

Sanae Hayashi, Carlos Souza Jr., Márcio Sales & Adalberto Veríssimo (Imazon)

SUMMARY

There was a reduction in deforestation for April and May, 2010 if compared to the same previous period. In April, deforestation reached 65 square kilometers (47% drop in relation to April, 2009) and in May totaled 96 square kilometers (39% reduction in relation to May, 2009).

However, when accumulated from August, 2009 to May, 2010, deforestation reached 1,161 square kilometers as opposed to 1,084 kilometers during the previous period (August, 2008 to May, 2009). That represents a small increase of 7% in deforestation during the current period.

In April, 2010, deforestation occurred mainly in Mato Grosso (59%), followed by Pará (23%) and Rondônia (10%). The remainder occurred in Amazonas (6%) and Acre (2%). In May, 2010, deforestation was greatest in Amazonas (33%) followed by Mato Grosso (26%), Rondônia (22%), Pará (17%) and Acre with only 2%.

Accumulated deforestation for the period of August, 2009 to May, 2010 resulted in the commitment of 76 million tons of equivalent CO₂ subject to direct and future emissions due to burning and decomposition events. That represents a 9% increase in relation to same previous period (August, 2008 to May, 2009) when the forest carbon affected by deforestation represented 69 million tons of equivalent Co₂.

In relation to forest degradation (forests intensely exploited by logging activity and/or fires) the total area affected in April and May, 2010 was 64 square kilometers.

The deforestation data may be underestimated due to cloud cover during the period; it was only possible to monitor 45% and 50% of the Amazon in April and May, 2010 respectively.

Deforestation Statistics

According to the Deforestation Alert System (Sistema de Alerta de Desmatamento -SAD), deforestation detected in the Legal Amazon reached 65 square kilometers in April, 2010. That represents a 47% drop in relation to April, 2009 when deforestation reached 121 square kilometers (Figure 1 and Figure 2). In May, 2010, deforestation reached 96 square kilometers and when compared to May, 2009, recorded deforestation dropped 39% (Figure 1 and Figure 3).

Accumulated deforestation for the period of August, 2009 to May, 2010 (ten months in the official calendar for measuring deforestation) reached 1,161 square kilometers. That represents a small increase of 7% in accumulated deforestation in that period (August, 2009 to May, 2010) in relation to the same period in the previous year (August, 2008 to May, 2009) when deforestation reached 1,084 square kilometers.

In the first eight months of the current deforestation calendar (August, 2009 to March, 2010) the SAD data revealed a 24% increase in deforestation compared to the previous period (August, 2008 to March, 2009). However with the significant drop in deforestation during the last two months (April and May, 2010), accumulated deforestation over the last ten months showed a 7% increase in relation to the same period from the previous year.

In April, 2010, deforestation occurred mainly in Mato Grosso (59%), followed by Pará (23%), Rondônia (10%), Amazonas (6%), and Acre (2%) (Figure 4). For its part in May, 2010, deforestation was most concentrated in Amazonas (33%), Mato Grosso (26%) and Pará (17%) (Figure 5).

¹ The official calendar for measuring deforestation begins in the month of August and ends in the month of July.

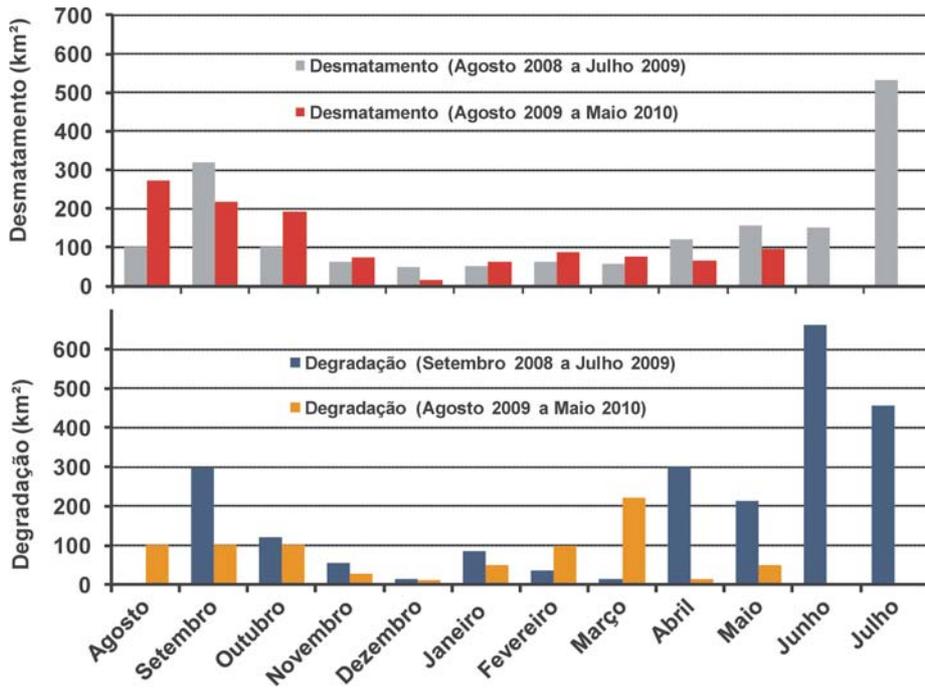


Figure 1. Deforestation from August, 2008 to May, 2010 and degradation from September, 2008 to May, 2010 in the Legal Amazon (Source: Imazon/SAD).

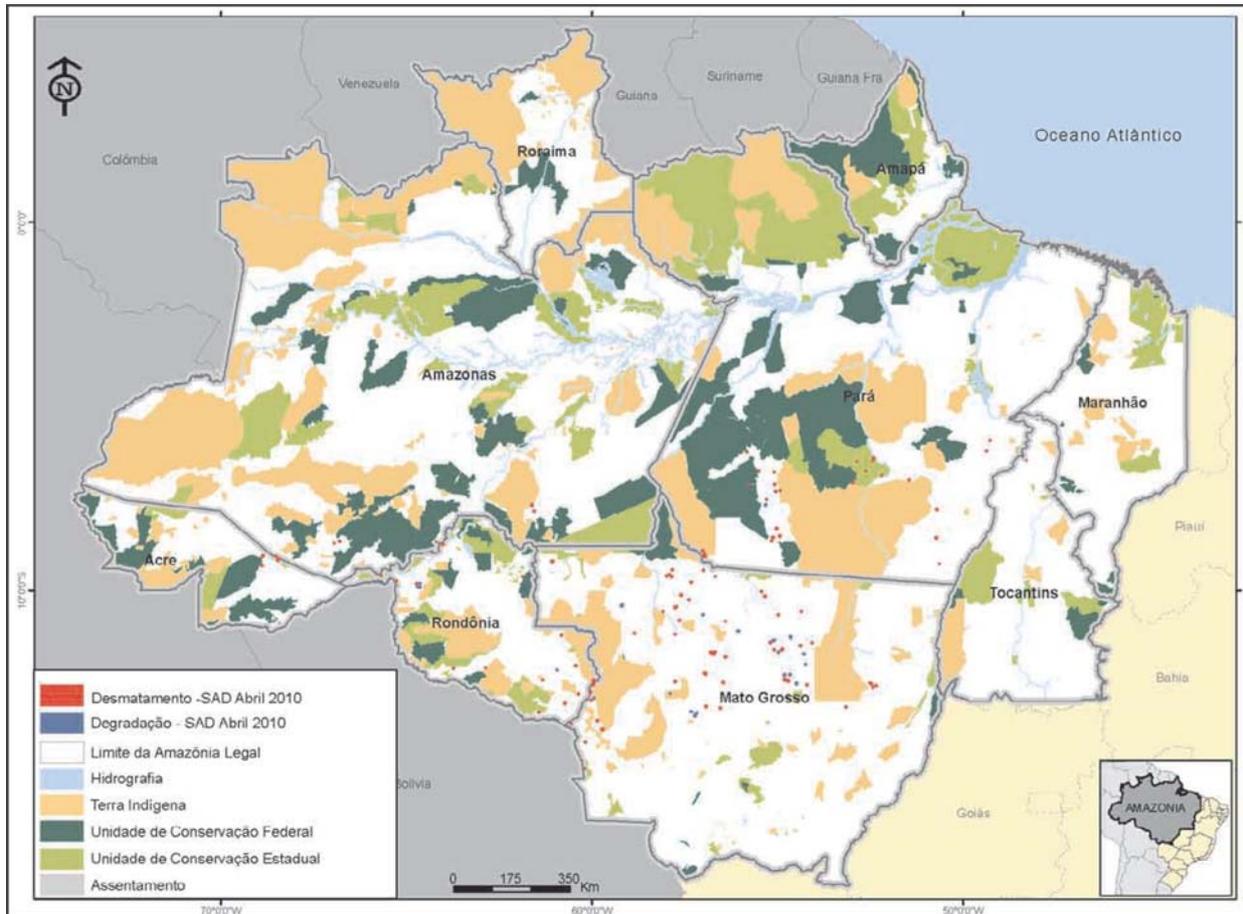


Figure 2. Deforestation and Forest Degradation in April, 2010 in the Legal Amazon (Source: Imazon/SAD).

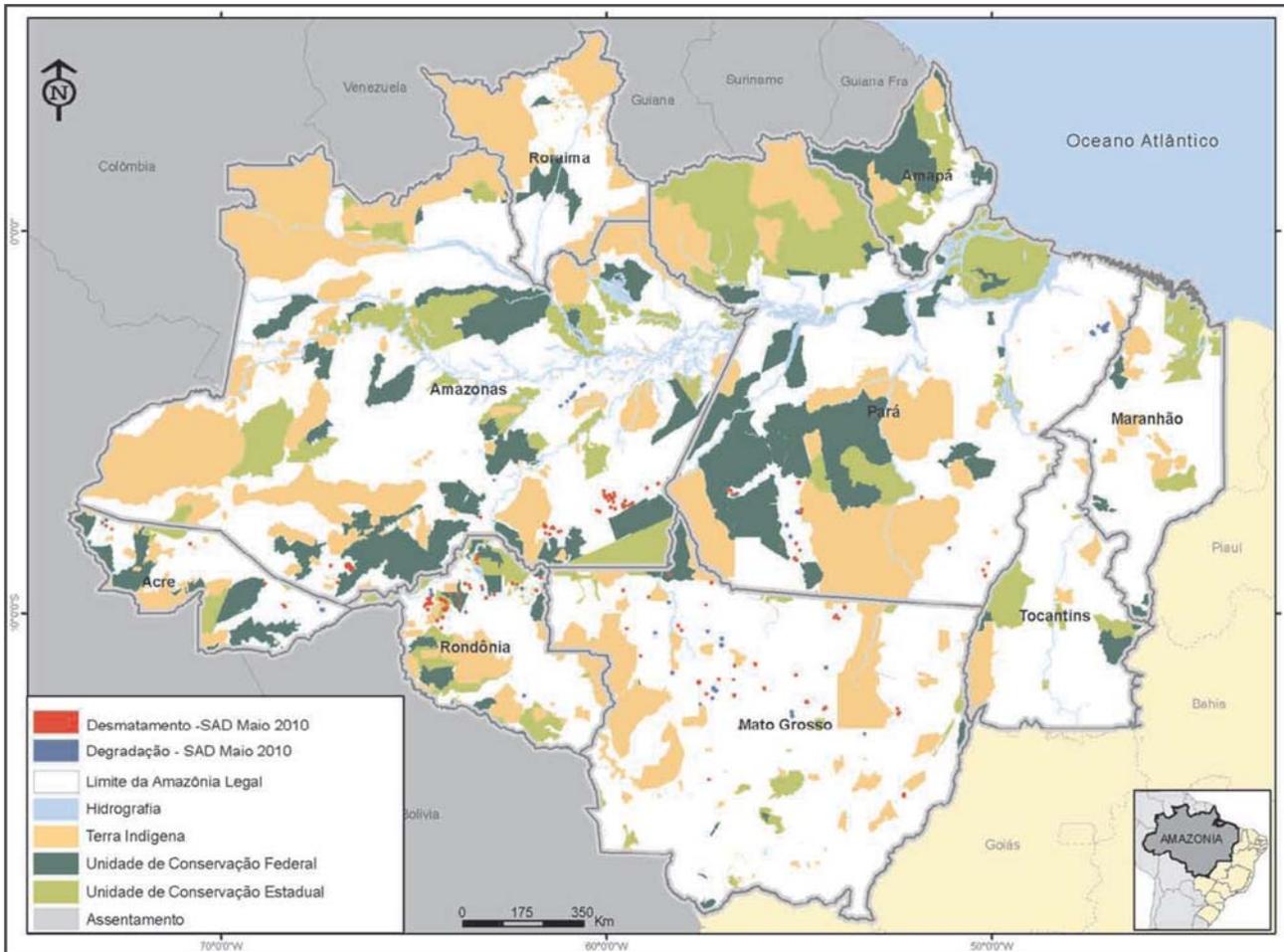


Figure 3. Deforestation and Forest Degradation in May, 2010 in the Legal Amazon (Source: Imazon/SAD).

In relation to forest degradation (meaning forests that have undergone intense logging and/or suffered forest fire), SAD recorded only 16 square kilometers (Figure 1 and Figure 2) for the month of April, 2010. Of that total, the great majority (84%) of forest degradation occurred in Mato Grosso, followed at a great distance by Rondônia (11%) and Pará (5%) (Figure 4).

In May, 2010, SAD detected 48 square kilometers of degraded forests (Figure 1 and Figure 3). Of that total, 46% occurred in Mato Grosso and 36% in Pará (36%). The remaining degradation occurred in Acre (7%), Amazonas (6%) and Rondônia (5%) (Figure 5).

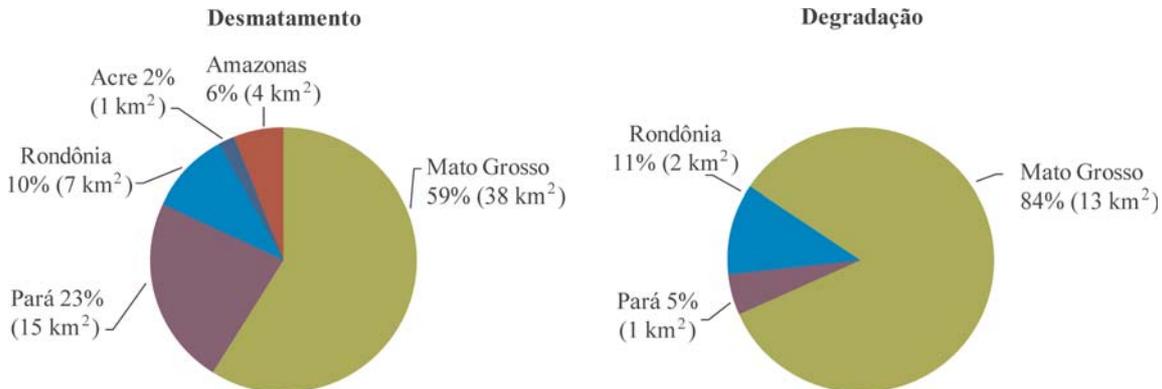


Figure 4. Share (%) of the Legal Amazon States in deforestation and degradation in April, 2010 (Source: Imazon/SAD).

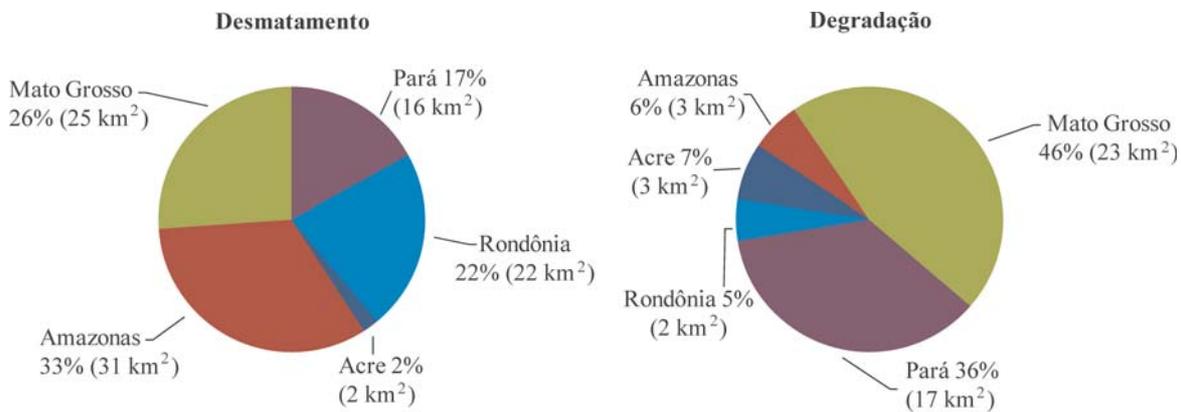


Figure 5. Share (%) of the Legal Amazon States in deforestation and degradation in May, 2010 (Source: Imazon/SAD).

Considering the first ten months of the current deforestation calendar (August, 2009 to May, 2010), Pará continues to lead the ranking with 44% of the total deforested during the period. Next come Mato Grosso with 25%, Rondônia with 12% and Amazonas with 11%. Those four states accounted for 91% of the deforestation occurring in the Legal Amazon in that period. The other 9% of deforestation were distributed between the states of Acre, Roraima, Amapá and Tocantins.

Comparing the deforestation occurring from August, 2009 to May, 2010 with the same period in the previous year (August, 2008 to May,

2009), there was a small increase of 7% in deforestation in the Legal Amazon (Table 1). In relative terms, that increase was most significant in Rondônia (71%), Amazonas (70%), and Acre (60%), followed by Pará (10%). On the other hand, there was a 94% decrease in Tocantins, 34% in Roraima and 19% in Mato Grosso.

In absolute terms, Pará leads the ranking for accumulated deforestation with 507 square kilometers, followed by Mato Grosso (288 square kilometers), Rondônia (135 square kilometers) and Amazonas (127 square kilometers).

Table 1. Evolution of deforestation among States in the Legal Amazon from August, 2008 to May, 2009 and from August, 2009 to May, 2010 (Source: Imazon/SAD).

State	August 2008 to May 2009	August 2009 to May 2010	Variation (%)
Acre	24	39	+ 60
Amazonas	75	127	+ 70
Mato Grosso	357	288	- 19
Pará	460	507	+ 10
Rondônia	79	135	+ 71
Roraima	77	50	- 34
Tocantins	12	1	- 94
Amapá	-	15	-
Total	1,084	1,161	+ 7

*Data from Maranhão were not analyzed.

Carbon Affected by Deforestation

Since January, 2010 we have been reporting estimates for committed carbon (meaning forest carbon subject to emissions due to burning and decomposition of forest biomass residues) coming from deforestation detected by SAD in the Legal Amazon. Information on the method for estimated forest carbon committed through deforestation is summarized in Box II.

In April, 2010, the 65 square kilometers of deforestation detected by SAD in the Legal Amazon committed 1.2 million tons (with a margin of error of 201 thousand tons) of carbon. That quantity of carbon affected is equivalent to 4.4 million tons of equivalent CO₂ (Figure 6). That represents a 54% reduction in relation to April, 2009 when the forest carbon affected was 2.6 million tons (with a margin of error of 412 thousand tons). That reduction in carbon affected by deforestation was proportional to the 47% reduction in deforestation detected by SAD for that month.

In May, 2010, the estimate of carbon affected by deforestation was 1,8 million tons (with a margin of error of 230 thousand tons of carbon). That is equivalent to 6.6 million tons of equivalent CO₂ (Figure 6). The amount of CO₂ detected in May, 2010 also represents a 41% reduction in relation to May, 2009 (11.2 million tons; with a margin of error of 358 thousand tons), which was proportional to the 39% reduction in the deforestation detected in that month.

The forest carbon committed from deforestation for the period of August, 2009 to May, 2010 (first ten months of the current deforestation calendar) was 20.7 million tons (with a margin of error of 646 thousand tons), which represented around 76 million tons of equivalent CO₂ (Figure 6). In relation to the same period in the previous year (August, 2008 to May, 2009) there was a small increase of 9% in the quantity of carbon committed through deforestation. The relative increase in forest carbon affected by deforestation, in relation to last year was proportional to the relative 7% increase in deforestation for the same period.

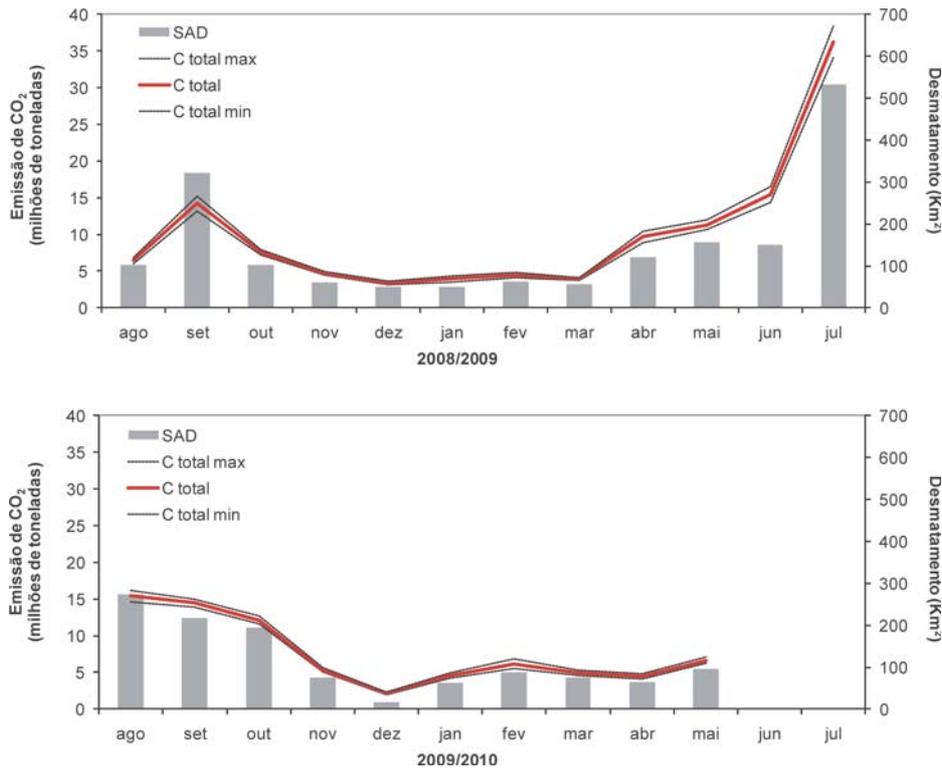


Figure 6. Deforestation and total emissions of equivalent carbon dioxide (CO₂) from August, 2008 to May, 2010 in the Legal Amazon (Source: Imazon).

Geography of Deforestation

In April, 2010, deforestation occurred principally in the central region of Mato Grosso and along the BR-163 (Santarém-Cuiabá) highway between the municipalities of Altamira (Castelo dos Sonhos District) and Novo Progresso. In May, 2010, deforestation was concentrated in southeastern Amazonas, in the municipalities around the BR-364 highway in northern Rondônia and in the central region of Mato Grosso.

In relation to land title situation, in April, 2010, the majority (73%) of deforestation occurred in private areas or on lands in various stages of possession. The remaining deforestation was recorded in Land Reform Settlements (15%), Indigenous Lands (7%) and Conservation Units (5%) (Table 2). In May, 2010, the majority (62%) of the deforestation occurred in private areas or under various stages of possession, 24% in Land Reform Settlements and 14% in Conservation Units (Table 3). In May, 2010 no deforestation was detected in Indigenous Lands.

Table 2. Deforestation by land title category in April, 2010 in the Legal Amazon (Source: Imazon/ SAD).

Category	April 2010	
	km ²	%
Land Reform Settlement	10	15
Conservation Units	3	5
Indigenous Lands	5	7
Private, Possession & Vacant ²	47	73
Total (km²)	65	100

² Includes private areas (titled or not) and non-protected public forests.

Table 3. Deforestation by land title category in May, 2010 in the Legal Amazon (Source: Imazon/ SAD).

Category	May 2010	
	km ²	%
Land Reform Settlement	23	24
Conservation Units	13	14
Indigenous Lands	-	-
Private, Possession & Vacant ³	60	62
Total (km²)	96	100

Land Reform Settlements

In April, 2010 SAD recorded 10 square kilometers in the Land Reform Settlements. The most affected were: Terra Nossa (Altamira, Pará), Tapurah/Itanhanga (Tanhanga, Mato Grosso) and Pingos D'Água (Querência, Mato Grosso) (Figure 7). As for May, 2010, deforestation in the

Settlements was more marked, totaling 23 square kilometers. The most deforested Settlements were Rio Juma (Apuí, Amazonas), Monte (Boca do Acre, Amazonas) and Terra Nossa (Altamira, Pará) (Figure 8).

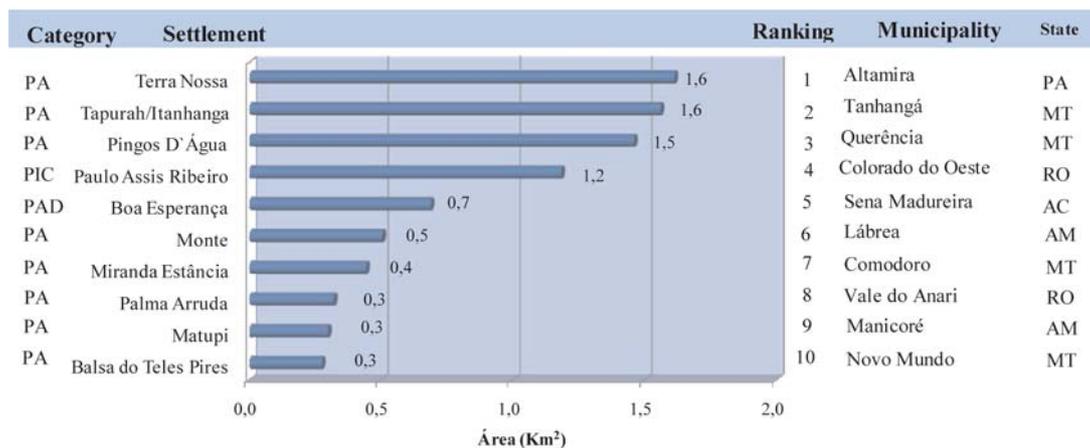


Figure 7. Most deforested Land Reform settlements in April, 2010 in the Legal Amazon (Source: Imazon/SAD).

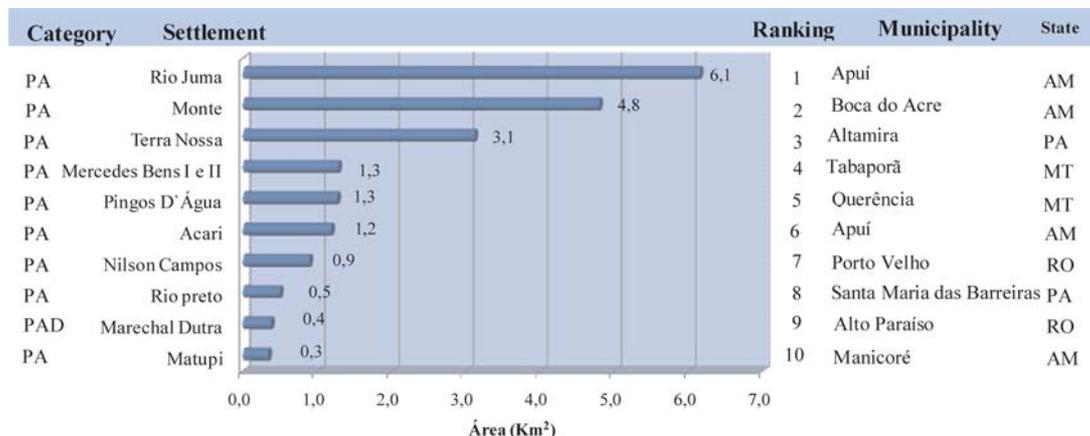


Figure 8. Most deforested Land Reform settlements in May, 2010 in the Legal Amazon (Source: Imazon/SAD).

³ Includes private areas (titled or not) and non-protected public forests.

Protected Areas

In April, 2010 SAD detected 7 square kilometers of deforestation in Protected Areas in the Legal Amazon. Of that total, approximately 5 square kilometers were in Conservation Units and 2 square kilometers in Indigenous Lands.

The most affected Conservation Units were APA Triunfo do Xingu (Pará), PES Serra Ricardo Franco (MT) and Flosur do Rio Vermelho (RO) (Figure 9). The Indigenous Lands affected by

deforestation were Kayapó (PA), Jacaréuba/Katawixi (AM), and Kayabi (PA) (Figure 11). As for May, 2010, SAD detected 10 square kilometers of deforestation in Conservation Units (Figure 10).

The most deforested Conservation Units are located in Rondônia (Resex do Rio Jaci-Paraná, Florex Rio Preto/Jacundá and Flona do Bom Futuro). No deforestation was detected in Indigenous Lands during May, 2010.

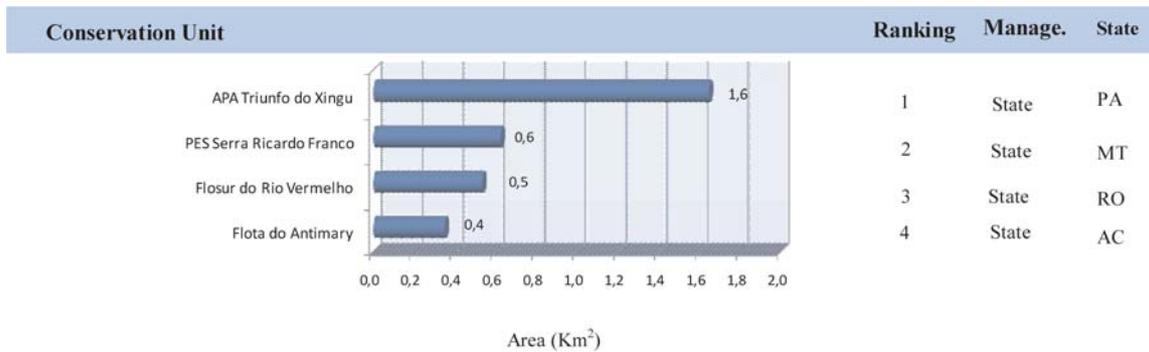


Figure 9. Most deforested Conservation Units in the Legal Amazon in April, 2010 (Source: Imazon/SAD).

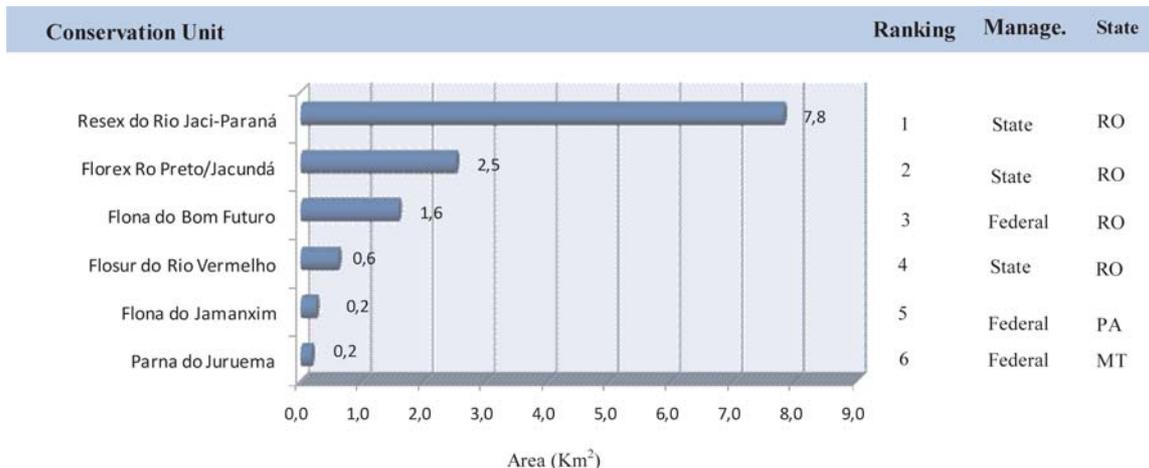


Figure 10. Most deforested Conservation Units in the Legal Amazon in May, 2010 (Source: Imazon/SAD).

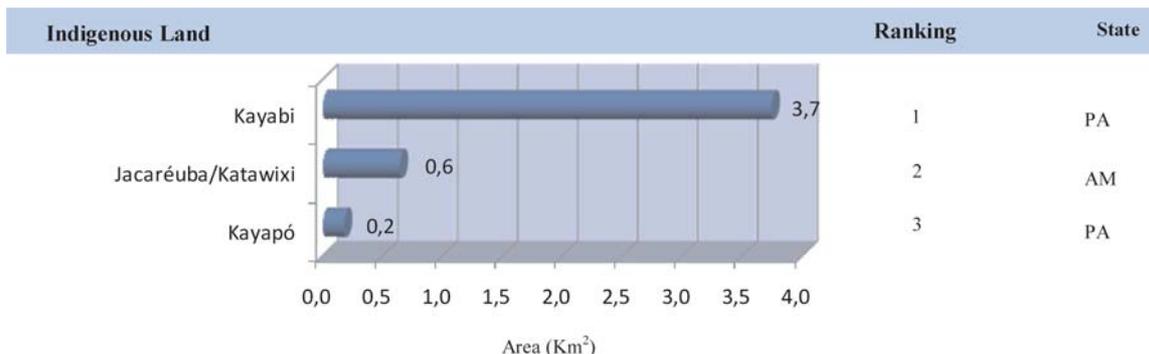


Figure 11. Most deforested Indigenous Lands in the Legal Amazon in April, 2009 (Source: Imazon/SAD).

Critical Municipalities

In April, 2010 deforestation was greatest in Porto dos Gaúchos (MT) with 5.2 square kilometers, followed by Altamira (PA) with 4.9 square kilometers, and Feliz Natal (MT) with 4.9 square kilometers (Figure 12 and Figure 14). As

for May, 2010, the most deforested municipalities were Porto Velho (RO) with 10.8 square kilometers, Apuí (AM) with 9.4 square kilometers and Manicoré (AM) with 8.1 square kilometers (Figure 13 and Figure 15).

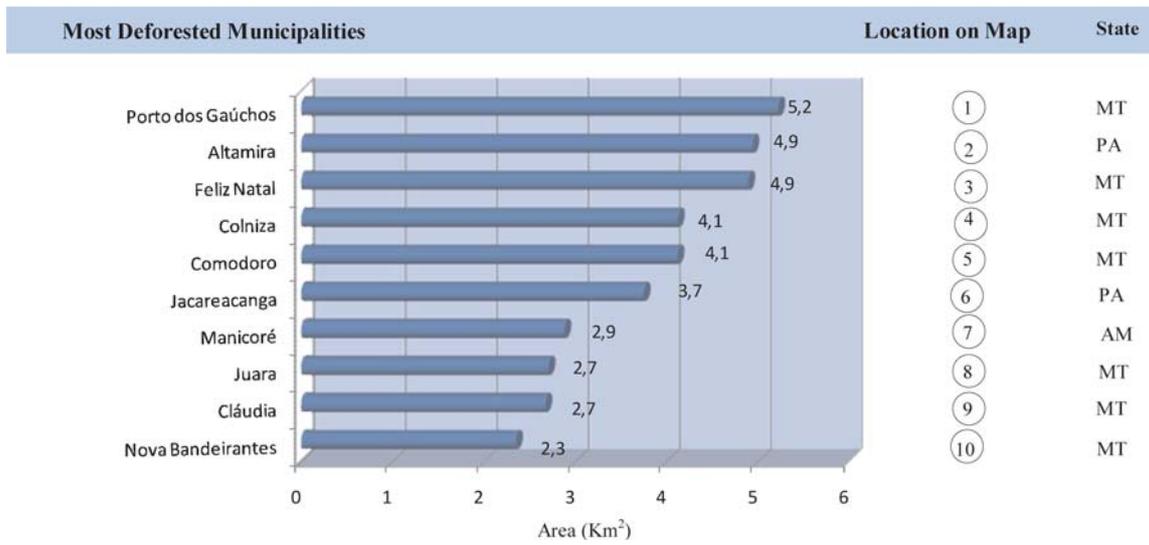


Figure 12: Most deforested municipalities in the Legal Amazon in April, 2010 (Source: Imazon/SAD).

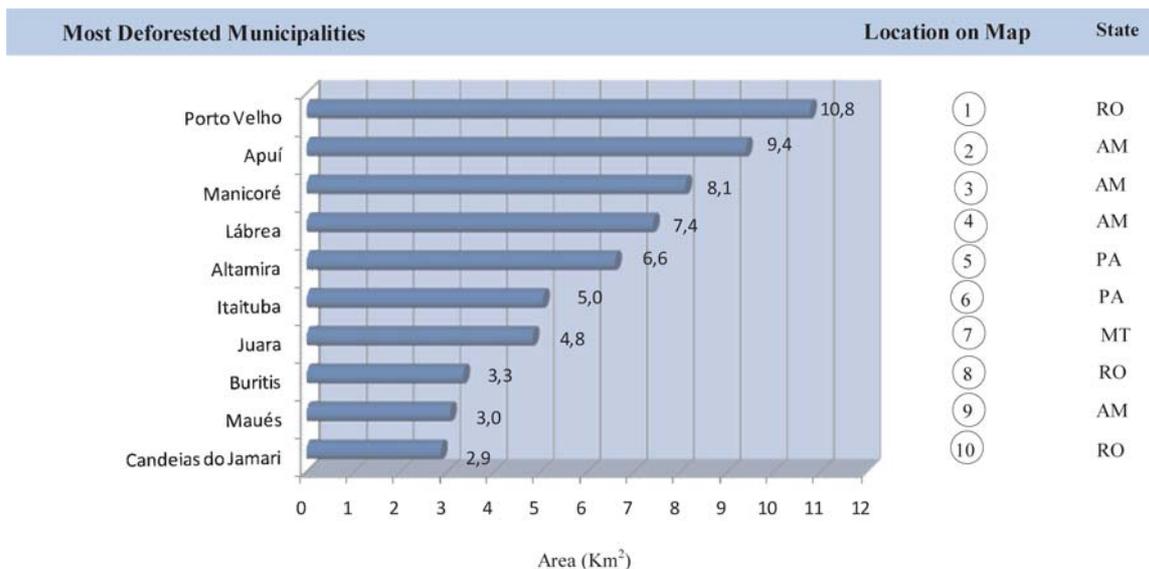


Figure 13: Most deforested municipalities in the Legal Amazon in May, 2010 (Source: Imazon/SAD).

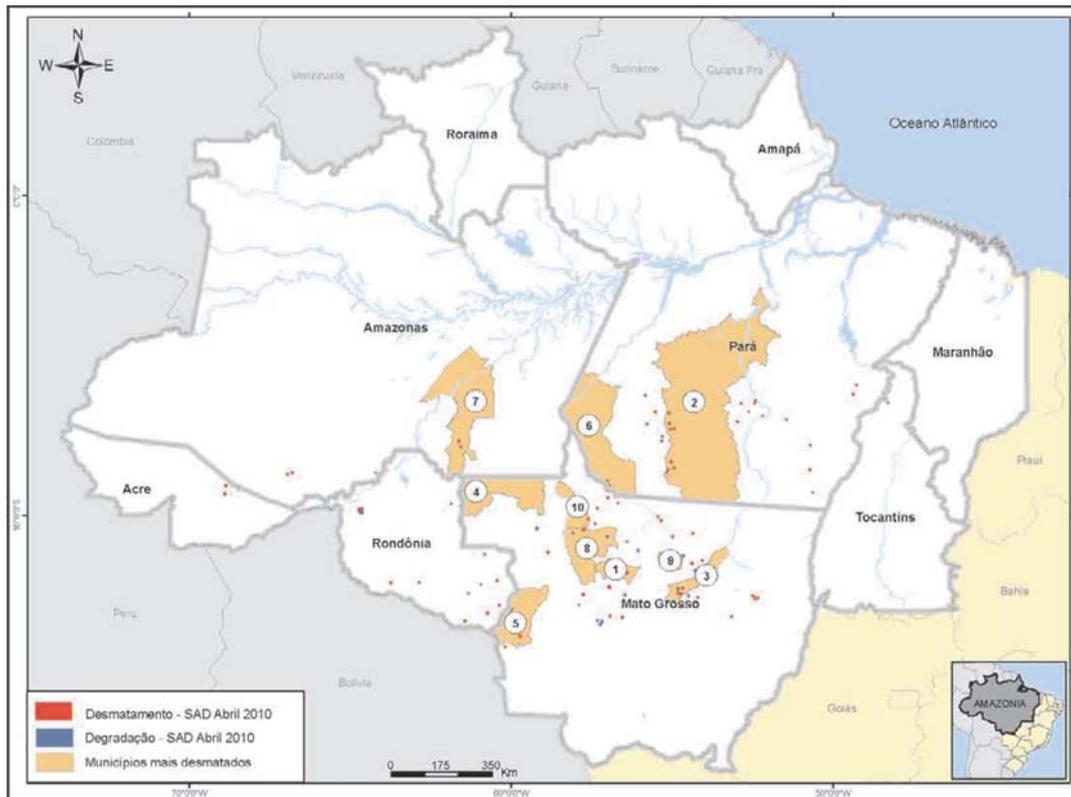


Figure 14. Most deforested municipalities in April, 2010 (Source: Imazon/SAD).

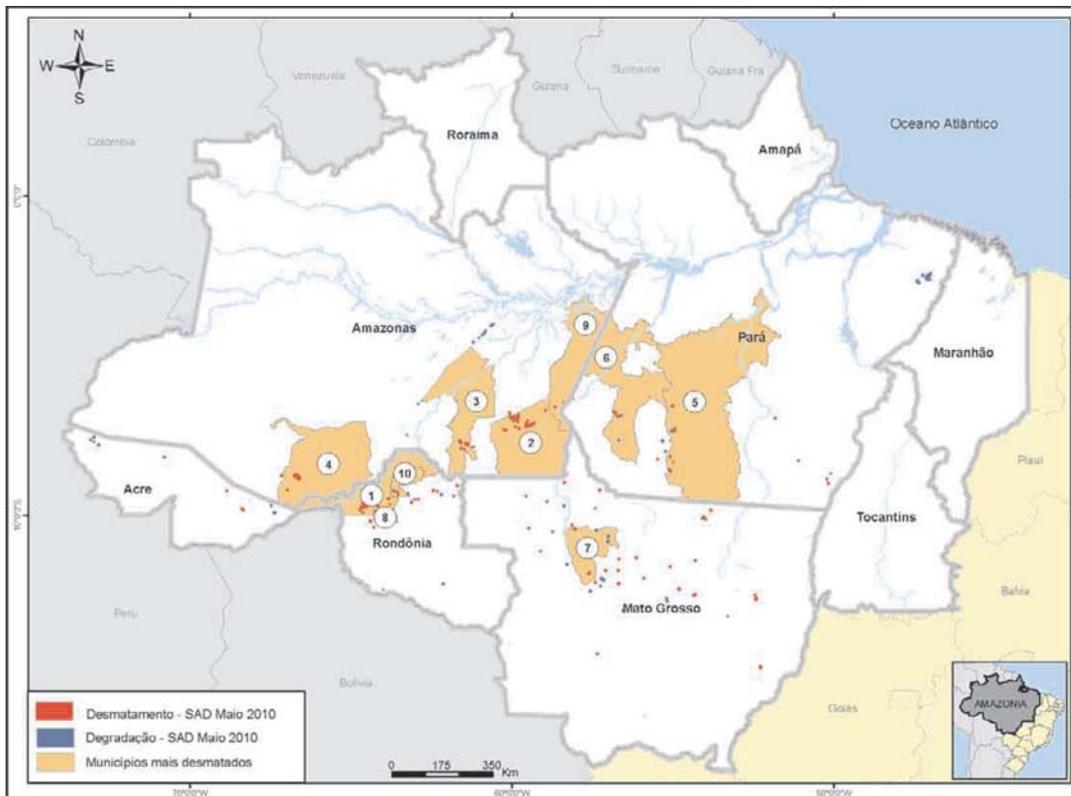


Figure 15. Most deforested municipalities in May, 2010 (Source: Imazon/SAD).

Cloud and Shadow Cover

In April and May, 2010, it was possible to monitor approximately half (45% and 50%, respectively) of the forest area Legal Amazon (Figure 16 and Figure 17) due to cloud cover in the region. In both April and May, 2010, the non-mapped region corresponds for the great majority (more than 70%) of the forest area in Amapá, Pará, and Roraima.

In those states cloud cover made it difficult to monitor deforestation with SAD during the months being analyzed. In April and May, 2009, cloud cover was also significant and affected approximately half of the territory. Therefore, the drop in deforestation in April and May, 2010 in relation to April and May, 2009 was real and not affected by the cloud cover.

* The portion of Maranhão belonging to the Legal Amazon was not analyzed.

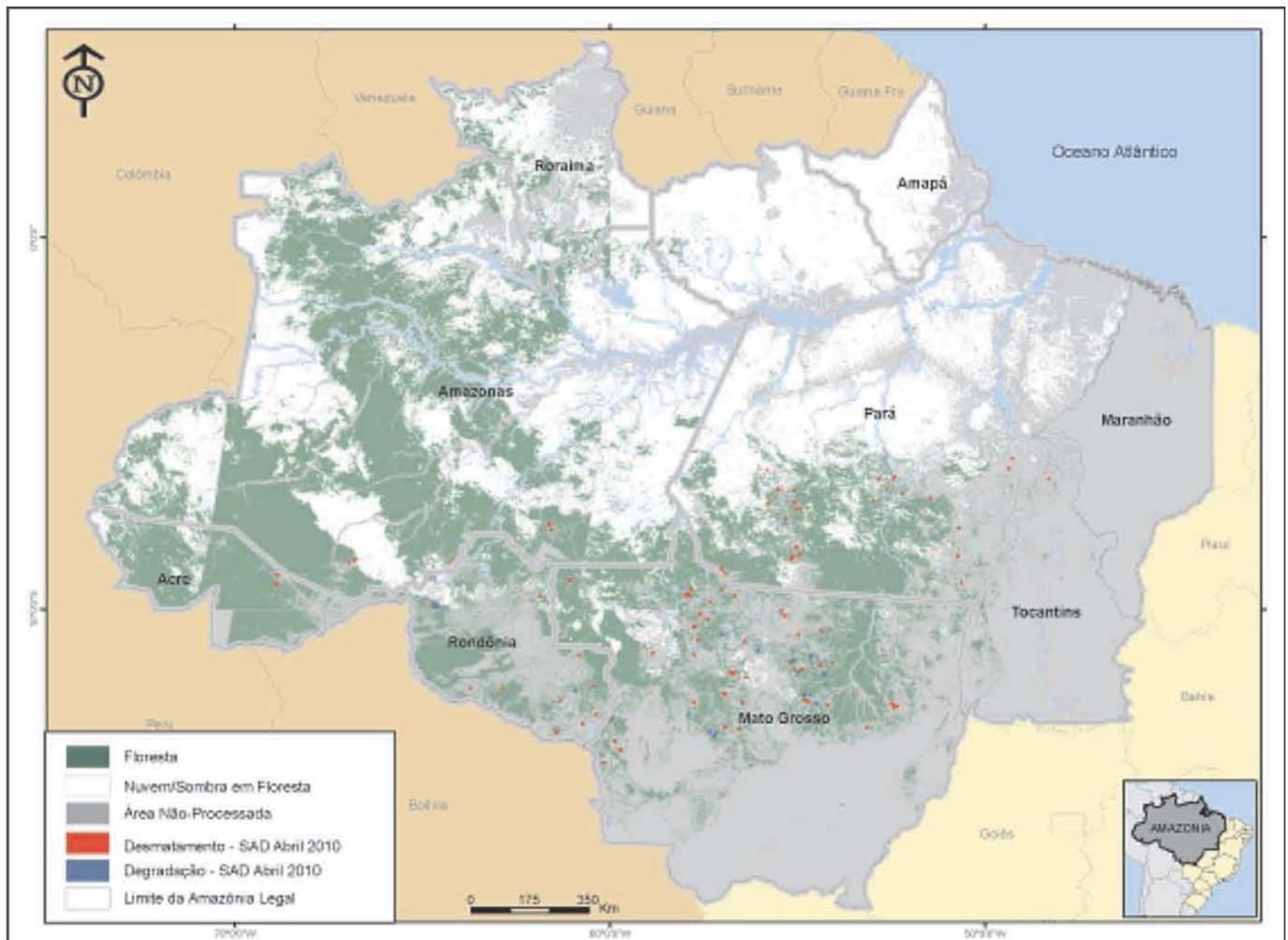


Figure 16. Area with cloud and shadow cover in April, 2010 in the Legal Amazon.

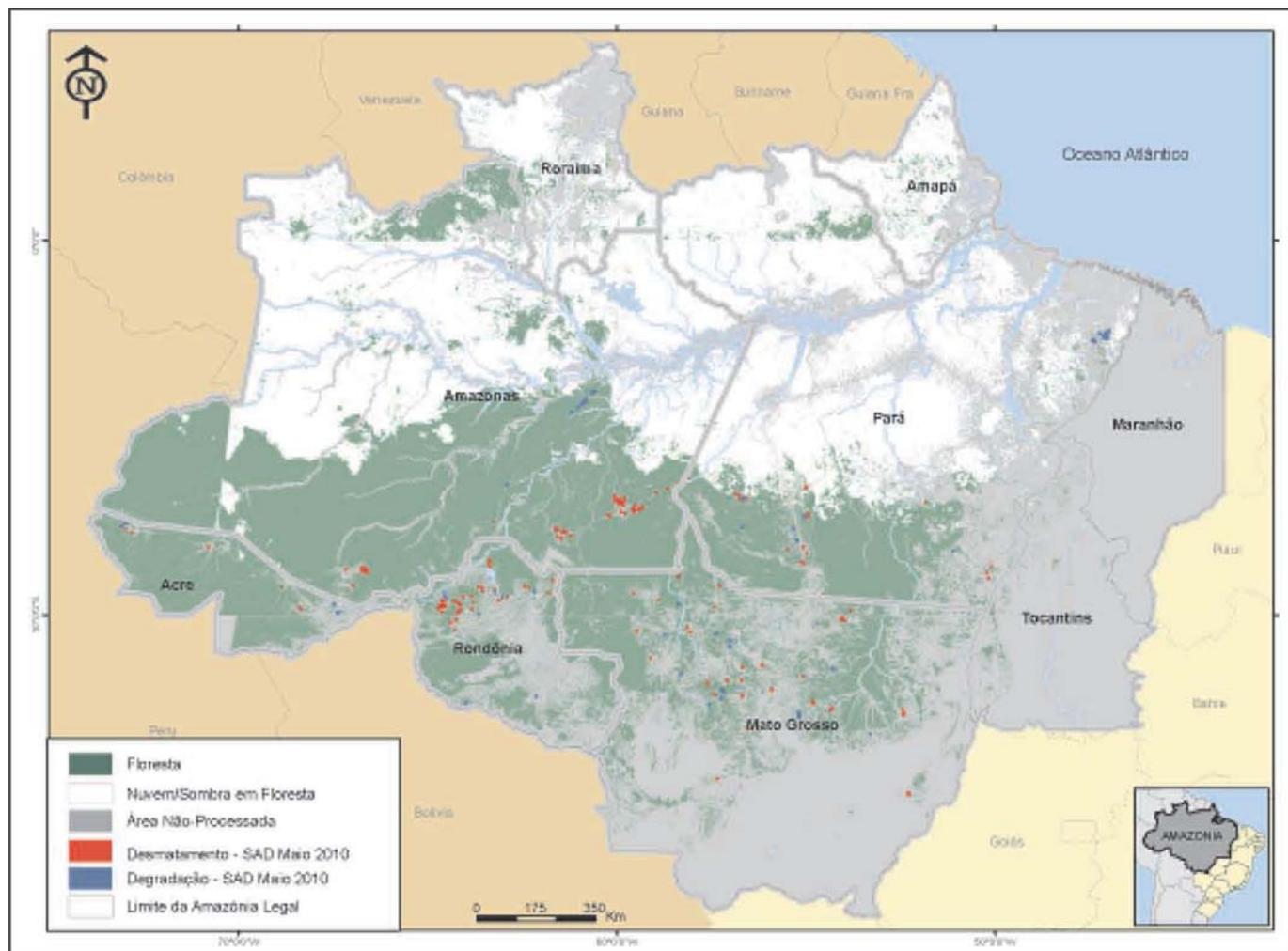


Figure 17. Area with cloud and shadow cover in May, 2010 in the Legal Amazon.

Validation of SAD data utilizing Landsat and Cbers Images

In 2008, Imazon improved validation of data from SAD, utilizing CBERS and Landsat images, with a finer spatial resolution (20 and 30 meters, respectively). We used the images available shortly after the month analyzed by SAD. All of the deforestation polygons detected by SAD are verified using the detailed images.

Deforestation events smaller than 6.25 hectares, in other words, below the SAD capacity for detection, are not included in the statistics, should they occur in the images with more detailed resolution. However, if false signals of deforestation detected by SAD are confirmed,

those are removed from the monthly statistics. What is new in the SAD validation process is that we have applied that methodology in almost real time, thanks to the availability of CBERS and Landsat images from the National Institute for Space Research (Inpe). In April, 2010, 80% of the deforestation detected by SAD was confirmed with Landsat images (Figure 18). The other 20% were not confirmed due to cloud occurrence in the Landsat and CBERS images available for the period. In May, 2010, it was possible to validate 90% of the deforestation cases with the Landsat images (Figure 19).

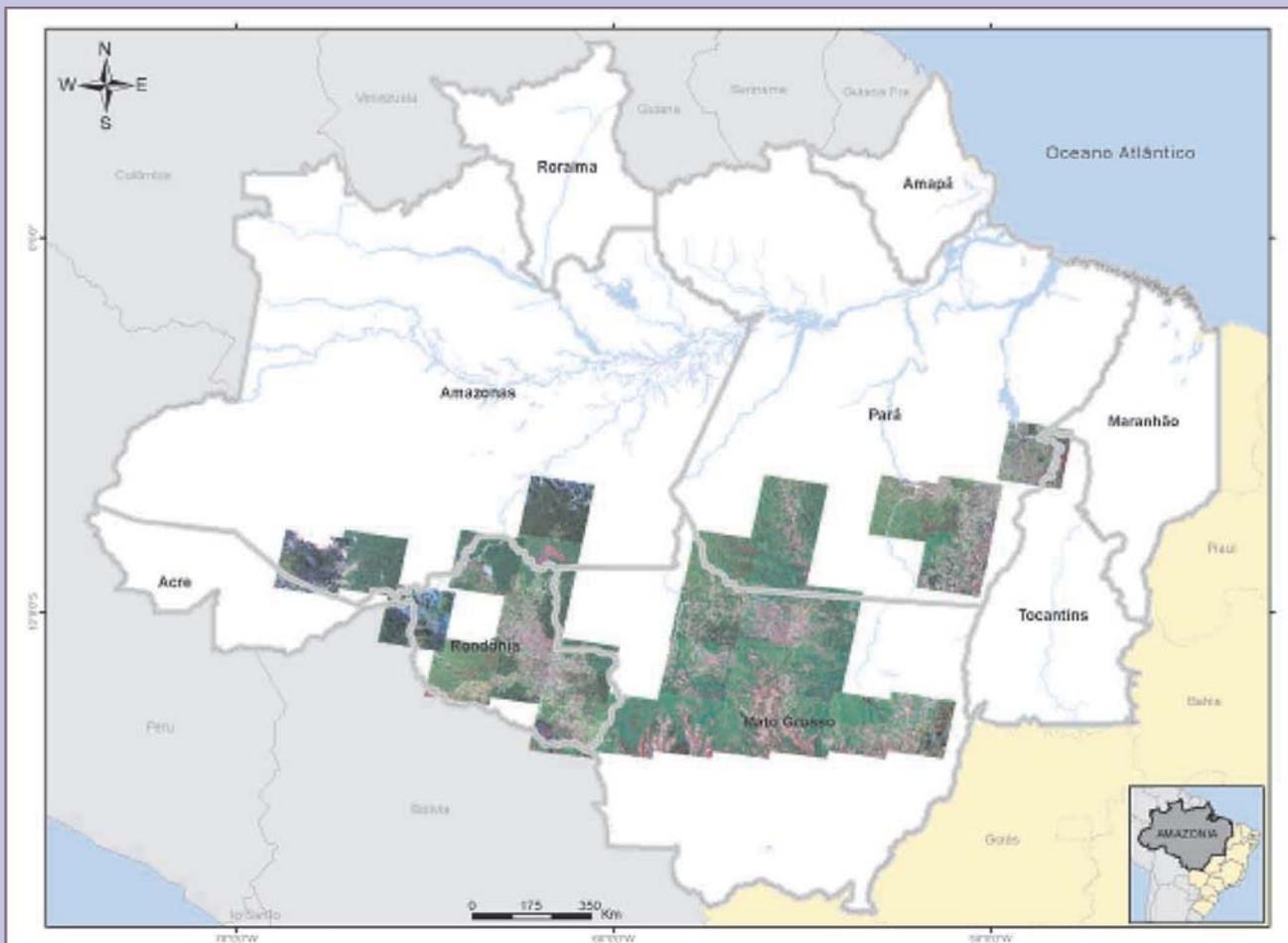


Figure 18. Landsat Scenes utilized in validating deforestation polygon detected by SAD in April, 2010.

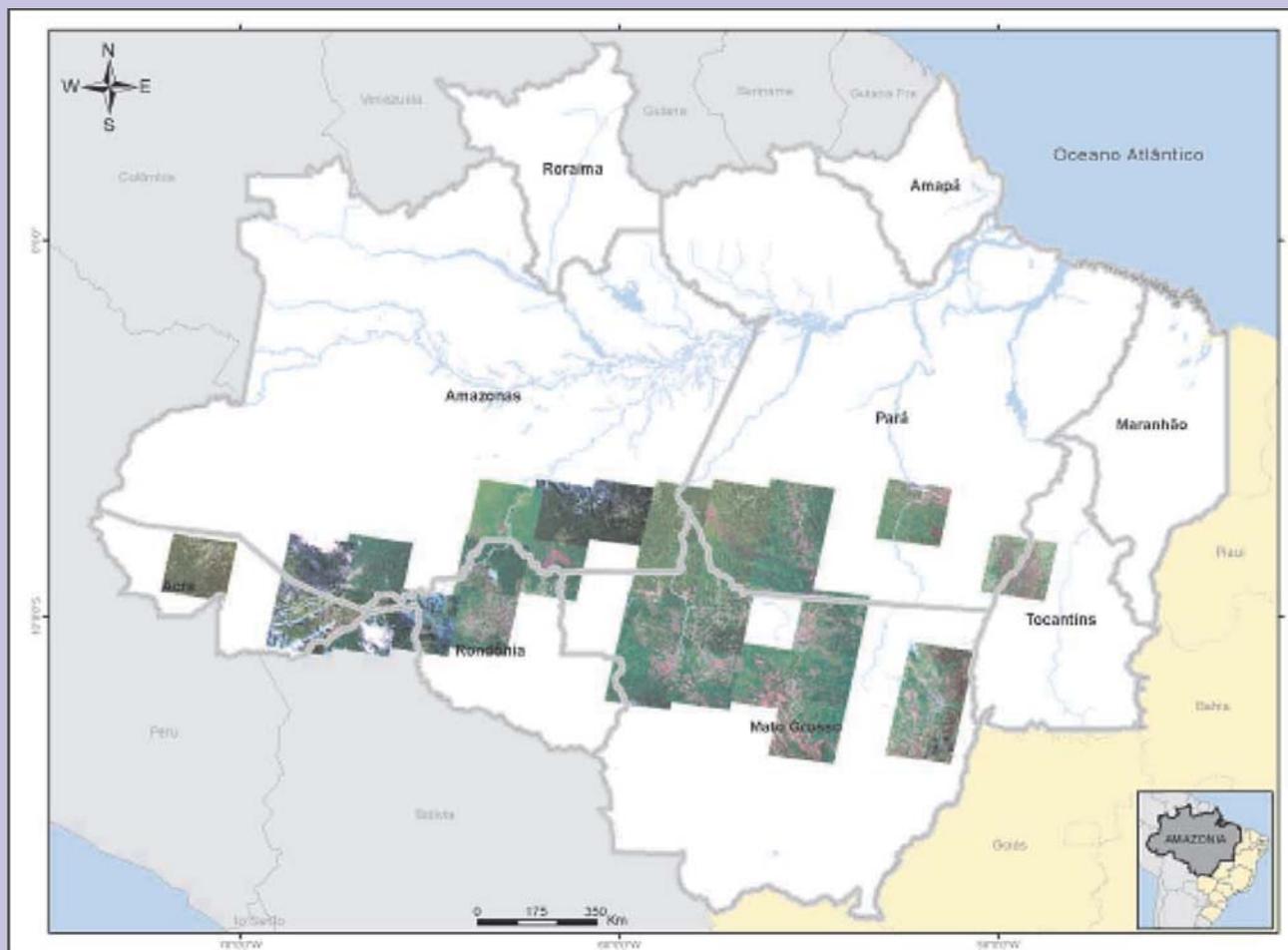


Figure 19. Landsat Scenes utilized in validating deforestation polygons detected by SAD in May, 2010.

Box I: SAD 3.0 Beta.

Beginning in August, 2009, SAD has presented some new features. First, we created a graphic interface to integrate all of the image processing programs used in SAD. Next, we began computing deforestation as a new class for areas that were covered by clouds in previous months. Finally, deforestation and degradation are detected with pairs of NDFI images in an algorithm for detecting changes. The principal methodology continues to be the same as SAD 2, as described below.

SAD generates a temporal mosaic of daily MODIS images from the MOD09GQ and MOD09GA products to filter clouds. Next, we utilize a technique for fusing different spectral resolution bands, meaning with pixels of different sizes. In that case, we made the change in scale from the bands with 500 meter pixels in MODIS to 250 meters. That allowed us to improve the spectral model for the pixel mix, by providing the capacity for estimating the abundance of Vegetation, Soils and Non-Photosynthetically Active Vegetation (NPV – Non-Photosynthetic components - Vegetation, Soil and Shadow) to calculate the NDFI, with the equation below:

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

Where VGs is the component Vegetation normalized for shadow given by:

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

The NDFI varies from -1 (pixel with 100% of exposed soil) to 1 (pixel with > 90% having forest vegetation). This way, we obtain a continuous image that shows the transition from deforested areas, going to degraded forests, until reaching forests with no signs of disturbance.

Detection of deforestation and degradation this month included the difference in NDFI images from consecutive months. Thus, a reduction in NDFI values of between -200 and -50 indicates possibly deforested areas and between -49 and -20 shows signs of degradation.

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

SAD has been operational in the State of Mato Grosso since August, 2006 and in the Legal Amazon since April 2008. In this bulletin, we present the monthly data generated by SAD from August, 2006 to May, 2010.

Box II: Carbon affected by deforestation.

The carbon estimates are generated based on the combination of SAD deforestation maps with simulations of the spatial distribution of biomass for the Amazon. We have developed a model for estimating carbon emissions, based on a stochastic simulation (Morton et al, in prep.) known as Carbon Emission Simulator (CES). We generated 1,000 simulations of the spatial distribution of biomass in the Amazon using a geostatistical model (Sales et al., 2007) and transformed those biomass simulations into C stocks using factors in the literature for converting biomass into C, 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_t: Carbon committed in month t.

C_t(S): Carbon emitted from a polygon deforested in time t.

S_D: Area deforested.

BVAS: Biomass above the soil in deforested region SD.

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

fc: fraction of charcoal (3 to 6%).

BAS₀: Biomass below the soil before deforestation.

pd: parameter for monthly decomposition of biomass below the soil after deforestation (0.0075).

$pd \times e^{-pd \times t}$: Monthly rate of decomposition of biomass below the soil after deforestation.

In applying the CES model using data from SAD we considered only the carbon committed by deforestation, meaning the fraction of forest biomass composed of carbon (50%) subject to instantaneous emissions due to forest burnt during deforestation, and/or the future decomposition of remaining forest biomass. Additionally, we adapted the CES model to estimate the forest carbon committed by deforestation on a monthly scale. Finally, the simulations allow us to estimate the uncertainty of the carbon committed, represented by the standard deviation (+/- 2 times) of the simulations of carbon affected in each month.

For conversion of the values of carbon into equivalent CO₂, a value of 3.68 is applied.

Bibliographical References

Morton, D., Sales, M., Souza, Jr. C. & Griscom, B.. *Baseline Carbon Emissions from Deforestation and Forest Degradation: A REDD case study in Mato Grosso, Brazil*. In press.

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

Project Team

General Coordination: Sanae Hayashi, Carlos Souza Jr.
and Adalberto Veríssimo (Imazon)

Team: Márcio Sales (Modeling and Statistics), Rodney Salomão,
Amintas Brandão Jr., João Victor (Geoprocessing)
and Bruno Oliveira (Communications)

Data Sources

Statistics for deforestation are generated using data from
SAD (Imazon);

Data from INPE – Deforestation (PRODES)

<http://www.obt.inpe.br/prodes/>

Support

Gordon & Betty Moore Foundation
David & Lucille Packard Foundation
Fundo Vale

Partnerships

Pará State Environmental Secretariat (SEMA)
Mato Grosso State Environmental Secretariat (SEMA)
Federal Public Prosecution Service in Pará
Pará State Public Prosecution Service
Roraima State Public Prosecution Service
Amapá State Public Prosecution Service
Mato Grosso State Public Prosecution Service
Instituto Centro de Vida (ICV – Mato Grosso)