Acta Scientiarum

http://www.uem.br/acta
ISSN printed: 1679-9275
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v39i2.32543

Effect of selective logging on floristic and structural composition in a forest fragment from Amazon Biome

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ABSTRACT. This study was conducted in one region of a Seasonal Semideciduous Forest located in Tapurah (Mato Grosso State, Brazil) with the aim of studying its floristic and structural composition. The fixed area method was applied to 10 × 250 m clusters, allocating and measuring five clusters with five subunits of 500 m² each. Species with a diameter at breast height greater than or equal to 10 cm were considered, and the sample sufficiency of the floristic survey was verified by a species accumulation curve. The similarities between the sample subunits were calculated by the Jaccard Similarity Index, and the species diversity with the Shannon Diversity Index and Pielou Evenness Index. The horizontal vegetation structure was characterized by density, frequency, dominance and the values of ecological importance, and diametric distribution were assessed by the Spiegel procedure. The families Vochysiaceae, Fabaceae and Sapindaceae were highly represented, and *Qualea paraensis*, *Aspidosperma discolor* and *Matayba arborescens* were the most important species. A high diversity and low ecological dominance were found, and the diametric structure of the trees presented a negative exponential distribution. In general, the structure, floristic composition and richness of vegetation correspond to a forest with stable and autoregenerative community after selective logging.

Keywords: bootstrap, phytosociology, environmental disturbance.

Efeito da extração seletiva na composição florística e estrutural de um fragmento florestal do Bioma Amazônico

RESUMO. Objetivou-se estudar a composição florística e estrutural de um fragmento secundário de Floresta Estacional Semidecidual em Tapurah (Estado do Mato Grosso, Brasil). Aplicou-se o método de área fixa com conglomerados de dimensões de 10 × 250 m, sendo alocados e medidos cinco conglomerados com cinco subunidades de 500 m² cada. Foram consideradas as espécies com diâmetro à altura do peito superior ou igual a 10 cm e verifirada a suficiência amostral do levantamento florístico pela curva espécie-área. A similaridade florística entre as subunidades amostrais foi obtida com o Índice de Jaccard e a diversidade de espécies pelos Índices de Diversidade de Shannon e Equabilidade de Pielou. Para caracterização da estrutura horizontal da vegetação foram utilizados a densidade, frequência e dominância, relativas e absolutas, e os valores de importância ecológica e a estrutura diamétrica pelo procedimento de Spiegel. Destacou-se a elevada representatividade das famílias Vochysiaceae, Fabaceae e Sapindaceae e como as mais importantes as espécies *Qualea paraensis*, *Aspidosperma discolor* e *Matayba arborescens*. Foi verificada elevada diversidade e baixa dominância ecológica das espécies e a estrutura diamétrica das árvores apresentou distribuição exponencial negativa. A estrutura, composição florística e riqueza da vegetação corresponde a de floresta com comunidade estável e autorregenerativa após a extração seletiva.

Palavras-chave: bootstrap, fitossociologia, perturbação ambiental.

Introduction

Anthropogenic pressures on native vegetation and the lack of relevant studies could compromise the conservation of forest remnants and endanger their species richness (Borém & Oliveira-Filho, 2002). Fragmentation affects the organization of natural communities by reducing the living area of the species and altering local climate conditions, and the mere presence of species does not guarantee that they will be maintained (Carvalho, Braga, Gomes, Souza, & Nascimento, 2006).

These remnants play an important role as ecological corridors that are able to provide gene flow between isolated populations, a critical factor for the conservation of many species (Silva & Tabarelli, 2000). Structural data comparisons are essential to assess the loss of biodiversity and the vulnerability of plant communities in fragmented areas and to evaluate potential losses and conserve natural resources in the long term (Corsini, Scolforo, Oliveira, Mello, & Machado, 2014).

Biological diversity conservation strategies require studies that quantify the species and their distribution in the environment and provide knowledge on the relationships between floristic composition and ecosystem diversity (Primack & Rodrigues, 2001). Conservation initiatives, management and restoration of forest fragments require detailed studies on the inventories of flora and the ecology of plant communities (Pinto et al., 2007).

Ribas, Meira Neto, Silva, and Souza (2003) consider this information essential to support any activities on the use, management, recovery and conservation of seasonal semideciduous forests. Moreover, knowing the history and analysing the successional stage of development of these fragments is essential to provide subsidies to the conservation and recovery of such formations (Leite & Rodrigues, 2008). Therefore, the aim of this study was to explore the floristic and structural composition of a fragment of Seasonal Semideciduous Forest submitted to selective logging in order to evaluate the richness, diversity and condition of the area.

Material and methods

A floristic and structural survey on a fragment with an area of 32.98 ha was conducted in the municipality of Tapurah, Mato Grosso State, Brazil (12°28'5.67"S; 56°33'32.14"W). The fragment is located in the field of a Submontane Seasonal Semideciduous Forest and suffers the effects of selective logging that occurred in the 1990s. The climate in the region is Am type according to the Köppen classification, with a short, dry winter, high annual rainfall of approximately 3,000 mm year^{-1}, and an average annual temperature of 25°C (Alvares, Stape, Sentelhas, Gonçalves, & Sparovek, 2013). For systematic sampling, the fixed area method was applied to 10 m × 250 m clusters with five subunits of 10 m × 50 m each, and a minimum border of 15 metres was considered.

The allocation of the clusters respected the greater variation gradients of the forest (Figure 1). All individuals with a diameter at breast height (DBH) greater than or equal to 10 cm were measured. The botanical material of the species that were unable to be identified in the field was collected for taxonomic analysis and identification in the herbarium of the Federal University of Mato Grosso. In order to update and confirm the nomenclature of species, the List of Species Flora of Brazil (Jardim Botânico do Rio de Janeiro [JBRJ], 2014) was used. The delimitation of families followed the APG III classification system (Angiosperm Phylogeny Group [APG], 2009).

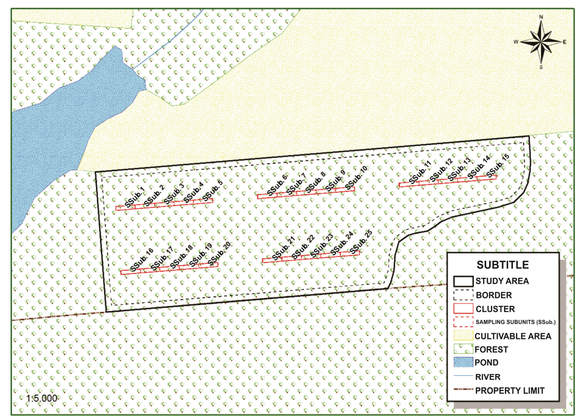

Figure 1. Scheme of the subdivision of sample subunits used for the study of the Seasonal Semideciduous Forest fragment under the influence of selective logging, Tapurah, Mato Grosso, 2014.

The floristic composition, including the number of families, genera and plant species, was analysed. The sample sufficiency was checked by the species accumulation curve (Felfili, Eisenlohr, Melo, Andrade, & Meira Neto, 2013) as constructed by the Bootstrap procedure (Efron & Tibshirani, 1993). For processing, the vegan package of *R* software version 2.2-0 (R Core Team, 2015) was used.

Based on field observations and literature review, the species were classified into ecological groups. The successional classification was based on the terminology of Gandolfi, Leitão Filho, and Bezerra (1995), and the species were categorized as pioneers, early secondary, late secondary or unclassified (NC). The floristic similarity among the sample subunits was obtained with the Jaccard Similarity Index, and the diversity of species in the sample subunits was measured by the Shannon Diversity Index (*H*') and Pielou Evenness Index (J') (Felfili & Rezende, 2003).

The vegetation's horizontal structure was characterized by the following phytosociological parameters: density, frequency, dominances (relative and absolute), and the values of ecological significance, as described in Mueller-Dombois and Ellenberg (1974), Felfili and Resende (2003) and Legendre and Legendre (2012). The diametric structure of individuals followed the Spiegel procedure (Felfili & Rezende, 2003).

Results and discussion

In the species-area curve, a tendency for stabilization between the sampling subunits 10 and 15 and between sampling subunits 24 and 25 was observed, while the average accumulation curve of species by the Bootstrap procedure also tended to stabilize with 25 sampling subunits (Figure 2).

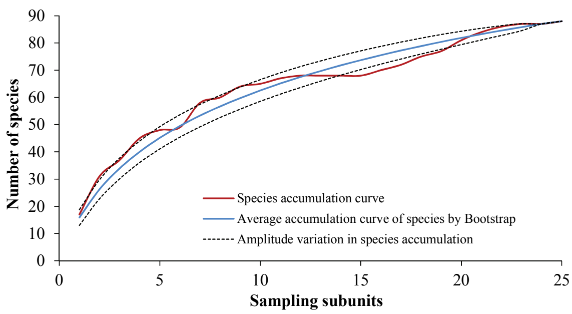

Figure 2. Species-area curve considering individuals collected in a sampling area consisting of 25 sampling subunits of 500 m² in the fragment of a Seasonal Semideciduous Forest under the influence of selective logging, Tapurah, Mato Grosso, 2014.

For density, only the number of living trees with a DBH greater than or equal to 10 cm was recorded (Table 1). Of the 575 trees measured, 15 were identified at the genera level, and seven were not identified. They were distributed in 88 species and 63 genera and belonged to 37 botanical families. The most prevalent families (38.44%) were Vochysiaceae, Fabaceae and Sapindaceae, and less than 1% belonged to the other 20 families. The predominance of species classified as late secondary, typical of the understory, was identified (Table 2).

Species diversity obtained by the *H'* ranged from 2.23 to 3.06, with low diversity for some sampling subunits and high diversity for others. Regarding the evenness obtained by *J'*, which ranged from 0.49 to 0.68, the distribution pattern of individuals among the species for the sampling subunits was of low to intermediate uniformity, respectively.

According to the Jaccard index, which ranged from 0.04 to 0.44, it was evident that the similarity between the sampling subunits varied from low to medium and was lower among subunits one to 18 and between subunits nine to 16 and higher among subunits 15 and 22. There was no relationship between the number of species and families present in each sampling subunit and the proportion of common species in the subunits. Subunits nine and 16 contained 17.04 and 13.63% of the species found in the study, respectively, while subunits 15 and 22 contained 12.5 and 17.04%, respectively.

Table 1. Descriptive characteristics of the sampling subunits collected in the Seasonal Semideciduous Forest fragment under the effects of selective logging, Tapurah, Mato Grosso State, 2014.

C	SSub	Nº Families	Nº Species	Nº Trees	D	Nº dead trees	Average DBH	Max DBH	$\bar{g}$	G
	1	7	12	17	340	1	16.26	30.94	1.22	24.39
	2	9	17	21	420	0	21.99	71.62	3.83	76.61
1	3	11	16	20	400	1	24.37	61.12	4.19	83.83
	4	9	14	21	420	1	19.72	42.02	2.41	48.20
	5	18	23	29	580	2	21.55	57.30	4.17	83.45
	6	12	18	29	580	0	17.43	50.93	2.65	53.02
	7	16	20	26	520	1	16.90	37.24	2.22	44.31
2	8	11	15	24	480	1	18.87	30.72	2.18	43.64
	9	13	15	20	400	0	17.86	32.37	1.72	34.49
	10	11	16	23	460	0	25.45	43.42	4.26	85.28
	11	10	16	23	460	1	16.21	33.84	1.67	33.46
	12	11	18	22	440	0	17.90	57.71	2.31	46.23
3	13	10	15	23	460	1	14.23	23.87	1.23	24.60
	14	10	15	19	380	0	16.29	24.83	1.33	26.60
	15	9	11	18	360	1	14.24	31.83	1.02	20.30
	16	9	12	17	340	2	21.42	43.61	2.30	46.03
	17	17	21	35	700	1	19.15	49.78	4.06	81.15
4	18	11	16	25	500	0	23.70	57.23	4.28	85.57
	19	14	20	24	480	0	18.37	38.36	2.38	47.57
	20	11	14	28	560	2	22.49	50.13	4.33	86.55
	21	11	15	20	400	0	21.43	48.38	2.85	57.02
	22	12	15	20	400	0	19.67	42.88	2.31	46.18
5	23	10	13	23	460	0	25.12	73.02	5.24	104.73
	24	11	14	24	480	1	25.86	71.94	5.38	107.61
	25	10	13	24	480	0	19.81	47.59	2.82	56.42
TOTAL				575		16			72.36	
Average				23	460		19.85	46.11	2.89	57.89

C – cluster; SSub – sampling subunit; Nº – number; D – density (trees ha^{-1}); DBH – diameter at 1.3 m (cm); Max DBH – maximum diameter (cm); $\bar{g}$ – basal area of the sampling subunit (m^2 500 m^2); G – basal area per hectare (m^2 ha^{-1}).

Table 2. Percentage of individuals by botanical family, genera and species; the number of individuals (N); the analysed phytosociological parameters; and the successional categories found in the fragment of a Seasonal Semideciduous Forest under the influence of selective logging, Tapurah, Mato Grosso State, 2014.

Family/Species	%	N	G	RF	RDo	RD	IV	EG
Anacardiaceae	1.91							
Anacardium giganteum W. Hancock ex Engl.		1	0.4961	0.26	0.85	0.17	0.43	LS
Tapirira guianensis Aubl.		10	0.8480	2.30	1.46	1.74	1.83	ES
Annonaceae	7.13							
Xylopia amazonica R. E. Fr.		9	0.6044	1.28	1.04	1.57	1.29	NC
Xylopia benthamii R. E. Fr.		1	0.0111	0.25	0.02	0.17	0.15	LS
Xylopia calophylla R. E. Fr.		6	0.1648	1.27	0.28	1.04	0.87	ES
Xylopia sp. 1		22	1.1054	3.83	1.9	3.83	3.19	NC
Xylopia sp. 2		1	0.0209	0.26	0.04	0.17	0.16	NC
Xylopia sp. 3		2	0.0571	0.51	0.1	0.35	0.32	NC
Apocynaceae	4.52							
Aspidosperma cf. *desmanthum* Benth. ex Müll.Arg.		1	0.0370	0.26	0.06	0.17	0.16	LS
Aspidosperma discolor A. DC.		25	6.2954	3.83	10.84	4.36	6.34	LS
Araliaceae	0.35							
Schefflera morototoni (Aubl.) Maguire et al.		2	0.9413	0.51	1.62	0.35	0.83	P
Bignoniaceae	0.87							
Jacaranda copaia (Aubl.) D. Don.		5	0.5612	0.51	0.97	0.87	0.78	P
Boraginaceae	0.70							
Cordia sellowiana Cham.		4	0.3893	0.77	0.67	0.70	0.71	ES
Burseraceae	1.39							
Protium heptaphyllum (Aubl.) Marchand		2	0.1906	0.51	0.33	0.35	0.40	P
Protium sagotianum Marchand		5	0.1333	1.02	0.23	0.87	0.71	LS
Trattinickia rhoifolia Willd.		1	0.1401	0.26	0.24	0.17	0.22	NC
Calophyllaceae	0.70							
Calophyllum brasiliensis Cambess.		2	0.1547	0.51	0.27	0.35	0.38	LS
Caraipa densifolia Mart.		2	0.0915	0.51	0.16	0.35	0.34	ES
Celastraceae	1.57							
Cheiloclinium cognatum (Miers) A. C. Sm.		9	0.5248	2.03	0.91	1.57	1.50	ES
Chrysobalanaceae	2.61							
Licania blackii Prance		8	0.9868	1.78	1.70	1.39	1.62	NC
Licania kunthiana Hook. f.		5	0.4652	1.02	0.80	0.87	0.90	LS
Licania sp. 1		2	0.0284	0.51	0.05	0.35	0.30	NC
Clusiaceae	0.70							
Tovomita umbellata Benth.		4	0.1259	1.02	0.22	0.70	0.64	NC
Connaraceae	0.17							
Connarus perrottetii (DC.) Planch.		1	0.0296	0.26	0.05	0.17	0.16	P
Elaeocarpaceae	0.70							
Sloanea sinemariensis Aubl.		4	0.1303	1.02	0.22	0.70	0.65	NC
Euphorbiaceae	0.70							
Cronton sp.		2	0.0658	0.51	0.11	0.35	0.32	NC
Mabea fistulifera Mart.		2	0.2210	0.51	0.38	0.35	0.41	P
Fabaceae	11.48							
Abarema jupunba (Willd.) Britton & Killip		8	0.6906	1.79	1.19	1.39	1.46	LS
Balizia pedicellaris (DC.) Barneby & J.W.Grimes		3	0.8351	0.77	1.44	0.52	0.91	NC
Cassia sp.		2	0.0736	0.26	0.13	0.35	0.24	NC
Copaifera langsdorffii Desf.		1	0.3892	0.26	0.67	0.17	0.37	LS
Diplotropis purpurea (Rich.) Amshoff		11	0.9957	1.79	1.71	1.92	1.81	LS
Hymenaea courbaril L.		1	1.0125	0.26	1.74	0.17	0.72	ES
Inga sp. 1		2	0.3716	0.51	0.64	0.35	0.50	NC
Inga sp. 2		2	0.0666	0.51	0.11	0.35	0.32	NC
Inga sp. 3		10	1.5222	2.03	2.63	1.74	2.13	NC
Inga sp. 4		2	0.0951	0.51	0.16	0.35	0.34	NC
Ormosia paraensis Ducke		1	0.3721	0.26	0.64	0.17	0.36	LS
Tachigali myrmecophila (Ducke) Ducke		5	0.7583	1.28	1.31	0.87	1.15	LS
Tachigali vulgaris L. G. Silva & H. C. Lima		18	0.9537	3.06	1.64	3.14	2.61	NC
Humiriaceae	0.35							
Sacoglottis guianensis Benth.		2	0.3709	0.51	0.64	0.35	0.50	NC
Lamiaceae	0.17							
Vitex panshiniana Moldenke		1	0.1820	0.26	0.31	0.17	0.25	ES
Lauraceae	8.52							
Endlicheria lhotzkyi (Nees) Mez		5	0.2326	1.28	0.40	0.87	0.85	NC
Nectandra cuspidata Nees		25	0.9396	3.57	1.62	4.36	3.18	P
Ocotea acutangula (Miq.) Mez		19	1.3459	2.55	2.32	3.31	2.73	LS
Malpighiaceae	0.52							
Byrsonima intermedia A. Juss.		3	0.7153	0.77	1.23	0.52	0.84	NC
Malvaceae	0.17							
Mollia lepidota Spruce ex Benth.		1	0.3942	0.26	0.68	0.17	0.37	NC
Melastomataceae	3.65							
Bellucia grossularioides (L.) Triana		10	1.2088	1.53	2.08	1.74	1.78	P
Miconia acutifolia Ule		7	0.5765	1.79	0.99	1.22	1.33	NC
Miconia minutiflora (Bonpl.) DC.		1	0.1404	0.26	0.24	0.17	0.22	P
Miconia sp. 1		1	0.0205	0.26	0.04	0.17	0.15	NC
Mouriri apiranga Spruce ex Triana		2	0.0660	0.51	0.11	0.35	0.32	ES

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Family/Species	%	N	G	RF	RDo	RD	IV	EG
Meliaceae	0.17							
Trichilia elegans A. Juss.		1	0.0370	0.26	0.06	0.17	0.16	LS
Menispermaceae	0.17							
Abuta grandifolia (Mart.) Sandwith		1	0.0093	0.25	0.02	0.17	0.15	NC
Moraceae	4.87							
Helicostylis tomentosa (Poepp. & Endl.) Rusby		8	0.8850	1.79	1.52	1.39	1.57	ES
Pseudolmedia laevigata Trécul		20	1.4975	3.57	2.58	3.48	3.21	ES
Myristicaceae	0.35							
Virola calophylla Warb.		2	0.0455	0.51	0.08	0.35	0.31	ES
Myrtaceae	1.39							
Myrcia amazonica DC.		5	0.3504	0.51	0.6	0.87	0.66	NC
Myrciaria floribunda (H. West ex Willd.) O. Berg		3	0.1375	0.51	0.24	0.52	0.42	LS
Ochnaceae	1.22							
Ouratea discophora Ducke		7	0.3152	1.53	0.54	1.22	1.10	NC
Olacaceae	0.17							
Minquartia guianensis Aubl.		1	0.0972	0.26	0.17	0.17	0.20	LS
Peraceae	0.87							
Chaetocarpus echinocarpus (Baill.) Ducke		4	0.2029	1.02	0.35	0.70	0.69	NC
Pera frutescens Leal		1	0.0289	0.26	0.05	0.17	0.16	NC
Rhizophoraceae	2.26							
Sterigmapetalum obovatum Kuhlm.		13	1.2410	2.81	2.14	2.26	2.40	NC
Rubiaceae	0.70							
Amaioua guianensis Aubl.		4	0.1769	1.02	0.30	0.70	0.67	LS
Salicaceae	1.74							
Casearia arborea (Rich.) Urb.		9	0.3279	1.79	0.56	1.57	1.31	ES
Casearia sp.		1	0.0298	0.26	0.05	0.17	0.16	NC
Sapindaceae	10.96							
Matayba arborescens (Aubl.) Radlk.		48	3.2019	4.82	5.53	8.35	6.23	P
Talisia guianensis Aubl.		3	0.2083	0.77	0.36	0.52	0.55	P
Toulicia guianensis Aubl.		12	0.8503	2.04	1.46	2.09	1.87	ES
Sapotaceae	6.61							
Chrysophyllum sp.		1	0.0218	0.26	0.04	0.17	0.16	NC
Micropholis venulosa (Mart. & Eichler) Pierre		2	0.0432	0.51	0.07	0.35	0.31	LS
Pouteria guianensis Aubl.		30	3.5305	3.83	6.08	5.23	5.04	LS
Pouteria macrophylla (Lam.) Eyma		1	0.0241	0.26	0.04	0.17	0.16	NC
Pouteria sp. 1		4	0.2104	0.77	0.36	0.70	0.61	NC
Indeterminate 1		1	0.0845	0.26	0.15	0.17	0.19	NC
Simaroubaceae	0.52							
Simarouba amara Aubl.		3	0.4965	0.77	0.85	0.52	0.71	ES
Urticaceae	0.87							
Cecropia sp.		3	0.2735	0.51	0.47	0.52	0.50	NC
Coussapoa trinervia Spruce ex Mildbr.		2	0.1872	0.51	0.32	0.35	0.39	ES
Vochysiaceae	16,00							
Erisma uncinatum Warm.		11	1.2546	2.30	2.16	1.92	2.12	LS
Qualea paraensis Ducke		42	8.4011	5.36	14.46	7.32	9.05	LS
Vochysia vismiifolia Spruce ex Warm.		39	3.7899	4.08	6.52	6.79	5.80	LS
Non-Identified	2.26							
Indeterminate 2		7	0.2309	1.79	0.40	1.22	1.13	NC
Indeterminate 3		1	0.0377	0.26	0.06	0.17	0.16	NC
Indeterminate 4		1	0.3814	0.26	0.66	0.17	0.36	NC
Indeterminate 5		1	0.0786	0.26	0.14	0.17	0.19	NC
Indeterminate 6		1	0.0299	0.25	0.05	0.17	0.16	NC
Indeterminate 7		1	0.0223	0.26	0.04	0.17	0.16	NC

N – number of individuals sampled; G – basal area per hectare (m^2 ha); RF – relative frequency (%); RDo – relative dominance (%); RD – relative density (%); IV – importance value (%); % - relative number of individuals per family; EG – ecological group; P – pioneer; ES – early secondary; LS – late secondary; NC – non-classified.

No single species was present in all sample subunits (Table 2). *Matayba arborescens* (Aubl.) Radlk. and *Qualea paraensis* Ducke were the species with the highest number of individuals sampled; *Q. paraensis* occurred in 21 subunits (84% of the area), and *M. arborescens* occurred in 19 subunits (76% of the area). And along with *Aspidosperma discolor* A.DC. were the species with the highest importance value. According to the Spiegel procedure, the diametric distribution of trees was a negative exponential (Figure 3).

The tendency for the species accumulation curve to stabilize in two stages was understood as a change in the environmental characterization (Figure 2). Within the fragment, the occurrence of terraces and skid trails in the subunits was verified, and selective logging was more intense in the region near the open area under agricultural activity – subunits 10 to 15 (Figure 1). The observation of small changes after the stabilization point of the curve could be interpreted as the sampling of a community different from the original (Schilling & Batista, 2008). As the line tended towards the horizontal asymptote (Figure 2), additional sampling effort was unnecessary due to the homogeneity of the area and because the cost-benefit ratio would be disadvantageous (Felfili et al., 2013). The richness obtained in this study (between 13 and 384 species) was within the range observed for samplings in secondary fragments of Seasonal Semideciduous Forests (Gaspar, Castro, Peloso, Souza, & Martins, 2014). The richness varied according to the degree of disturbance of the fragment and the secondary succession stage.

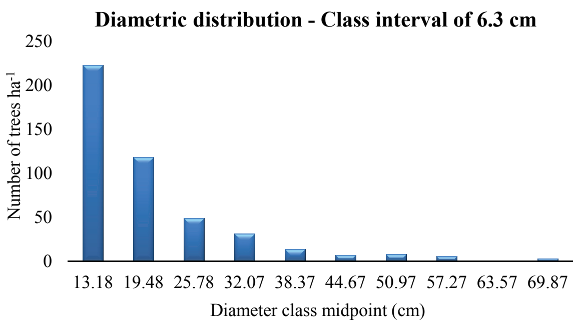

Figure 3. Diametric distribution of the fragment of the Seasonal Semideciduous Forest under the effect of selective logging, Tapurah, Mato Grosso State, 2014.

The inverse relationship between density and basal area was not observed, as would be expected in tropical forests (Machado et al., 2004) (Table 1). The basal area was 57.89 m^2 ha^{-1}, which is considered high for exploited fragments (Campos, Silva, Meira Neto & Martins, 2006; Pinto et al., 2007; Dias Neto et al., 2009). Only individuals of commercial interest, those that had a minimum DBH of 45 cm, and individuals for use in property maintenance were extracted.

Regarding the density of individuals (Table 1), the fragment agreed with general observations for Seasonal Semideciduous Forests (Abreu, Silva, & Silva, 2013; Souza, Meira Neto, & Souza, 2013; Corsini et al., 2014). The reduction of the density of smaller diameter trees and the growth of larger diameter trees are representative of areas in the recovery and in advanced successional stages (Fonseca & Rodrigues, 2000; Oliveira-Filho et al., 2007; Higuchi et al., 2008). A lack of regeneration in areas of old plains and trails was observed in the fragment, probably associated with their sporadic use.

The marked climatic seasonality and floristic aspects of the fragment, including the presence of the genera *Xylopia* (Annonaceae); *Aspidosperma* (Apocynaceae); *Protium* and *Trattinnickia* (Burseraceae); *Saccoglotis* (Humiriaceae); *Miconia* and *Mouriri* (Melastomataceae); *Myrcia* (Myrtaceae); and *Qualea* and *Vochysia* (Vochysiaceae), characterize it as a Submontane Seasonal Semideciduous Forest (Table 2). These types of vegetation are from the Amazon, with species that have expanded through the river system. The deciduous species that characterize this formation belong to the Amazonian genera *Hymenaea* (Fabaceae) and *Copaifera* (Fabaceae). However, the dominant genus is *Aspidosperma* (Apocynaceae) (Oliveira-Filho & Fontes, 2000; Instituto Brasileiro de Geografia e Estatística [IBGE], 2012).

The predominance of Fabaceae species (Table 2) matches patterns typically found in Submontane Seasonal Semideciduous Forests (Meira Neto, Souza, Silva, & Paula, 1997; Souza et al., 2013) showing that, although disturbed, the floristic pattern of this fragment is close to that observed in other studies. Regarding the successional groups registered in the fragment, there was a predominance of the late secondary category (47% of individuals classified) (Table 2). This result was higher than the values (approximately 30%) found by other authors in fragments at advanced stages of secondary succession (Lopes, Silva, Souza, & Meira Neto, 2002; Marangon, Soares, Feliciano, & Brandão, 2007; Abreu et al., 2013).

In a study with a temporal gradient, Alves, Zaú, Oliveira, Lima, and Moura (2005) observed the significant presence of the late secondary stage only after 25 years, with an increase in the mature stage. However, other authors obtained more late species in more preserved areas of the fragments analysed (Fonseca & Rodrigues, 2000; Leite & Rodrigues, 2008). Though disturbed, this fragment is able to preserve its original structure and provide superior stratum coverage.

The occurrence of typical late secondary species of underbrush and understory, such as *Amaioua guianensis* Aubl., *A. discolor*, *Copaifera langsdorffii* Desf., *Q. paraensis* and *Vochysia vismiifolia* Spruce ex Warm., emphasizes the importance of shading as a succession strategy and also indicates the resilience of the forest after human disturbances because this group of plants is very important in the colonization of clearings (Martins & Rodrigues, 2002; Martins, Colletti Júnior, Rodrigues, & Gandolfi, 2004). The remaining fragments are important because they have high residual diversity (Tabarelli, Mantovani, & Peres, 1999), including the species *Protium heptaphyllum* (Aubl.) Marchand. In other studies, the value of small fragments for conservation was demonstrated (Campos et al., 2006; Carvalho, Nascimento, & Braga, 2007; Arroyo-Rodríguez, Pineda, Escobar, & Benítez-Malvido, 2009; Carvalho, Braga, & Nascimento, 2009; Dan, Braga, & Nascimento, 2010).

Even though the fragment has suffered and still suffers the effects of selective logging, high diversity was found ($H' = 3.82$ nats ind^{-1}); this was evident in the plains and trails that still have not recovered. Regarding the total area of the fragment ($J' = 0.85$), an individual uniform distribution and low ecological dominance was evident among species, in agreement with the value found by Silva et al. (2012), *J '= 0.82*. In tropical forests, the ecological dominance is often more pronounced at the extremes of high and low availability of soil resources, resulting in higher species diversity in intermediate conditions (Ashton, 1990). Therefore, the *J*' value indicated that 85% of the maximum hypothetical diversity *(H')* was obtained, suggesting the intermediate availability of soil resources.

Among the sampling subunits, according to the Jaccard index (0.04 to 0.44), the similarity ranged from low to medium. Santos and Kinoshita (2003) noted that the fragmentation can behave in a way that makes sampling subunits increasingly distinct from each other. According to Carvalho and Marques-Alves (2008), frequent disturbances are representative and alter the vegetation, species distribution, abundance and successional stage. The low similarity between the sampling subunits may have been one of the reasons for the inability of the species accumulation curve to stabilize.

In the fragment studied, 22% of the species exhibited 66% of the total IV (Table 2), higher than the result found by Pinto and Hay (2005) in the Chapada dos Guimarães National Park, where 20% of the tree species exhibited 56% of the total IV. According to Felfili (1994), it is expected that species with higher IV can better exploit the resources available in the area and maintain their stable participation in the community structure, provided that there are no pronounced disorders.

The vegetation structure of the fragment represented a community with strong specific dominance and a slight decrease in the IV in the first five species (*Q. paraensis, A. discolor, M. arborescens, V. vismiifolia and Pouteria guianensis* Aubl.), which together totalled 32.46% of the total IV (Table 2). In addition to showing the highest IV, the species *Q. paraensis* e *A. discolor* stood out from other species because it presented a high relative dominance. High dominance is associated with stressful situations, as it is an indicator of disturbances in the environment (Leite & Rodrigues, 2008; Abreu et al., 2013).

Individuals with low IV (less than 2%) represented 85.23% of the species (Table 2). According to Vibrans et al. (2008), this value is represented by the existence of great vulnerability in their populations before the process of fragmentation and the degradation of forest remnants. The presence of rare species (less than one tree per hectare) was not observed.

After the distribution of the sampled individuals into diameter classes, it was possible to observe predominance in the first, second and third classes, which corresponded to 84.87% of the total sample with DBH between 10 and 29 cm (Figure 3). The biggest DBH found was 73.02 cm from an individual of the species *A. discolour.* This result (a negative exponential) corroborates the results of other studies in seasonal semideciduous forests in different locations and successional stages (Rocha et al., 2005; Moreira et al., 2013).

A negative exponential pattern is typical of heterogeneous forests and is found in stable and autorregenerative communities where there is a balance between mortality and recruitment of individuals, as the stock of young plants is able to replace senile or decrepit adults. The high frequency of skinny trees (the first diameter class) indicated that the fragment is recovering from disturbances in the environment (Figure 3).

Conclusion

The studied fragment represents a stable and autoregenerative community, preserving features of the original structure. This emphasizes the need to adopt appropriate management practices and conservation efforts.

Ackowledgements

Thanks to CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brazil) for providing a scholarship to the first author and the forester Diogo Cavazzini for enabling us to carry out this research. Finally, the authors are grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil). The authors are grateful to Silvo Rodrigues by identification of the species.

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Received on July 4, 2016.
Accepted on October 12, 2016