deforestation in Settlements of Land Reformation in March 2013 (Picture 7).
The settlements most affected by the deforestation were Pedro Peixoto (Plácido Castro; Acre), Merceds Bens I and II (Tabaporã, Mato Grosso) and Santa Maria II (Machadinho D'Oeste, Rondônia).

Settlement		Ranking	County	ST
PAD PEDRO PEIXOTO	1,5	1	Placido Castro	AC
PA MERCEDES BENS I E II	0,8	2	Taboporã	MT
PA SANTA MARIA - II	0,7	3	Machadinho D'Oeste	RO
PA LAJES	0,5	4	Machadinho D'Oeste	RO
PA MARANHÃO	0,5	5	Iracema	RR
PAD MARECHAL DUTRA	0,5	6	Alto Paraíso	RO
PA WESLEY MANOEL DOS SANTOS - ANT MERC V	0,4	7	Ipiranga do Norte	MT
PAD Humaitá	0,2	8	Porto Acre	AC
PA Berlim Recreio	0,2	9	Feijó	AM

Area (km²)

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

Protected Areas

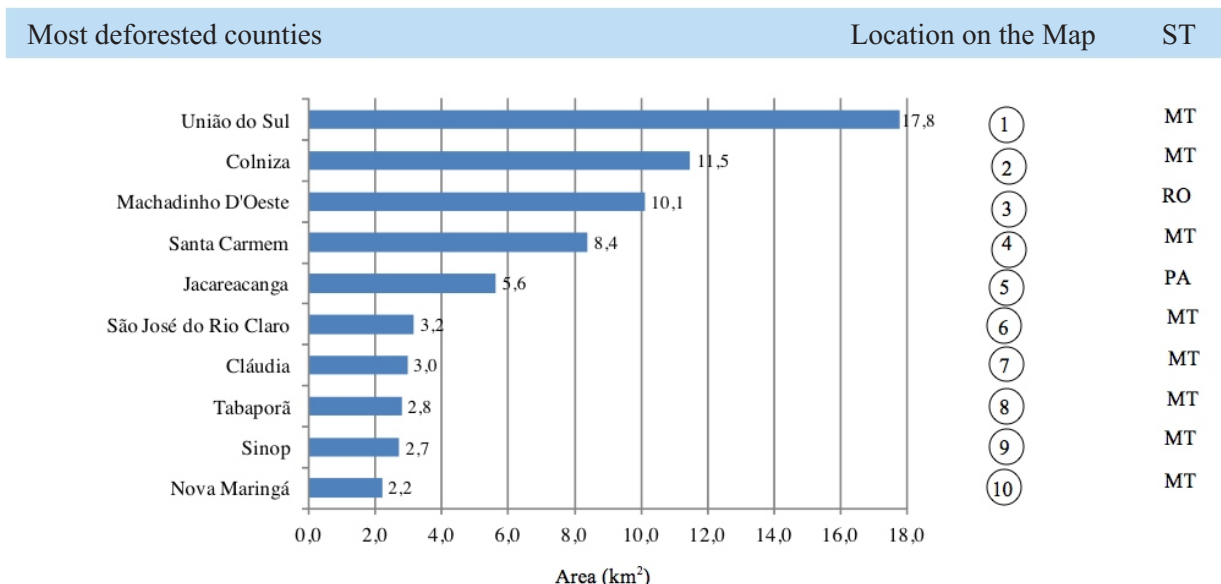In March 2013, due the high level of clouds coverage, SAD detected only 6 square kilometers of deforestation only in the Indigenous Land Kaiabi (Pará).
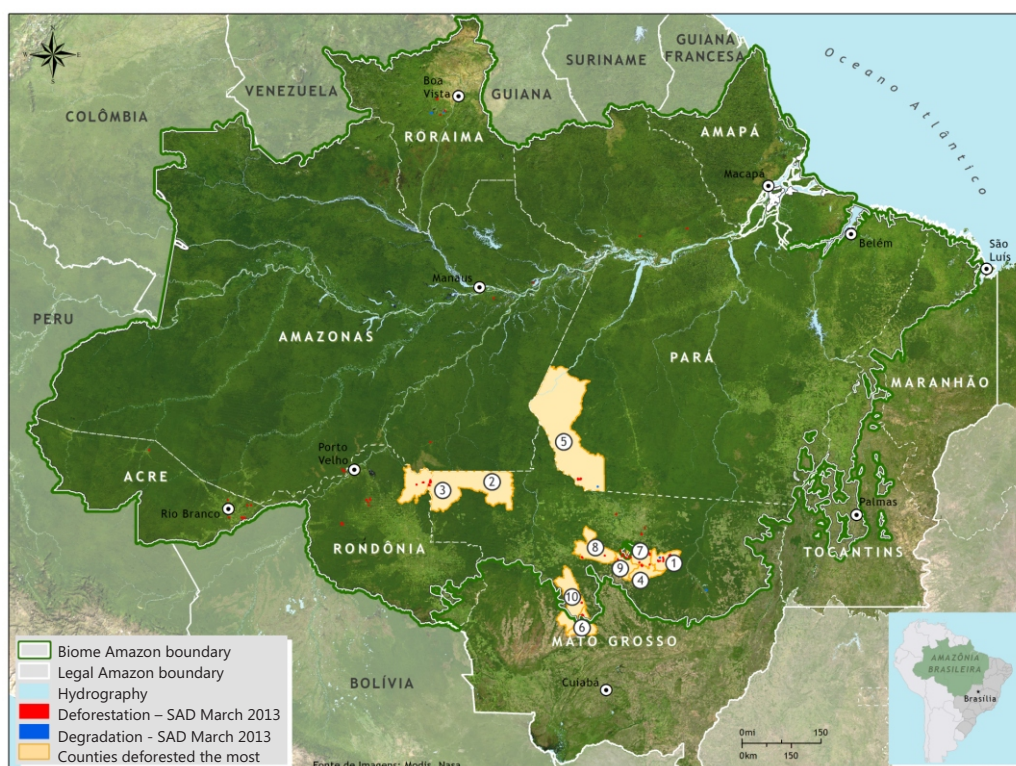
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Critical Municipalities

In March 2013, the most deforested municipalities were: União do Sul (Mato Grosso) and Colniza (Mato Grosso) (Figure 7 and 8).

Most deforested counties	Location on the Map	ST

**Figure 7.** Most deforested municipalities in Brazilian Amazon in March 2013 (Source: Imazon/SAD).

Figure 8. Most deforested municipalities in March 2013 (Source: Imazon/SAD).

Coverage by clouds and Shade

In March 2013, it was possible to monitor via SAD only 40% of the forest area in Brazilian Amazon. The other 60% of the forest land were covered by clouds which made the forest degradation and deforestation detection more difficult. The states which presented a higher level of clouds coverage were Amapá (92%), Rondônia (82%) and Pará (81%). Because of this, the data on the deforestation and the forest degradation in March 2013 may be underestimated Figure 9).

* Data related to the state of Maranhão, that integrates Legal Amazon, was not analyzed.
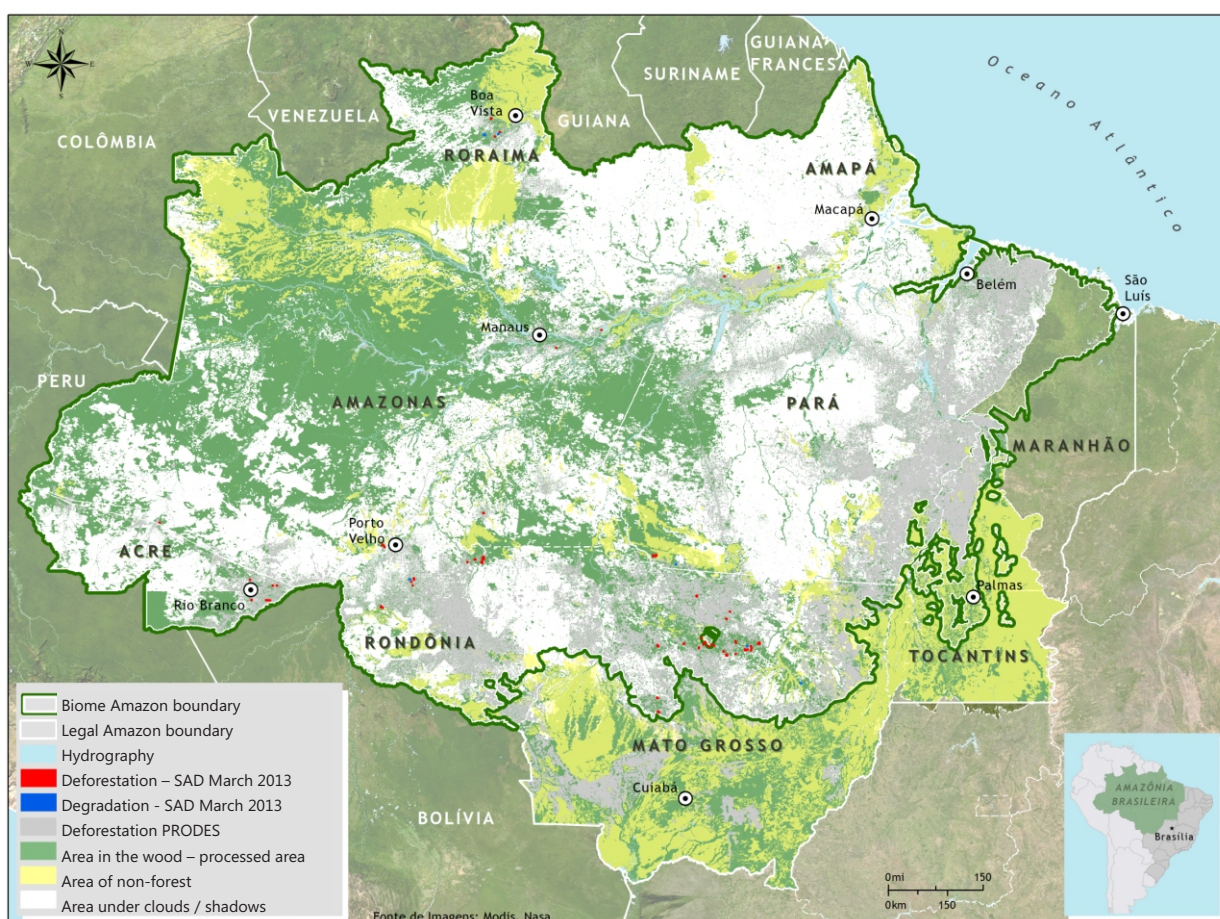
Figure 9. Areas covered by clouds and shade in March 2013 in Brazilian Amazon.

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).
$pd \; x \; e^{(- pdxe)}$: 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:

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 – 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.

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