EFFECT OF TIMBER HARVESTING ON DENSITY AND BASAL AREA OF LECYTHIDACEAE SPECIES IN THE EASTERN AMAZON

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Abstract

Dynamics of Lecythidaceae species were evaluated 13 years after logging in a dense tropical rain forest located in the municipality of Moju, Pará (02º 08' 14'' and 02º 12' 26'' S; 48º 47' 34''S and 48º 48' 14'' W - SAD 69). Two hundred ha out of a 1,050 ha forest area were selectively logged for timber (23 m^3 ha-1 harvested from 25 species) in 1997. Twenty-two permanent sample plots of 0.5 ha (11 ha sample area) were established and all trees with DBH ≥ 10 cm were measured and identified in 1995, 1998 and 2010. Density (trees ha^{-1}) and basal area (m^2 ha^{-1}) of the species were evaluated in the three occasions. The opening of canopy caused by logging reduced the density and basal area of five species, but produced a positive response in nine species, boosting their natural regeneration and allowing the ingrowth of one species that was not present in the studied area in the beginning.
*Keywords***:** Forest dynamics; Tauari; forest management; Amazon Forest.

Resumo

Efeito da exploração de madeiras na densidade e área basal de espécies de Lecythidaceae no leste da Amazônia. Analisou-se a dinâmica de espécies de Lecythidaceae 13 anos após a exploração madeireira, em uma Floresta Ombrófila Densa no município de Moju, Pará (02º 08' 14'' e 02º 12' 26'' S; 48º 47' 34''S e 48º 48' 14'' W - SAD 69). De uma área de floresta de 1.050 ha, foram selecionados 200 ha para exploração seletiva, em 1997, de 25 espécies comerciais madeireiras (intensidade de 23 m^3 ha^{-1}). Foram alocadas 22 parcelas permanentes de 0,5 ha, totalizando 11 ha amostrais, onde foram medidas todas as árvores com DAP≥ 10 cm, nos anos de 1995, 1998 e 2010. Analisou-se a densidade (árvores ha^{-1}) e área basal (m^2 ha^{-1}) das espécies, nas três ocasiões. A abertura do dossel causada pela exploração reduziu a densidade e a área basal de cinco espécies, porém produziu impacto positivo em nove espécies, estimulando a sua regeneração natural e, inclusive, proporcionando o ingresso de uma espécie que não estava presente na área monitorada
Palavras-chave: Dinâmica da floresta; Tauarí; manejo florestal; Floresta Amazônica.

INTRODUCTION

The amazon forest represents the largest extension of tropical forest and includes the biggest plant diversity of the planet. Each one of its different forest environments has a rich and various floristic patrimony, with multiple mutual relations between biotic and abiotic components, forming a set of highly complex ecosystems (OLIVEIRA; AMARAL, 2004).

Besides its ecological importance, the amazon forest has a great economic potential, mainly in the wood industry sector. The gross yearly revenue of the wood industry estimated in the amazon region, in 2009, was approximately five billion reais. To this total, the contribution of Pará State was 44%, followed by Mato Grosso with 32% and Rondônia with 14%, generating approximately 204 thousand direct and indirect jobs (PEREIRA *et al*., 2010).

However, the best way to use the forest resources in a sustainable way must be addressed. According to Azevedo (2006), researchers, decision makers, economic agents, social leaderships and environmental organizations have recognized the forestry potential of the Amazon and consider the economic development of the region possible and compatible with the conservation of its immense natural richness. According to Reis *et al.* (2010), forest management is a wise alternative to ensure sustainable exploitation its resources, to maintain the biodiversity and sustain the wood industry, which is one important income generator in the Northern region.

The sustainable management of the amazon forest requires studies on its behavior in response to logging. Understanding how the species behave helps the decision making on how to manage the forest.

According to Jardim *et al*. (2008), knowledge of the forest structure and composition allows deductions about ecological characteristics and forest dynamics, which are among the basic elements for a forest management project.

Density and basal area are important structural parameters used to monitor the forest behavior. These parameters are good descriptors of the wooden plants communities. Basal area is a good descriptor because it goes through few modifications when the inclusion diameter is changed, because the smaller individuals give relatively little contribution to the basal area (DURIGAN, 2009). However, density is one of the most commonly used descriptors in plant communities characterization, because it is easy to obtain in plot based surveys (MARTINS; SANTOS, 1999).

Analyses on dynamic and impact of forest logging are generally performed on the plant community as a whole and they rarely give specific information on a single group of species, genera and botanic families. It is assumed that the harvest is not uniform between all the tree species, due to the great biodiversity of the amazon forest and to the complexity of botanic identification. Based on this understanding, it is possible to interfere in the forest applying silvicultural practices, in case they are needed, to ensure the perpetuity of these species and increase their productivity.

Many are the botanical families encountered in the amazon forest, and between them, the Lecythidaceae family comes out as the one with the biggest forest dominance, according to Ruschel (2008), which has a great ecological and economic importance for the region. Lecythidaceae distribution is concentrated in the neotropical region, including about 25 genera and 300 species. Their occurrence in Brazil includes 14 genera and approximately 100 species, mainly in the amazon forest (SOUZA; LORENZI, 2008). According to Mori *et al*. (2001), over 50% of all the neotropical Lecythidaceae species are found in the Amazon. In the State of Pará, 28 Lecythidaceae species are currently exploited for wood production, according to the Secretariat of Environment of Pará State (SEMA-PA, 2012).

This study aimed at evaluating the effect of low impact logging on 14 Lecythidaceae species, based on the temporal variation of the basal area, in order to generate information helping the decision making process concerning the management of commercial wood species and other species of the family.

MATERIAL AND METHODS

The study was carried out in Embrapa Amazônia Oriental´s research station, in the municipality of Moju, State of Pará (02º 08' 14'' and 02º 12' 26" latitude south; 48º 47' 34" and 48º 48' 14" longitude west from Greenwich - SAD 69), km 30 of the PA-150 highway, with a total area of 1.050 ha.

Climate of the region is Ami type, according to Köppen´s classification, with annual rainfall variation from 2,000 to 3,000 mm, irregularly distributed, with short dry periods, with the biggest rainfall concentration from February to April, and the driest period from August to October. The average annual temperature is 26 °C, with a monthly thermal amplitude variation from 21 °C to 33 °C. Relative humidity is around 85%. The relief is flat and the predominant soil in the experiment area is Dystrophic Yellow Latosol. Typology of the experimental area is dry land Tropical Rain Forest, with height of trees varying from 25 to 35 m and presence of some palms in the understory (LOPES *et al*., 2001).

Two hundred ha of forest were selected in 1995 for logging. A census of the forest (100% inventory) was carried out, in which all commercial trees with DBH ≥ 25 cm (DBH = diameter at breast height measured at 1.3 meter above ground) in a plot of 100 ha and trees with DBH ≥ 45 cm in another 100 ha plot were recorded, (Costa *et al*. 1998). Along the same year all vines with diameter bigger than 2 cm were cut in the entire 200 ha area, and 22 permanent plots measuring 50 x 100 m (0.5 ha) were set up, for a total of 11 ha of sampling area. Each one was then divided into 50 sub plots of 10 x 10 m, where all the trees with DBH ≥ 10 cm were measured and had their common name determined. Three measurements took place in the plots, the first back in 1995, before logging, and then, after logging, in 1998 and 2010.

Logging took place in 1997 applying reduced impacts techniques, in the 200 ha area. An average of 3.3 trees ha^{-1}, corresponding to a volume of 23 m^3 ha^{-1}, from a total of 25 species were harvested. The minimum felling diameter was 65 cm. *Couratari guianensis* Aubl was the only Lecythidaceae species harvested, with an average of 0.21 trees ha^{-1} logged, which gave a volume of 1.84 m^3 ha^{-1}.

For the botanical identification o, a minimum of five specimens were collected from each assigned common name of Lecythidaceae, totalizing 102 collections. Identification was performed by comparing to botanic samples stored in the IAN herbarium of Embrapa Amazônia Oriental and referring to Mori and Prance (1990) taxonomical revision.

The variables studied were density (trees ha^{-1}) and basal area (G -m^2 ha^{-1}) of the Lecythidaceae species. These variables were evaluated in the following time periods: 1995 to 1998, 1995 to 2010 and from 1998 to 2010.

The *t* test for paired samples was performed to verify the effect of logging on the remaining community. Before the application of the *t* test, a Kolmogorov-Smirnov normality test was performed. When data did not present normality and heteroscedasticity, a Box-Cox (1964) transformation was performed to obtain data normalization. If after data transformation, normality was still not achieved, a Wilcoxon (*signed-ranks*) test was performed on paired samples at 5% of significance. Statistical tests were applied only for density and basal area of the species to individuals found in at least four plots.

Data were processed with MFT (Monitoramento de Florestas Tropicais) *software,* developed by Embrapa Amazônia Oriental to monitor tropical forest dynamics and with Microsoft Excel 2010 *software* spreadsheets. Statistical analyses were processed with Bioestat 5.3 software.

RESULTS AND DISCUSSION

In the 11 ha sampling area, in 1995, the community presented 5,413 trees with DBH ≥ 10 cm (492.1 trees ha^{-1}± 16.3). One year after the logging, 5,355 trees were registered (486.8 trees ha^{-1}± 26.4), with no significant difference between the years 1995 and 1998 ($p= 0.5541$). For the 15 year period (1995 to 2010), sampling registered 5,729 trees with DBH ≥ 10 cm (520.8 trees ha^{-1}± 17.5), which represents a significant increase of 5.8% ($p= 0.0068$). This increase after the logging may indicate that canopy opening had a favorable effect on establishment and growth of of the remaining individuals, when compared to pre-logging conditions.

In 2010 the species composition was comprised of 47 botanic families, 165 genera and 380 species. From these 56 species were determined only up to genus because of the lack of fertile botanic material at the time of collection. Lecythidaceae was represented by three genera distributed in 14 species: *Eschweilera* Mart. ex DC. with the species *E. coriacea* (DC.) S.A. Mori, *E. grandiflora* (Aubl.) Sandwith, *E. amazonica* R. Knuth, *E. ovata* (Cambess.) Mier, *E. pedicellata* (Rich.) S.A. Mori, *E. nana* (O. Berg) Miers, *E. albiflora* (DC.) Mier; *Lecythis* Loefl. with the species *L. idatimon* Aubl., *L. lurida* (Mieônrs) S.A. Mori, *L. pisonis* Cambess., *L. chartacea* O. Berg, and *Couratari* Aubl. with the species *C. guianensis* Aubl., *C. oblongifolia* Ducke & R. Knuth, *C. stellata* A.C. Sm. The family represented 3.4% of all the species found in the area, ranking seventeen in species richness of the studied area.

Density of Lecythidaceae

Lecythidaceae was the most representative family as far as density is concerned (109.2 trees ha^{-1}; CI= ± 14.1), accounting to 22.9% of the total community density in 2010 (Table 1). Evaluating this parameter over time in the period from 1995 to 1998, there was a reduction of 0.5%, caused by logging, natural mortality and collateral damage related to logging. Considering the whole 15-year period (1995-2010), this 0.5% loss was recovered. However, reduction and increase were not statistically significant ($p= 0.7307$; $p= 0.8212$).

Lecythidaceae has been regarded as one of the most important families in the floristic composition of various locations in the Brazilian Amazon region. For example, Oliveira and Amaral (2004), studying a 10 ha sample area of the central Brazilian Amazon, reported Lecythidaceae as the most populous of the area in terms of individuals and the second family with the largest number of species; Pinheiro *et al*. (2007), considering the number of individuals and the number of species, reported

Lecythidaceae as the second most important family of the 12 ha studied area, located in northeast of Pará; Reis *et al*. (2010) registered Lecythidaceae as one of the three families with the largest number of species in the 64 ha studied area (9 ha sampling area), located in the Tapajós National Forest, west of Pará State.

Table 1. DA – Absolute density (trees ha^{-1}); DR – Relative density (%) of Lecythidaceae species with Dbh ≥ 10 cm in an 11 ha sample of a tropical rain forest in the municipality of Moju, State of Pará.

Tabela 1. DA - Densidade absoluta (árvores ha^{-1}); DR - densidade relativa (%) das espécies de Lecythidaceae com DAP ≥ 10 cm, em uma amostra de 11 ha de floresta ombrófila densa no município de Moju, estado do Pará.

Species	1995		1998		2010		1995-1998	1995-2010
	DA	DR	DA	DR	DA	DR	P-value	
Eschweilera coriacea	49.45	10.05	49.64	10.19	50.64	9.72	(1) p= 0.8623 (ns)	(1) p= 0.5257 (ns)
Lecythis idatimon	42.00	8.53	40.64	8.34	40.36	7.75	(1) p= 0.143 (ns)	(1) p= 0.1674 (ns)
Eschweilera grandiflora	10.09	2.05	11.09	2.28	12.36	2.37	(1) p= 0.0008 (**)	(1) p= 0.0006 (**)
Eschweilera amazonica	2.64	0.54	2.73	0.56	1.73	0.33	(2) p= 0.5930 (ns)	(2) p= 0.0593 (ns)
Lecythis pisonis	1.55	0.31	1.45	0.30	1.27	0.24	(2) p= 0.3173 (ns)	(2) p= 0.1088 (ns)
Couratari guianensis	0.91	0.18	0.64	0.13	0.73	0.14	(2) p= 0.1088 (ns)	(2) p= 0.5930 (ns)
E. ovata	0.64	0.13	0.64	0.13	0.73	0.14	(2) p > 0.05 (ns)	(2) p= 0.3173 (ns)
Couratari oblongifolia	0.55	0.11	0.55	0.11	0.55	0.11	(2) p > 0.05 (ns)	(2) p > 0.05 (ns)
Couratari stellata	0.36	0.07	0.36	0.07	0.36	0.07	(2) p= 0.3173 (ns)	(2) p= 0.3173 (ns)
Lecythis chartacea	0.18	0.04	0.18	0.04	0.18	0.03	-	-
Eschweilera pedicellata	0.09	0.02	0.09	0.02	0.09	0.02	-	-
Eschweilera nana	0.09	0.02	0.09	0.02	0.09	0,02	-	-
Eschweilera albiflora	-	-	-	-	0.09	0.02	-	-
Lecythis lurida	0.09	0.02	-	-	-	-	-	-
Lecythidaceae	108.64	22.08	108.10	22.20	109.18	20.96	(1) p=0.7307 (ns)	(1) p=0.8212 (ns)
Community	492,07	-	486,83	-	520,82	-	(1) p=0,5541 (ns)	(1) p=0,0068 (**)

(1) t paired test at 5% of significance; ns: not significant; **: significant. (2) Wilcoxon test (signed-ranks) for paired samples. (-) Statistical tests not performed (n<4).

The Lecythidaceae species with the highest density in 2010 were, in decreasing order: *E. coriacea* (50.64 trees ha^{-1}; CI= ± 6.7), *L. idatimon* (40.36 trees ha^{-1}; CI= ± 11.1) and *E. grandiflora* (12.36 trees ha^{-1}; CI= ± 3.3). From 1995 to 1998 *E. coriacea* and *E. grandiflora* presented an increase in density respectively of 0.3% and 9.9% (Table 1). However, only *E. grandiflora* showed a significant increase (p= 0.0008). Density of *L. idatimon*, in the same period, decreased by 3.2%, but this reduction not significant at the the community level (p= 0.143).

Pereira *et al*. (2011) reported *Eschweilera* among the genera with the highest importance value in a dry land forest located in the State of Amapá, eastern Amazon. According to studies carried out elsewhere in Pará State (LIMA FILHO *et al*., 2004; LOPES, 2007), *E. coriacea* presented the largest number of individuals in the community. *E. coriacea* is common and with a wide distribution in the Amazon region, being a species that shows high density in several studies (LIMA FILHO *et al*., 2004; SOUZA *et al*., 2006; SILVA *et al*., 2008; REIS *et al*., 2010).

Three species (*E. coriacea*, *E. grandiflora* and *L. idatimon*) together represented 23.63% of the trees in the community. Similarly to this study, Souza and Souza (2009) found *L. idatimon* and *E. coriacea* as the species with the highest density in Paragominas, State of Pará.

Considering the entire period (1995 to 2010), *E. grandiflora* and *E. coriacea* presented an increase in density of 22.5% (p= 0.0006) and 2.4% (p=0.5257), respectively, which was not significant for the latter. *L. idatimon* presented a reduction of 3.9% (p= 0.1674) over the same period, but this was not significant. One year after logging (1998), the main cause of reduction in density was damage related to the logging operations, which caused the death of 24 trees (2%).

The Lecythidaceae species with lowest density were: *E. nana*, *E. albiflora* and *L. lurida* which presented a density of 0.09 trees ha^{-1}. *L. lurida* was registered only in 1995 (Table 1). In 1998 and 2010 the species was not found anymore, due to mortality related to logging damage. These species are classified as rare according to Kageyama and Gandara (2000) and Ferretti (2002), who consider rare the species with less than one individual per hectare (DBH ≥ 10 cm).

It well understood that rare species are indicators of conservation, even more when associated to endemism as is the case of *L. lurida* which is considered endemic in Brazil (SMITH *et al*., 2012). Species with low density and that could disappear of a forest area after logging, must be treated with measures to mitigate the effects of exploitation, to ensure their conservation. Enrichment planting and reduced impact logging are among silvicultural practices, to avoid destruction rare species.

It is worth pointing out that in all the studied periods (1995, 1998 and 2010), and considering the definition of rarity given by the above mentioned authors, there were nine rare species in the sample area: *C. guianensis, C. oblongifolia*, *C. stellata*, *E. ovata*, *E. pedicellata*, *E. nana*, *E. albiflora, L. chartacea* and *L. lurida*. According to Pinheiro *et al*. (2007), in some regions rare species present characteristics which explain their low densities, such as pollinating agents and distance between mother trees. According to Alves and Miranda (2008), the occurrence of rare species is common in the Amazon bioma.

Although *L. lurida* was no more registered in the studied area, the other rare species continued stable. *C. guianensis* and *E. ovata* even increased density after logging, but kept their condition of rarity.

In this study, out of the 13 species registered in 2010, seven are endemic to Brazil (SMITH *et al*., 2012): *E. ovata* (Amazon, Caatinga, Cerrado and Atlantic Forest), *E. nana* (Amazon and Cerrado), *L. lurida* and *L. pisonis* (Amazon and Atlantic Forest) and three are endemic only to the Amazon (*E. grandiflora*, *E. amazonica* and *L. idatimon*). According to Mittermeier *et al*. (2002), in the Amazon region there are 30,000 species of endemic plants. For this reason a good planning of the forest activities is necessary, in order that species considered rare and endemic will not suffer consequences leading to their disappearance from the forest.

Couratari is a frequent genus in the Amazon region, as reported by Procópio *et al*. (2010), who studied the geographic distribution patterns of species commonly known as "tauari" in dry land forests of the Amazon region. They encountered *C. guianensis*, *C. stellata* and *C. oblongifolia* in all the six studied areas, located in Pará, Amazon region and French Guyana.

Density of *C. guianensis* was reduced by 29.7% one year after logging (1998), and by 19.8% over the entire observation period (1995-2010). Thirteen years were not yet enough for the species to recover its initial density. However there is a trend for this recovering to occur, observing the 14% increase registered over the post logging period (1998 to 2010).

C. oblongifolia with 0.55 trees ha^{-1} and *C. stellata* with 0.36 trees ha^{-1} maintained the same number of individuals in the area before and after the logging (Table 1). Oliveira (2005), reported that *C. oblongifolia* did not recover its initial density, 21 years after logging. But where thinning was associated to logging, this species showed an increase in density and basal area. This demonstrates that *Couratari* may need post logging silvicultural treatments to recover the stock.

C. guianensis had its density reduced due to logging whereas *C. oblongifolia* and *C. stellata* maintained stable densities. The diminution in number of species soon after logging and the following recovering (increase in density) were also observed by Reis *et al*. (2010) in the Tapajós National Forest.

Basal Area of Lecythidaceae

In 1995, before logging (Table 2), Lecythidaceae species presented a basal area of 5.98 ± 1.82 m^2 ha^{-1} (23.5% of the community). One year after logging (1998) it increased to 6.03 ± 1.6 m^2 ha^{-1} but compared to the status before logging this increase was not significant (p= 0.4886). Analyzing the whole period (1995 to 2010), there was a positive balance as the species of this family increased basal area by 9.4% (p= 0.0016), presenting, in 2010, 6.54 ± 1.63 m^2 ha^{-1} (24.2% of community). It may be inferred that logging had a positive effect on growth and recruitment of Lecythidaceae species due to increasing solar radiation as a consequence of canopy opening.

According to Mori (1990), Lecythidaceae is one of the most ecologically important families of trees in dry land forests. This is confirmed in various studies performed in the Amazon region, which report the family having the highest density and dominance, for example in Pereira *et al*. (2011), Souza and Souza (2009), Oliveira *et al*. (2008), Souza *et al*. (2006) and Maciel *et al*. (2000).

Table 2. G – Absolute basal area (m^2 ha^{-1}); GR – Relative basal area (%) of Lecythidaceae species with Dbh ≥10 cm in a 11 ha sample of a tropical rain forest in the municipality of Moju, State of Pará.

Tabela 2. G - Área basal absoluta (m^2 ha^{-1}); GR – Área basal relativa (%) das espécies de Lecythidaceae com DAP ≥ 10 cm, em uma amostra de 11 ha de floresta ombrófila densa no município de Moju, estado do Pará.

Species	1995		1998		2010		1995-1998	1995-2010
	G	GR	G	GR	G	GR	P-value (t-test)	
Eschweilera coriacea	2.93	11.53	3.01	12.59	3.42	12.65	(1) p= 0.0759 (ns)	(1) p< 0.0001 (**)
Lecythis idatimon	1.65	6.51	1.62	6.76	1.67	6.16	(1) p= 0.3718 (ns)	(1) p= 0.8169 (ns)
Lecythis pisonis	0.60	2.34	0.61	2.56	0.53	1.97	(2) p= 0.0186 (*)	(2) p= 0.1520 (ns)
Eschweilera grandiflora	0.35	1.36	0.39	1.62	0.45	1.66	(1) p< 0.0001 (**)	(1) p< 0.0001 (**)
Couratari guianensis	0.17	0.68	0.13	0.53	0.18	0.67	(2) p= 0.9528 (ns)	(2) p= 0.4446 (ns)
Eschweilera ovata	0.11	0.42	0.11	0.45	0.13	0.47	(2) p= 0.6858 (ns)	(2) p= 0.0277 (*)
Couratari oblongifolia	0.06	0.23	0.06	0.24	0.06	0.23	(2) p= 0.7150 (ns)	(2) p= 0.1441 (ns)
Eschweilera amazonica	0.06	0.25	0.07	0.29	0.05	0.17	(2) p= 0.0186 (*)	(2) p= 0.2721 (ns)
Couratari stellata	0.03	0.12	0.03	0.13	0.04	0.14	(2) p= 0.1088 (ns)	(2) p= 0.0679 (ns)
Lecythis chartacea	0.00	0.02	0.00	0.02	0.01	0.02	-	-
Eschweilera nana	0.00	0.02	0.00	0.02	0.01	0.02	-	-
Eschweilera albiflora	-	-	-	-	0.00	0.00	-	-
Eschweilera pedicellata	0.00	0.00	0.00	0.00	0.00	0.01	-	-
Lecythis lurida	0.01	0.03	-	-	-	-	-	-
Lecythidaceae	5.98	23.52	6.03	25.23	6.54	24.18	(1) p=0.4886	(1) p=0.0016
Community	25.42		23.91		27.04		(1) p=0.0157	(1) p=0.0058

(1) t paired test at 5% of significance ; ns: not significant; **: significant. (2) Wilcoxon test (signed-ranks) for paired samples. (-) Statistical tests not performed (n<4).

In 1995 *E. coriacea* presented the biggest basal area (Table 2) of the community with 2.93 ± 0.56 m^2 ha^{-1}, representing 11.5% of the community's total basal area. In 1998, one year after logging, the species increased BA by 2.8%. In various studies carried out in the Amazon region, this species is reported as one of the highest dominance (SOUZA *et al*., 2006; ALARCON; PEIXOTO, 2007; SILVA *et al*., 2008). Souza and Souza *et al*. (2009) showed *E. coriacea* as the second species with the highest dominance in the 15 ha sampling area, in a dry land tropical rain forest located in the municipality of Paragominas, State of Pará.

Lecythis idatimon (1.67 ± 0.42 m^2 ha^{-1}) and *Lecythis pisonis* (0.53 ± 0.33 m^2 ha^{-1}) were among the species with the highest basal area in 2010, considering both the family and the community. Similar observation was pointed out by Souza *et al*. (2006) and by Francez *et al*. (2009) in dry land forests located in eastern Amazon.

Regarding the 15-year studied period (1995 to 2010), ten out of the 14 Lecythidaceae species presented a positive balance, *viz E. coriacea, E. grandiflora, E. ovata, E. nana*, *E. pedicellata, L. idatimon, L. chartacea*, *C. guianensis*, *C. stellata*, *C. oblongifolia*. This finding indicates canopy opening as a consequence of logging increased basal area when compared to the situation before the harvesting.

Notwithstanding *C. guianensis*, had basal area reduction by 26.9% due to harvesting (1995 to 1998), it recovered 5.4% of its dominance when the whole period (1995 to 2010) was considered. Studies carried out by Salomão *et al*. (2007) in the main municipalities of Belo Monte region, Pará, revealed that *C. guianensis* presented the highest relative dominance in the area subjected to selective logging, when compared to another area without any intervention.

E. amazonica presented a negative balance of 26%, caused by natural mortality. On the other hand *L. pisonis*, even being among the species with the highest basal area, had a reduction of 10.6% in the 15 year period, caused by impacts related to harvesting.

It is worth pointing out that *E. albiflora* was not detected in the sampled area on the 1995 and 1998 surveys but was found in the 2010 assessment. It may be concluded that this species was recruited into the communityThis finding corroborates studies conducted by Plumptre (1996), in Budongo Forest Reserve, Uganda (West Africa), where logged areas showed an increase in the any number of species when compared to primary forest without intervention.

CONCLUSIONS

- Except for *L. idatimon, L. pisonis, E. amazonica, C. guianensis* and *C. stellata* which had their density and/or basal area reduced by harvesting and its impacts, logging increased density and basal area of other nine Lecythidaceae species studied, when compared to the status before logging, and promoted ingrowth of *E. albiflora*, a species not found in the initially surveyed population.

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