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An herbaceous-shrub flora under prescribed fire in a Brazilian Cerrado

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Abstract: Monitoring of vegetation on the herbaceous layer in a Cerrado *sensu stricto* in Planaltina (DF) was carried out eight times from 1988 to 1994 and in 2012, in two areas of 1.25 ha (Area 1, Area 2). Using the interception method on line, two transections of 100 m in length were defined, which were subdivided in sample units measuring one meter, totaling 200 units per area. In Area 1, prescribed burnings were applied in 1988, 1990 and in 1992. Area 2 was protected until July 1994, however an accidental fire hit the whole area in August the same year. Species of different habits up to a meter high were recorded in both areas. A number ranging between 92 and 134 species was observed from 1988 to 1994, and 115 species were recorded in 2012 in Area 1. Also, a number between 97 and 129 species was observed from 1988 to 1994, and 106 species were recorded in 2012 in Area 2. The results indicated the recovery and resiliency of the community after biennal burnnings. Biennal prescribed fires did not change the richness and diversity, but the community structure. The suppression of fire for 18 years did not promoted differences in the richness, but in the community diversity and structure. The exclusion of fire for 18 years also did not favored the floristic similarity between the two areas.

Key words: Diversity; Dynamic; Structure.

Flora herbáceo-arbustiva em um Cerrado sob queimas prescritas

Resumo: O monitoramento da vegetação do estrato herbáceo em Cerrado sentido restrito em Planaltina (DF) foi realizado em oito ocasiões de 1988 a 1994 e em 2012, em duas áreas de 1,25 ha (Área 1, Área 2). Pelo método de interceptação na linha, foram demarcadas duas transecções de 100 m de comprimento, que foram subdivididas em unidades amostrais de um metro, totalizando 200 unidades por área. Na Área 1, foram aplicadas queimas prescritas em 1988, 1990 e 1992. A Área 2 foi protegida até julho de 1994, mas, nesse ano, um fogo acidental atingiu toda a área. Foram registradas espécies de diferentes hábitos até um metro de altura. Na Área 1, foram observadas de 92 a 134 espécies, no período de 1988 a 1994, e 115 espécies, em 2012. Na Área 2, foram registradas de 97 a 129 espécies, no período de 1988 a 1994, e 106 espécies, em 2012. Os resultados indicaram a recuperação e a resiliência da comunidade após queimadas bienais. As queimas bienais prescritas não modificaram a riqueza e a diversidade, mas a estrutura da comunidade. A exclusão do fogo por 18 anos não promoveu diferenças na riqueza, mas na diversidade e estrutura da comunidade. A exclusão do fogo também não favoreceu a similaridade florística entre as duas áreas.

Palavras-chave: Dinâmica; Diversidade; Estrutura.

1. INTRODUCTION

The Cerrado has a number of herbaceous species greater than that of tree species (MENDONÇA et al., 2008). Frequent fires generally reduces the density of woody species (MUNHOZ & AMARAL, 2010; GORGONE-BARBOSA et al., 2016) favoring the colonization of the herbaceous layer, altering the floristic composition (LOIOLA et al., 2010; SILVA et al., 2011) and the structure of the communities (SALAZAR & GOLDSTEIN,

2014; GORGONE-BARBOSA et al., 2020). On the other hand the suppression of fire can inhibit growth and reduce species richness in this layer (MEDEIROS & FIEDLER, 2011; BUISSON et al., 2019).

After long periods of fire suppression, the vegetation is more prone to fire, especially in the dry season (BUISSON et al., 2019). The dead biomass that graminoids can accumulate during the dry season represents the main fuel load (MEWS et al., 2013; SALAZAR & GOLDSTEIN, 2014). However, the herbaceous layer grows vigorously in a few days due to the incidence of light (MUNHOZ & AMARAL, 2010) and the stimulus of vegetation regeneration by the local seed bank or by the ability to resprout from the bud banks of some species (FIDELIS et al., 2014; PAUSAS et al., 2018; PILON et al., 2020).

The Cerrado herbaceous layer is highly resilient to fire (MEWS et al., 2013; VIELDMAN et al., 2015). Fire-prone ecosystems have different strategies that allow the vegetation communities to regenerate after fire (PILON et al., 2020). Some species have distinctive traits that allow them to survive or regenerate rapidly after the disturbance, resulting in low mortality and massive blooming as well as vigorous resprout just a few days or weeks after the fire (ANDRADE & MIRANDA, 2010; MIRANDA et al., 2010; FIDELIS et al., 2019). Bud banks, belowground structures and fire cues germination are among these strategies (APEZZATO-DA-GLÓRIA et al., 2008; BUISON et al., 2019; PILON et al., 2020). Grasses have an alternative strategy, they are mainly caespitose with basal resprouting and some form a densely imbricated base protecting meristematic tissue (FIDELIS & PIVELLO, 2011; PILON et al., 2020).

The effects of fire on composition and dynamics of the Cerrado *sensu stricto* herbaceous layer are still not well known (PILON et al., 2020). Studies on this issue are needed so that to support management programs, implementation of conservation measures, as well as to encourage the rational use of plant resources. The current study aims to analyze and compare the floristic composition, its richness and diversity, as well as the structure of the herbaceous layer of a Cerrado *sensu stricto* fragment, in two areas with different fire histories from 1988 to 1994 and in 2012. In order to serve as a guide to this study, the following questions were addressed: (1) Does the incidence of biennial fires over a six-year period (from 1988 to 1994) change richness and diversity as well as the structure of community of the herbaceous layer? 2) Does the exclusion of fire for 18 years (from 1994 to 2012) change richness and diversity and alter the community structure of the herbaceous layer? 3) Does the exclusion of fire for 18 years (from 1994 to 2012) alter the floristic similarity of the herbaceous layer between areas with different fire histories?

2. MATERIAL AND METHODS

Study area

The study was carried out in a Cerrado *sensu stricto* fragment in a Reserve which belongs to Embrapa Cerrados, in Planaltina, Federal District (15º39'S- 47º44'W), Central West region of Brazil. The climate is Aw according to the Köppen classification, with dry winters and rainy summers and mean annual rainfall of 1577.0 mm. The total annual rainfall was 1818.6 mm, 1788.6 mm, 1348.1 mm, 1843.8 mm, 2220.0 mm, 1175.0 mm, 1568.3 mm, in the period from 1988 to 1994, respectively; and 1288.4 mm in 2012. The mean annual temperature range from 20.4 °C to of 26.6 °C, with average minimum of 15.8 °C, situated at an elevation of 1,100 m. The soil is a Red Latosol type, with very clay texture, flat to soft wavy relief (SPERA et al., 2000; RIOS et al., 2019).

Sampling and data collection

There were no fire records in the studied areas from 1978 to 1988. An 2.5 ha area was divided into two 1.25 ha area – Area 1 and Area 2. Biennial prescribed fires were applied in August, during the dry season (modal), in Area 1, in 1988, 1990 and 1992, in the morning; from September 1994 to 2012 the area was protected from fire. Area 2 was protected from 1988 until July 1994 and from September 1994 to 2012. An accidental fire occurred in August 1994 in both areas.

The vegetation sampling followed the method of line interception (CANFIELD, 1941), which is indicated to studies on herbaceous-graminoids vegetation (MEIRELLES et al., 2002; MUNHOZ & ARAÚJO, 2011). In each area, in May 1988 and in July 2012, two transects with 100 m of length, separated 20 m from each other were demarcated in the same point. Each transect was subdivided in 1 m sections, totaling 200 units per area. Monitoring of vegetation began in 1988 and carried out for eight years (1988, 1989, 1990, 1991, 1992, 1993, 1994, 2012). A line was extended from one end to another, at each transection and one meter above ground level (CANFIELD, 1941). The vertical projection view of the line was constructed using a frame of three one-meter sticks, two vertical ones connected to a horizontal one.

In 1988, before prescribed fire, it was carried out a vegetation sampling. And from 1989 to 1994, monitoring took place in June-July, in the drought season, always before the application of prescribed fires, and in 2012, in August. All species up to one meter height was included in the vegetation sampling. The herbaceous-shrub layer comprised graminoids, forbs and shrubs, including woody species. The species sampling in vegetation were classified as growth forms and according to literature and field observations as to the habit in: herb – non-woody and terrestrial plant –, shrubs – woody plant branched from the base –, sub-shrubs – woody base and herbaceous apex –, vine – climbing plants – (POLISEL, 2011) and tree – woody plant (SILVA JÚNIOR, 2005). Vegetation communities were sampled in each sampling unit and it was identified as family, genus and species always when is

possible. Scientific or common names were recorded from each sampling unit. Expert consultations, literature and comparison with herbarium exsiccates helped to identify the species. Also, regarding scientific names the List of Species of Flora of Brazil (FLORA DO BRASIL 2020 EM CONSTRUÇÃO, 2018) was referred and collections of fertile botanical material were assembled throughout the study period. This material was deposited in the Herbariums of the University of Brasilia (UB), Ezechias Paulo Heringer (HEPH), IBGE Ecological Reserve and Embrapa Genetic Resources and Biotechnology (Cenargen – CEN).

Data analysis

The floristic composition was based on the species sampled in the transects of the two areas, from 1988 to 1994 as well as in 2012. A species list was made yearly, according to APG III – The Angiosperm Phylogeny Group (CHASE & REVEAL, 2009). Then, floristic composition was analyzed at different sampling times (1988 to 1994 as well as in 2012). The number of species was obtained in each area (Area 1 and Area 2) and these data were compared by means of the test of $\chi 2$ (chi square) (SOKAL & ROHLF, 2009) to verify if the species richness changed from 1988 to 1994 and from 1994 to 2012.

The number of species according to the habit – herb, sub-shrub, shrub, vine and tree – was also compared at different times by the $\chi 2$ test. The species-area curve was generated to evaluate the sufficiency of sampling in relation to species richness by PC-ORD 5.0 software (MCCUNE & MEFFORD, 2006). The similarity between the two areas, at the sampling times, was analyzed by the Unweighted Pair Group Method with Arithmetic Mean (UPGMA). The dendrogram based on the presence and absence of the species used the Jaccard index. As a measure of agreement between the formed clusters and the original matrix, the cophenetic correlation coefficient was calculated (VALENTIN, 2000) using the program FITOPAC 2.1 (SHEPHERD, 2010). The diversity was compared using Diversity Profiles and the exponential series of Rényi (LEINSTER & COBBOLD, 2012) by the PAST 2.08 program (HAMMER et al., 2001).

The description of the community structure was recorded yearly. The Absolute and relative frequencies were calculated by Microsoft Office Excel 2010, Windows. The following formulas were used (MEIRELLES et al., 2002; MUNHOZ & ARAÚJO, 2011):

$$FAi = \left(\frac{ni}{n}\right)100 \quad (1)$$

$$FRi = \left(\frac{FAi}{\sum FAi}\right)100 \quad (2)$$

Where: FA_i= absolute frequency; FR_i= Relative Frequency; $\sum FA_i$ = sum of the absolute frequency of all species; n_i = number of sample units (UA's) in which species (i) occurred, and n = total number of sample units.

The relative frequencies of each species from 1988 to 2012 were compared between the two areas, as well as for each area by the Kolmogorov-Smirnov test (ZAR 2009), at a significance level of 5%. In order to verify differences in species distribution according to the habit ─ herb, sub-shrub, shrub, vine, tree ─, the relative frequencies were compared for each year, between the two areas and in each area by the Kolmogorov-Smirnov test (ZAR, 2009), at a significance level of 5%. The PAST program version 2.15 (HAMMER et al., 2001) was used in these analyzes.

3. RESULTS

There was an increase in the richness from 1988 to 1994 in both areas and there was a reduction in the number of species in 2012 compared to 1994, before the accidental fire (Table 1). In the Area 1, a total of 184 species, 134 genera and 59 botanical families were recorded over the whole period. The lowest number of species, 92, was observed in 1988, but in 1993 the species number increased to 134, and in 2012 it decreased to 115 (Table 1). Out of the 92 species recorded in 1988, 15 did not occur in 1994, and 25 did not occur in 2012. The number of families ranged from 39 to 52 and the number of genera from 76 to 106, from 1988 to 2012 (Table 1).

Table 1. Number of families, genera and species in two Cerrado *sensu stricto* areas with different fire histories, in Planaltina (Federal District), where: Area 1 = biennial burnings in 1988, 1990 and 1992; Area 2 = excluded from fire from 1988 to July 1994; both areas protected from September 1994 to 2012.

	Area 1								**Area 2**							
Year	1988	1989	1990	1991	1992	1993	1994	2012	1988	1989	1990	1991	1992	1993	1994	2012
Families	39	44	45	44	51	52	50	43	38	43	41	42	43	45	46	39
Genera	76	92	102	94	106	106	104	87	82	89	93	93	102	103	102	84
Species	92	108	124	115	130	134	132	115	97	104	112	119	126	127	129	106

In the Area 2, 170 species, 126 genera and 52 families were recorded during the study. The smallest number of species (97) occurred in 1988 and the largest (129) in 1994, before the accidental fire. Out of the 97 species

observed in 1988, nine did not occur in 1994 and 28 did not occur in 2012. The number of genera ranged from 82 to 103 and the number of families from 38 to 46 (Table 1). The species occurring in only one sampling unit varied in the two areas throughout the period, being 17 species in the Area 1 and 15 in the Area 2 in 1994. In 2012, there was an increase in the number of these species, corresponding to 38 in Area 1 and 23 in Area 2. Four species considered invasive according to Mendonça et al. (2008) were sampled: *Cassytha filiformis* L. from 1988 until 1993 in Area 2, and in 2012, in Area 1; *Schizachyrium condensatum* (Kunth) Nees in both areas from 1988 until 2012; *Schizachyrium sanguineum* (Retz.) Alston in both areas from 1988 until 1994; and *Melinis minutiflora* P.beauv. in 2012 in the Area 2.

The species-area curve for 1988 in both areas indicated a tendency towards stabilization considering that half of the sample units was sampled. In Area 1 approximately 88% of the species were sampled in half the sample units and in Area 2, 86% of the species. Thus, the results indicated that the sample was sufficient to represent the floristic richness in the area. The $\chi 2$ tests did not show significant differences ($p > 0.05$) in the number of species regarding both treatments, i.e., the biennial prescribed fires from 1988 to 1994 and exclusion of fire from 1994 to 2012.

Concerning both areas, from 1988 to 1994, tree plants had the largest number of species, followed by sub-shrub and herb species (Figure 1; Appendix A). However, there were no significant differences ($p > 0.05$) by the $\chi 2$ test in the number of species of each life form, comparing the data of 1988 with the other years (1989 to 2012) and the data of 1994 and 2012. Regarding Area 1, from 1988 to 1994, the number of species of trees and shrubs ranged from 41 to 62, and of herbaceous and sub-shrub species ranged from 50 to 70. As to Area 2, from 1988 to 1994, the number of species of trees and shrubs varied from 44 to 56, and herbaceous and sub-shrub habits, from 53 to 71. The families that comprised the greatest species richness in Area 1 and Area 2 were Fabaceae, Poaceae, Myrtaceae and Asteraceae (Figure 2; Appendix A). The number of families that comprised one species varied in Area 1, corresponding to 23 (in 1988) and 20 (in 2012), and in Area 2, corresponding to 20 (in 1988) and 16 (in 2012) (Figure 2; Appendix A).

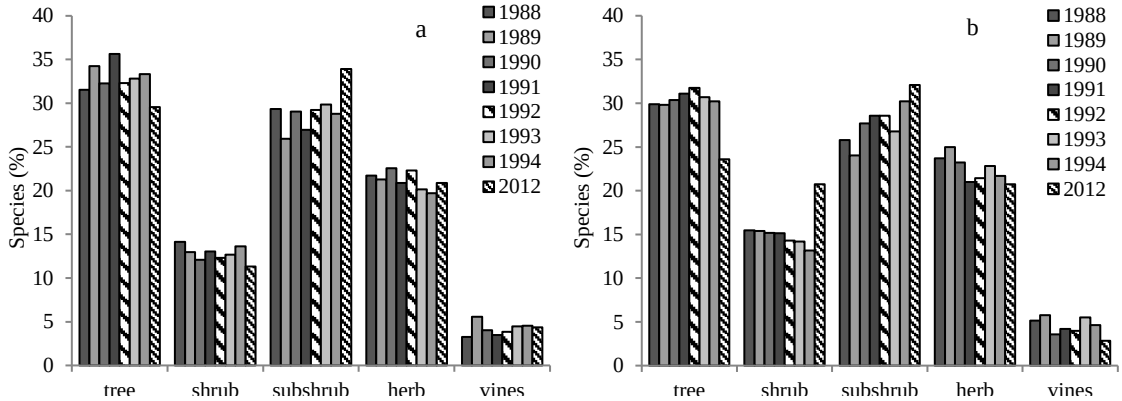

Figure 1. Percentages of species, according to the life form, in two areas of a Cerrado *stricto sensu* in Planaltina, Federal District, Brazil; a = Area 1, biennial prescribed fires in 1988, 1990 and 1992; b = Area 2, excluded from fire from 1988 to 1994 (July); protection of both areas from September 1994 to 2012.

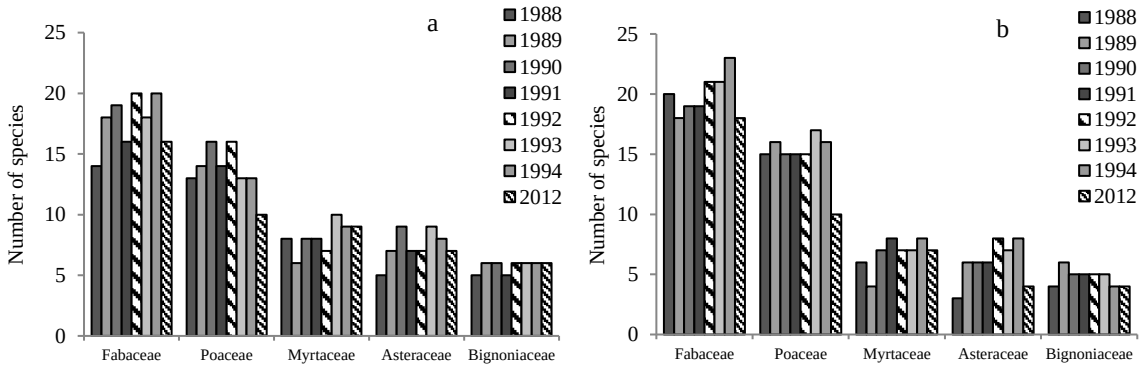

Figure 2. Families that comprised the greatest number of species, in two areas of a Cerrado *stricto sensu* in Planaltina, Federal District, Brazil; a = Area 1, biennial prescribed fires in 1988, 1990 and 1992; b = Area 2, excluded from fire from 1988 to 1994 (July); protection of both areas from September 1994 to 2012.

The cluster analysis indicated the formation of three distinct groups (Figure 3). However, no group was formed in four years of monitoring. Group A consisted of Area 1 from 1990 to 1994; Group B, for Area 2, from 1990 to 1994; and Group C for both Area 1 and Area 2 in 1989. In 1988 and 2012, the two areas were separated and presented no floristic similarity. The cophenetic correlation coefficient (0.94), considered high, showed little changings regarding original similarity (Figure 3). Total diversity showed variation over time and in both areas. In 1988, in both areas the diversity was lower than in the following years until 1994, when it was higher. In 2012, the diversity was lower in both areas (Figure 4).

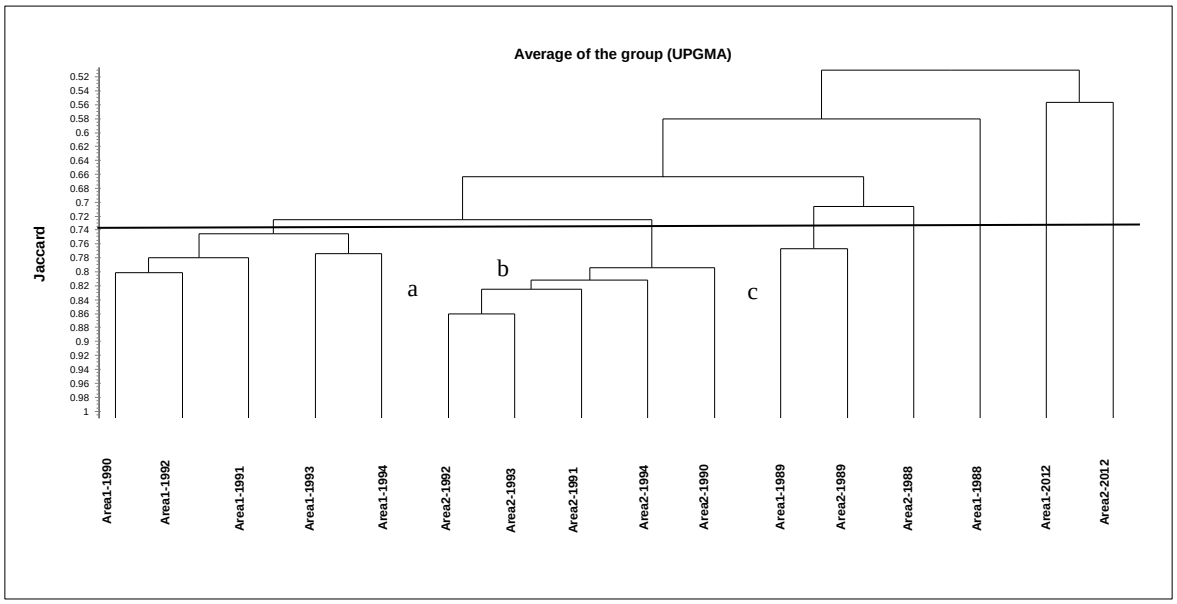

Figure 3. Cluster Analysis Dendrogram (UPGMA) based upon Jaccard´s Index in two areas of Cerrado *stricto sensu*, in Planaltina, Federal District, Brazil. Division in three groups, where a = Area 1, from 1990 to 1994; b = Area 2, from 1990 to 1994; and c = Area 1 and Area 2, in 1989. There was no formation of groups in 1988 (Area 1 and Area 2) and in 2012 (Area 1 and Area 2). Area 1 = biennial prescribed fires in 1988, 1990 and 1992; Area 2 = protected against fire from 1988 to 1994 (July); exclusion of fire from September 1994 to September 2012. Cophenetic correlation = 0.94.

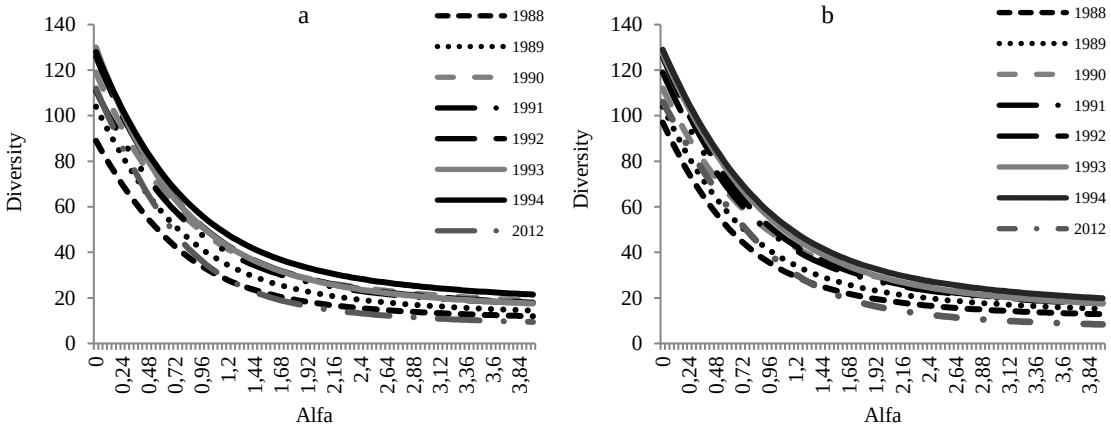

Figure 4. Diversity profile of the herbaceous species in two areas of Cerrado *stricto sensu*, in Planaltina, Federal District, Brazil, from 1988 to 1994 and 2012; the Diversity Profile was based on Rényi exponential series; a = Area 1, biennial prescribed fires in 1988, 1990 and 1992; b = Area 2, excluded from fire from 1988 to 1994 (July); exclusion of fire from September 1994 to 2012.

In both areas, there was variation in the relative frequencies of species and families over time (Figure 5; Appendix A). The Kolmogorov-Smirnov test indicated significant differences ($p < 0.05$) in the distribution of relative species frequencies between the two areas in 1989, 1993 and 2012. In 1988, regarding Area 1, the 10 species showing the highest relative frequency were: *Echinolaena inflexa* (Poir.) Chase, *Schizachyrium tenerum* Nees, *Axonopus barbigerus* (Kunth) Hitchc., *Axonopus* marginatus (Trin.) Chase, *Merremia digitata* (Spreng.) Hallier f., *Ruellia asperula* (Mart. ex Ness) Lindau, *Bauhinia dumosa* Benth., *Diplusodon oblongus* Pohl, *Myrsine guianensis* (Aubl.) Kuntze and *Croton campestris* A.St.-Hil. In 1988, concerning to Area 2, the 10 species showing the highest relative frequency were:

Echinolaena inflexa, *Axonopus barbigerus*, *Axonopus marginatus*, *Schizachyrium tenerum*, *Merremia digitata*, *Diplusodon oblongus*, *Myrsine guianensis*, *Elionurus muticus* (Spreng.) Kuntze, *Trachypogon* sp. and *Casearia altiplanensis* Sleumer. In both areas, the four species of Poaceae showed higher relative frequency.

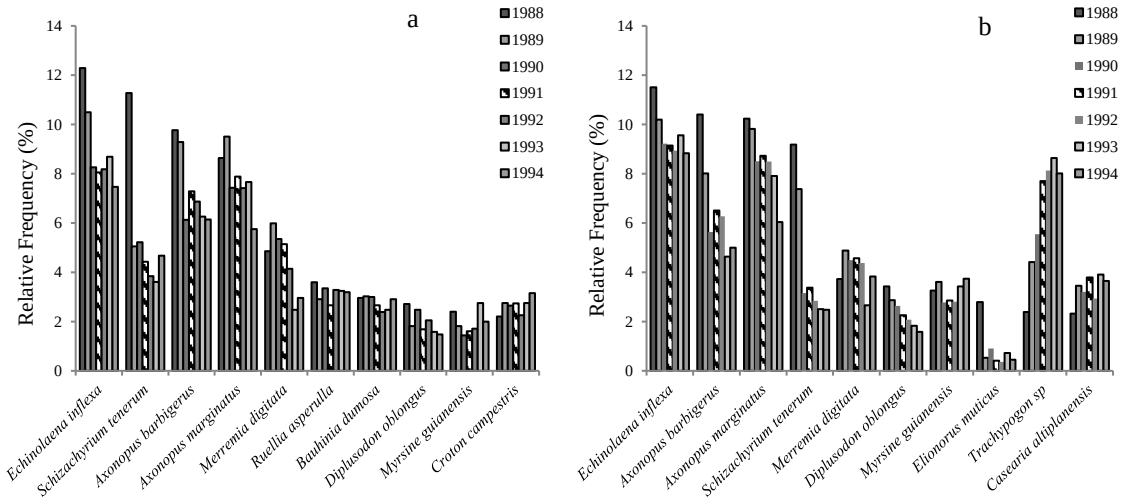

Figure 5. Relative Frequency Variation (%), in 1988, among the ten species with the greatest values in two Cerrado *stricto sensu* areas in Planaltina, Federal District, Brazil. The mentioned variation was compared from 1989 to 1994; a = Area 1, biennial prescribed burnings in 1988, 1990 and 1992; b = Area 2, protected against fire from 1988 to 1994 (July); exclusion of fire from September 1994 to 2012.

For both areas, the relative frequency of herbs and subshrubs was higher concerning all years (Figure 6). Trees, shrubs and vines were less frequent. The Kolmogorov-Smirnov test did not show significant differences ($p > 0.05$) in the frequency distribution according to the habit – tree, shrub, subshrub, herb, vine – in each area and between the two areas. In Area 1, the families Poaceae, Fabaceae, Convolvulaceae and Euphorbiaceae were among the five families showing the highest relative frequencies from 1988 to 1994 (Appendix A); Fabaceae and Poaceae also appear among the five most important families by 2012. In Area 2, Poaceae and Fabaceae were among the five families showing the highest frequencies from 1988 to 2012.

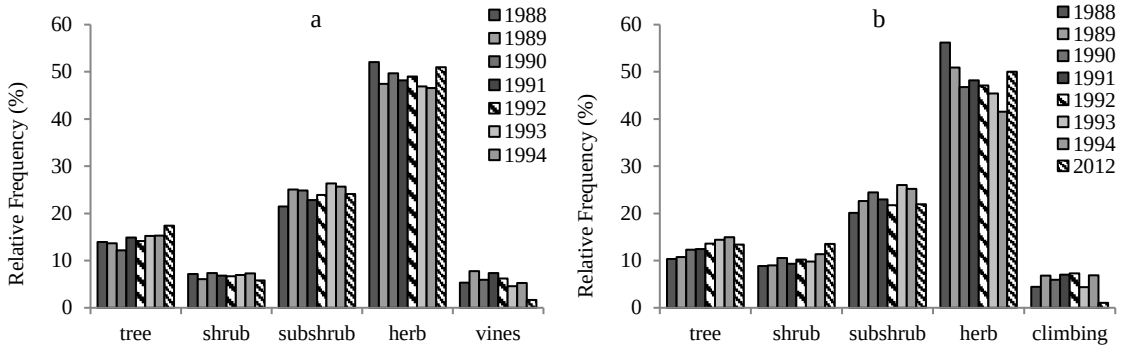

Figure 6. Relative Frequency (%) of the herbaceous layer, according to the habit, in two areas of a Cerrado *stricto sensu* with different fire histories, in Planaltina, Federal District. Vegetation sampling was made eight times of the floristic survey; a = Area 1, biennial prescribed fires in 1988, 1990 and 1992; b = Area 2, excluded from fires from 1988 to 1994 (July); protection of both areas from September 1994 to 2012.

4. DISCUSSION

Fabaceae, Poaceae, Myrtaceae and Asteraceae had great number of species in both areas in Embrapa Cerrados areas, Planaltina. Those families had the greatest species richness in the Federal District (BRAGA, 2010) and in other parts of the Cerrado like the National Park of Emas-State of Goiás, Brazil (BATALHA & MARTINS, 2007).

According to research findings about the two areas there are a high number of families comprising only one species in opposition to the large number of species in a few families (BATALHA & MANTOVANI, 2000).

The number of species of the herbaceous layer, from 92 to 134 species in both areas, in all sampling vegetation, was similar to those observed in some areas of the Cerrado *sensu stricto*, as in the IBGE-DF Ecological Reserve, where 128 species were detected, including tree and shrub species (CASTRO-NEVES, 2007). Fire generally favors herbaceous layer in the Cerrado (LOIOLA et al., 2010; SILVA et al., 2011), but the recovery of this vegetation and differences in the richness of herbaceous species in Cerrado areas may be related to changes in species composition (MIRANDA et al., 2010; GORGONE-BARBOSA et al., 2016), climate variations, the physical and chemical factors of the soil (MUNHOZ & AMARAL, 2010), season (RISSI et al., 2017), fire regime (BOND & KEELEY 2005; BUISON et al., 2019), presence of invasive species (GORGONE-BARBOSA et al., 2015) and methodological differences, as the sampling method (CASTRO-NEVES, 2007).

The annual richness results may be an indicative of community resilience to disturbance and the post-burning vegetation recovery possibly due to adaptation strategies, such as the presence belowground organs and bud banks (APEZZATO-DA-GLÓRIA et al., 2008; BUISON et al., 2019; PILON et al., 2020). Resprouting (PAUSAS et al., 2018; PILON et al., 2020) and seed recruitment are also important post-fire regeneration mechanisms (SILVA et al., 2011; FIDELIS et al., 2014). The time of the year may have also influenced the results, as the type and the amount of the fuel load varies throughout the year (FIDELIS et al., 2013; RISSI et al., 2017) and many graminoids and herbs dry out the above-ground parts and allocate resources to underground organs in the dry season (FILGUEIRAS, 2002; FIDELIS et al., 2013; RISSI et al., 2017). In this work there was no significant difference between the two areas, but the monitoring was carried out only once a year, in the drought season. Some studies evidenced the importance of sampling throughout the year and observed that there is a trend of richness to approach pre-disturbance values in richness within a year after the fire (SILVA & NOGUEIRA, 1999; MUNHOZ; FELFILI, 2008; PILON et al., 2020).

Fire may affect recruitment and lead to changings in the frequency of rare species and in the dominance of common or invasive species (GORGONE-BARBOSA et al., 2016). After the fire, the herbaceous layer has a rapid regeneration (BUISON et al., 2018; PILON et al., 2020) with the exclusion of some species, as well as an increase in the abundance of other species (WHELAN, 2002). At the present study biennial prescribed fires in August, in the dry season, probably favored the dominance of some herbaceous and sub-shrub species and reduced the frequency of some grasses, causing differences in floristic similarity between the two areas from 1990 to 1994. In 1989, one year after the first prescribed fire, possibly due to the large number of species common to both areas a higher floristic similarity was observed. Among the species, *Croton campestris* has increased frequency and *Casearia altiplanensis* presented higher frequency values in all years in comparison to 1988. On the other hand, the grasses *Echinolaena inflexa*, *Axonopus barbigerus* and *A. marginatus* decreased the relative frequencies over the period and *Trachypogon* sp. increased its frequency and was also considered the second most frequent species in 1994.

Differences in the relative frequency of the species one year after the first prescribed fire, in 1989, despite the floristic similarity, and after three prescribed biennial burnings, in 1993, were possibly related to the frequency of the fire (MIRANDA et al., 2010), to the strategies of regeneration and the consequent regenerative success of the species after fire (ANDRADE & MIRANDA, 2010). Post-fire environment may also influence the variation in the species' recovery capacity (RAMOS et al., 2017). In 1988, with the exclusion of fire for about 10 years, possibly the accumulation of dry biomass in the superficial layer of the soil in the dry season provided a higher proportion of fire (SILVA et al., 2011) affecting species survival and persistence (RISSI et al., 2017). In 1993, probably, the regeneration of the herbaceous layer was also related to the decrease of the average annual precipitation (KANEGAE et al., 2000) and of the precipitation in the rainy season and consequently by the exposure of the plants to the water deficit (SILVA & NOGUEIRA, 1999; RAMOS et al., 2017; ZUPO, 2017). In this year some species increased their relative frequency, such as *Spiranthera odoratissima* A.St.-Hil. Other species capable of resprouting (RIOS et al., 2018) had a reduction in the relative frequency from the year of 1992 to 1993, like *Styrax ferrugineus* Nees & Mart. and *Guapira graciliflora* (Mart. ex Schmidt) Lundell. However, there was an increase in the relative frequency in the following year, indicating indirectly resprouting.

A higher frequency of herbs in both areas was probably due to the favoring of those with belowground organs and bud bank (APEZZATO-DA-GLÓRIA et al., 2008; PAUSAS et al., 2018; PILON et al., 2020) or persistent foliar bases protecting the buds (MIRANDA et al., 2009; PILON et al., 2020). Besides that the production of flowers, fruits and seeds is faster in many species, ensuring the release of seeds in the rainy season following the fire and also the recovery of vegetation until the next dry period (ANDRADE & MIRANDA, 2010; GORGONE-BARBOSA et al.; 2020), when the survey was done.

The frequency of burnings is an important factor in the dynamics of Cerrado vegetation (BUISON et al., 2019). Some studies suggest that periodic fires can increase, decrease or maintain the diversity of the herbaceous component (MUNHOZ & AMARAL, 2010; RISSI, 2016). In the two areas there were no diferences between them in each year of monitoring. A similar result was found within an area of *Campo sujo* in Serra do Tombador Natural Reserve (State of Goiás), in which fire did not change the diversity of the herbaceous vegetation (RISSI, 2016). The diversity variation over time may have been related to the frequency of burnings and to vegetation samplings being carried out only in the drought, one and two years after prescribed fire. The mortality of the aerial part of some

dominant herbs in the dry season probably increased the equitability and influenced the diversity between the two areas from 1988 to 1994.

The protection of the two areas with different fire histories for 18 years favored some species and excluded others, providing differences in floristic composition and frequency of species. In 2012, the number of species of the herbaceous layer was reduced in both areas, comparing to 1994. The exclusion of fire also did not significantly modify the species richness of the tree-shrub layer, but, on the other hand, favored the increase in density (RIOS et al., 2018) and aerial biomass of these species (RIOS et al., 2019). Possibly, the increased coverage of tree and shrub species reduced coverage and richness of the herbaceous layer (MUNHOZ & AMARAL, 2010; EUGÊNIO et al., 2011; ABREU et al., 2017). The diversity was also similar between the two areas in 2012, but lower than that in 1994. This reduction may be related to the dynamics of the species due to seasonality in the exclusion of fire (MUNHOZ & AMARAL, 2010; SILVA et al., 2011; RISSI, 2016). Besides that, it was observed higher relative frequency of herbs and sub-shrubs in this year compared to 1994. The most frequent species varied in the two areas, and 80% of the relative frequency was composed of 32 species in each area, thus accounting for less equitability and diversity in 2012. In Area 1, there were more species comprising one occurrence, probably because the sampling vegetation was done only in the dry season. *Echinolaena inflexa*, *Trachypogon* sp. and *Rhynchospora exaltata* Kunth had increased relative frequency in both areas.

Invasive species can be used as a parameter for assessing levels of human intervention in the ecosystems of the Cerrado (MUNHOZ & AMARAL, 2010) and, usually, germinate faster than native species (GORGONE-BARBOSA et al., 2020). Invasive species can alter fire regimes and affect native plant community composition (BUISON et al., 2019), as well as modify their structure in relation to fuel load combustible material (GORGONE-BARBOSA et al., 2016). In 2012, the invasive species *Schizachyrium condensatum* was found in both areas. *Cassytha filiformis* was observed in Area 1 and *Melinis minutiflora* in Area 2. Thus, the differences between the two areas in 2012 may also be due to others abiotic factors related to the effects of fragmentation as a result of the human pressure nearby the Reserve.

5. CONCLUSIONS

The results indicated the recovery of community after biennal burnnings. Biennial prescribed fires did not change richness and diversity, but they altered the structure of the community. The exclusion of fire for 18 years did not change richness, but the diversity and structure of the community. The exclusion of fire for 18 years also did not favored the floristic similarity between the two areas.

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