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Analysis of Natural Regeneration in a Cerrado Sensu Stricto Fragment Through Seed Bank Evaluation

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ABSTRACT

Cerrado is the second largest biome in South America and occupies a large area exhibiting a peculiar fauna and flora; however, is one of the world's hotspots of biodiversity, since it undergoes an exceptional habitat loss due to human actions. Its degradation process can be reversed by natural regeneration using the seed bank. This way, our research aimed to analyze the soil seed bank potential contribution in succession processes and natural regeneration in a disturbed fragment of cerrado *sensu stricto* (located at the University of Brasilia - UNB/Brasilia, Brazil), by analyzing germinated seeds in two different seasons (dry and wet). Fifteen random plots were thrown within the area in which the seed bank was performed using units of 0.25 x 0.25 x 0.05 m from the middle of each plot in two periods, at the end of the dry and rainy seasons. Over 90 days, emerged seedlings from sampled soil were counted. After this period, we proceeded sifting and counting of non-germinated seeds remained in the soil. Emergency data were subjected to normality and homoscedasticity tests and subsequently log transformed and then subjected to the paired t-test for sample comparison. It was observed a higher number of germinated grass seed than herb / subwoody plants in both periods. Moreover, in both periods, we recorded a significant number of non-germinated seeds. Due to the grass predominance, the studied seed bank has potential to contribute to natural regeneration of this area, although it has no ability to restore species richness in short-term.

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INTRODUCTION

Cerrado is one of the richest and most endangered biomes on the planet, representing one of the world's biodiversity hotspots (Myers *et al*., 2000). This biome covers 200-million hectares over a wide variety of savanna-like physiognomies that make up Central Brazil landscape (Unesco, 2002).

Forty-four years after the beginning of its occupation, the cerrado has lost 73.8% original cover (Felfili, 2000). It is possible to see agricultural and urban areas taking place of 11,961 ha in 2001, while reforested area rates has decreased (Unesco, 2002).

Vegetation impact may occur at different manners and levels. Impact degree depends on local activities. Reis *et al*. (1999) defined degraded area as an area that has suffered environmental impacts in a way that its ability to "return" to the original state through natural means has dramatically decreased; i.e. it is an environment of low or no resilience. The authors also defined disturbed areas as those that keep the means of natural regeneration after disturbance.

Burning is, as a rule, one of the main modifying agents of structure and composition of plant communities in savanna ecosystems (Medeiros and Miranda, 2005), since it provides competition of invasive species and climax species regeneration (Felfili and Silva Júnior, 2001). Clear-felling and opening gaps (anthropogenic disturbance and natural disturbance, respectively) are also frequent in cerrado (Oliveira, 2007).

Regeneration of cerrado areas with disturbance history is compromised even after decades from the last event, as they promote significant changes in physiognomy (Felfili, 2001). Natural regeneration

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can be a good alternative for a successful recovery for less severe cases of degradation (Miranda, 2010). The main means of natural regeneration are sprouting, soil seed bank and seed advent from other native areas (seed rain). When the area is resilient, human action may be limited solely to prevent new disturbances, since, according to Melo *et al*. (2008) disturbance ceasing is the initial and an essential step in any recovery program.

Thus, the capacity of regeneration in areas under some type of degradation can be evaluated by studying the soil seed bank, which is, in some cases the only source available for recovery.

The seed bank can be defined as the stock of viable seeds within the soil in an area and at a certain time (Almeida-Cortez, 2004). Knowing the seed bank composition is of fundamental importance to understand vegetation dynamics, because after a disturbance of a natural area its vegetation structure will be conditioned, at first, by seeds of species in this soil (Campos and Souza, 2003).

According to Oliveira (2007), the seed bank acts as a stabilizer in environments where soil is often disturbed, which ensures the survival of uncultivated species. In this sense, the analysis of viable seed banks in soils of forest and savanna areas may determine vegetation succession directions in case of area degradation.

However, a seed bank success depends on the seed rate ready to germinate when a plant is required to be replaced and when environmental conditions are favorable for its establishment (Carvalho and Favoretto, 1995).

Given the above mentioned, this study aimed to analyze the potential contribution in succession processes and natural regeneration of the soil seed bank in a disturbed fragment of cerrado *sensu stricto*, located at the University of Brasilia - UNB - Campus Darcy Ribeiro/ Brasilia-Brazil, by analyzing the number of germinated seeds in two different seasons (dry and wet).

MATERIALS AND METHODS

The experiment was carried out in a cerrado *sensu stricto* fragment with 110 ha (Fig. 1), located at the Environmental Protection Area of Paranoá, in the Olympic Training Center of the University of Brasília - UnB, Brasília City, Federal District, Brazil. This fragment lies between the coordinates 15°46'S – 7°50'W and 15°45'S – 47°51'W. Although the studied area has potential to carry extension and research projects, as long as leisure activities (Assunção and Felfili, 2004; Farias *et al*., 2002; Silva Júnior, 2005), it has been degraded with illegal waste-dumping constant fires (Assunção and Felfili, 2004).

Fig. 1: Cerrado *sensu stricto* fragment.

The predominant climate in the region is classified as *Cwa* type according to Köppen – also kwon as Savannah Tropical. Annual rainfall varies from 1,400 to 1,450 mm with rains concentrated within the summer. Area slope ranges between 2 and 5 % and the altitude from 1,000 to 1,050 m (Ferrante *et al*., 2001). This cerrado fragment is characterized by open-area vegetation, comprising areas of cerrado *sensu stricto*, open cerrado and rough cerrado (Eiten, 1983). The main soil in the area is Dark Red Latosol (Oxisol) (Haridasan, 1994).

In order to perform this study we have thrown fifteen 1.0 m x 1.0 m plots in which we collected samples from the middle in an area of 0.25 x 0.25 x 0.05 m, with the aid of a spading tool. These plots were georeferenced and were far from each other by at least 10 meters.

Seed bank survey was performed by random collection of 15 sample units of 0.25 x 0.25 x 0.05 m in two periods at the end of the dry season (September 2011) and at the end of rainy season (March 2012). Then, the samples were taken to the Laboratory of Seeds and Forest Nurseries of the University of Brasilia, where they were deposited into plastic trays containing approximately 5-cm vermiculite layer (Fig. 2) and being daily irrigated.

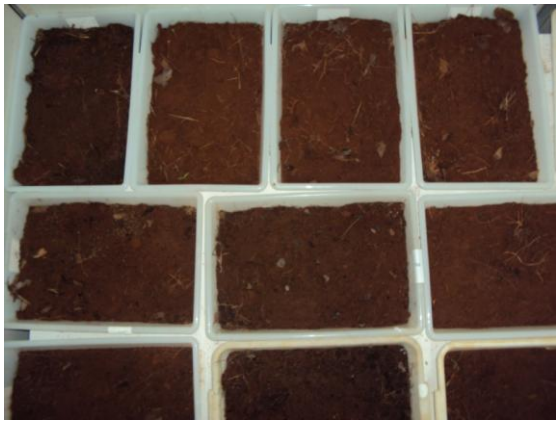

Fig. 2: Collected samples placed onto plastic trays.

Seed bank analysis was taken over 90 days with weekly evaluations totaling 13 weeks. Seedling emergence monitoring in the first collection (end of the dry season) was conducted in September, October and November of 2011 and the second one (end of the rainy season) in March, April and June of 2012.

We analyzed the following parameters: seed bank presence or absence at each sample from the total number of emerged seedlings; classification of the emerged seedlings into arboreal, herbaceous and grassy; and counting of germinated and non-germinated seeds.

After 90 days, samples were sifted (sieve mesh of 20, 24, 28) to account non-germinated seeds.

Data were submitted to Shapiro Wilk normality test and Bartlet homoscedasticity test, in a completely randomized design with two treatments (dry and rainy season) and 15 repetitions. When these assumptions were not met, we performed data logarithmic transformation. Then, we performed paired t-test (α = 5%) to compare the samples using the statistical software R.

RESULTS AND DISCUSSION

By analyzing presence or absence of seed banks within samples, we observed no seedling emergence at the end of the dry season at approximately 46% samples. Yet at the end of the rainy season, only 26% of the samples showed no seedling emergence.

After 90 days, we found seeds or part of them that has not been germinated or were preyed for all samples with no seedling germination during evaluation period.

The difference observed for seedling emergence between the two seasons proved a seasonal influence on seed bank quantity and quality. In Northeastern Brazil, Costa and Araújo (2003) reported a low seed bank density in caatinga soils and hypothesized the existence of a direct relationship between rainfalls and seed density in soil. Therefore, the number of viable seeds in a soil bank is related to rainfall intensity.

According to these authors, seasonal climate influences the distribution of alive organisms and consequently the seed bank density throughout the year. As the cerrado areas have a seasonal and irregular rainfall regime, so its seed bank would probably have similar behavior. Supplementing this, Almeida-Cortez (2004) stated that full spatial and temporal variations in seed bank composition can also be explained by dispersal characteristics and seed dormancy.

It can be also observed that only grass and herbaceous / subwoody species have germinated in both seasons. There was no emergence of tree species seedlings. Moreover, during both seasons, seedling emergence occurred between the 2nd and 8th week (Fig. 3a, b).

Different results had been found by Oliveira (2007), Baskin and Baskin (1998) and Costa and Araújo (2003), who obtained higher germinated seed rates in the last two weeks. This fact can be explained by no dormancy-break of seeds, blockage mechanism, quiescence state, or lack of any external factor required for germination such as water, light, temperature change or oxygen concentration (Cardoso, 2004).

The total number of germinated seeds had no difference between evaluated seasons (dry and rainy) ($t_{14;\alpha=0,05}$= -1.739; p=0.103). However, it was observed a larger number of germinated grass seeds than herb / subwoody ones for both periods [dry ($t_{14;\alpha=0.05}$= 2.476; p=0.026); rainy ($t_{14;\alpha=0.05}$ = 2.885; p=0.011)].

This predominance of grasses found in samples collected for both periods which, according to Martins (1996), is positive for regeneration, once grasses are important for degraded area recovery, by means of providing shade to species after germination.

The large amount of grass seedlings found in soil samples confirms that forest succession in tropical regions after burning or cutting can be described by a facilitation method, in which pioneer species invade available areas and, thus, facilitate subsequent establishment of other species. In this

way, the grass is considered as a shelter for dispersion promoters, providing most favorable habitats to recruitment and providing enhanced soil fertility (Connell and Slatyer, 1977).

After 90 days, we performed a comparison between the amount of non-germinated and germinated seeds within the 15 samples. Non-germinated seeds were preyed, which enabled their classification. In general, we observed considerable amount of non-germinated seeds in both seasons (Fig. 4a, b).

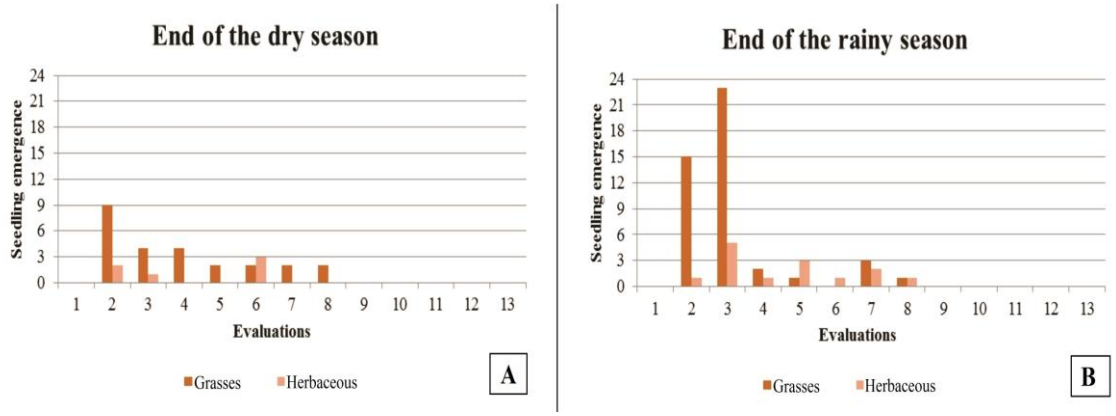

Fig. 3: Seedling emergence along 13 weeks at the end of the dry season (a) and at the end of the rainy season (b).

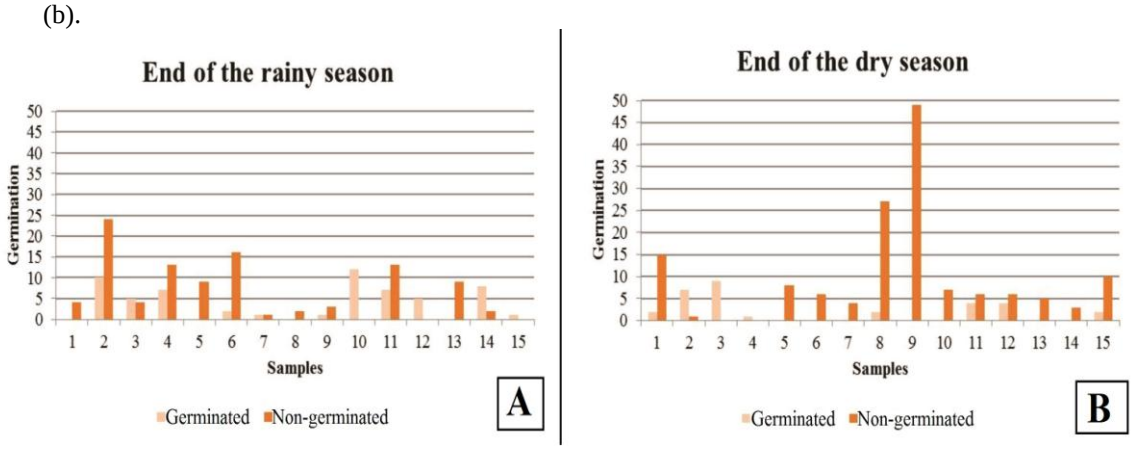

Fig. 4: Seed bank comparison between the end of the dry season (a) and the rainy season (b).

Accounting for germinated and non-germinated seeds, we found 178 seeds in dry season samples, of which 83% did not germinate and were preyed. In contrast, for the rainy period, it was accounted 159 seeds, of which 63% did not germinate.

Plant species composition found in the seed bank suggested a contribution to the area regeneration, unfortunately not for restoration of woody species richness. As consequence, it is not advisable to base area recovery singly on seed stock available bearing in mind that succession final stage species, such as trees, are not represented within the seed bank.

Conclusion:

Our results showed that the cerrado *sensu stricto* fragment of the Olympic Training Center of the University of Brasília - UnB presented a seed bank in the soil with predominance of grass species seeds, followed by herbaceous / subwoody ones.

Due to grass predominance, the seed bank has potential to contribute to local natural regeneration, but not for species richness restoration in short-term. Therefore, other complementary practices must be applied, such as artificial perches, species enrichment and reintroduction to accelerate the restoration of the studied area.

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