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Article

Verificadores de sostenibilidad en inventarios forestales del bosque amazónico en el estado de Mato Grosso (Brasil)

Sustainability verifiers of forest inventories of the tropical forest of the *Mato Grosso* State, Brazil

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Abstract

Sustainable management plans for tropical forests including wood harvesting should be based on 100 % forest inventories, according to official Brazilian standards. To evaluate the forestry work carried out in 20 sites managed under sustainable forest management plans, located in *Mato Grosso* state, Brazil, 140 tropical sustainability forest verifiers were analyzed, 17 of them only to monitor the details of the forest inventories, completed and ongoing. 65 % of the 17 verifiers received the annotation to carry out corrective actions within one year, 18 % urged to perform corrective actions in 60 days, 5 % had the annotation of recommended, and 12 % were subject to suspension in the execution of the respective sustainable management forest plans. The textual and cartographic information collected in the technical reports and thematic maps had field verification, allowing to know the position of the felled trees and the location of the usable trees. Official verification standards were objective enough to leave little room for the subjectivity of inventory quality assessors. The evaluation system was efficient. The inventory workers shrew an enormous lack of dendrological knowledge in relation to botanical identification.

Key words: Forest certification, sustainability evaluation, indicator, forest survey, forest management, sustainable forest management plan.

Resumen

De acuerdo con lo establecido en las normas oficiales de Brasil, los planes de manejo sostenible para los bosques tropicales en los que se pretende ejecutar extracciones madereras, deben basarse en inventarios forestales realizados en 100 % de la superficie sujeta al aprovechamiento. Para evaluar los trabajos forestales realizados en 20 sitios gestionados con planes de manejo forestal sostenible localizados en el estado de *Mato Grosso*, Brasil, se analizaron 17 verificadores tropicales de sostenibilidad de un total de 140, relativos a los inventarios forestales concluidos y en curso. Los resultados mostraron que 65 % de ellos requieren acciones de corrección en el plazo máximo de un año, 18 % en 60 días, 5 % tenían solo carácter de recomendación, y 12 %

proponían la suspensión de los programas forestales de manejo. Se contrastó sobre el terreno la información textual y cartográfica procedente de los inventarios, lo cual permitió conocer la localización geográfica de los árboles derribados y de los aprovechables. Las normas oficiales de verificación son suficientemente objetivas como para dejar poco margen a la subjetividad de los evaluadores de la calidad de los inventarios. El sistema de evaluación fue eficiente. La identificación botánica evidenció una enorme carencia de conocimientos dendrológicos por parte de los responsables de los inventarios.

Palabras clave: Certificación forestal, evaluación de sostenibilidad, indicador, inventario forestal, ordenación forestal, plan de manejo forestal sostenible.

Introduction

Forest management in the sustained yield regime considers that in the management of a stand, only what the forest is capable of producing in a certain period will be extracted, without compromising its natural structure. Brazilian legislation (Brasil, 2007) establishes that the Amazon forest must be exploited under this principle. However, the norms referring to the intensities of sustainable logging were established in 2004, by the government forest bodies: Brazilian Institute of Renewable Natural Resources and Environment and the National Environment Council. These intensities are intended to be economically viable and ecologically acceptable, as well as capable of being modified according to the growth rate of each species, and with the development dynamics of the stand itself.

DeFries *et al.* (2006), UNEP (2012) and Kleinn (2015) consider it necessary to carry out a rigid monitoring of the forest, especially in areas of forest concessions under

an efficient active control of the institutional administration; this would result in a coherent execution of forest inventories carried out at 100 %.

Forest inventory is conceived as the basis for efficient forest planning, in which it is considered that a consistent survey of qualitative and quantitative information can be obtained through a well-structured inventory process (Imaña-Encinas, 2021). For the sustainable management plans of tropical forests for timber harvesting purposes, the inventory will offer the determination or estimation of the mensuration variables and the corresponding growth potential (Imaña-Encinas, 2011; 2021), in addition to showing their relationship with ecological and natural environment elements, as well as the phytosanitary status of the trees.

In this context, it is justified that sustainable forest management plans subject to official standards should be structured on the execution of comprehensive forest inventories. In this way, its results will show representative dasometric parameters of the tree population, which allow the efficient planning of wood extraction, and the implementation of the sustainable forest management system itself.

Mallén and Guerra de la Cruz (2008) indicate that the criteria and indicators (C&I) of sustainability of forest management must meet the budget of social, economic and ecological laws guaranteed by the amount of communal goods and services, which are increasingly used by state control agencies (Narváez *et al.*, 2003; FAO, 2015; Ross, 2015; Reygadas and Franco, 2016; Martín and Lafuente, 2017). Thus, the C&I are presented as key concepts for the development of effective information and communication systems as a reference framework to define, monitor and evaluate forest management through their corresponding results (Prabhu *et al.*, 1998; Pokorny and Adams, 2003; González, 2012; Magrama, 2012).

In the definition of C&I, the first-order concepts are formed by fundamental truths or strategic evaluation (Luján *et al.*, 2003) which are the laws that are called Principles. At a second level, the criteria are the standards that judge the principles. In the case of sustainable forest management, they must express the real state or condition of the forest that is intended to be managed. Indicators are usually specific actions, information or prescriptions that can be evaluated as indicators of the respective criteria. The verifiers, at a fourth level, express pertinent information for the evaluation of the indicators (Magrama, 2012).

According to Barthod (1998), the C&I for sustainable forest management began to form part of the political debate at the initiative of the Canadian delegation in the preparatory process for the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. The proposal gave rise to the well-known Agenda 21 (Brasil, 2007). From the C&I it is possible to establish the limits of sustainability of natural resources, since they form the basis for monitoring their environmental quality, in addition to conditioning the survey and systematization of the measurement variables, which allows their transformation into synthetic indicators (Morán *et al.*, 2006; FAO, 2015).

The principles of the C&I offer a primary structure that is considered essential for sustainable forest management (Prabhu *et al.*, 1998; FSC Brasil, 2002; Forest Management Division, 2003; Nobre da Silva, 2012; FAO, 2015), in addition to justifying the application of the corresponding criteria, indicators and checkers. According to Lammerts van Bueren and Blom (1997), they represent the rules for reasoning and define them as the hierarchical frame of reference for evaluating the quality of forest management. Its aim is to monitor, assess and report on the state

of sustainable forest management, at the local, regional or national level (Meza *et al.*, 2003; Magrama, 2012; FAO, 2015).

Therefore, criteria are the characteristic feature of a process based on the practices of sustainable forest management, which can be considered, interpreted and evaluated.

An indicator is a quantitative or qualitative parameter that can be assessed in relation to a certain criterion (Poschen, 2000; Mendoza and Prabhu, 2002).Criteria are established as intermediate points of the information provided by the indicators. These are structured as a descriptive, quantitative and qualitative attribute that, when measured or monitored periodically, indicates the corresponding level of forest management that is being executed.

The verifier is the set of data or information that is highlighted to evaluate an indicator (Brasil, 2007; González, 2012). Consequently, at the fourth level of specificity, verifiers must provide intrinsic details that indicate or reflect a specific condition of an indicator (Lammerts van Bueren and Blom, 1997; Reygadas and Franco, 2016).

The Brazilian Agricultural Research Company (Embrapa), the Center for International Forestry Research (Cifor), the Brazilian Forest Administrations (Ibama) and the Brazilian Forest Service (SFB, as of 2006) have developed the C&I to evaluate the adoption of the sustainable forest management of Amazonian forests (Brasil, 2007).

As of January 2nd, 2019, the SFB was integrated into the organizational chart of the Ministry of Agriculture, Livestock and Supply, created in 2006 by the Ministry of the Environment (SFB, 2019). In 2007, the basic standards were established for the preparation of field procedures aimed at the evaluation of sustainable forest management plans, and the issuance of the corresponding reports (Brasil, 2007;

SFB, 2019). For this, 140 verifiers were defined for the stages and aspects of the forest management chain (Embrapa and Ibama, 2006). For each verifier, its evaluation method was determined, which considers the corresponding quantitative limits to facilitate the interpretation of the information contained in the relevant operations.

In this context, Mexico has a guide with 10 principles, 25 criteria, 40 identifiers and 69 verifiers (Reygadas and Franco, 2016). Ecuador, on the other hand, considers another concept of quality of life and equity to achieve insertion in the markets for environmental goods and services, which seeks to reconcile population growth with the use of forest products and services (Santamaría, 2019, Almeida-Guzmán and Díaz-Guevara, 2020): biodiversity, forests, bio-aquatic resources, soil, marine, insular and continental water resources, beaches and bays, nature tourism and energy. Chauchard *et al.* (2016) presents 30 exemplary cases of success in sustainable forest management.

The objective of this study was to assess the forest work carried out in 20 sites managed with sustainable forest management plans, located in the state of *Mato Grosso*, Brazil, based on 17 tropical sustainability verifiers out of a total of 140, relative to the Forest inventories completed and in progress.

Materials and Methods

The study was carried out in 20 sites with forest management plans (SMF) approved by Ibama, which are located in the north of the state of *Mato Grosso* (Figure 1). Among the 140 verifiers included in the regulations of the Forest Administration of Brazil, the 17 relative and exclusive ones were applied for the evaluation of the accomplished forest inventories (Table 1). Thus, the methods established in the federal regulations (Embrapa e Ibama, 2006; Brasil, 2007) that evaluate the quality of the forest inventory carried out were used.

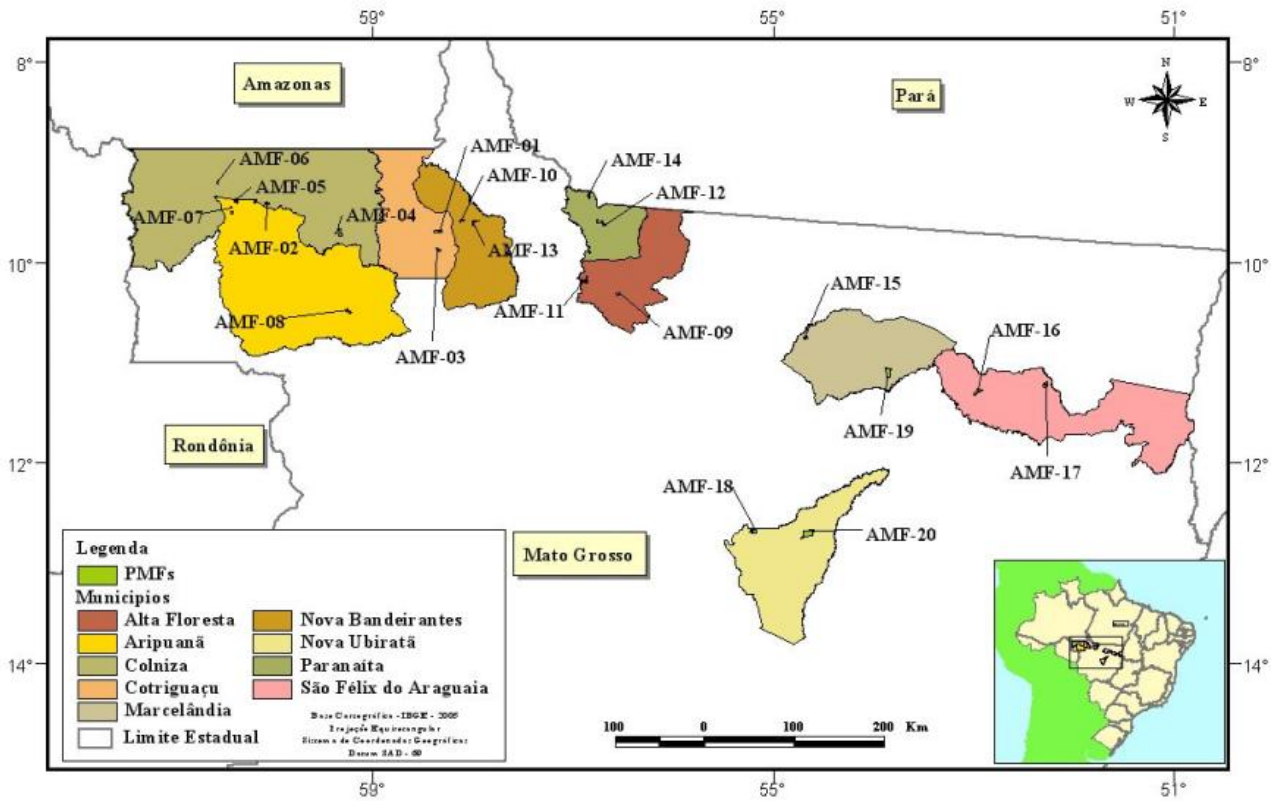

Figure 1. Location of the 20 sites with sustainable forest management plans (AMF).

Table 1. Verifiers for the assessment of the forest inventories.

Verifier	Verification subject
V-8	Distances between exploitation accesses and the management plan
V-9	Systematic enumeration of accesses
V-10	Access markings and orientation
V-11	Azimuth orientation
V-12	Minimum normal diameter (*dn*) of the inventoried commercial species
V-13	Log quality
V-14	Identification of the three main commercial species inventoried
V-15	Identification of other commercial species
V-16	Existence of felled trees with a diameter smaller than the cut
V-17	Circumferences of the inventoried trees
V-18	Height estimation
V-19	Labeling of inventoried trees
V-20	Permanence of the data in the labels
V-21	Microzonation data quality

V-22A	Location of inventoried trees
V-22B	Coincidence of the location of the inventoried trees with the maps
V-23	Other data on the microzoning of the work units.

For the V-8 verifier, the norm indicates to consider two random accesses located on the edge of the work unit (UT), and check their coincidence with the Annual Operational Plan (POA) that is based on the result of 100 % of the inventory. A 50 m tape measure (open tape measure with two metric and inch scales, Startools model) and the maps of each annual production unit (UPA), as well as the UT, were used. For the V-9, the UPA and UT maps were used. In the 20 sites, two accesses were selected for verification in the field. The V-10 was tested within 100 m of a random access point on the UT maps. The azimuth of the V-11 verifier was recorded with a Suunto compass (typical model with 360 degrees, horizontal scale).

For the V-12 verifier, groups of 25 trees were randomly selected on the UPA and UT maps. The quality class of the logs from the V-13 verifier was evaluated in a set of 10 inventoried trees, still standing. Verification of V-14 and V-15 was carried out by a field technician participating in the corresponding inventory, who selected the same trees relative to verifiers V-13, V-17 and V-20.

The V-16 verifier was obtained by choosing from two UT maps per site, five preselected trees for cutting. The coincidence of the circumferences of the V-17 verifier was made in groups of 10 inventoried trees, with a diameter tape or pi tape (Forestry Suppliers Inc., 5 meter diameter tape). In 10 selected trees, by means of a Haga hypsometer, the total height of the tree was measured (verifier V-18). In

the same set of trees, the existence of the corresponding labels (V-19) and the information (V-20) recorded in them were verified.

Two UT maps per site were chosen, which contained microzonation information. In them, the V-21 checker was analyzed. For the V-22A and V-22B verifiers, groups of 10 trees were selected on the UT maps, for later verification in the field. The V-23 verifier was obtained by subjective analysis, by comparing the information on the maps with visual observation.

Results and Discussion

For each of the 17 verifiers per site, one of the following values was established: AC/PS corrective action (AC) to be carried out within a period of less than one year (before the next evaluation [PS], which would be in one year); AC/60 corrective action, to be fulfilled in 60 days; CR with recommendation, which identifies the voluntary application of a recommendation for the sustainable forest management plan (PMFS) and does not imply corrective action or administrative sanction; SS subject to suspension, in relation to the PMFS. The final annotation assigned was the one that appeared the greatest number of times in the overall analysis of the 20 sites analyzed.

The AC/PS annotation was recorded in 11 verifiers (65 %), corresponding to V-8, V-10, V-11, V-12, V-13, V-15, V-17, V-18, V-19, V-20 and V-23; the AC/60 annotation in three (18 %) of the verifiers: V-16, V-21 and V-22B; one verifier (5 %) obtained the CR annotation for

the V-9 verifier, and two verifiers (12 %) received the SS annotation (V-14 and V-22A), as shown in Table 2.

Table 2. Results of the general annotation.

Verifier	Note			
	AC/PC	**AC/60**	**CR**	**SS**
V-8	X			
V-9			X	
V-10	X			
V-11	X			
V-12	X			
V-13	X			
V-14				X
V-15	X			
V-16		X		
V-17	X			
V-18	X			
V-19	X			
V-20	X			
V-21		X		
V-22A				X
V-22B		X		
V-23	X			

AC/PC = Corrective action in less than one year; AC/60 = Corrective action in 60 days; CR = With recommendation for voluntary action; SS = Subject to suspension.

The results of the 17 verifiers were grouped on a percentage scale of four verifier applicability groups: 1) Non- applicable (NA), when the verifier did not exceed 25 %; 2) Little applicable (PA), if it belonged to an interval between 26 and 50 % of applicability; 3) Applicable (AP), when the verifier was between 52 and 75 %; and 4) Applicable without restriction (AsR), from 76 %; the results are shown in Table 3.

Table 3. Final results of the verifiers related to forest inventories.

Verifier	Final note			
	NA	**PA**	**AP**	**AsR**
V-8			X	
V-9				X
V-10				X
V-11			X	
V-12			X	
V-13		X		
V-14		X		
V-15		X		
V-16			X	
V-17		X		
V-18		X		
V-19				X
V-20				X
V-21			X	
V-22A			X	
V-22B			X	
V-23			X	

NA = Non-applicable; PA = Little applicable; AP = Applicable; ArS = Applicable without restiction.

The verifiers V-8, V-9, V-10 and V-11 referring to the distances between the paths of orientation and access to the inventory, showed high precision according to the provisions of the standards for sustainable forest management plans and annual operating plans. It was determined that 100 % of the trails were numbered systematically and in increasing order as established by Ibama Execution Standard No. 1 (December 18th, 2006) (Brasil, 2007).

Markings were verified along 100 m on selected trails to assess trail width and distance between stakes. In these trails, a high precision of the azimuth direction was verified, which was verified between the observation point and a stake 25 m away. On only four occasions was a small alteration of less than 10 degrees recorded, with respect to the indicated course.

In the extensive literature review in relation to Brazil and Latin American countries carried out for the purposes of this study, no forest inventory verifiers were found; for this reason, the concepts of the methodologies applied in Chile, Colombia, Mexico and Peru were compared (Melero and Steinmetz, 2017). While the use of environmental verifiers has been documented in Argentina (Ministerio de Salud y Ambiente de la Nación Argentina, 2006; Gándara and Guerrero, 2013; Secretaria de Ambiente y Desarrollo Sustentable de la Nación, 2015), Chile (SEA, 2013; Ministerio del Medio Ambiente de Chile, 2019), Ecuador (Grubb *et al.*, 1963; Santamaría-Arinas, 2019; Almeida-Guzmán and Díaz-Guevara, 2020), Colombia (Bárcena and Gurria, 2014), Mexico (Pérez-Calderón, 2010) and Peru (Tacusi-Oblitas *et al.*, 2012; Chappuis, 2019).

All trees with constant normal diameter (*dn*) in the lists and reports were assigned. The minimum normal diameter (*dn*) and the quality of the log (V-12 and V-13) were verified in groups of 25 trees of each commercial species included in the PMFS. For V-14 (confirmation of the identification of the three most common commercial species) the same trees were used that were used to verify the quality of the stem.

The botanical names of the selected trees were compared with those listed in the sustainable forest management plans. This verification was of the utmost importance, since negative results (SS note) could conclude with the suspension of the commercial activities established in the sustainable management plan. Only an incorrect identification was accepted as a margin of error. The final result of the V-14 verifier was disastrous, since in none of the sites were high coincidences between the botanical names of the species and the *in situ* identification obtained.

The verification of the identification of the forest species (V-15) registered in the inventory lists during the field work was carried out in the groups of trees used for the verifiers V-13 and V-17 to V-20. 10 inventoried trees per species were used. The verified V-15 showed a huge discrepancy and insufficient information in all the cases analyzed. At none of the sites did the field staff record the correct scientific name on more than 80 % of the trees, as required by the corresponding method. The error in the botanical identification was higher than what was acceptable by the methodology, which had a significant impact on the verifiers V-14 and V-15. These results show insufficient dendrological knowledge of the great wealth of forest tree species existing in the study area, a situation that detracts from the quality of the corresponding inventories.

The verification of the V-16 verifier was done visually when accessing the cutting areas. V-17 and V-18 were verified with a new measurement of circumferences and heights in two previously inventoried sites, in addition to the marking of 50 trees that would be felled.

The information labels (V-19, V-20) were made of weather resistant material, which made it possible to keep the information of the UPA, UT and tree number. The result of its verification was satisfactory, since only one site did not meet the established standards.

The standard requires identifying all inventoried trees by means of their location on the maps of the Operational Management Plan (V-22A, V-22B). In 51 % of the maps it was not possible to locate all the individuals inventoried. The UT maps showed the microzoning data: topographical variations, water courses, springs or permanent conservation areas. A high coincidence was observed with the legends of the maps (verifiers V-21, V-23). Only in a map was confirmed the need for corrective action.

In an exhaustive literature review on Argentina (Ministerio de Salud y Ambiente de la Nación Argentina, 2006; Secretaria de Ambiente y Desarrollo Sustentable de la Nación, 2015), Chile (SEA, 2013; Ministerio del Medio Ambiente de Chile, 2019), Colombia (Ministerio de Ambiente y Desarrollo Sostenible, 2018), Ecuador (Santamaría-Arinas, 2019; Almeida-Guzmán and Díaz-Guevara, 2020), Mexico (Reygadas and Franco, 2016) and Peru (Dancé and Sáenz, 2013) the use of environmental verifiers was confirmed to identify and qualify the payment for environmental services.

In the present study, no verifier not applicable (NA) was recorded at any of the sites. Four verifiers (V-9, V-10, V-19, V-20) were considered as applicable without restrictions (AsR), as opposed to five others (V-13, V-14, V-15, V-17 and V-18) that

need to be restructured (PA). Of the latter, verifiers V-14 and V-15, referring to the identification of species, were the most sensitive and critical in their evaluation, considering that the details of any inventory are based on them.

Conclusions

The official verification standards are well described, with clear methods, which considerably reduces the subjectivity of the quality evaluators when they assign the corresponding note to the inventory carried out.

The annual operational production map (POA) is the main product of the forest inventories carried out.

The procedure did not allow the precise location of the inventoried trees that appear indicated on the maps of the work units.

Four areas attended the verifiers minimally, which would represent the immediate cancellation of the right to forest use by the government entity that grants the licenses for the application of sustainable forest management plans.

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Conflict of interest

The authors declare no conflict of interest.

Contribution by autor

The authors declare that they contributed equitably in the writing, review and pertinent comments.

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