

Satellite Images for Evaluating Forest Management Plans

André Monteiro* & Carlos Souza Jr.

Timber harvesting with forest management is selective, meaning that three to five trees are removed per hectare (<5%), leaving behind small clearings. Those clearings are generally considered difficult to detect using satellite images. However, studies at Imazon have demonstrated that it is possible to detect log harvesting and assess the quality of forest management by using such images. In this *The State of the Amazon*, we represent the results of an assessment of the quality of forest management plans in the central-western region of the Legal Amazon, using “good practice” forest management indicators based on Landsat images. Of a total of 87 plans authorized in 2003 by Ibama for that region, the majority (54%) presented evidence of irregularities based on those images. Among the irregularities are: lack of signs of timber harvesting, logging carried out before authorization, logging followed by deforestation and area logged larger than the area declared in the plan. We suggest that the method be used in the licensing and monitoring process for private areas with and without forest certification and in areas under forest concession in the Amazon.

Central-Western Amazon

We analyzed 87 forest management plans¹, approved in 2003 by Ibama, located in the central-western region of the Legal Amazon, which covers the eastern part of the State of Pará and southwestern Amazonas State (Figure 1).

This region has been the target for opening thousands of kilometers of illegal roads² and new deforestation fronts. Additionally, depletion of timber stocks in old timber production centers^{3,4} has forced the timber industry to migrate to the region. Responding to such pressure, the federal government and the Amazonas State government have created a broad mosaic of Conservation Units to halt the advance of the deforestation frontier into the central-western Amazon.⁵

Forest Management Plans in the Satellite Images

Monitoring of forest management plans in the Amazon requires time-consuming and costly verification in the field. However, Imazon studies on monitoring

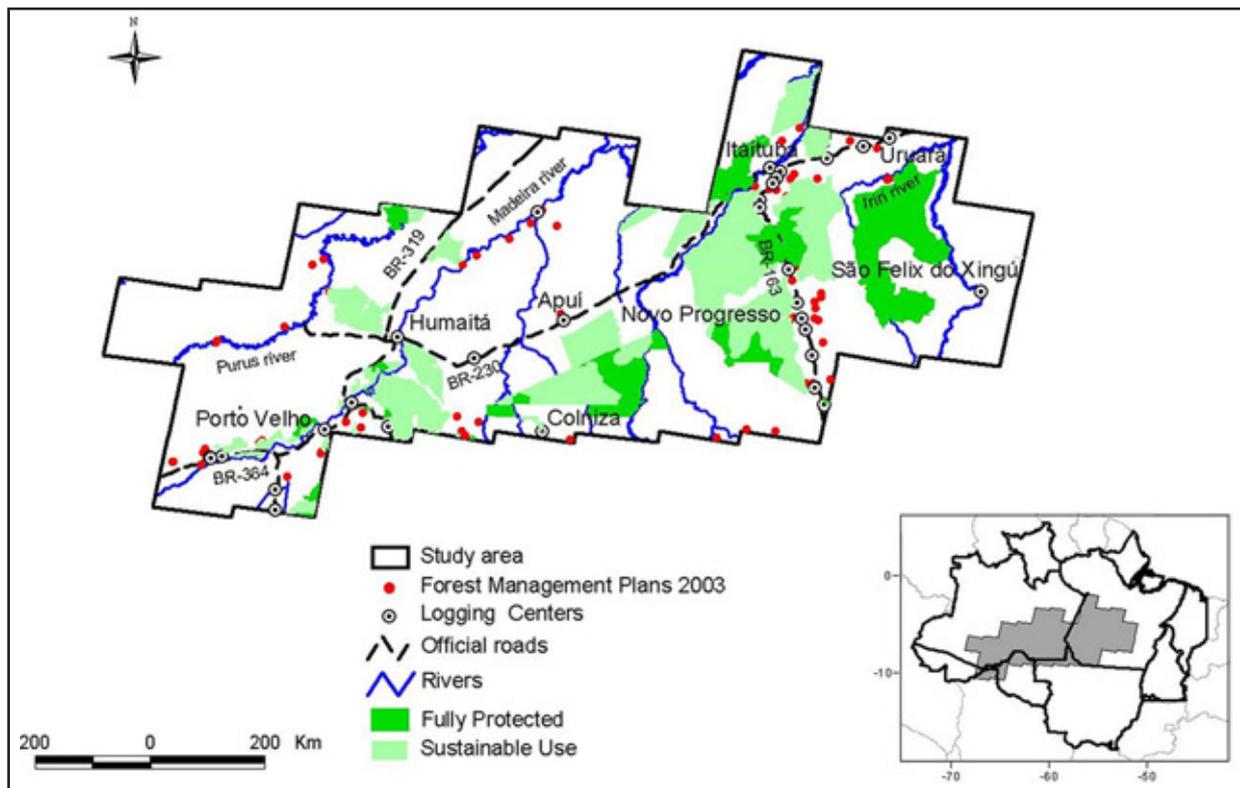


Figure 1. Forest management plans authorized in 2003 in the central-west Legal Amazon.

logging with satellite images have demonstrated that it is possible to evaluate the quality of management plans using such images.^{6,7} Furthermore, it is possible to assess whether the plans have or have not been carried out, if logging has occurred before authorization and if the management plan area has been deforested after logging.⁸

Situation of the Forest Management Plans

Of the 87 management plans evaluated, 43 (49%) presented visible scars⁹ from log harvesting in the images. Of these, 10% were logged before receiving authorization and 3% were deforested after logging. The remainder (51%) did not present visible scars in the images (Figure 2).

Among the plans that were visible in the image, almost all (93%), according to Ibama data¹, were apt or

apt with restrictions^{10,11} for timber harvesting (Table 1). Non-apt or suspended plans totaled 7% of the plans carried out. Carrying out a plan that has not received authorization for logging constitutes an infraction and serves as an alert for an on-site inspection.

On the other hand, of the 44 management plans that were not visible in the images, the great majority (80%) were apt or apt with restrictions for logging. The remaining plans, not detected in the images (20%), were not apt, were cancelled or were suspended¹¹ (Table 1). Absence of logging scars in the image of the management plan harvest area may be considered an alert, which requires on-site verification of the situation. This type of problem may be associated with three factors: (i) geographic localization errors in the management plan; (ii) management plan not carried out in the field in the authorized area¹²; and (iii) unauthorized timber harvesting in other areas.¹³

In considering all of the problems with the management plans (apt plans without signs of logging, logging before authorization and deforestation after logging), we concluded that 54% of the management plans in this study presented some type of irregularity (Figure 2).

Quality of the Forest Management Plans

We compared the 43 management plans detected in the satellite images with 4 management plans examined in the field in the regions of Paragominas, in Pará, and Sinop, in Mato Grosso – where the tests and validation were conducted (Table 2)⁷. The management plans were assessed with indicators that can be measured in the satellite images and analyzed regarding the quality of forest management.

The management plans analyzed present indicators¹⁴ (density of log decks and roads, distance between secondary roads and between log decks) similar to those obtained for predatory logging in Sinop (Table 2). Therefore, we may infer that construction of the log decks and roads in the management plans analyzed may have been poorly planned. Field inspections may be made to verify those indications. The form of the harvested area and the spatial distribution of the log decks and roads were classified as systematic and non-systematic¹⁵ (Figure 3). The majority (79%) of the management plans presented a systematic form for the logged area,

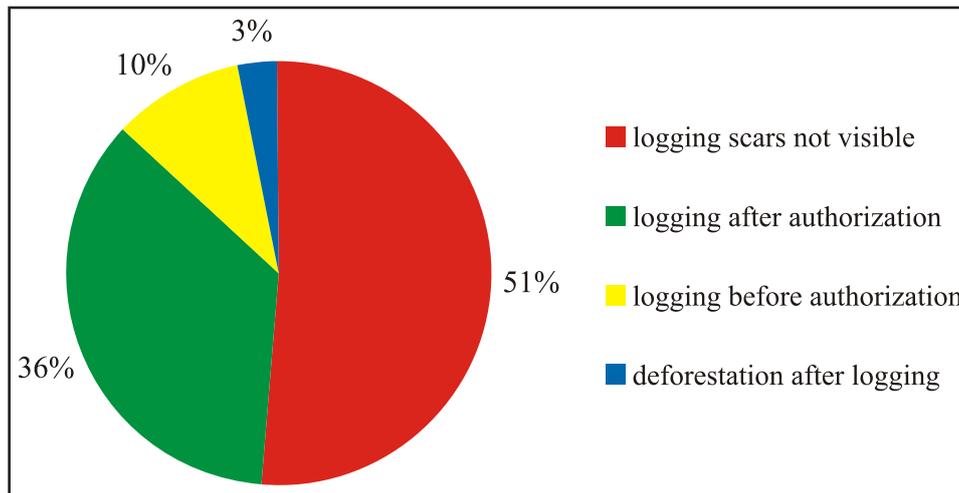


Figure 2. Situation of the forest management plans in satellite images.

Table 1. Legal situation of the visible and non-visible forest management plans in the satellite images.

Plan Non-Visible		
Apt	31	71%
Apt with restrictions	4	9%
Not apt + Suspended	8	18%
Cancelled	1	2%
Total	44	100%
Plan Visible		
Apt	39	91%
Apt with restrictions	1	2%
Not apt + Suspended	3	7%
Total	43	100%

Table 2. Comparison between the indicators (average) measured in the images from the central-western Amazon and those measures in the field in Paragominas and Sinop.

Region	Logging type	Density		Distance	
		Road (m ha ⁻¹)	Log landing (n ha ⁻¹)	Secondary roads (m)	Log landing (m)
Central-West Legal Amazon	Managed*	16	0,03	623	484
Paragominas (PA)	Managed	23	0,08	469	260
	Predatory	36	0,15	513	301
Sinop (MT)	Managed	32	0,07	455	347
	Predatory	19	0,01	508	512

*Declared in the plans as forest management.

whereas log decks (60%) and roads (58%) presented a non-systematic distribution. (Figure 4). According to the technical specification¹⁶ for installing infrastructure established and approved in the management plan, the non-systematic distribution of log decks and roads may indicate poor quality in planning infrastructure for storing and transporting timber. Infractions of this rule call for corrective action that must be fulfilled by the time of the next harvest.¹⁶

We also evaluated the relation between the area authorized for logging in the management plan with the harvested area detected in the satellite image. We observed that only 6% of the management plans showed that the area logged was approximately equal to the area authorized; 32% presented a logged area greater than the area authorized; and 11% showed a logged area smaller than the area authorized. The remainder (51% of the plans) did not present visible signs of logging in the images.

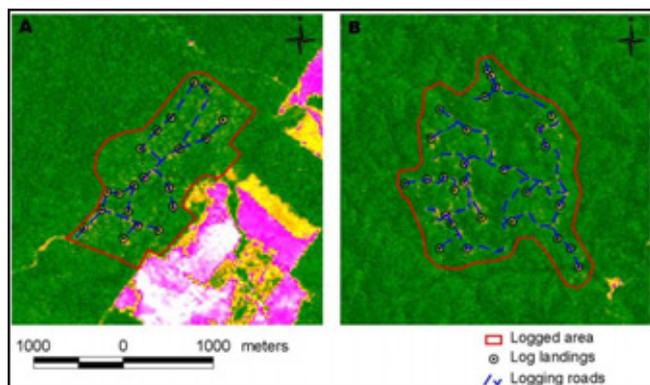


Figure 3. Examples of forest management plans seen in the Landsat images, indicating the shape of the logged area – systematic (A) and non-systematic (B)– and the spatial distribution of log decks and roads –systematic (A) and non-systematic (B).

When we add the management plans that presented a logged area larger than the area authorized with plans that presented a logged area that was not visible in the image (apt plans), we noted that 72% of them showed an indication of problems in relation to the area logged.

Information on the situation and quality of the plans may be combined for a general assessment.

Our analyses revealed that the majority of plans (82%) presented some type of alert that deserves to be verified in the field.

Suggestions for Public Policies

The results of this study showed that it is possible to monitor forest management plans in the Amazon by means of satellite images. Thus, we suggest two applications of the method for public policies:

Licensing. Guarantee that the licensed areas are primary forests, with the potential for production and

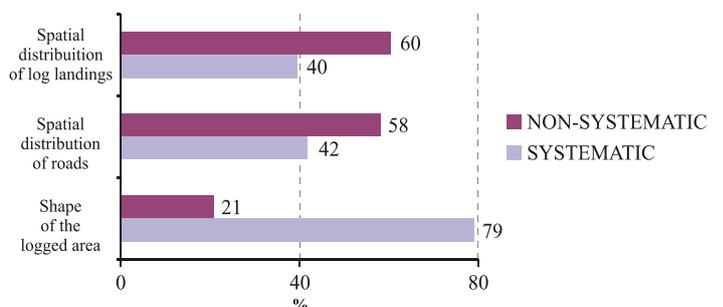


Figure 4. Evaluation of the scale of the logged area and the spatial distribution of log decks and roads in the forest management plans obtained through satellite images.

legalized land title situation. Therefore, by overlaying the management plan polygon on images of NDFI⁸ and Protected Areas, it would be possible to prevent approval of plans in irregular or inappropriate areas (deforested areas, Indigenous Lands, Full Protection Conservation Units, Permanent Preservation Areas, and others). Inclusion of criteria related to: (i) density of log decks and roads; (ii) distance between roads and between log decks; and (iii) data (day/month/year) of the felling and skidding operations – in regulations for approving management plans – could contribute towards increasing transparency of the forest sector in the Amazon.

Monitoring. Identify irregularities in execution of management plans. That way it would be possible to

verify: if the plan was carried out, if logging occurred before authorization, if the area in the plan was deforested after logging, if the area logged was authorized for harvesting and if the plan presents evidences of poor planning for log decks and roads. Therefore, it would be possible to select management plans for an annual technical inspection in the field by the appropriate environmental agency, and prioritize the most critical areas.

Additionally, the method could be used for monitoring Public Forests¹⁷ under a forest concession and certified area regime in the Amazon. In the latter case, it would be used to determine the areas to be inspected in the field, as part of the forest certification process, as well as to annually monitor them, for the auditing process.

Notes

* Corresponding author: andreluiz@amazon.org.br

¹ Map of forest management plans supplied by the Ministry of the Environment (MMA) and produced with data from Sisprof/Ibama. The information contained in the management plans includes: information on date of authorization issuance, total area, authorized area, volume authorized, geographic location, and other data.

² Souza Jr., C.; Brandão Jr.; A., Anderson, A. & Veríssimo, A. 2005. Avanço das Estradas Endógenas na Amazônia. *O Estado da Amazônia nº 1*. Belém: Imazon. 2 p.

³ Timber centers in eastern Pará, northwestern Mato Grosso, northern Rondônia and the lower Acre region.

⁴ Lentini, M.; Pereira, D.; Celentano, D. & Pereira, R. *Fatos Florestais da Amazônia 2005*. Belém: Imazon. 140 p. Available at: <http://www.imazon.org.br/downloads/im_livros_015.zip>. Access on: April 28, 2006.

⁵ 3.1 million hectares of Conservation Units were created in the region of Apuí, in Amazonas (Decreets N.º 24.806/2005, 24.807/2005, 24.808/2005 and 24.812/2005) and 6.1 million along the BR-163 highway in Pará (Decreets sn of 2/13/06 National Forests: Crepori, Jamanxim, Trairão and Amana), with some 4.7 million hectares, destined for production forests.

⁶ Souza Jr., C.; Monteiro, A. L. & Barreto, P. 2003. Exploração madeireira na Amazônia: é possível monitorar por satélite? *Ciência Hoje* 197: 62-65.

⁷ Monteiro, A.L. 2005. (Avaliação de Indicadores de Manejo Florestal na Amazônia Legal Utilizando Sensoriamento Remoto. Universidade Federal do Paraná – Curitiba, Master's Thesis in Forest Management. 105 p.).

⁸ First, we plotted those management plans on the NDFI images {index developed by Souza Jr. (2005) to highlight areas under selective timber harvesting and degraded by logging and fire} generated using Landsat images (42 images were used). Next, since we did not have the polygons delimiting the area of the management plans, we digitalized the perimeter of the area potentially harvested in the plan, considering the localization coordinates, the area declared in the management plan and the signs of logging (log deck, storage and road scars and canopy disturbances). Finally, we simultaneously inspected the three images (2002, 2003 and 2004), identifying the image in which the scars from timber harvesting, with reference to the management plan, were present.

⁹ Defined by logging roads, log decks and forest areas with small clearings opened.

¹⁰ Forest management plan with unresolved legal or technical issues.

¹¹ Report after the last field inspection by Ibama.

¹² Hummel, A.C. 2001 (Normas de Acesso ao Recurso Florestal na Amazônia Brasileira: O Caso do Manejo Florestal Madeireiro. Universidade Federal do Amazonas (Ufam) and Instituto Nacional de Pesquisas da Amazônia (Inpa) – Manaus, Master's Thesis in Tropical Biology and Natural Resources. 104 p).

¹³ According to Antônio Carlos Hummel (Forestry Director at Ibama), 60% of forest production in 2003 was of illegal origin. Hummel, A.C. DOF: a tecnologia contra o crime. Available at: <<http://www.oeco.org.br>>. Access on: November 30, 2006.

¹⁴ Information on the density of log decks and roads and on the distance between roads and between log decks for storing timber in the forest are not required in the management plans. However, such data are important to show the level of planning for timber harvesting.

¹⁵ An area systematically harvested presents a perimeter with rectilinear segments with an approximately rectangular shape, whereas a non-systematic area has perimeters with sinuous contours and a non-rectangular shape. Systematic spatial distribution of log decks and roads occurs when the roads are rectilinear and parallel and contain log decks regularly distributed along the roads, while a non-systematic spatial distribution is defined by sinuous roads with log decks interconnected by their segments.

¹⁶ Embrapa/Ibama. 2006. *Manual de vistoria de campo para planos de manejo florestal madeireiro na Amazônia*. Brasília: Paquiderme Propaganda. 106 p. The technical specifications for infrastructure installation require that the secondary roads be built with rectilinear tracing and be arranged in parallel, unless the approved management plan calls for other tracing due to the topography of the terrain, and that the log decks for storage be distributed in a systematic manner.

¹⁷ Natural or planted forests, located in the various Brazilian biomes, in assets under the domain of the Federal Government, the States, the municipalities, the Federal District or indirectly administered agencies (Law N.º 11.284, of March 2, 2006).

Research for this *The State of the Amazon* was financed by the Gordon & Betty Moore Foundation. We would like to thank Adalberto Veríssimo and Paulo Barreto for their collaboration.