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SUMMARY

In December 2010, the Deforestation Alert System (SAD) detected 175 square kilometers of deforestation in the Legal Amazon. This represented a significant increase of 994% in relation to December 2009 when the deforestation totaled only 16 square kilometers. However, January 2011 registered an increase of 83 square kilometers of deforestation, which represented an increase of 22% in relation to January 2010 when the deforestation affected 68 square kilometers.

The accumulated deforestation between August 2010 and January 2011, corresponding to the first six months of the current deforestation calendar, totaled 858 square kilometers. There was a slight increase of 3% in relation to the same previous period (August 2009 to January 2010) when the deforestation totaled 836 square kilometers.

The degraded forests in the Legal Amazon totaled 541 square kilometers in December 2010. Compared to December 2009, when the degradation totaled 11 square kilometers, there was a highly significant increase of 4,818%. In relation to January 2011, the forest degradation affected 376 square kilometers. This represented an increase of 637% compared to January 2010 when the forest degradation was 51 square kilometers.

The accumulated forest degradation between August 2010 and January 2011 totaled 3,722 square kilometers. This represented a significant increase (338%) compared to the previous period (August 2009 to January 2010) when the forest degradation totaled 850 square kilometers.

The forest carbon affected by the deforestation between August 2010 and January 2011 (first six months of the current deforestation calendar) was 13.9 million tons, that is, about 51 million tons of CO₂ equivalent. This represents a reduction of 5.2% in relation to the previous period (August 2009 to January 2010) when forest carbon affected by deforestation was about 47 million tons of CO₂ equivalent.

Through SAD it was only possible to monitor 30% of the forest area in the Legal Amazon in December 2010 and January 2011. The remaining 70% was covered by clouds, which made monitoring of the region difficult, especially in Amapá, Pará e Acre, which had over 80% of the forest area covered by clouds. Based on this, the deforestation and degradation data for November may be underestimated.

Deforestation Statistics

According to Imazon's Deforestation Alert System (SAD), deforestation (that is, full suppression of the forest with soil exposure) in the Legal Amazon in December 2010 affected 175 square kilometers (Figure 1 and Figure 2).

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This represented a significant increase of 994% in the deforestation of December 2010 in comparison to the deforestation detected in December 2009 when the deforestation affected 175 square kilometers. There was also an increase in January 2011 when 83 square kilometers of deforestation was recorded, which represented an increase of 22% in relation to January 2010 when the deforestation affected 68 square kilometers (Figure 1 and Figure 3).

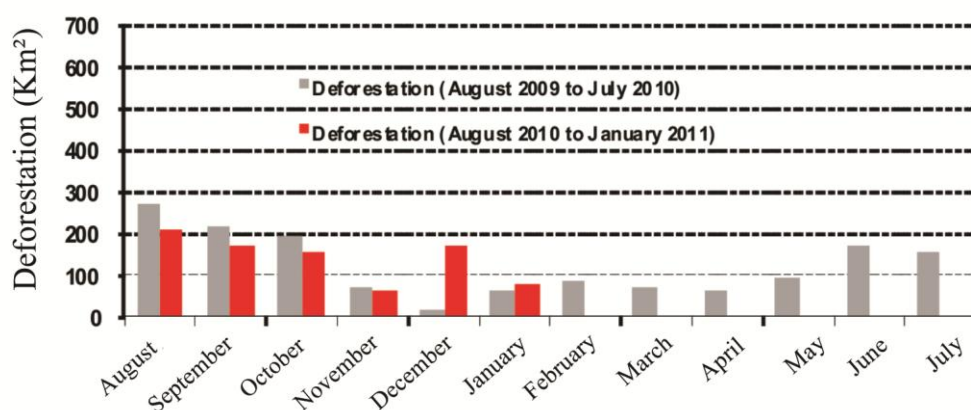


Figure 1. Deforestation of August 2009 to January 2011 in Legal Amazon (Source: Imazon/SAD).

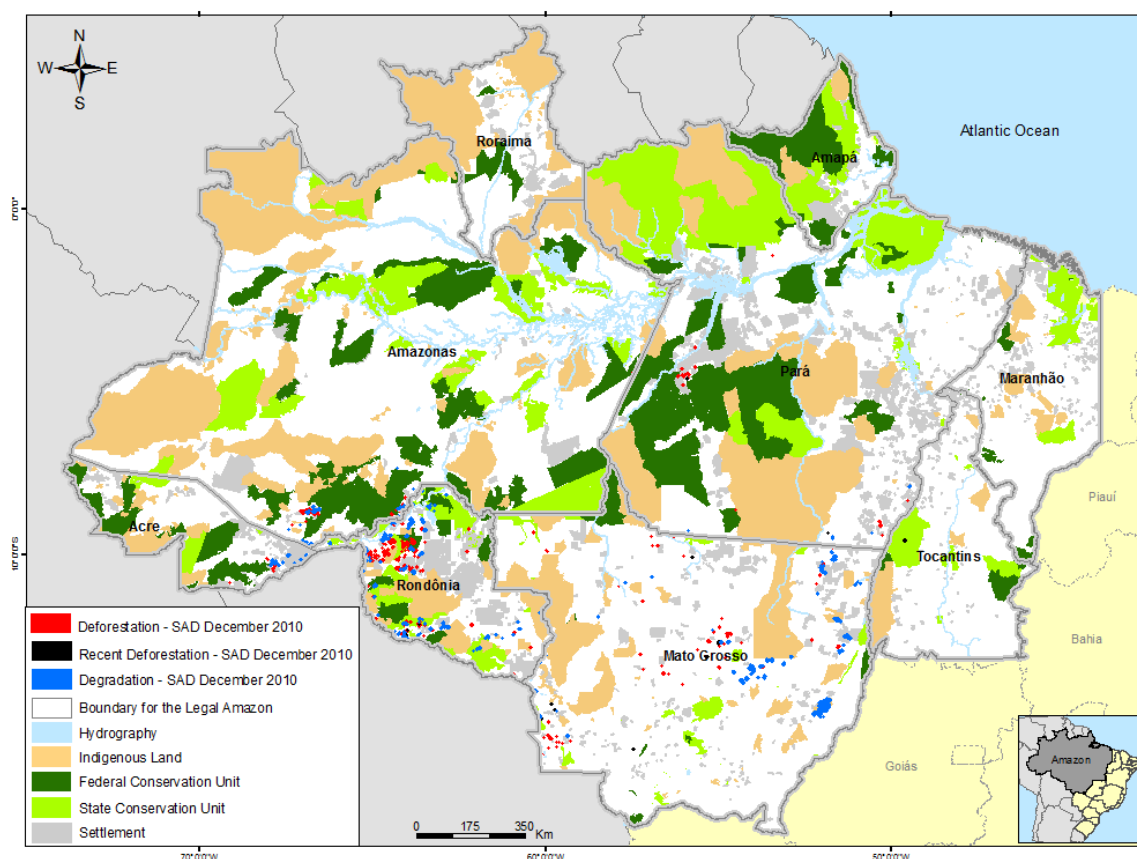


Figure 2. Deforestation and Forest Degradation in December 2010 in the Legal Amazon (Source: Imazon/SAD).

*The recent deforestation may have occurred in December or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

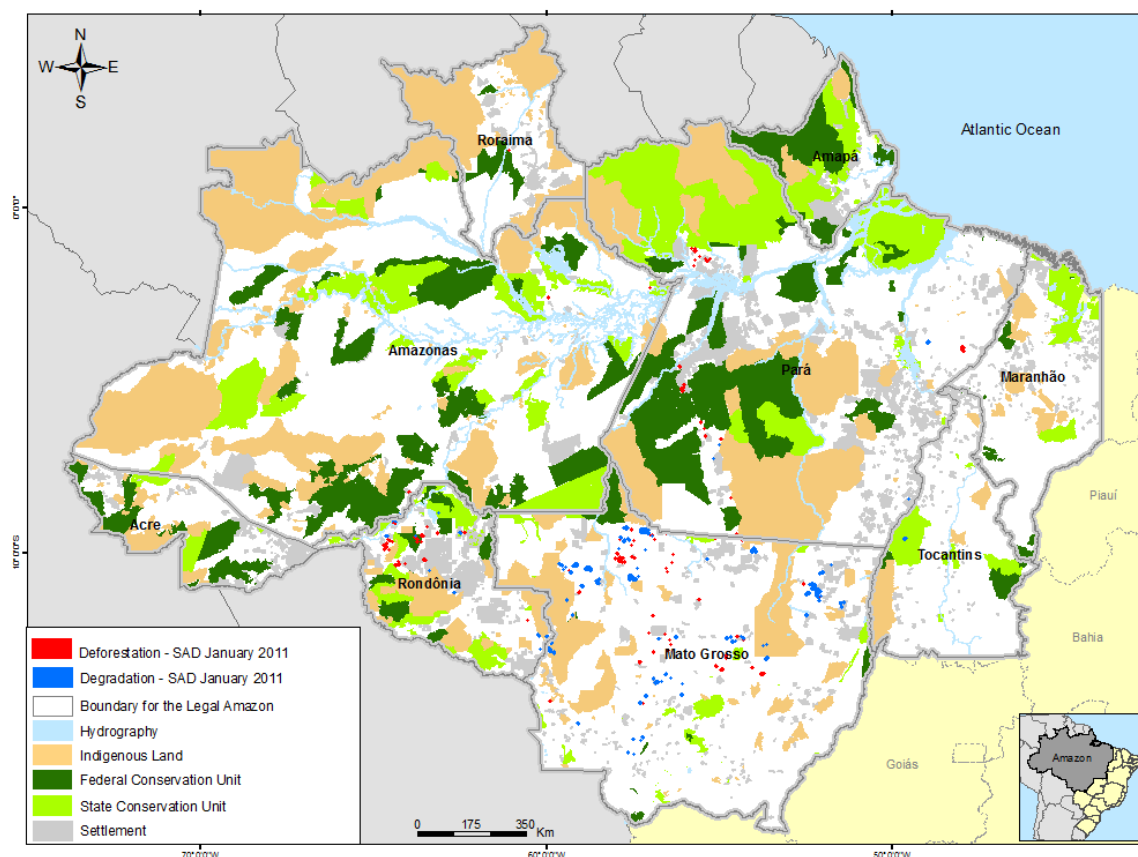


Figure 3. Deforestation and Forest Degradation in January 2011 in the Legal Amazon (Source: Imazon/SAD).

*The recent deforestation may have occurred in January or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

The accumulated deforestation between August 2010 and January 2011¹, corresponding to the first six months of the official deforestation measurement calendar, affected 858 square kilometers. This represents a slight increase of 3% in the accumulated deforestation of this period (August 2010 to January 2011) compared to the same period the previous year (August 2009 to January 2010) when the deforestation affected 836 square kilometers.

In December 2010, Rondônia contributed with 43% of the total deforested area in the Legal Amazon (Figure 4). Followed by Mato Grosso with 31% and Amazonas with 16%. The deforestation in the other States was proportionally smaller, with Pará contributing with 5%, Acre with 4% and Tocantins with 1%. The deforestation in Pará was smaller in December 2010, probably due to the heavy cloud cover in this State (85% of cloud cover in the forest area).

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

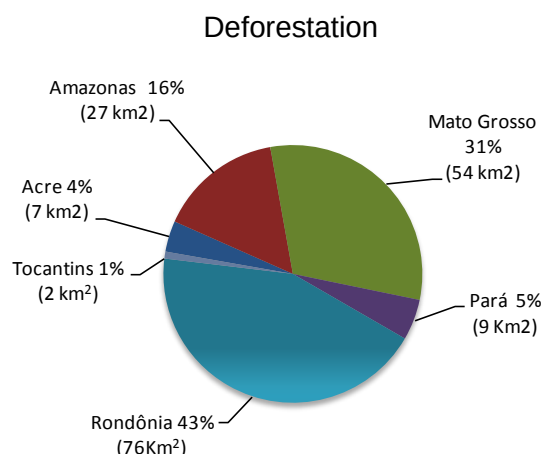


Figure 4. Deforestation (%) in the States of the Legal Amazon in December 2010 (Source: Imazon/SAD).

In January 2011, the deforestation in Mato Grosso was higher with 57% of the total, followed by Pará with 20% and Rondônia with 18% (Figure 5). The remaining occurred in Amazonas with 4% and Roraima with 1%.

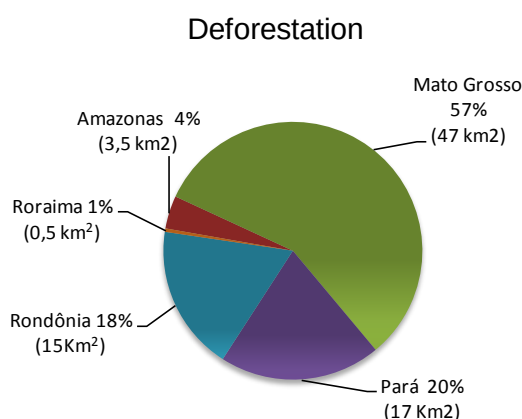


Figure 5. Deforestation (%) in the States of the Legal Amazon in January 2011 (Source: Imazon/SAD).

Considering the first four months of the current deforestation calendar (August 2010 to January 2011), Mato Grosso leads the ranking with 30% of the total deforestation in the period. Followed by Pará with 27%, Rondônia with 22% and Amazonas with 14%. These four states are responsible for 93% of the deforestation that occurred in the Legal Amazon during this period. The remaining (7%) deforestation occurred in Acre, Roraima and Tocantins.

Comparing the deforestation that occurred between August 2010 and November 2010 with the same period the previous year (August 2009 and January 2010), there was a 3% increase in the deforestation of the Legal Amazon (Table 1). In relative terms, this increase was more significant in Mato Grosso (+98%), followed by Rondônia (+88%), Acre (+48%) and Amazonas (+33%). On the other hand, there was a reduction of 88% in Roraima and 45% in Pará.

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In absolute terms, Mato Grosso leads the accumulated deforestation ranking with 256 square kilometers, followed by Pará (234 square kilometers), Rondônia (190 square kilometers) and Amazonas (120 square kilometers).

Table 1. Evolution of deforestation between the States of Legal Amazon from August 2009 to January 2010 and August 2010 to January 2011 (Source: Imazon/SAD).

State	August 2009 to January 2010	August 2010 to January 2011	Variation (%)
Acre	33	49	+ 48
Amazonas	90	120	+ 33
Mato Grosso	129	256	+ 98
Pará	427	234	- 45
Rondônia	101	190	+ 88
Roraima	41	5	- 88
Tocantins	-	4	-
Amapá	15	-	-
Total	836	858	+3

*The data of Maranhão were not analyzed.

Forest Degradation

In December 2010, SAD registered 541 square kilometers of degraded forests (forests intensely explored by the timber activity and/or fires) (Figures 2 and 6). This corresponds to an extremely significant increase of 4,818% compared to the same period the previous year (December 2009) when the forest degradation affected only 11 square kilometers. From the total, majority (53%) of this degradation occurred in Mato Grosso, followed by Rondônia (32%), Amazonas (10%), Acre (4%) and Pará (1%) (Figure 7).

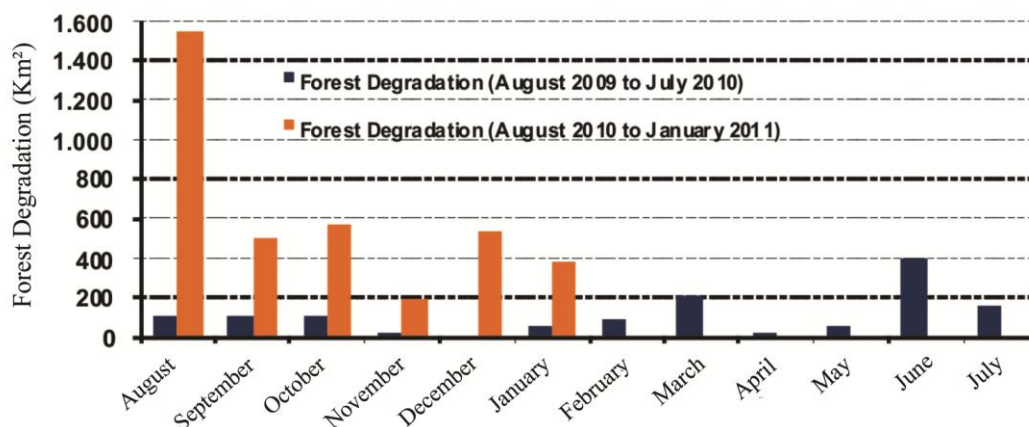


Figure 6. Forest Degradation of August 2009 to January 2011 in Legal Amazon (Source: Imazon/SAD).

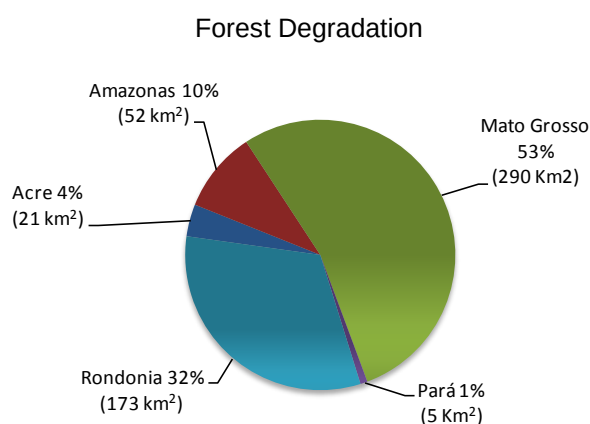


Figure 7. Forest Degradation (%) in the States of Legal Amazon in December 2010 (Source: Imazon/SAD).

In January 2011, SAD registered 376 square kilometers of degraded forest (Figures 3 and 6). This corresponds to an increase of 637% compared to the same period the previous year (January 2010) when the forest degradation affected 51 square kilometers. From the total, majority (93%) of this degradation occurred in Mato Grosso, followed by Rondônia (4%), Amazonas (1%), Pará (1%) and Tocantins (1%) (Figure 8).

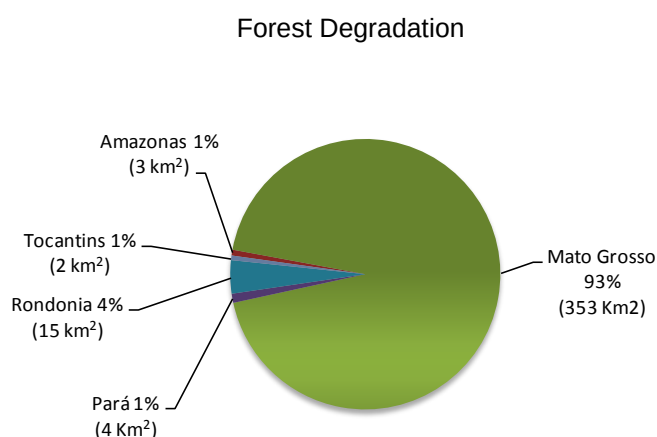


Figure 8. Forest Degradation (%) in the States of Legal Amazon in January 2011 (Source: Imazon/SAD).

The accumulated forest degradation between August 2010 and January 2011², (first six months of the official deforestation measurement calendar) affected 3,722 square kilometers. This represents a highly significant increase of 338% in the accumulated forest degradation in this period (August 2010 to January 2011) compared to the same period the previous year (August 2009 to January 2010) when the forest degradation affected 850 square kilometers (Table 2).

In relative terms, Tocantins presented a significant increase of 2,500%, however, in absolute terms, the increase was highly reduced, changing from only 1 square kilometer

² The official deforestation measurement calendar begins in the month of August and ends in the month of July.



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between August 2009 and January 2010 to 26 square kilometers between August 2010 and January 2011. Other states also contributed to the increased forest degradation: Amazonas (+557%), Acre (+504%), Mato Grosso (+482%), Rondônia (+302%) and Pará (+147%). Only Roraima presented a reduction of 75% in forest degradation in the analyzed period.

Mato Grosso leads the ranking with 59% of the total accumulated degraded forest areas between August 2010 and January 2011, followed by Pará with 20% and Rondônia with 13%. These three states were responsible for 92% of the forest degradation in the Legal Amazon during this period. The remaining 8% occurred in Amazonas, Acre, Tocantins and Roraima

In absolute terms, Mato Grosso leads the ranking of accumulated forest degradation with 2,181 square kilometers, followed by Pará (741 square kilometers), Rondônia (491 square kilometers), Acre (145 square kilometers), Amazonas (138 square kilometers), Tocantins (26 square kilometers) and Roraima (2 square kilometers).

Table 2. Evolution of forest degradation between the States of Legal Amazon from August 2009 to January 2010 and August 2010 to January 2011 (Source: Imazon/SAD).

State	August 2009 to January 2010	August 2010 to January 2011	Variation (%)
Acre	24	145	+504
Amazonas	21	138	+557
Mato Grosso	375	2,181	+482
Pará	300	741	+147
Rondônia	122	491	+302
Roraima	8	2	-75
Tocantins	1	26	+2,500
Amapá	1	-	-
Total	850	3,722	+338

*The data of Maranhão were not analyzed.

Carbon Affected by the Deforestation

In December 2010, the 175 square meters of deforestation detected by SAD in Legal Amazon affected 2.6 million tons of carbon (with an error margin of 385 thousand tons). This amount of affected carbon results in 9.5 million tons of CO² equivalent (Figure 9). This represents an increase of 346% in relation to December 2009 when the affected forest carbon was 582 million tons.

In January 2011, the 83 square meters of deforestation detected by SAD in Legal Amazon affected 1.4 million tons of carbon (with an error margin of 194 thousand tons). This amount of affected carbon results in 5.1 million tons of CO² equivalent

(Figure 9). This represents an increase of 16% in relation to January 2010 when the affected forest carbon was 1.2 million tons.

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The forest carbon affected by the deforestation from August 2010 to January 2011 (first six months of the current deforestation calendar) was 13.9 million tons (with an error margin of 339 thousand tons), which represented about 51 million tons of CO₂ equivalent (Figure 9). In relation to this same period of the previous year (August 2009 to January 2010) there was a 5.2% reduction in the amount of carbon affected by the deforestation.

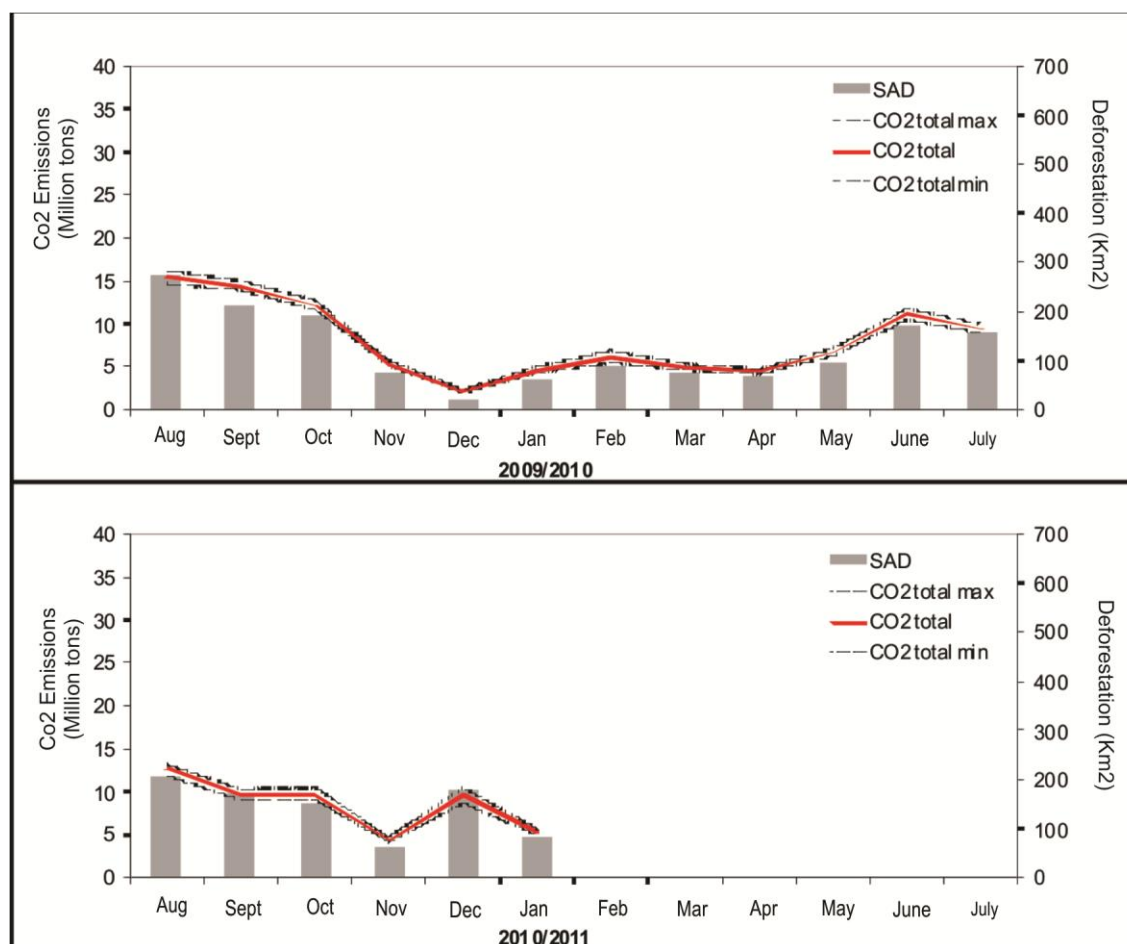


Figure 9. Deforestation and total emissions of Carbon Dioxide (CO₂) equivalent from August 2009 to January 2011 in Legal Amazon (Source: Imazon).

Geography of the Deforestation

Regarding the land situation in December 2010, majority (78%) of the deforestation occurred in private areas or in areas under different stages of ownership. The remaining deforestation was recorded in Conservation Units (14%), followed by Agrarian Reform Settlements (6%) and Indigenous Lands (3%) (Table 3). In January 2011, majority (86%) of the deforestation occurred in private areas or areas under different stages of ownership, 8% in Agrarian Reform Settlements and 6% in Conservation Units (Table 4).

Table 3. Deforestation per land category in December 2010 in the Legal Amazon (Source: Imazon/SAD).

Category	December 2010	
	km ²	%
Agrarian Reform Settlement	10	6
Conservation Units	24	14
Indigenous Lands	5	3
Private, Owned & Vacant ³	137	78
Total (km²)	176	100

Table 4. Deforestation per land category in January 2011 in the Legal Amazon (Source: Imazon/SAD).

Category	January/2011	
	km ²	%
Agrarian Reform Settlement	7	8
Conservation Units	5	6
Indigenous Lands	-	-
Private, Owned & Vacant ⁴	71	86
Total (km²)	83	100

Agrarian Reform Settlements

SAD registered 10 square kilometers in the Agrarian Reform Settlements in December 2010. The settlements most affected by the deforestation were Monte (Lábrea; Amazonas), Joana D'Arc-I (Porto Velho; Rondônia) and Joana D'Arc-III (Porto Velho; Rondônia) (Figure 10). In January 2011, the deforestation at the Agrarian Reform Settlements was 7 square kilometers. The most deforested Settlements were Arauna (Novo Mundo; Mato Grosso), São Francisco (Canutama; Amazonas) and Joana D'Arc-III (Porto Velho, Rondônia) (Figure 11).

³ Includes private areas (owned or not) and unprotected public forests.

⁴ Includes private areas (owned or not) and unprotected public forests.

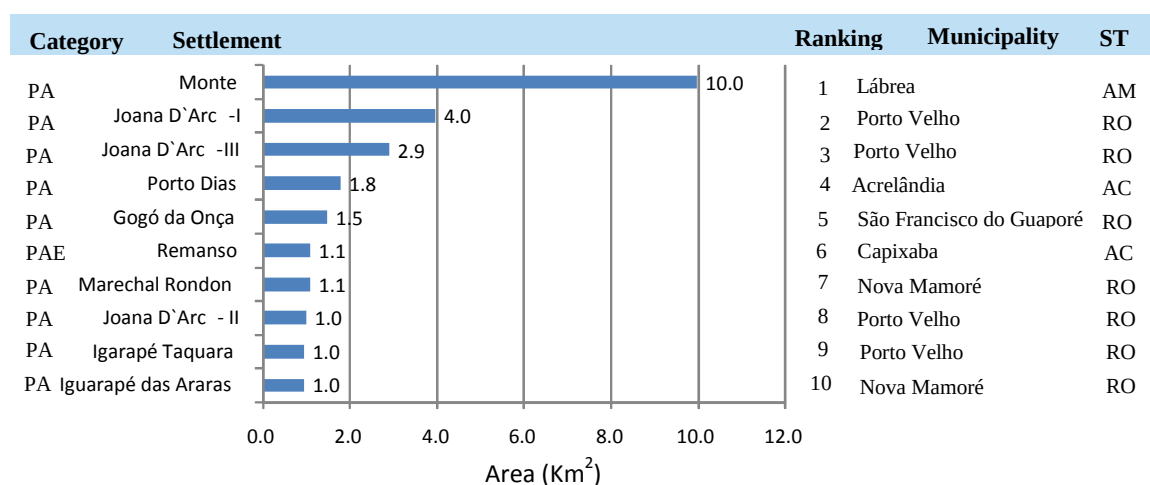


Figure 10. Most deforested Agrarian Reform Settlements in December 2010 in Legal Amazon (Source: Imazon/SAD).

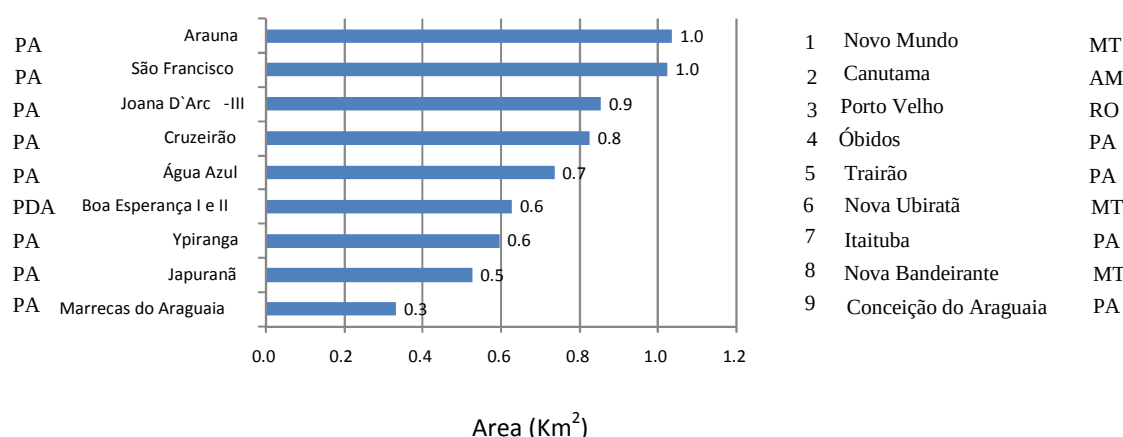


Figure 11. Most deforested Agrarian Reform Settlements in January 2011 in Legal Amazon (Source: Imazon/SAD).

Protected Areas

SAD detected 24 square kilometers of deforestation in the Conservation Unit in December 2010 (Figure 12). The Conservation Units that suffered deforestation the most were: RESEX Jaci Paraná (Rondônia), APA Rio Pardo (Rondônia), and APA Leandro (Ilha do Bananal/Cantão) (Tocantins). In January 2011, the deforestation totaled 5 square kilometers at the Conservation Units (Figure 13). The Conservation Units that suffered deforestation the most were: APA Rio Pardo (Rondônia), APA Leandro (Ilha do Bananal/Cantão) (Tocantins) and Flona do Bom Futuro (Rondônia).

In the case of Indigenous Lands, 5 square kilometers were detected in December 2010. The most deforested Indigenous Lands are in Rondônia: Tubarão/Latundê, Sagarana and Pacaás-Novas (Figure 14). Deforestation was not detected in the Indigenous Lands of the Legal Amazon in January 2011.

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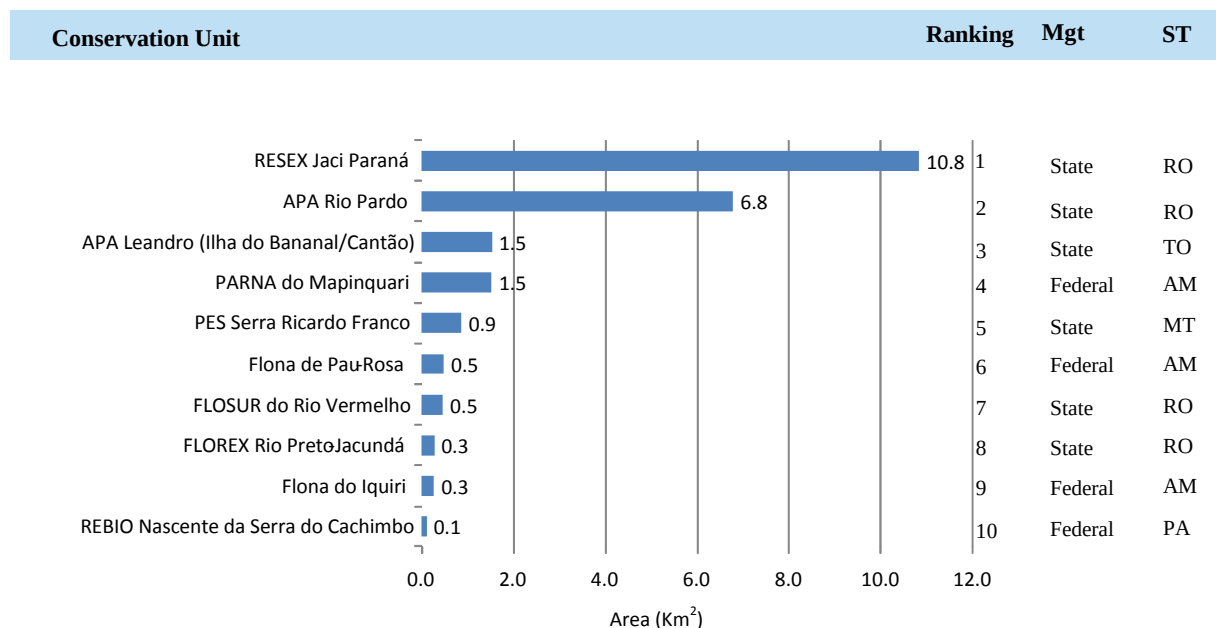


Figure 12. Most deforested Conservation Units in Legal Amazon in December 2010 (Source: Imazon/SAD).

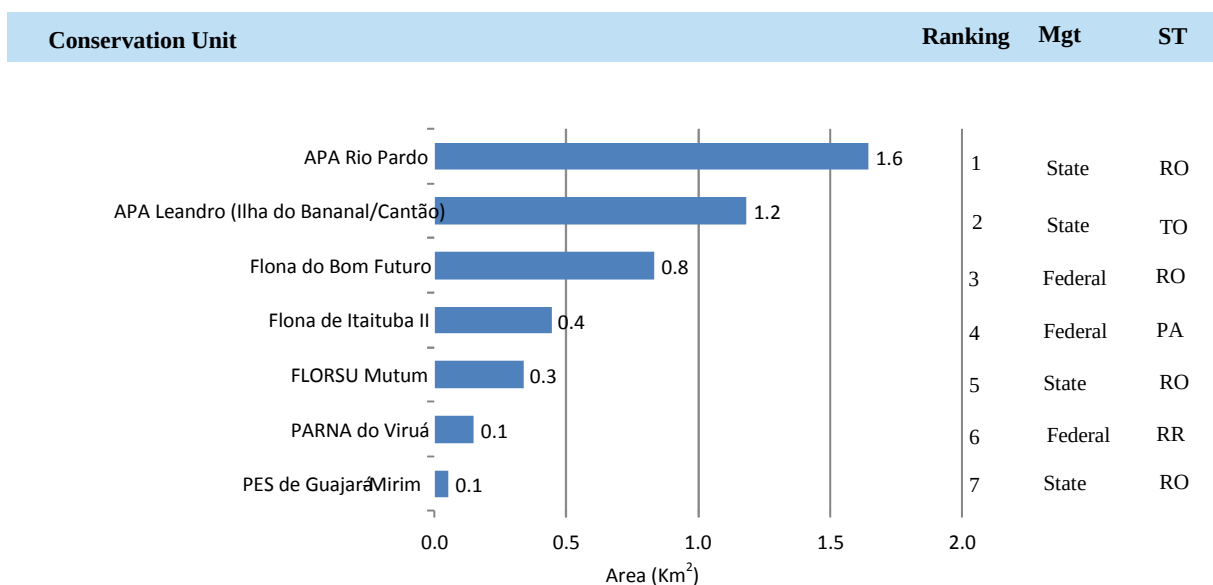


Figure 13. Most deforested Conservation Units in Legal Amazon in January 2011 (Source: Imazon/SAD).

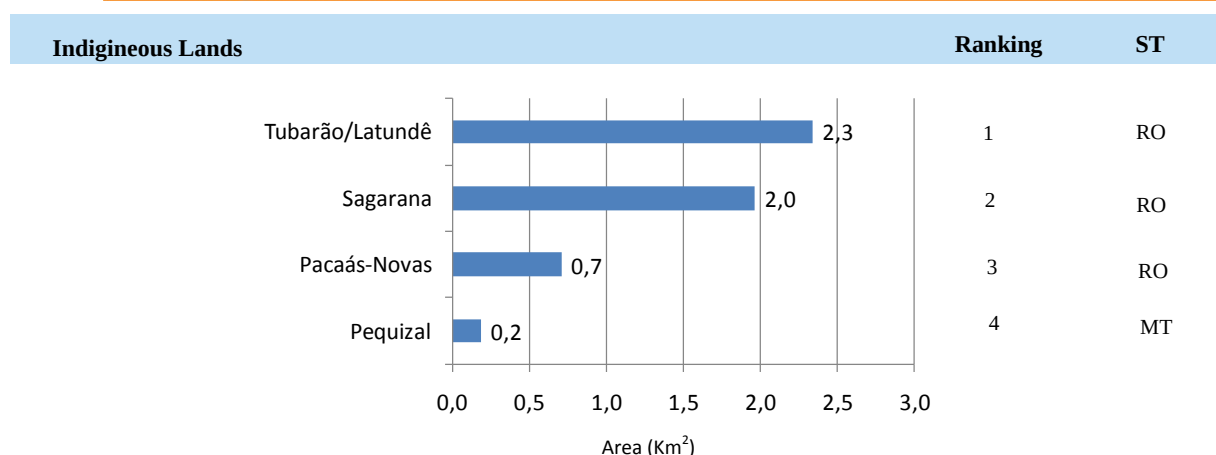


Figure 14. Most deforested Indigenous Lands in Legal Amazon in December 2010 (Source: Imazon/SAD).

Critical Municipalities

The most deforested municipalities in December 2010 were: Porto Velho (Rondônia) with 39 square kilometers, Lábrea (Amazonas) with 17.6 square kilometers, and Feliz Natal (Mato Grosso) with 16.5 square kilometers (Figures 15 and 17). In January 2011, the deforestation was more significant in the municipalities of Nova Ubiratã (Mato Grosso) with 11 square kilometers, Gaúcha do Norte (Mato Grosso) with 7.6 square kilometers and Porto Velho (Rondônia) with 7.5 square kilometers (Figure 16 and Figure 18).

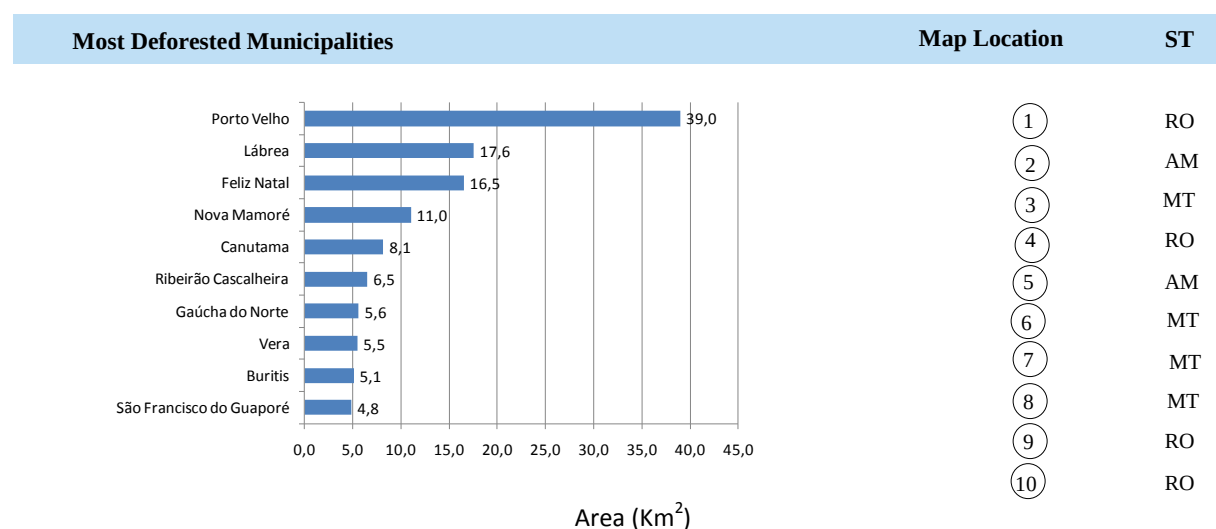


Figure 15. Most deforested municipalities in Legal Amazon in December 2010 (Source: Imazon/SAD).

Most Deforested Municipalities	Map Location	ST
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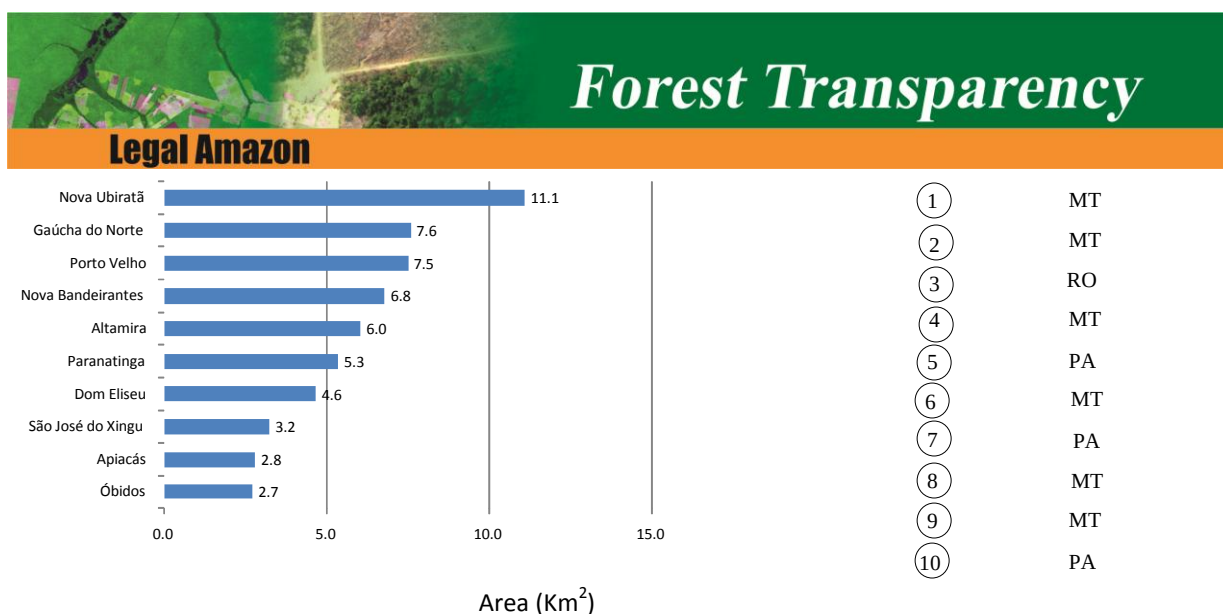


Figure 16. Most deforested municipalities in Legal Amazon in January 2011 (Source: Imazon/SAD).

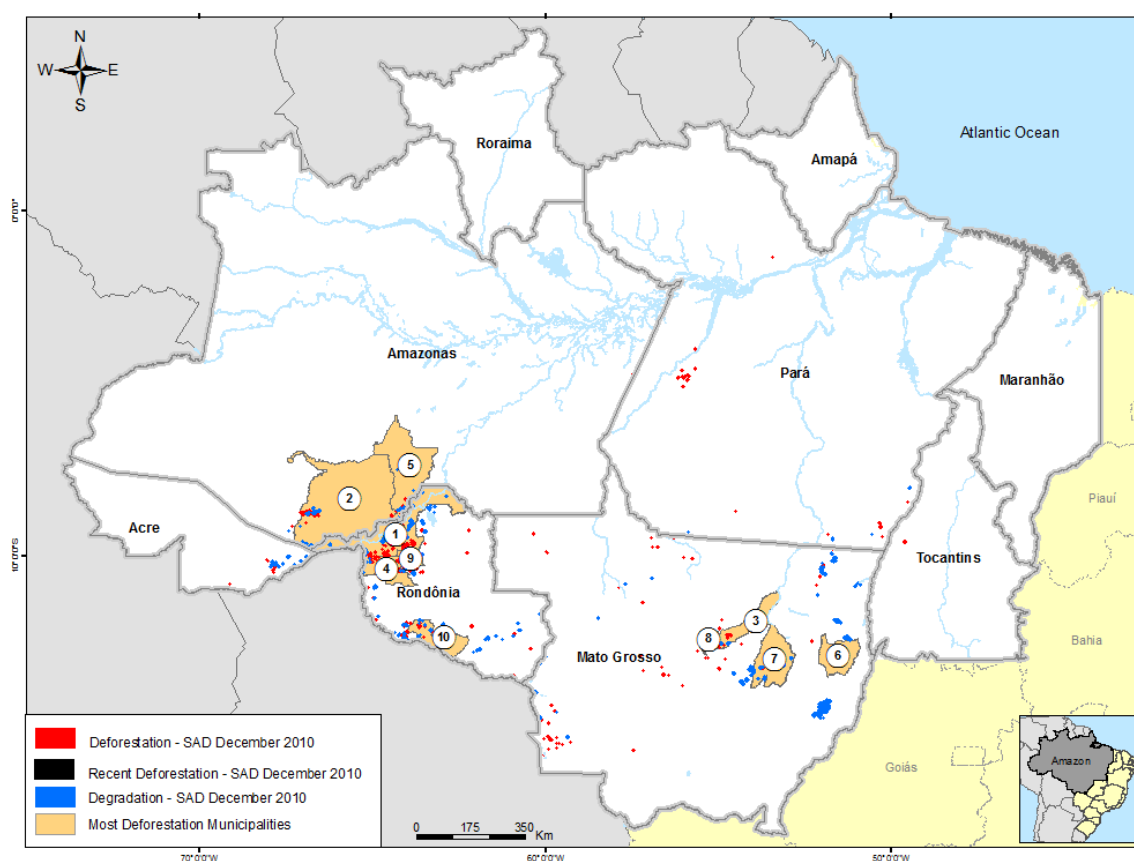


Figure 17. Most deforested municipalities in November 2010 (Source: Imazon/SAD).

*The recent deforestation may have occurred in December or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

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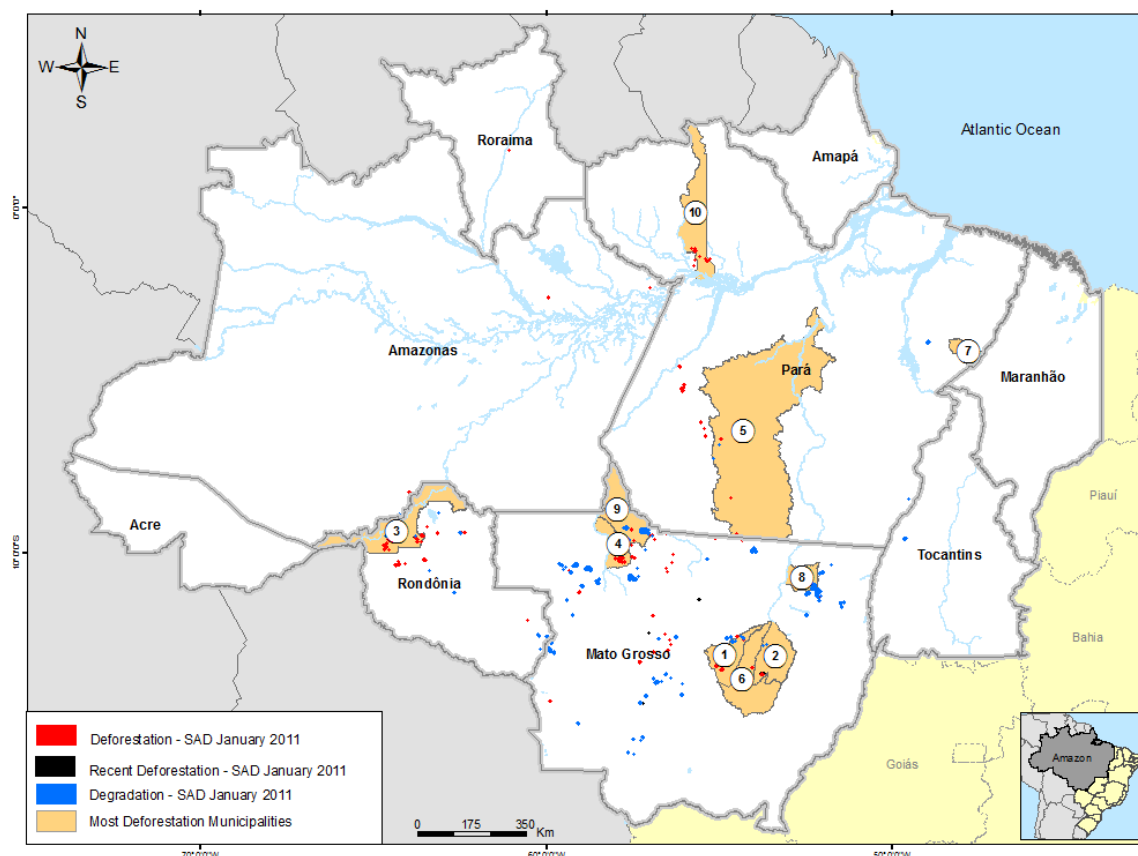


Figure 18. Most deforested municipalities in January 2011 (Source: Imazon/SAD).

*The recent deforestation may have occurred in January or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

Cloud and Shade Cover

Through SAD it was only possible to monitor 30% of the forest area in the Legal Amazon in December 2010 and January 2011. The remaining 70% of the land was covered by clouds, which made deforestation monitoring difficult. The unmapped region corresponds to over 80% of the forest area of Acre, Amapá and Pará (Figure 19 and Figure 20). Based on this, the deforestation data for these States may be underestimated for December 2010 and January 2011.

* The part of Maranhão that is part of the Legal Amazon was not analyzed.

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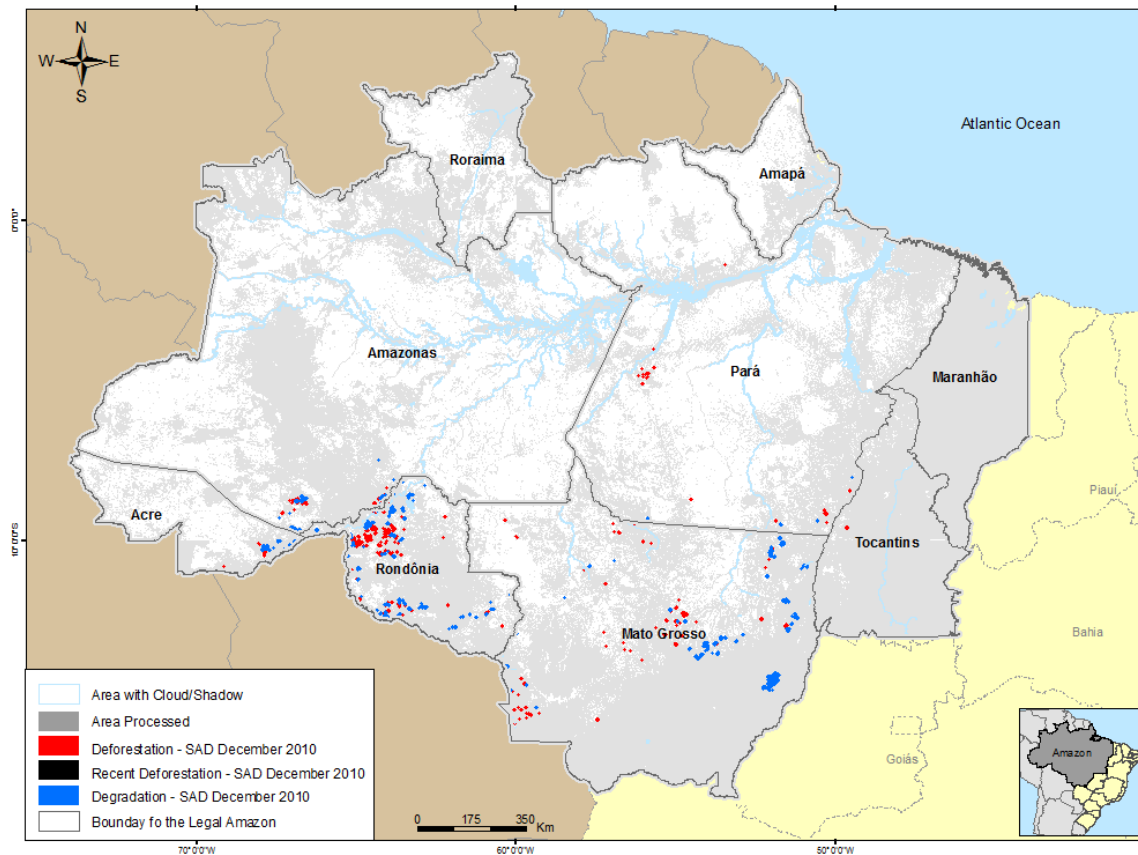


Figure 19. Area with cloud and shade in December 2010 in Legal Amazon.

*The recent deforestation may have occurred in December or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

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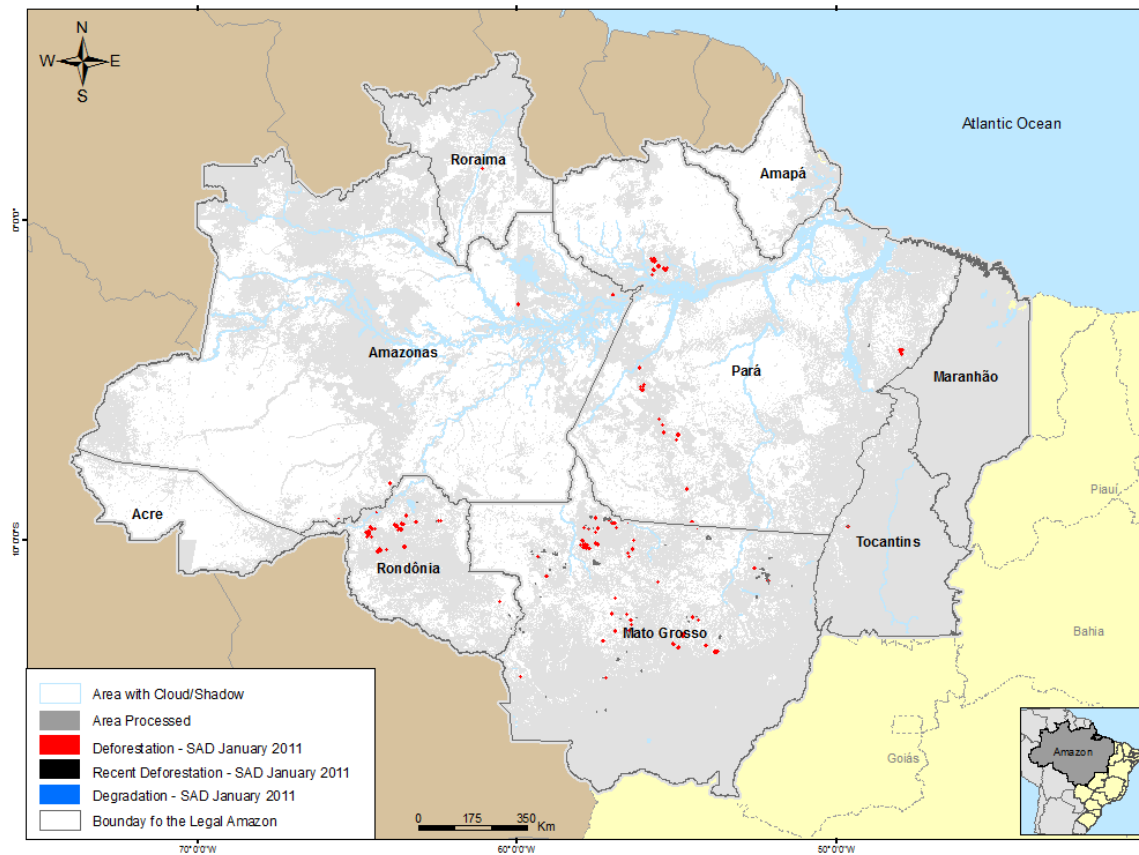


Figure 20. Area with cloud and shade in January 2010 in Legal Amazon.

*The recent deforestation may have occurred in January or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

Validation of SAD data using Landsat and Cbers Imaging

SAD data are validated using CBERS and Landsat imaging (higher spatial resolution) provided by the National Institute for Space Research (Inpe). The images available soon after the month analyzed by SAD are used. All deforestation polygons detected by SAD are checked using the detailed images. Deforestation less than 6.25 hectares, that is, below the detection capacity of SAD, are not included in the statistics, in case they occur in the images with more detailed resolution. However, in the case of confirmation of false deforestation signals detected by SAD, these are removed from the monthly statistics.

In December 2010 and in January 2011, it was possible to validate 60% and 70% of the deforestation detected by SAD, respectively, using Landsat images (Figure 21 and Figure 22). The other 40% (December 2010) and 30% (January 2011) of the deforestation were not confirmed due to the high occurrence of clouds in the Landsat and CBERS images provided at the time.

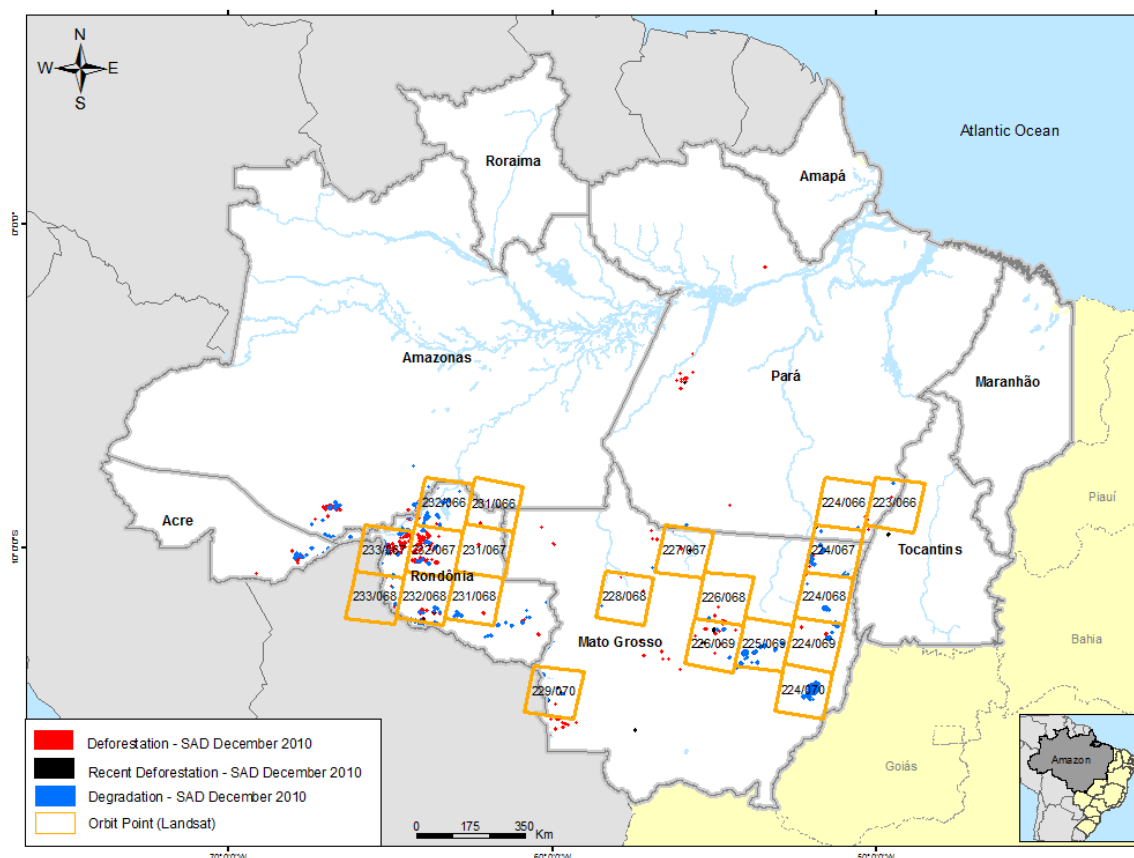
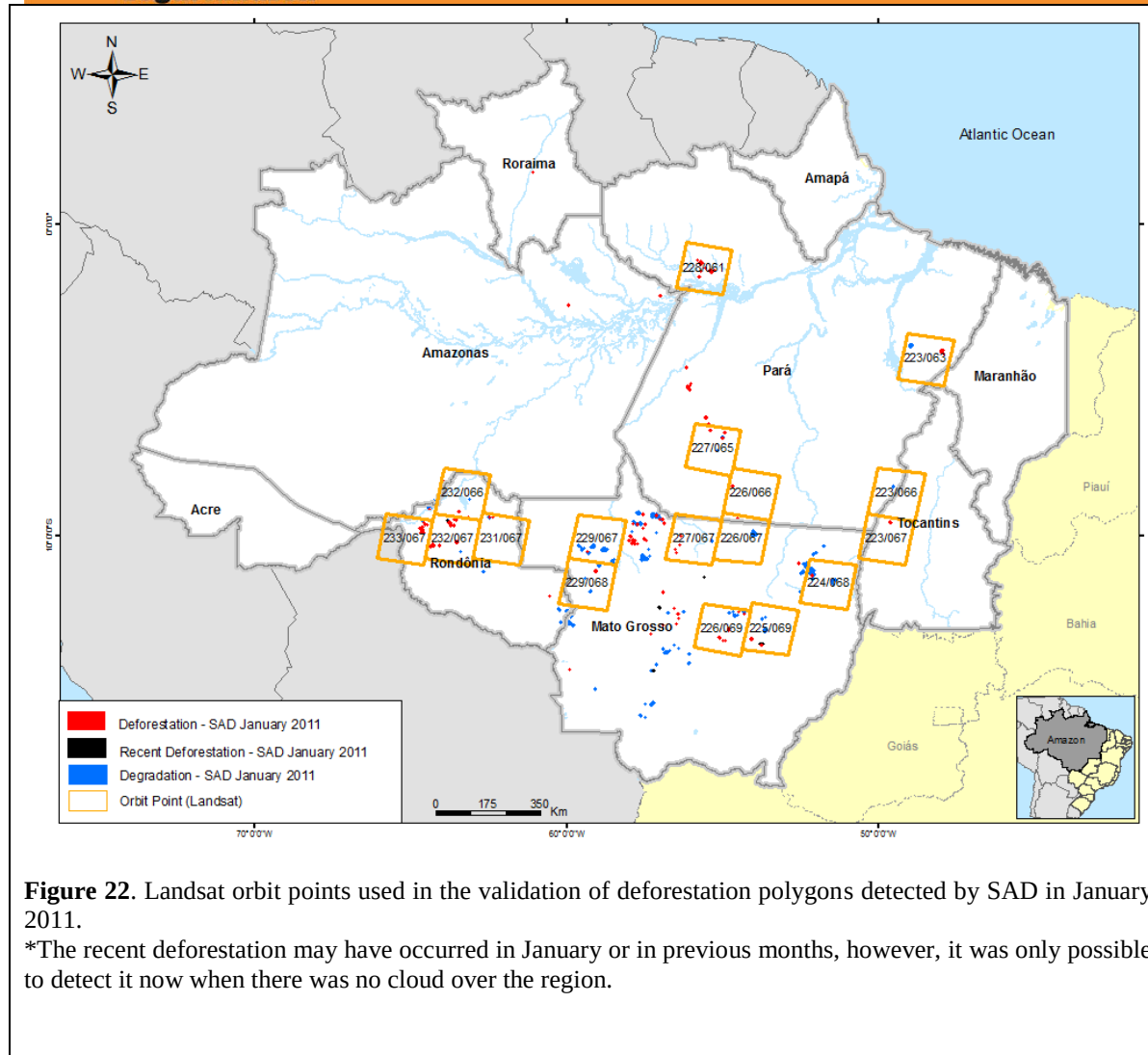


Figure 21. Landsat orbit points used in the validation of deforestation polygons detected by SAD in December 2010.

*The recent deforestation may have occurred in December or in previous months, however, it was only possible to detect it now when there was no cloud over the region.

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Section I: SAD 3.0

SAD generates temporary MODIS mosaic images daily from the products MOD09GQ and MOD09GA for cloud filtration. A fusion technique for different spectral resolution bands, that is, with pixels of different sizes, was then used. In this case, the 5 bands scale with a pixel of 500 meters of the MODIS was changed to 250 meters. This allowed the improvement of the spectral pixel mixture model, providing the ability to estimate the abundance of Vegetation, Soils and Non-Photosynthetic components (NPV) (Vegetation, Soil and Shade) 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 Vegetation component normalized for shade given by:

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

NDFI varies from -1 (pixel with 100% of exposed soil) to 1 (pixel with > 90% with forest vegetation). Therefore, we have a continuous image showing the transition of the deforested areas, passing through degraded forest until it reaches forests without signs of disturbance.

This month the detection of the deforestation and degradation had different NDFI images of consecutive months. Therefore, a reduction in the NDFI values between -200 and -50 indicated possibly deforested areas and between -49 and -20 with signs of degradation.

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

SAD is already operating in the state of Mato Grosso since august 2006 and in Legal Amazon since April 2008. This bulletin presents the monthly data generated by SAD from August 2006 to November 2010.

Section II: Carbon affected by the deforestation

The carbon estimates are generated based on the combination of SAD deforestation maps with simulations of the spatial biomass distribution for the Amazon. A carbon emission estimation model called *Carbon Emission Simulator* (CES) was developed based on the stochastic simulation (Morton *et al.*, in prep.). One thousand (1000) spatial biomass distribution simulations in the Amazon were generated using a geostatic model (Sales *et al.*, 2007), and these biomass simulations were transformed into C-stocks using biomass conversion factors for C from 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_t : Carbon emitted in month t.

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

S_D : Deforested area:

BVAS: Biomass aboveground at the deforested region S_D .

BPF: Biomass from forest products removed from forests before deforestation.

fc: coal fraction (3 to 6%).

BAS_0 : Underground biomass before deforestation.

pd: monthly decomposition parameter of the underground biomass after deforestation (0.0075).

$pd \times e^{(-pd \times t)}$: Monthly decomposition rate of underground biomass after deforestation.

To apply the CES model using SAD data, only the carbon affected by the deforestation was considered, which is the fraction of forest biomass made up of carbon (50%) subject to instant emissions caused by forest fires from the deforestation and/or future decomposition of the remaining forest biomass. Also, the CES model was modified to estimate the forest carbon affected by deforestation on a monthly scale. Lastly, simulations enabled the estimation of affected carbon uncertainty, represented by the standard deviation (+/- 2 fold) of simulations of the carbon affected each month.

Apply the value 3.68 to convert carbon values to CO₂ equivalent.

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. In preparation.

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



Notes:

Team Responsible:

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Team: Marcio Sales (Modeling and statistics), Rodney Salomão, Amintas Brandão Jr., João Victor (Geoprocessing) and Bruno Oliveira (Communication)

Data Source:

The deforestation statistics are generated from SAD data (Imazon);

INPE Data - Deforestation (PRODES)

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

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David & Lucille Packard Foundation through CLUA (Climate Land Use Alliance)

Gordon & Betty Moore Foundation

Vale Fund

Environmental State Secretariat

Partnerships:

Environmental State Secretariat of Pará (SEMA)

Environmental Secretariat of Mato Grosso (SEMA)

Federal Public Ministry of Pará

State Public Ministry of Pará

State Public Ministry of Roraima

State Public Ministry of Amapá

State Public Ministry of Mato Grosso

Instituto Centro de Vida (ICV- Mato Grosso)