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SUSTAINABLE MANAGEMENT OF NATURAL FORESTS IN PANTANAL REGION, BRAZIL

MANEJO SUSTENTÁVEL DE FLORESTAS NATURAIS DA REGIÃO DO PANTANAL, BRASL.

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ABSTRACT

The Pantanal region in Brazil has an area of 140,000 km², with approximately 30 % of natural forests distributed as deciduous, semideciduous, and forested savannas. The subregion of Nhecolandia represents 19 % of this area. There is constant concern about the sustainability of these forested areas, as there is a constant demand for wood for farm maintenance, mainly for making fence poles. The objective of this article is to indicate sustainable forest management practices in the Pantanal region of Nhecolandia. The methodology of this novel approach consisted of the recovery and organization of the available information to calculate the sustainable allowable cut per hectare, considering: cutting cycle, wood stock, periodic annual increment (PAI) in percentage of volume from the commercial or interesting species and the stand structure. For forested savannas, the diameter at breast height (DBH) of 529 trees per hectare were estimated as follows: 28 % with a DBH lower than 10 cm, 36 % from 10 to 20 cm, 21 % from 20 to 30 cm, 10 % from 30 to 40 cm and only 4 % greater than 40 cm. The estimated total volume per hectare was 84.2 m³ and the estimated basal area was 18.6 m². The forested areas of the Pantanal region present potential for sustainable use. However, due to regional characteristics and the lack of available information, an enhancement in research is recommended to establish a basic management guide to ensure its perpetuation for future generations.

Keywords: forest management; precision silviculture; dendrochronology; phytosociology.

RESUMO

A região do Pantanal no Brasil apresenta uma área de cerca de 140.000 km², com aproximadamente 30 % de florestas naturais, distribuídas como florestas decíduas, semidecíduas e savanas florestadas. A subregião da Nhecolândia representa 19 % dessa área. Existe uma preocupação constante em relação a sustentabilidade dessas florestas, pois a demanda de madeira para manutenção das propriedades é constante, principalmente para moirões de cerca. O objetivo desse artigo é indicar práticas de manejo florestal sustentável para a região da Nhecolândia. A metodologia dessa primeira abordagem desse tema consistiu na recuperação e organização da informação disponível e no cálculo da taxa de corte sustentável por hectare, considerando o ciclo de corte, o estoque de madeira, o incremento periódico anual (IPA), em volume percentual, das espécies comerciais ou de interesse, e a estrutura do talhão. Para savanas florestadas, o diâmetro a altura do peito (DAP) de 529 árvores por hectare foram estimados como segue: DAP menor que 10 cm (28 %), de 10 a 20 (36 %), de 20 a 30 (21 %), de 30 a 40 (10 %), e apenas 4 % acima de 40 cm. O volume total estimado por hectare foi 84,2 m³ e a área basal estimada foi 18,6 m². As áreas florestadas da região do Pantanal apresentam potencial para o uso sustentável. Entretanto, devido as características da região e a falta de informação

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disponível, recomenda-se que pesquisas sejam incrementadas para se estabelecer um plano de uso que garanta a sua perpetuação para gerações futuras.

Palavras-chave: manejo florestal; silvicultura de precisão; dendrocronologia; fitossociologia.

INTRODUCTION

The Pantanal region in Brazil has an area of approximately 140,000 km² (SILVA and ABDON, 1998), with about 30 % of natural forests, distributed in formations including semideciduous and deciduous forests and forested savannas. The Nhecolandia subregion represents 19 % of the Pantanal region. This subregion presents typical phytophysionomy, with many lakes and small elevations, covered by savannas, forested savannas, semideciduous and gallery forests, which are not flooding areas (RATTER et al., 1988). Some important tree species that serve as a source of wood in the region are: *Astronium fraxinifolium* Schott., *Magonia pubescens* A.St.-Hil., *Qualea grandiflora* Mart., *Diptychandra aurantiaca* Tul., and *Terminalia argentea* Mart., among several others (POTT and POTT, 1994). Between 1990 and 1991, approximately 4 % of the Pantanal area had already been deforested (SILVA et al., 1998); the deforestation rate was estimated to be 8.8 % until 2000 (PADOVANI et al., 2004) and 17 % until 2004 (HARRIS et al., 2006), with deforestation being mainly due to the introduction of cultivated pastures.

The producers and technicians are concerned about the sustainability of these natural forests, as the extraction of certain tree species has become a common practice, mainly for replacement of fence poles. The problem is more evident when farm workers tend to replace the preferential species throughout the years due to the scarcity of traditional species. There is no document available in the literature to serve as a guide for the use of Pantanal natural resources, considering sustainability according to the specificity of the region.

The incentive toward management and the interest in tropical forests are decisive factors for the formation of natural barriers that prevent the expansion of deforestation and forest fires, creating new concepts of use of the natural forests (BRAZ et al., 2005a).

Tropical forest management must be conceived as a set of activities that optimize forest productivity as a whole, focusing on the environmental and economic aspects, including social factors in forest production. Moreover, the wood volume of a native area varies according to the productive capacity of the soil and the irregular distribution of the species (HOWARD, 1993).

Distribution of tree species in the forest should be determined and data on areas with different forest typologies should be collected. This information along with studies on growth, soil attributes, and drainage basins will allow more specific interventions of sustainable management. Precise treatments in the forest will increase the annual average volume of commercial wood, making it possible to reduce the cutting cycle and to improve environmental conservation, facilitating forest certification (BRAZ et al., 2005b).

The potential of growth ring analysis in tropical regions is high, although the use of these results for management plans is still rare (WORBES, 2002). These studies would contribute toward the elaboration of forest management plans, as well as the maintenance of natural forests (JACOBY, 1989), reconstruction of climatic data, and also the understanding of the population dynamics (WORBES, 2002).

Recently, information pertaining to growth rings has been used as a basis for management plans in tropical forests (COURALET et al., 2005; BRIENEN and ZUIDEMA, 2006) and as a tool to understand the responses of trees in tropical forests to climatic changes (ENQUIST and LEFFLER, 2001), among others applications.

Several articles regarding the Nhecolândia subregion have been published, with important subjects, such as floristic surveys (POTT et al., 1986; POTT and POTT, 1994), phytosociology (RATTER et al., 1988; DUBS, 1992; SALIS, 2000, 2004; SALIS et al., 2006a), anatomy, dendrochronology and growth and age estimation (MATTOS et al., 1999, 2000, 2004, 2005; MATTOS and SEITZ, 2008), biomass production (SALIS et al., 2006b) and soil (CUNHA, 1980, 1981; SANTOS et al., 1997), among others, which could be analyzed together, aiming to establish a preliminary approach to sustainable use of the forested areas. Until now, the wood extractions in the farms of the region are carried out without technical planning that considers future sustainability of the local forests. It is clear that for this region, forest management will be considered selective exploitation for farm maintenance. In this context, the objective of this work is to establish guidelines for the sustainable forest management of these forest formations, according to the concept of precise management of natural forests, compiling and analyzing the currently available information for the region.

MATERIAL AND METHODS

The first step in this study consists of documentation of the study area, following a procedure adapted from BRAZ et al. (2005b):

Step 1. Survey of information regarding the physical and biotic characteristics of the forest area suitable for use or management

If this information is not available, the study could be initiated from step 2, although this would not be ideal.

The Nhecolandia subregion presents small elevations, where there is no flooding, and is covered by savannas, forested savannas, semideciduous forests, and gallery forests (RATTER et al., 1988). The climate of the region is type Aw, according to the Köppen system, and tropical megathermic, with 80 % of rains concentrated in the summer (SORIANO and GALDINO, 2002). The annual average of precipitation and temperature, from 1977 to 1995, was 1,182.7 mm and 25.5^{o}C, respectively (SORIANO, 1999). The highest average precipitation, of 216.8 mm, occurs in January and the lowest, 19.7 mm, occurs in July (SORIANO and GALDINO, 2002). Absolute maximum temperatures can be 40 ^{o}C from October to January and the minimum, close to 0 ^{o}C in June and July (EMBRAPA, 1997). The region can present an annual water deficit greater than 300 mm, mainly from August to October (SORIANO, 1999; SORIANO and GALDINO, 2002).

The landscape is flat, with an altitude around 90 m above sea level (RATTER et al., 1988). The soils are, predominantly, Ferrocarbic, Hydromorfic Spodosol (EMBRAPA, 1999), which, under natural conditions, usually present high fertility restrictions for intensive agro-pastoral management. Considering the soil texture of the low-elevation areas of the Nhecolandia subregion, Cunha (1980, 1981) and Santos et al. (1997) have verified that they are uniform, presenting high percentages of sand and low percentages of mineral clay (2 to 5 %).

Step 2. Analysis of forest structure, soil, and landscape

The vegetation type presents characteristics of an Ecological Savanna Region and the forest formations are: savanna, forested savanna and semideciduous forest, according to IBGE (1992).

The most frequent species observed in the Pantanal region of the Nhecolandia forested savanna are *Magonia pubescens*, *Handroanthus ochraceus* (Cham,) Mattos (=*Tabebuia ochracea* (Cham.) Standl.), *Terminalia argentea*, *Caryocar brasiliense* Cambess., *Astronium fraxinifolium*, *Qualea grandiflora*, *Lafoensia pacari* A.St.-Hil., *Guazuma ulmifolia* Lam., *Diptychandra aurantiaca*, *Protium heptaphyllum* L. Marchand, *Hymenaea stigonocarpa* Mart. ex Hayne, *Mouriri elliptica* Mart., *Zanthoxylum rigidum* Humb. & Bompl. ex Willd. (=*Fagara hassleriana* Chodat), and *Alibertia sessilis* K. Schum. (RATTER et al., 1988; SALIS et al., 1999; SALIS, 2000). Many authors (RATTER et al., 1988; SALIS et al., 1999, SALIS, 2000) state that the more predominant species in savanna areas are *Curatella americana* L., *Zanthoxylum rigidum*, *Hymenaea stigonocarpa*, *Mouriri elliptica*, *Caryocar brasiliense*, *Handroanthus aureus* Mattos (=*Tabebuia aurea* (Silva Manso) S. Moore), *Acrocomia aculeata* Lodd. ex Mart., *Byrsonima coccolobifolia* Kunth, *Buchenavia tomentosa* Eichler, *Byrsonima orbignyana* A. Juss. and *Couepia grandiflora* Benth. According to Ratter et al. (1988), the more predominant species in the semideciduous forests are: *Handroanthus impetiginosus* (Mart. ex DC.) Mattos (=*Tabebuia impetiginosa* (Mart. ex DC.) Standl.), *Anadenanthera colubrina* var. *cebil* (Griseb.) Altschul, *Vitex cymosa* Bert. ex Spreng., *Myracrodruon urundeuva* M. Allemao and *Astronium fraxinifolium*.

Data from phytosociology surveys performed on different tree phytophysionomy in the Nhecolandia subregion were used. The results were collected from published phytosociology surveys (SALIS, 2004; SALIS et al., 2006a) or from surveys, which have not been published yet. Information from 11 collection areas was considered, representing 2.29 hectares of sampled area (Table 1). For the forest component, tree species having DBH (Diameter at Breast Height) greater than 5 cm were included and for the sapling component, a DBH ranging from 1 to 5 cm was included using the point-quarter method. It is interesting to point out that for the Piquete forested savanna and Babaçu forest areas, there was a high density and dominance of palm trees (*Attalea phalerata* Mart. ex Spreng. in both areas and *Attalea speciosa* Mart. in the Babaçu forest), but these were not considered in the data processed in this article.

The basal area and volume were calculated and the most predominant species were identified. These data were used to estimate the abundance distribution in 6 diametric classes, from 10 to 10 cm. The information was analyzed and the parameters of horizontal and vertical structure of the forest, including parameters of natural regeneration were estimated.

Step 3. Planning silvicultural treatments and defining sustainable allowable cut

The information analyzed formed the basis for recommendations and applications of necessary silvicultural treatments.

In this step, the available information about anatomy and dendrochronology of Pantanal tree species was investigated (MATTOS, 1999; MATTOS et al., 1999; MATTOS et al., 2003, 2005; MATTOS and SEITZ, 2008), and the data were organized considering age, diameter, mean annual increment in the diameter at breast height (DBH) and periodic annual increment (PAI) for the past five years, as presented in Table 2.

To calculate the sustainable allowable cut per hectare for natural forests, at least 4 criteria should be considered: cutting cycle, stock, periodic annual increment (PAI), in percentage of volume, in the center of the classes from commercial species or species of interest, and the stand structure, measured as the number of trees per hectare and per diameter class.

In a careful analysis, the condition of each species was considered with respect to its diameter class distribution, sapling population and possibility of transition between classes until commercial cutting diameter was attained. This analysis, at least as a preliminary approach, was performed from the prognosis inventory, in which it was possible to have a broad view of the area. Considering the lack of

TABLE 1: Sampled area characterization, according to area, number of trees, volume and basal area.
TABELA 1: Características das áreas amostradas, de acordo com a área, número de árvores, volume e área basal.

Forested areas	Studying area (ha)	Number of trees/ha	Tree volume (m^3/ha)	Basal area (m^2/ha)
Forested savanna Capivari	0.21	524	63.4	13.8
Forested savanna Zequinha	0.17	647	90.5	19.3
Forested savanna Negro	0.21	648	114.9	25.4
Forested savanna Caron	0.14	750	89.7	20.1
Forested savanna Imaculada	0.21	543	121.9	25.8
Forested savanna Nhumirim	0.17	488	55.2	12.3
Semideciduous forest Angico de Rancharia	0.15	667	128.9	29.1
Semideciduous forest Salina Campo Alto	0.23	465	99.6	22.4
Semideciduous forest Babaçu de Rancharia	0.18	367	74.4	16.6
Savanna Piquete de Rancharia	0.25	460	54.4	11.9
Savanna Campo Alto de Cameron	0.37	265	33.4	7.3
Average		529	84.2	18.6

TABLE 2: Information about age, diameter, mean annual increment, and periodic annual increment for the last five years, for tree species of the Nhecolandia Pantanal.

TABELA 2: Informações sobre idade, diâmetro, incremento diamétrico médio, e incremento periódico anual dos últimos cinco anos, para espécies do Pantanal da Nhecolândia.

Species	Age at DBH (years)	Diameter (cm)	MAI (mm)	PAI of five years (mm)
Anadenanthera colubrina var. *cebil*	13	10.4	8.0	10.6
Anadenanthera colubrina var. *cebil*	18	14.2	8.0	10.4
Anadenanthera colubrina var. *cebil*	20	14.1	7.0	7.0
Anadenanthera colubrina var. *cebil*	12	8.4	7.0	7.0
Anadenanthera colubrina var. *cebil*	24	16.7	7.0	7.8
Anadenanthera colubrina var. *cebil*	14	8.9	6.4	6.6
Anadenanthera colubrina var. *cebil*	15	8.8	5.8	8.8
Anadenanthera colubrina var. *cebil*	26	14.2	5.4	4.2
Handroanthus impetiginosus	11	12.7	11.6	11.0
Handroanthus impetiginosus	15	10.7	7.2	6.6
Handroanthus impetiginosus	11	7.7	7.0	7.6
Handroanthus impetiginosus	15	12.5	5.0	6.0
Handroanthus impetiginosus	22	10.8	5.0	6.0
Handroanthus impetiginosus	19	9.2	4.8	6.2
Albizia niopoides (Spruce ex Benth.)Burkart	29	32.6	11.2	13.2
Bowdichia virgilioides Kunth	20	20.6	10.2	9.4
Rhamnidium elaeocarpum Reissek	22	9.1	4.2	3.6
Terminalia argentea	15	17.8	9.6	6.8
Handroanthus heptaphyllus (Mart.) Mattos	14	13.6	11.8	7.2
Sclerolobium aureum Baill.	13	7.0	14.6	15.4
Pouteria ramiflora Radlk.	10	14.6	5.4	6.4
Sterculia apetala (Jacq.) H. Karst.	12	22.5	18.8	14.8
Qualea grandiflora	12	11.7	9.8	11.2
Protium heptaphyllum	12	7.7	6.4	8.8
Hymenaea stigonocarpa	8	3.4	4.2	4.8

DBH = Diameter at breast height; MAI = Mean annual increment in DBH; PAI = Periodic annual increment. (MATTOS,1999)

information from permanent plots (PP), it would also be possible to use the balanced forest criteria established by Liocourt and Meyer (SCHNEIDER and FINGER, 2000), which consider a transition probability among classes, to ensure a balanced number among different DBH classes.

At the end of the project, as a extension to this work, an evaluation should be carried out to determine which trees should remain as seed trees and to identify the sustainable allowable cut limit recommended for species, using the prospective inventory or census (100 %), which would make it possible to achieve more precision in the final definition of the cut rate of the forested areas.

An equation was modified to relate these increments to the DBH center class, considering that they were related to the volume increment, as presented in stem analysis, by Schneider and Finger (2000). Later, the average PAI was calculated from the DBH as grouped classes.

The sustainable allowable cut was determined according to the Mexican Method, mentioned by Schneider and Finger (2000). This method considers that the annual growth of a tree or stand may be accumulated as expressed by the law of compound interest, the idea being that the forest may grow again the volume of wood produced in the considered cycle. The cycle to be used here is 25 years, according to the Brazilian forest legislation. The cut rate was applied to the available volume per hectare.

The cut rate was estimated using the expression (SCHNEIDER, 1993):

$$CR = \{1- (1/1{,}0i^{cc}) \} * 100$$

Considering: CR = Cut rate, in percentage of volume; i = Percentage of periodic annual increment, in volume; cc = Cutting cycle, in years.

The sustainable allowable cut is obtained by the following expression:

$$SAC = \{Vc \,.\, CR / 100\}$$

Considering: SAC = Sustainable allowable cut; CR = Cut rate to a specific cutting cycle, in volume; Vc = Commercial volume per hectare, in cubic meters.

The concept of balanced forest was used for estimating a “q” (Lioucourt coefficient), compatible to classes of use (ALEXANDER, 1977), making it possible to suggest a balanced intervention, establishing a guarantee of a defined residual basal area. The “q” value is an important criterion of regulation, as it can be used to guide management decisions. According to Leuschner (1992), the “q” value is a function of species and forest quality, but there are also other determinants such as products and market. In the considered region, the native woods are used for different purposes, mainly on the farm, such as for fence poles and boards, which require different diameter classes.

The maximum limit of exploitation must be complemented later by species, considering individual structural conditions. The process would much easier by recovering all this information from a 100 % inventory. The possibility of regeneration would be verified for each species according to its structure. If positive, the sustainable allowable cut must be determined, taking into consideration the time necessary to recompose the remnant-forested area, considering the stock.

After the felling operations, tree extraction should be adapted to reduced impact logging (RIL) rules (OLIVEIRA and BRAZ, 1995). These rules are based mainly on the 100 % inventory, considering a minimum starting diameter, the correct planning of the extraction routes and storage areas, preferentially at the border areas, with minimum costs and damage to the remnant forest (BRAZ et al., 2005b).

Step 4. Forest management monitoring

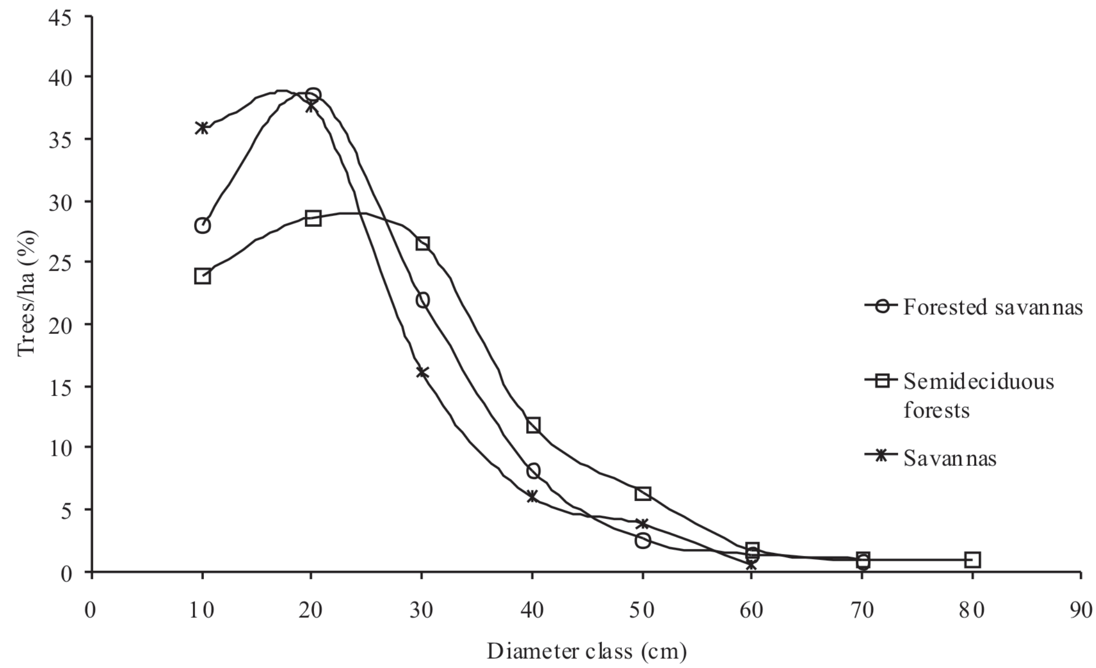
In this stage of the study, there were no permanent plot data available, as they were recently installed. Permanent plots (PP) will provide information about forest dynamics, such as growth, recruitment, mortality, and floristic composition, in the evaluation to be carried out during the following steps.

RESULTS AND DISCUSSION

The diametric class distribution of adults and sapling trees are presented in Figures 1a and 1b. Figure 1a indicates the high variation of trees in the region, which also suggests a high basal area variation (between 9 and 27 m^2). The diametric class distribution of tree volume, estimated for one hectare, is represented in Figure 2.

In Pantanal Mato-Grossense region, studies on the percentage of dead trees in floristic surveys are rare. Salis (2000), who studied the tree composition around a lake in the Pantanal Mato-Grossense region, observed a relative density of dead trees of 8 %, varying from 3 to 20 %, and mentioned fire as the most frequent cause of death.

In Figures 1a and 1b, it is possible to observe that the analyzed tree composition presents a distribution compatible to natural forests. However, it is possible to point out that the problems of regeneration or environmental changes presented by class 10 could even be a result of previous interventions, and these should be investigated. This tendency can be seen not only in the class distribution, but also between class transitions, until the commercial diameter is attained. In addition, in Figure 2, it is possible to observe a good volumetric supply between classes 30 and 70, which may be indicative of a future possibility of management, although the studied areas presented different species combinations and class distributions, habitats and,



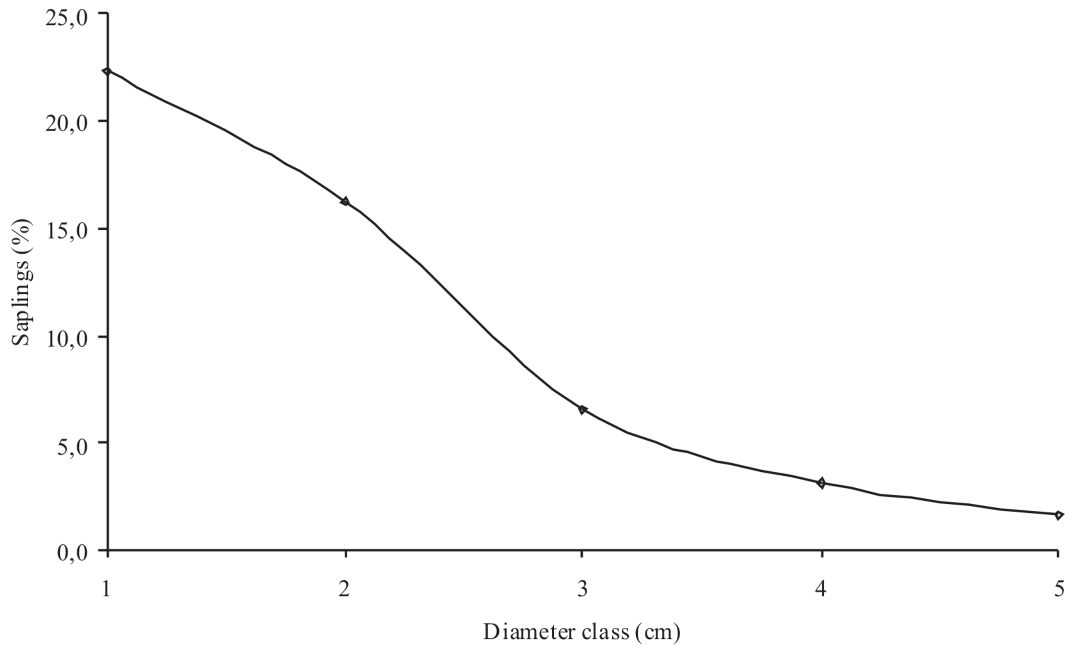


FIGURE 1: Diametric class distribution of adult trees for different sites in Pantanal (a) and mean diametric distribution for saplings (b).

FIGURA 1: Distribuição em classes diamétricas de árvores adultas para diferentes locais do Pantanal (a) e média da distribuição diamétrica para plantas jovens (b).

possibly, different sub-typologies, which may demand adaptations in the sustainable allowable cut, according to the ongoing studies and according to the potential of each forest.

The frequently studied species *Anadenanthera colubrina* var. *cebil* and *Handroanthus impetiginosus* presented an average PAI of 0.78 and 0.72 cm, respectively, and the other species presented an average PAI of 0.92 cm (Table 2). These are very high values, when compared with natural forests in the Rain Forest, which presented PAI values of 0.30 and 0.40 cm (OLIVEIRA and

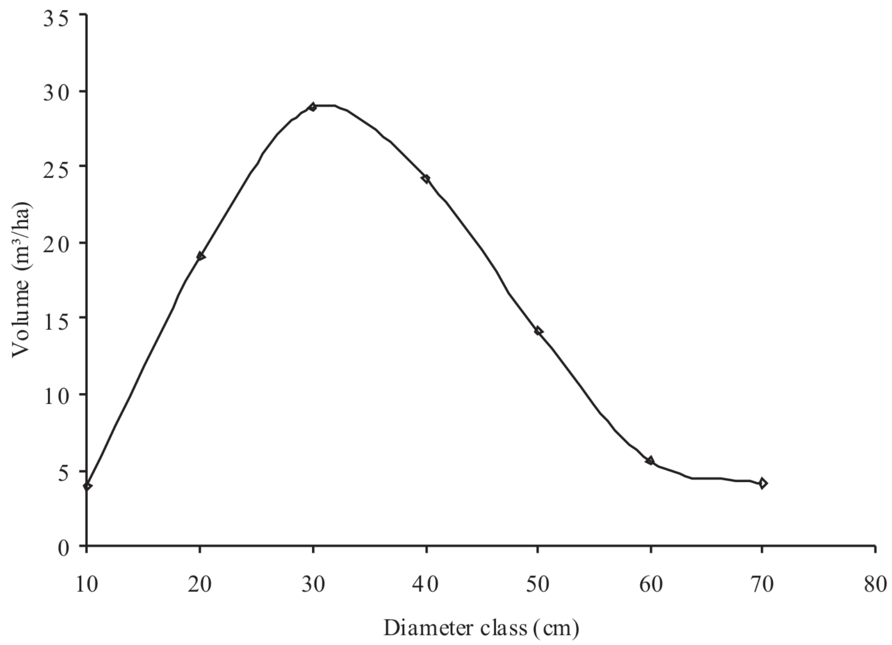


FIGURE 2: Volume distribution by diametric class per hectare.
FIGURA 2: Distribuição do volume por hectare por classe diamétrica.

BRAZ, 1998). Nevertheless, these results must be considered with restrictions, until more data are collected, as the trees studied are very young compared with the trees of natural forests.

The diameter distribution by age class was done for all tree species studied (Figure 3). From Figures 3, it is possible to confirm a correlation of 51 % (according to simple correlation among variables by Pearson coefficient) between age and diameter. These results show that these species presented ages compatible with their growth, considering a natural forest, indicating possibility of

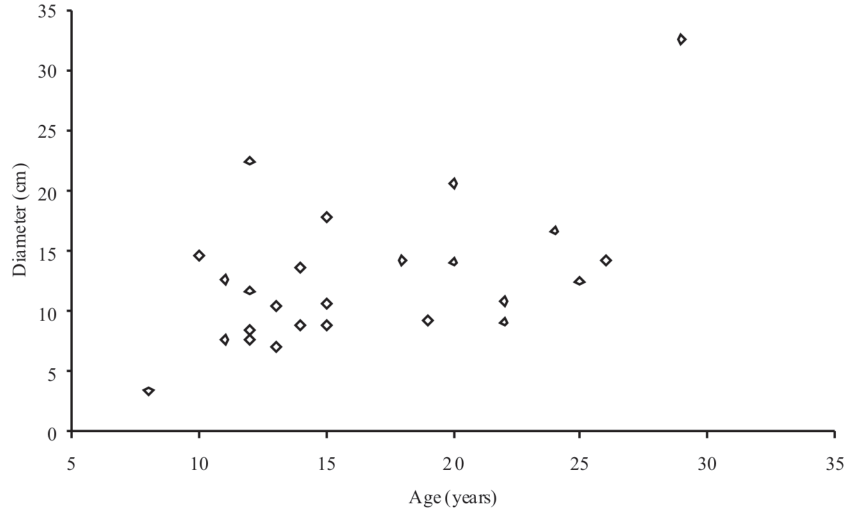


FIGURE 3: Diameter distribution by age class for different tree species of Pantanal Mato-Grossense.
FIGURA 3: Distribuição diamétrica por classe de idade para diferentes espécies do Pantanal Mato-Grossense.

management, as these species were not old trees that were suppressed for many years. However, the dominance of species should be evaluated, as part of the trees may be in temporary suppression stage.

Figure 4 shows the curve of periodic annual increment (PAI), in percentage of volume, fitted in relation to DBH, according to the equation: Ln PAI = $b_o - b_{1*}$LnDBH

To adjust the equation (Figure 4), a R^2 value of 0.4353 and a variation coefficient of 16.99 were obtained. The statistical parameters were compatible with natural forest conditions, where several causes of influence may occur, such as differing competition, site conditions, species combination, and mainly, where thin wooded trees are not necessarily younger than the thick wooded trees (SCHAAFT et al., 2006).

Table 3 shows the mean periodic annual increment (PAI), in percentage of volume, calculated according to the commercial volume available by the center of the DBH class. As a precaution, the first class center was not included, as the first class was the basis of the forest structure, thereby reducing the mean PAI% from 3.42 to 3.10. These values are compatible with other information relative to natural tropical forests (SCOLFORO, 1998; SCHNEIDER and FINGER, 2000).

According to the available volumes, 80 and 76.7 m³/ha, the cycle of 25 years, and considering the average PAI %, the cut rate and the sustainable allowable cut were calculated:

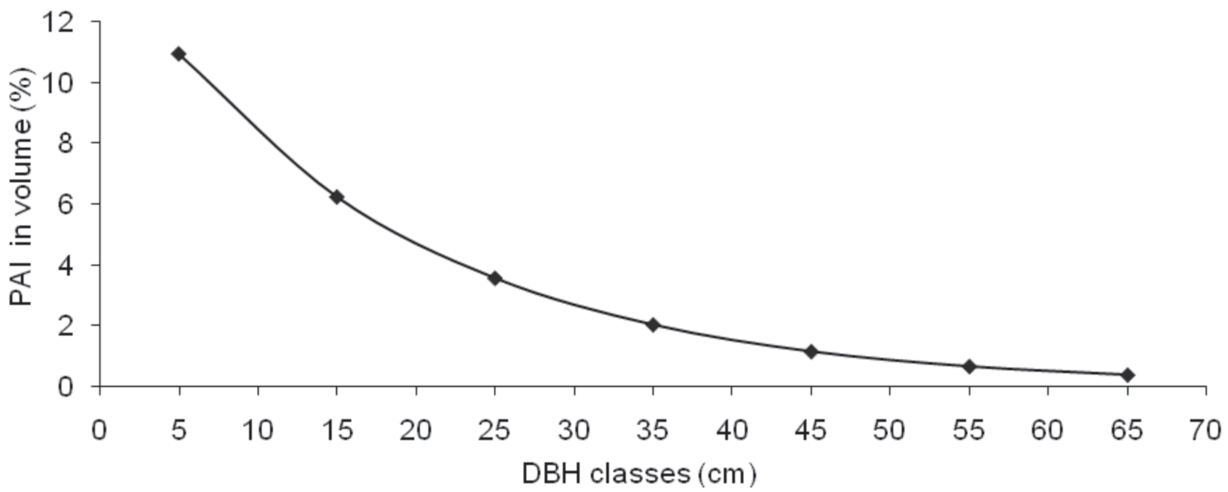


FIGURE 4: Curve of periodic annual increment (PAI), in percentage of volume, as a function of diameter.
FIGURA 4: Curva de ajuste do incremento periódico anual percentual (IPA), em volume percentual, em função do diâmetro.

TABLE 3: Determination of the mean periodic annual increment (PAI), in percentage of commercial volume.
TABELA 3: Determinação da percentual médio de incremento periódico anual (IPA %) em volume comercial.

	CC DBH	volume/ha	PAI%	V*PAI	CC DBH	Volume/ha	PAI%	V*PAI
	5	3.3	10.93	36.06	5	NC	NC	0.0
	15	15.0	6.23	93.45	15	15.0	6.23	93.45
	25	25.2	3.56	89.71	25	25.2	3.56	89.71
	35	19.0	2.03	38.57	35	19.0	2.03	38.57
	45	11.0	1.15	12.65	45	11.0	1.15	12.65
	55	4.0	0.66	2.64	55	4.0	0.66	2.64
	≥ 65	2.5	0.38	0.95	65	2.5	0.38	0.95
Total	-	80.0	-	274.04	-	76.7	-	237.97
Average PAI%	-	-	3.42 (1)	-	-	-	3.10 (2)	-

CC DBH = DBH class center; V= volume/ha; NC = class not considered.

CR % (80 m³/ha) = 56.82% (SAC=45.45 m³) and

CR % (76.7 m³/ha) = 53.42% (SAC=40.90 m³)

On the basis of these values, the residual basal area was defined (8.0 m² per hectare) relative to the classes that would be logged, and a balanced distribution was calculated, making increment and cut rates compatible.

The "q" obtained from the stand was 2.33, the R^2 value 0.9866, and the variation coefficient 4.8 (considering both F significant at 1 % level, and the b coefficient significant at 5 % level), to the equation:

Ln N = 6.6997 – 0.045*DBH

This "q" value confirmed a standard structure in the forest. In the first frequency distribution (N) obtained from the equation (Table 4), the higher classes were not considered for management, thus an inclination according to the "q" 2.7 was aimed at, recalculating the curve coefficients. Therefore, a higher equilibrium of extraction among classes was sought aiming at different assortment possibilities. It was possible to reduce the basal area due to the sustainable allowable cut. Also, a "q" value was sought in order to obtain a structure that would preserve the smaller classes and prioritize the use of higher classes, making possible its sustainable use.

Table 5 shows the number of trees that can be logged, considering diameter class. The values and differences were calculated and then the desired residual basal area was estimated, according to the new "q". Figure 5 shows the graphic representation of different inclinations, according to the "q" values, suggesting that 2.7 was adequate for the desired intervention, maintaining the defined residual basal area.

It is evident that the cut rate, now adapted to the number of trees that may be logged based on class diameter, must be alleviated, avoiding damage to the floristic diversity (SCOLFORO, 1998). Therefore, the number of trees per species that could

TABLE 4: Number of trees to remain and to be logged in the first approximation of the equation.
TABELA 4: Número de árvores remanescentes e a serem cortadas na primeira aproximação da equação.

CC DBH	Real N	Adjusted N	Cut N
15	188	228.65	-40.65
25	117	98.22	18.78
35	48	42.19	5.81
45	18	18.12	-0.12
55(*)	7	7.76	-0.76

CCDBH = DBH class center; N = Number of trees per hectare; (*) maximum diameter.

TABLE 5: Balanced N, according to the new "q" and defined residual basal area.
TABELA 5: N balanceado, de acordo com o novo "q" e área basal restante definida.

CCDBH	Adjusted N (q = 2.7)	Cut N	Res.ba/ha	Coefficient calculated to the new equation	
15	129.859	58.141	2.2948	B0	6.3564
25	48.09	68.91	2.3606	B1	-0.0993
35	17.81	30.19	1.7135		
45	7.00	11.00	1.1133		
>55	2.44	4.56	0.5797		
Total			8.0619		

N = Number of trees per hectare; Res.ba/ha= residual basal area desired per hectare.

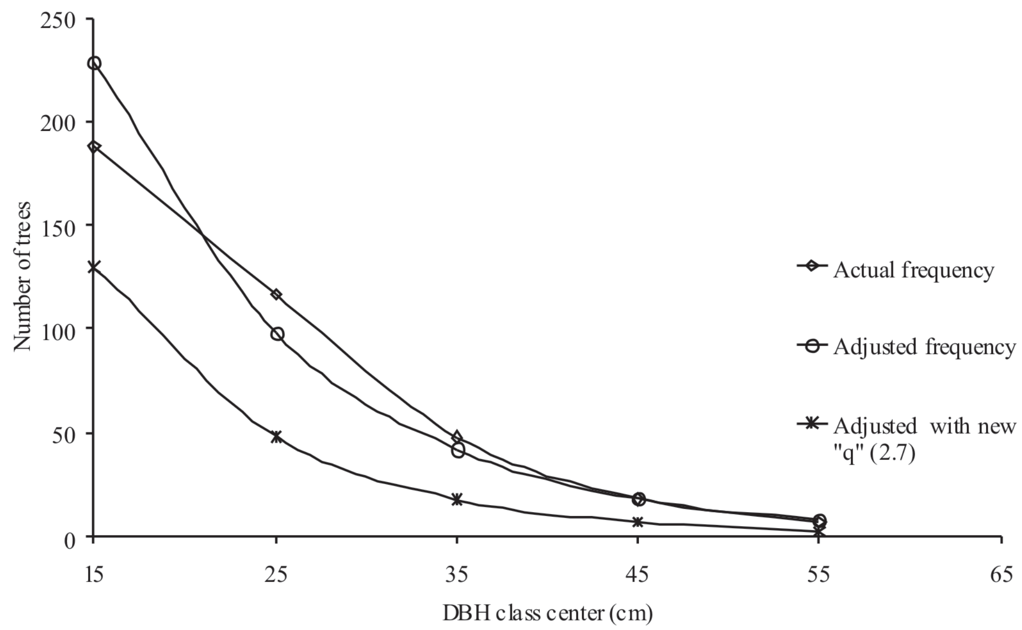


FIGURE 5: Different inclinations, according to the “q” value.
FIGURA 5: Inclinações diferentes, de acordo com o valor de “q”.

be removed without harming the sustainability of the species based on DBH class should also be defined. When this dependency is established, the sustainable allowable cut will probably be below that predicted.

CONCLUSIONS

By analyzing the data available until now, it is possible to conclude that the Pantanal forested areas present potential for sustainable use, as long as some minimum steps of management are followed. However, due to the low soil fertility, climate restrictions throughout the year and over the course of years and discontinued forest formations in “cordilheiras,” there will be several sub-typologies, demanding a more detailed characterization of each site, to establish a use plan that guarantees its perpetuation for future generations.

Considering the difficulties to obtain representative information from growth conditions of the forested areas, enhanced efforts toward continuous monitoring research is suggested, with the establishment of more permanent plots, to make further evaluations possible (model according prognosis, recruitment, mortality, etc). In addition, further phytosociological surveys should be carried out, to obtain more representative information, including the development of stem analyses, for at least 10 tree species, through studies on growth rings, considering larger diameters, and the evaluation of the forest structure and the permanent plots after exploitation.

This preliminary sustainable allowable cut can be used as the first management criterion for the considered sub-typologies and the primary basis for monitoring by institutions responsible for local control.

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