THREATS TO THE CERRADO REMNANTS OF THE STATE OF SÃO PAULO, BRAZIL

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ABSTRACT: Patches of natural vegetation remaining in landscapes occupied by man are continuously under threat due to the edge effects and also to land use types around these remnants. The most frequent threats and land use types in the vicinity of 81 Cerrado (tropical savanna type) fragments in the State of São Paulo, Brazil, were analyzed in order to verify if the frequency of every type of disturbance to the natural ecosystem depends on the neighboring land use. The hypothesis of the study assumes that environmental threats are correlated with land use around protected areas. From the 81 areas, the most frequent human-induced land cover types around the Cerrado remnants were: pasture (recorded in 78% of the areas), sugarcane plantations (26%), roads (19%), annual crops and reforestation (14% each). The most frequent sources of threats were invasive grasses (35% of the areas partially or totally invaded) and cattle (observed in 32% of the areas), followed by deforestation (21%), and fire (21%). The chi-square analysis revealed that, with the exception of deforestation, which does not depend on land use, all other threats are influenced by the neighboring land use. The occurrence of invasive grasses and fires are strongly favored by the presence of roads and urban areas. Sugarcane, reforestation, and permanent crops were the less impacting land use types found in the study area, when only considering impact frequency. These land use types have fire and weed control, and also exclude cattle, indirectly protecting natural ecosystems.
Key words: savanna, conservation, impact, fragmentation, land use

AMEAÇAS A FRAGMENTOS DE CERRADO NO ESTADO DE SÃO PAULO, BRASIL

RESUMO: Fragmentos remanescentes de vegetação natural em paisagens antropizadas sofrem ameaças permanentes, devido aos efeitos de borda e às atividades antrópicas nas áreas limítrofes. Para verificar a hipótese de que o tipo de ameaça ao ecossistema e a sua freqüência dependem do uso da terra no seu entorno, foram analisados 81 fragmentos de Cerrado no estado de São Paulo. Para cada fragmento foram registrados os tipos de perturbação no ecossistema e os tipos de uso da terra no seu entorno. Os usos mais freqüentes foram pastagens cultivadas (registradas em 78% das áreas), plantio de cana-de-açúcar (26%), rodovias (19%), reflorestamento (14%) e culturas anuais (14%). As ameaças mais freqüentemente registradas foram gramíneas invasoras (35% das áreas parcial ou totalmente invadidas), presença de gado (32%), desmatamento (21%) e fogo (21%). A análise da freqüência observada de cada tipo de impacto mediante a freqüência esperada caso não houvesse influência do uso da terra (qui-quadrado), mostrou que as ameaças dependem do uso da terra nas áreas ao redor dos fragmentos, exceto para o desmatamento, que tem ocorrido indiferentemente ao tipo de uso. Gramíneas invasoras e fogo são muito mais freqüentes na vizinhança de rodovias e zonas urbanas, enquanto que o plantio de cana-de-açúcar, silvicultura e fruticultura têm sido os usos da terra menos impactantes para a vegetação de Cerrado, considerando-se apenas a freqüência de ocorrência dos impactos. Esses cultivos envolvem o controle de plantas invasoras e a prevenção e controle de incêndios, e a eliminação do gado, com reflexos positivos para a conservação dos ecossistemas naturais.
Palavras-chave: savana, conservação, impacto, fragmentação, uso da terra

INTRODUCTION

The Cerrado vegetation occupies more than 2 million km^2 in the central part of South America and is the largest, richest and possibly most threatened tropical savanna in the world (Silva & Bates, 2002), and has been highlighted as a global hotspot for biodiversity conservation (Myers et al., 2000).

The causes of destruction and the present situation of the Cerrado biome was analyzed by Alho & Martins (1995), Ratter et al. (1997), Cavalcanti & Joly (2002), Klink & Moreira (2002), Machado et al. (2004), Alho (2005), Felfili et al. (2005), Pivello (2005), Ribeiro et al. (2005) and Ratter et al. (2006). These studies show that from an almost no impacting low density cattle raising some 40 years ago, the land use of the Cerrado domain has changed to cultivated pastures with African grasses or modern mechanized agriculture, with their techniques for the rapid clearing of extensive landscapes and for the improvement of the soil fertility through liming and fertilization. Current estimates (Machado et al., 2004) place the remaining more or less intact areas of Cerrado vegetation in ca. 34% of its original surface in Brazil.

The Cerrado vegetation, which covered originally 14% of São Paulo State (São Paulo, 1997) has been even more drastically reduced, the remnants corresponding to only 0.81% of the state (Kronka et al., 2005). The current Cerrado vegetation in the state (less than 7% of the original cover) has been split into thousands of small areas, and surrounded by pasture, sugarcane, soybean, reforestation, perennial crops, and urban zones.

The main threats to the Cerrado biodiversity, (Alho & Martins, 1995; Pivello, 2005) are the deforestation, fire and invasive grasses, which are subject of the present study. Every change in land use around natural areas brings its own consequences to the ecosystem, and yet this relationship has rarely been studied.

Fragments of the Cerrado vegetation in São Paulo State (public natural reserves not included) were the subject of the present study, in order to verify whether the frequency of different types of impacts on the fragments depends on the land use around it. This study also aimed to determine the most frequent threats to the Cerrado vegetation and the most frequent land use types around the remnants in the state.

MATERIAL AND METHODS

The sites

In 1998, the Brazilian Ministry of the Environment promoted a national workshop to define conservation priority areas for conservation of the biodiversity in the Brazilian Cerrado (Brasil, 1999). A number of priority areas were identified, based on biodiversity richness and threat. Some of the selected areas, located in São Paulo State, had been previously identified in a workshop held in 1995 by the government of São Paulo State (São Paulo, 1997), identifying 23 areas of high priority for conservation.

In both national and state meetings, every priority area included some large and/or clustered fragments with high biodiversity, frequently under threat, and generally located in regions where none or few reserves existed.

A set of 81 fragments, containing cerrado or ecotonal vegetation Cerrado / Atlantic forest, inserted in those priority areas were evaluated in this study (Table 1). The fragments were selected and surveyed on the following principles: all large fragments in the priority areas; fragments of different size (large - 400 ha or over, median - 100 to 400 ha, small - less than 100 ha) were surveyed in each area, and sites representing all different Cerrado physiognomies in an area.

These fragments were submitted to a rapid biological assessment and to a phytogeographical analysis (Durigan et al., 2003) that showed distinct floristic patterns in the different regions.

Every fragment had its physical attributes (coordinates, limits, Cerrado physiognomies, topography, water bodies etc.) previously mapped based on satellite images (Landsat 5 and 7, Thematic Mapper sensor, years 2000-2001) using Arc View Geographical Information System (ESRI). Using these maps, and field surveys, the fragments were evaluated according to their biophysical attributes, integrity of natural resources and external influences, and were classified according to the conservation priority criterium (Durigan et al., 2006).

Some of these records were used in the present analysis: land uses around the Cerrado fragment and threats to the ecosystems, including incidence of fire, biological invasion by African grasses, presence of cattle, and deforestation.

Land use

Land use along the perimeter of the Cerrado remnants was classified in the field, according to the following categories:

Pasture: including native grasses, but all surveyed areas used for cattle raising planted with African grasses, especially those from the genus *Urochloa* (“braquiárias”); **Annual crops**: all crops of short cycles, such as soybean, corn, cassava, peanuts, etc., which imply in soil preparation and planting at least once a year; **Perennial crops**: woody plants which do not require soil preparation and annual planting, and that also do not depend on cutting or pruning, such as fruit, coffee and rubber tree plantations; **Sugarcane**: considered as a separate category since its management usually includes human-induced fires, supposed to increase fire incidence in Cerrado

Table 1 - Location of 81 Cerrado fragments in the São Paulo State.

Code	Locality	Coordinates	Size
			ha
A1	Campos Novos Paulista	22°33'07"S 50°04'43"W	1,800
A16	Campos Novos Paulista	22°31'24"S 50°02'01"W	83
A17	Campos Novos Paulista	22°31'49"S 49°59'31"W	151
A20	Campos Novos Paulista	22°32'49"S 50°06'54"W	66
A29	Echaporã	22°33'29"S 50°08'11"W	395
A6	Ocauçu	22°29'11"S 50°01'44"W	22
A8	Ocauçu	22°30'05"S 50°00'58"W	320
B1	São Pedro do Turvo	22°41'13"S 49°42'32"W	757
B10	São Pedro do Turvo	22°41'45"S 49°42'44"W	27
B16	São Pedro do Turvo	22°41'01"S 49°44'05"W	49
B2	Ubirajara, S. Pedro do Turvo	22°40'09"S 49°37'21"W	818
B34	São Pedro do Turvo	22°38'37"S 49°41'38"W	216
B5	São Pedro do Turvo	22°41'31"S 49°38'32"W	628
B6	São Pedro do Turvo	22°42'51"S 49°40'50"W	328
B9	São Pedro do Turvo	22°43'38"S 49°41'11"W	27
C13	Agudos	22°36'24"S 49°02'41"W	281
C14	Agudos	22°34'11"S 49°01'29"W	93
C15	Agudos	22°36'15"S 49°04'08"W	39
C2	Agudos	22°30'42"S 48°59'44"W	304
C22	Lençóis Paulista	22°37'17"S 48°59'31"W	102
C30	Lençóis Paulista	22°39'03"S 48°59'23"W	125
D10	Pederneiras	22°14'25"S 48°53'54"W	155
D14	Bauru; Pederneiras	22°16'44"S 48°59'58"W	399
D17	Bauru	22°17'54"S 48°59'58"W	20
D20	Bauru	22°19'52"S 49°00'44"W	1,155
D22	Pederneiras	22°19'24"S 48°57'37"W	75
D46	Pederneiras	22°17'17"S 48°56'27"W	490
E1	Reginópolis	21°59'55"S 49°09'05"W	1,255
E10	Arealva	22°06'38"S 49°00'15"W	70
E12	Bauru	22°07'28"S 49°09'44"W	221
E16	Reginópolis	22°01'53"S 49°09'55"W	149
E7	Arealva	22°03'09"S 48°59'28"W	75
G0	Rancharia	22°22'18"S 50°58'43"W	546
G1	Martinópolis, Indiana	22°10'13"S 51°12'31"W	341
G18a	Martinópolis, Rancharia	22°14'01"S 51°06'30"W	507
G18b	Martinópolis	22°13'21"S 51°02'49"W	295
G2	Martinópolis	22°09'47"S 51°08'36"W	50
G32	Rancharia	22°14'23"S 50°58'48"W	63
H1	Taciba	22°26'57"S 51°17'30"W	389
H6	Martinópolis	22°28'56"S 51°13'43"W	472
H7	Martinópolis	22°29'43"S 51°14'47"W	51
H8	Taciba	22°28'46"S 51°19'36"W	622
H9	Taciba	22°28'35"S 51°19'51"W	37

Continue...

Table 1 - Continuation.

K19	Pereira Barreto	20°50'27"S 50°56'41"W	50
M41	Promissão	21°27'27"S 49°49'11"W	117
M47	Promissão	21°28'21"S 49°50'39"W	526
M0	Avanhandava	21°23'08"S 49°57'28"W	20
M1	Avanhandava	21°24'00"S 49°56'42"W	67
M4	Avanhandava	21°21'43"S 49°55'35"W	150
P0	Boa Esperança do Sul	22°00'31"S 48°27'17"W	181
P10	Bocaina	22°05'37"S 48°30'51"W	129
P11	Bocaina	22°05'00"S 48°31'42"W	460
P7	Boa Esperança do Sul	21°59'33"S 48°30'54"W	684
Q18	Brotas	22°06'35"S 48°01'23"W	499
Q1	Ribeirão Bonito	22°06'20"S 48°10'34"W	43
Q12	São Carlos	22°02'45"S 48°02'39"W	395
Q14	Ribeirão Bonito	22°06'30"S 48°02'55"W	122
Q7	Ribeirão Bonito	22°03'14"S 48°08'31"W	700
R1	Rifaina	20°07'10"S 47°23'14"W	400
R2	Rifaina	20°05'47"S 47°24'00"W	300
R3	Rifaina	20°05'09"S 47°26'17"W	13
R4	Pedregulho	20°14'22"S 47°23'44"W	450
R5	Pedregulho	20°10'56"S 47°18'25"W	120
S11	Colômbia	20°16'58"S 48°46'14"W	1,600
S15	Colômbia	20°17'38"S 48°43'32"W	320
S10	Colômbia	20°14'23"S 48°42'18"W	71
T1	Barretos	20°29'14"S 48°52'16"W	207
T3	Barretos	20°29'27"S 48°48'37"W	563
U2	Olímpia	20°38'20"S 48°57'09"W	500
V12	Nova Granada	20°33'28"S 49°15'05"W	913
W207	Taubaté	23°03'58"S 45°37'10"W	13
W200	São José dos Campos	23°12'30"S 45°51'46"W	200
W201	São José dos Campos	23°16'55"S 45°51'37"W	50
W206	Caçapava	23°04'15"S 45°38'21"W	10
W209	Taubaté	23°00'56"S 45°31'29"W	10
Z1	Itirapina	22°10'35"S 47°52'32"W	300
Z2	Brotas	22°11'38"S 47°53'59"W	300
Y3	Paranapanema	23°21'42"S 48°55'27"W	792
Y2	Paranapanema	23°22'20"S 48°59'45"W	359
Y1	Angatuba	23°22'43"S 48°31'20"W	399
Y4	Paranapanema	23°20'08"S 48°49'11"W	347

remants; **Reforestation**: trees for fuel or timber, mostly *Pinus* or *Eucalyptus* species, which are periodically harvested; **Urban zones**; **Roads** (asphalted roads only); **Railroads**; and **Large water bodies**, such as dams.

A number of areas were surrounded by more than one land use, and all were recorded as present or absent in the vicinity of every fragment.

Threats

Threats to the Cerrado ecosystem were classified as follows:

Invasive grasses: four categories were considered for the diagnosis: absent; only at the edges of the natural vegetation; area partially invaded; area totally invaded; **Fire:** three categories were considered: no evidence of fire; area partially burned; area totally burned;

Cattle: present; absent inside the natural area; **Deforestation:** classified in two categories: trees sparsely cut or area partially deforested after the last mapping (Kronka et al., 1993) about ten years before this evaluation; no cutting recorded.

Chi-square analysis

Applied to verify weather the disturbance frequency is correlated to land use in the vicinity of the Cerrado fragments, by comparing the observed against the expected frequency of each type of disturbance. The observed frequency was the number of fragments in which each kind of disturbance was recorded in the field, for every land use.

The expected frequency was calculated as the number of fragments which were expected to have suffered impact if its frequency was the same for all land uses. If the observed and the expected frequency were not significantly different, the null hypothesis would be confirmed and the type of disturbance, and its recurrence would be independent of the land use around the Cerrado area.

For the chi-square analysis, areas were classified according to invasion as: partially or totally invaded; invasive grasses absent or just at the edges. For fire, areas were classified under two categories: fire recorded (area partially or totally burned); fire not recorded.

Two types of land uses were excluded from the chi-square analyses: water bodies and railroads, since they were both recorded in only two areas, a number insufficient for inclusion within the chi-square analysis. Seven land uses, with two categories each, resulted in six degrees of freedom for every land use.

RESULTS AND DISCUSSION

The diagnosis concerning to the most common land use types around the Cerrado remnants in São Paulo State between 2000 and 2001 is in Figure 1. Pasture is also the most widespread land use for the Brazilian Cerrado Domain as a whole (Sano et al., 2001). These authors found pastures (native or planted) corresponding to 61% of the deforested areas, followed by annual crops (8%), and other uses such as perennial agriculture, reforestation and urban zones (altogether corresponding to 31%). The main difference from the national scenario is that sugarcane has been reported as replacing the Cerrado vegetation only in the São Paulo State (Kronka et al., 2005; Durigan et al., 2004). In other states of the core Cerrado Domain, soybean has been recently the main cause of deforestation, followed by corn. According to Klink & Moreira (2002), 40% and 22% of national production of soybean and corn, respectively, come from the Cerrado region.

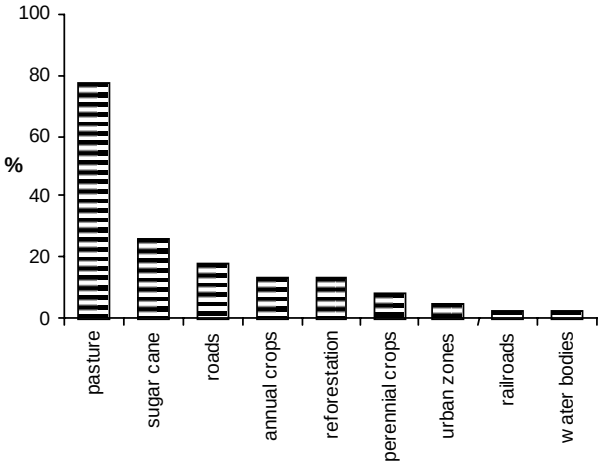

Figure 1 - Frequency of land uses in the vicinity of 81 Cerrado remnants in São Paulo State, Brazil (% means the percentage of the surveyed areas where the land use was recorded).

In the São Paulo State, there is a recent tendency of replacing vast areas of pasture by sugarcane, especially in the west, where soil fertility, climate and topography are suitable for this monoculture. The international demand for biofuel, which has been continuously increasing, and the economic and environmental attractiveness of sugar cane as a renewable energy resource for climate change mitigation through substitution of fossil fuels lead sugar cane area to keep growing (Cerri et al., 2007).

Analysing the threats to the Cerrado ecosystem in São Paulo State (Figure 2), the invasion of African grasses (Figure 2A) has been the most common disturbance, recorded in 72% of the fragments (37% only at the edges). African grasses have been reported as one of the most widespread threats to the Cerrado ecosystem, since they proliferate, persist and spread, jeopardizing the ecosystem (Klink, 1994; Berardi, 1994; Pivello et al., 1999a; 1999b). They also increase the flammable biomass considerably, intensifying the damage caused by wildfires.

Although considered a very important threat to the Cerrado Biome when intensified by human activities (Pivello, 2005), fire has become rare in the São Paulo State, since its use in natural areas is forbidden by law. Only 9% of all sites in this study had been totally burned, 12% were partially affected by recent fires and 79% had no evidences of fire at all (Figure 2B). There is a debate on the negative effects of fire on the Cerrado ecosystem, since it has been recorded since the arrival of the first inhabitants in South

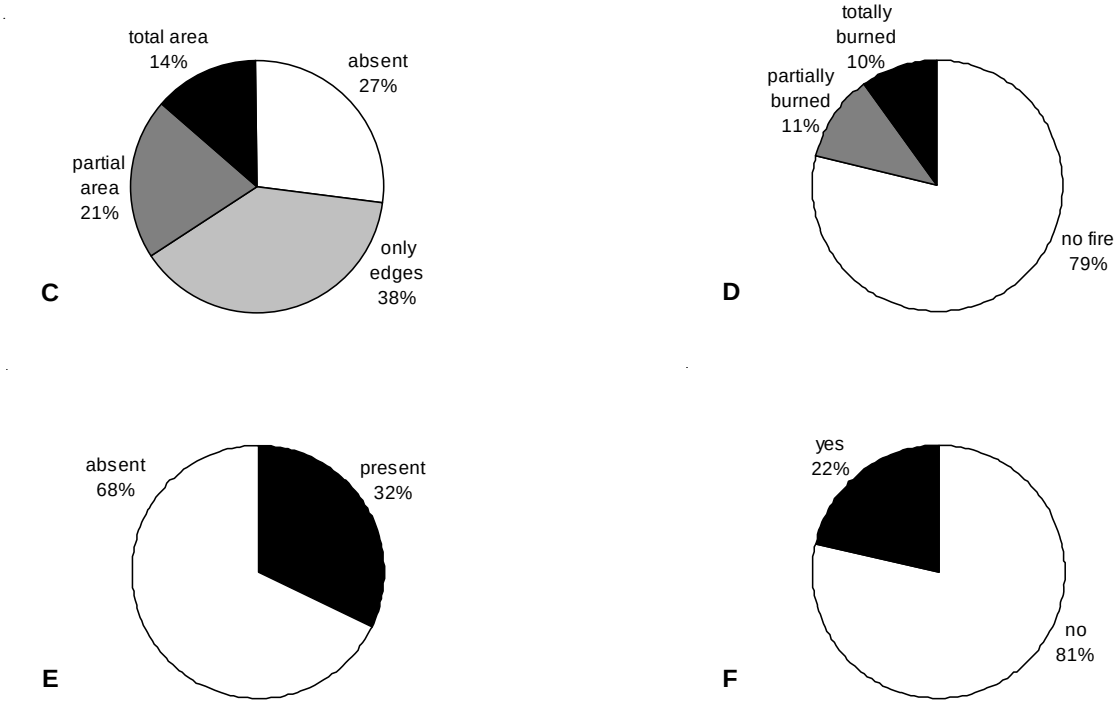

Figure 2 - Threats to the Cerrado remnants in São Paulo State and their frequency. A: invasive grasses; B: fire; C: cattle; D: deforestation.

America (Dean, 1995) and even before that, caused by natural causes (Ramos-Neto & Pivello, 2000; Miranda & Sato, 2005). Some authors point out benefits of fire to the Cerrado ecosystem (e.g. Coutinho, 1990). However, the increase in fire frequency and modification of the fire season can have negative effects on the regeneration of woody plants, favouring the herbaceous layer (Hoffman, 1999; Hoffmann & Moreira, 2002; Klink & Moreira, 2002), thereby changing both plant and animal communities (Durigan et al., 1994; Sato & Miranda, 1996; Hoffmann, 1998; Ramos-Neto & Pivello, 2000; Pivello, 2005). Protection against fire favours the Cerrado physiognomies to become denser, as observed in a number of areas (Goodland & Ferri, 1979; Ratter et al., 1988; Ratter, 1992; Moreira, 2000; Durigan & Ratter, 2006) and these changes seem to be the natural direction towards a new climax for most of the Cerrado remnants, especially in the São Paulo State.

Extensive cattle grazing (Figure 2C) was recorded in 31% of the areas. Whether the presence of cattle inside the natural fragments is negative to the Cerrado ecosystem or whether it helps to control invasive grasses, decreasing the risk of wildfires, is another controversial aspect. In spite of considerably reducing grass biomass, cattle can remarkably change the structure and dynamics of the Cerrado vegetation, by selective herbivory and mechanical impact (Souza et al., 2006).

Deforestation (Figure 2D) includes both cases: partial clear-cutting (habitat reduction) in a ten-year period from the last mapping (Kronka et al., 1993) or trees sparsely cut (changing the community structure without reducing the size of the fragment). This impact was recorded in 21% of the fragments. More than ten years ago (Kronka et al., 1993), the Cerrado was considered one of the most devastated vegetations in São Paulo state. Unfortunately, recent studies (see Kronka et al., 2005) indicate that deforestation is still ongoing. In 1988, a federal law prohibiting any exploitation or deforestation of the Atlantic Forest was issued (Decreto 750, Brasil, 1993). As a consequence, Cerrado and even ecotonal areas started being the only possible areas to be converted into agriculture or pasture in the state, thus accelerating the destruction of the already scarce and unprotected Cerrado vegetation.

The analysis of the types of disturbance to the Cerrado remnants in São Paulo State according to land uses in the vicinity of the natural vegetation showed that, except for deforestation, the frequency of all other disturbances depended on neighbouring land uses (Figure 3).

Invasive grasses (Figure 3A) and fire (Figure 3B) have a very similar relationship with land use and are positively correlated ($\chi^2 = 9.19$, $\chi^2_{0.01(1d.f.)} = 6.64$), grasses increasing fire and vice-versa. They both increase when the Cerrado has roads or urban zones in the vicinity, and decrease when the land use is refor-

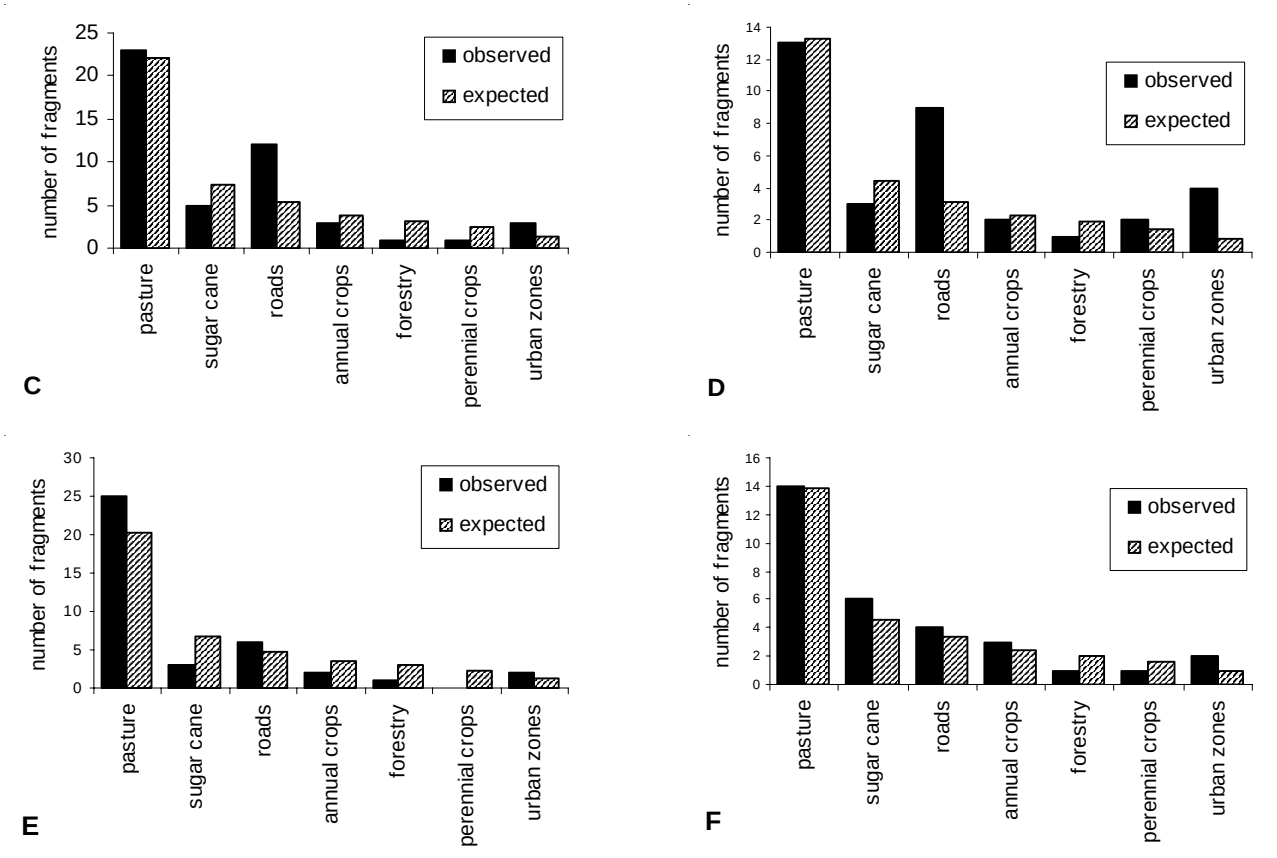

Figure 3 - Observed and expected frequency of disturbance in Cerrado fragments of the São Paulo State. A: invasive grasses ($\chi^2 = 21.2$; $\chi^2_{0.01(6d.f.)} = 16.81$); B: fire ($\chi^2 = 30.2$; $\chi^2_{0.001(6d.f.)} = 22.46$); C: cattle ($\chi^2 = 11.85$; $\chi^2_{0.10(6d.f.)} = 10.64$); D: deforestation ($\chi^2 = 3.6$; n.s.).

estation or sugarcane. The expected high incidence of fire in Cerrado fragments correlated with the yearly burned sugarcane in the vicinity was not confirmed. This means even being a land use that requires fire every year, the fire control was efficient in the period of the present study (2000-2001), so that native vegetation was less frequently burned where the land use around was sugarcane than where it was pasture, annual crops, roads or urban zones. The presence of cattle inside the fragments (Figure 3C) was slightly over the expected when the natural vegetation in the vicinity was pasture or urban zones and significantly reduced if the land use around was reforestation, perennial crops or sugarcane.

Reforestation, sugarcane and perennial crops promote the use of or are prone to fire and weed control, and also exclude cattle, thus indirectly protecting the natural ecosystems. The positive role of *Eucalyptus* plantations to the Cerrado fragments was also pointed out by Shida & Pivello (2005), who noticed a wide variety of mammals using the cerrado/plantation matrix as a habitat.

Although the observed frequency of deforestation (Figure 3D) has been slightly higher than that expected for the Cerrado fragments close to urban zones and sugarcane, the dependence of land use was not significant. This means that the frequency of Cerrado deforestation has been practically the same for all land use types under comparison. The extension of the deforested area for each land use, however, was not analyzed. Other aspects such as the permeability of different land use types for fauna and the relative harm of the threats to the ecosystems were not analyzed as well. Therefore, our discussion is based just on how different land uses in the vicinity of Cerrado fragments can raise the probability of bringing a certain disturbance.

The threats resulting from different land use pressures to the remnants of natural vegetation must be considered in reserve selection and conservation policies. Conservation strategies and costs will be, necessarily, different among Cerrado areas surrounded by urban zones and roads or, in the opposite, by reforestation or perennial crops. Public policies must consider this, so that those land uses which increase disturbance frequency should be discouraged in the neighborhood of the scarce Cerrado remnants, while those which decrease the threats should be stimulated, not disregarding other aspects, such as the permeability of every land use to the fauna.

Analyzing the results of the present study as to how they can be applied to select an area for conservation is a controversial issue. The final decision usually takes into consideration the principle: 'if it ain't broke, don't fix it'. In other words, priority has been given to areas under imminent risk of suppression or degradation. Although controversy exists, this has been the criteria for the indication of global hotspots (Myers et al., 2000) and also for priority areas for biodiversity conservation in Brazil (São Paulo, 1997; Brasil, 1999; Brasil, 2000). On the basis of this rationale, Cerrado fragments surrounded by urban zones or highways would be considered priority areas for establishing new reserves.

However, this study indicates that selecting areas for natural reserves must consider also the investment risks and costs, and, except when supported by their uniqueness or irreplaceability, natural areas under permanent threat should not be considered a priority when selecting areas for establishing new reserves.

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REFERENCES

ALHO, C.J.R.; MARTINS, E.S. **De grão em grão o Cerrado perde espaço**. Impactos do processo de ocupação. Brasília: WWF, 1995. 65p (Documento para discussão).

ALHO, C.J.R. Desafios para a conservação do Cerrado, em face das atuais tendências de uso e ocupação. In: SCARIOT, A.; SOUSA-SILVA, J.C.; FELFILI, J.M. (Org.). **Cerrado**: ecologia, biodiversidade e conservação. Brasília: Ministério do Meio Ambiente, 2005. p.367-381.

BERARDI, A. **Effects of the African grass Melinis minutiflora on Plant Community Composition and fire characteristics of a Central Brazilian Savanna**. London: University College, University of London, 1994. 49p. (Master's thesis).

BRASIL. **Ações prioritárias para a conservação da biodiversidade do Cerrado e Pantanal.** Brasília: Ministério do Meio Ambiente, FUNATURA, Conservation International, Fundação Biodiversitas, Universidade de Brasília, 1999. 26p.

BRASIL. **Avaliação e ações prioritárias para a conservação da biodiversidade da Mata Atlântica e Campos Sulinos**. Brasília: Ministério do Meio Ambiente; SBF, 2000. 40p.

BRASIL. Decreto 750**,** de 10 de fevereiro de 1993. Dispõe sobre o corte, a exploração e a supressão de vegetação primária ou nos estágios avançado e médio de regeneração da Mata Atlântica. **Diário Oficial Da União**, Brasília, DF, 10 fev. 1993.

CAVALCANTI, R.B.; JOLY, C.A. Biodiversity and conservation Priorities in the Cerrado region. In: OLIVEIRA, P.S.; MARQUIS, R.J. (Ed.). **Ecology and natural history of a Neotropical Savanna.** New York: Columbia University Press, 2002. p.351-367.

CERRI, C.E.P.; SPAROVEK, G.; BERNOUX, M.; EASTERLING, W.E.; JERRY M. MELILLO, J.M.; CERRI, C.C. Tropical agriculture and global warming: impacts and mitigation options. *Scientia Agricola*, v.64, p.83-99, 2007.

COUTINHO, L. M. O Cerrado e a ecologia do fogo. **Ciência Hoje**, v.12, p.23-30, 1990.

DEAN, W. **With broadax and firebrand: the destruction of the Brazilian Atlantic Forest.** Berkeley: University of California Press, 1995. 482p.

DURIGAN, G.; RATTER, J.A. Successional changes in Cerrado and Cerrado/forest ecotonal vegetation in western São Paulo State, Brazil, 1962-2000. **Edinburgh Journal of Botany**, v.63, p.119-130, 2006.

DURIGAN, G.; LEITÃO FILHO, H.F.; RODRIGUES, R.R. Phytosociology and structure of a frequently burnt Cerrado vegetation in SE Brazil. **Flora,** v.189, p.153-160, 1994.

DURIGAN, G.; FRANCO, G.A.D.C.; SIQUEIRA, M.F. A vegetação dos remanescentes de Cerrado no Estado de São Paulo. In: BITENCOURT, M.D.; MENDONÇA, R.R. (Org.). **Viabilidade da conservação dos remanescentes de Cerrado no Estado de São Paulo**. São Paulo: Annablume; FAPESP, 2004. p.29-56.

DURIGAN, G.; SIQUEIRA, M.F.; FRANCO, G.A.D.C.; RATTER, J.A. Seleção de fragmentos prioritários para a criação de unidades de conservação do Cerrado no estado de São Paulo. **Revista do Instituto Florestal**, v.18, p.23-37, 2006.

DURIGAN, G.; SIQUEIRA, M.F.; FRANCO, G.A.D.C.; BRIDGEWATER, S.; RATTER, J.A. The vegetation of priority areas for Cerrado conservation in São Paulo State, Brazil. **Edinburgh Journal of Botany**, v.60, p.217-241, 2003.

FELFILI, J.M.; SOUSA-SILVA, J.C.; SCARIOT, A. Biodiversidade, ecologia e conservação do Cerrado: avanços do conhecimento. In: SCARIOT, A.; SOUSA-SILVA, J.C.; FELFILI, J.M. (Org.). **Cerrado**: ecologia, biodiversidade e conservação. Brasília: Ministério do Meio Ambiente, 2005. p.25-44.

GOODLAND, R.; FERRI, M.G. **Ecologia do Cerrado**. São Paulo: EDUSP, 1979.193p.

HOFFMANN, W.A.; MOREIRA, A.G.. The role of fire in population dynamics of woody plants. In: OLIVEIRA, P.S. & MARQUIS, R.J. (Ed.). **Ecology and natural history of a Neotropical Savanna**. New York: Columbia University Press, 2002. p.159-177.

HOFFMANN, W.A. Fire and population dynamics of woody plants in a neotropical savanna: matrix model predictions. **Ecology**, v.80, p.1354-1369, 1999.

HOFFMANN, W.A. Post-burn reproduction of woody plants in a neotropical savanna: The relative importance of sexual and vegetative reproduction. **Journal of Applied Ecology**, v.35, p.422-433, 1998.

KLINK, C.A. Clipping effects on size and tillering of native and African grasses of the Brazilian savannas (the "Cerrado"). **Oikos**, v.70, p.365-376, 1994.

KLINK, C.A.; MOREIRA, A. Past and current human occupation, and land use. In: OLIVEIRA, P.S.; MARQUIS, R.J. (Ed.). **Ecology and natural history of a Neotropical Savanna**. New York: Columbia University Press, 2002. p.69-88.

KRONKA, F.J.N.; MATSUKUMA, C.K.; NALON, M.A.; CALI, I.H.D.; ROSSI, M.; MATTOS, J.F.A.; SHIN-IKE, M.S.; PONTINHA, A.A.S. **Inventário florestal do estado de São Paulo.** São Paulo: SMA; CINP; Instituto Florestal, 1993.199p.

KRONKA, F.J.N.; NALON, M.A.; MATSUKUMA, C.K.; KANASHIRO, M.M.; YWANE, M.S.S.; PAVÃO, M.; DURIGAN, G.; LIMA, L.M.P.R.; GUILLAUMON, J.R.; BAITELLO, J.B.; BORGO, S.C.; MANETTI, L.A.; BARRADAS, A.M.F.; FUKUDA, J.C.; SHIDA, C.N.; MONTEIRO, C.H.B.; PONTINHA, A.A.S.; ANDRADE, G.G.; BARBOSA, O.; SOARES, A.P. **Inventário florestal da vegetação natural do estado de São Paulo**. São Paulo: Secretaria do Meio Ambiente; Instituto Florestal; Imprensa Oficial, 2005. 200p.

MACHADO, R.B.; RAMOS NETO, M.B.; PEREIRA, P.G.P.; CALDAS, E.F.; GONÇALVES, D.A.; SANTOS, N.S.; TABOR, K.; STEININGER, M. **Estimativas de perda da área do Cerrado brasileiro**. Brasília: Conservação Internacional, 2004. 26p. Available at: http://.conservation.org.br/arquivos/RelatDesmatamCerrado.pdf. Accessed in: 2 fev. 2007.

MIRANDA, H.S.M.; SATO, M.N. Efeitos do fogo na vegetação lenhosa do Cerrado. In: SCARIOT, A.; SOUSA-SILVA, J.C.; FELFILI, J.M. (Org.). **Cerrado**: ecologia, biodiversidade e conservação. Brasília: Ministério do Meio Ambiente, 2005. p.93-105.

MOREIRA, A.G. Effects of fire protection on savanna structure in Central Brazil. **Journal of Biogeography**, v.27, p.1021-1029, 2000.

MYERS, N.; MITTERMEIER, R.A.; MITERMEIER, C.G.; FONSECA, G.A.; KENT, J. Biodiversity hotspots for conservation priorities. **Nature**, v.403, p.853-858, 2000.

PIVELLO, V.R. Manejo de fragmentos de Cerrado: princípios para a conservação da biodiversidade. In: SCARIOT, A.; SOUSA-SILVA, J.C.; FELFILI, J.M. (Org.). **Cerrado**: ecologia, biodiversidade e conservação. Brasília: Ministério do Meio Ambiente, 2005. p.401-413.

PIVELLO, V.R.; CARVALHO, V.M.C.; LOPES, P.F.; PECCININI, A.A.; ROSSO, S. Abundance and distribution of native and invasive aliean grasses in a "Cerrado" (Brazilian savanna) biological reserve. **Biotropica**, v.31, p.71-82, 1999a.

PIVELLO, V.R; SHIDA, C.N.; MEIRELLES, S.T. Allien grasses in Brazilian savannas: a threat to the biodiversity. **Biodiversity and Conservation,** v.8, p.1281-1294, 1999b.

RAMOS-NETO, M.B.; PIVELLO, V.R. Lightning fires in a Brazilian savanna national park: rethinking management strategies. **Environmental Management,** v.26, p.675-684, 2000.

RATTER, J.A. Transitions between Cerrado and forest vegetation in Brazil. In: FURLEY, P.A.; PROCTOR, J.; RATTER, J.A. (Ed.). **Nature and dynamics of forest – savanna boundaries.** London: Chapman & Hall, 1992. p.417-430.

RATTER, J.A.; RIBEIRO, J.F.; BRIDGEWATER, S. The Brazilian Cerrado vegetation and threats to its biodiversity. **Annals of Botany**, v.80, p.223-230, 1997.

RATTER, J.A.; BRIDGEWATER, S.; RIBEIRO, J.F. Biodiversity patterns of the woody vegetation of the Brazilian Cerrado. In: PENNINGTON, T.; LEWIS GWILYM, P.; RATTER, J.A. (Org.). **Neotropical Savannas and dry forests:** diversity, biogeography and conservation. Boca Raton: Taylor & Francis, 2006. p.31-66.

RATTER, J.A.; LEITÃO FILHO, H.F.; ARGENT, G.; GIBBS, P.E.; SEMIR, J.; SHEPHERD, G.; TAMASHIRO, J. Floristic composition and community structure of a southern Cerrado area in Brazil. **Notes of Royal Botanical Garden of Edinburgh**, v.45, p.137-151, 1988.

RIBEIRO, J.F.; BRIDGEWATER, S.; RATTER, J.A.; SOUSA-SILVA, J.C. Ocupação do bioma Cerrado e conservação da sua diversidade vegetal. In: SCARIOT, A.; SOUSA-SILVA, J.C.; FELFILI, J.M. (Org.). **Cerrado**: ecologia, biodiversidade e conservação. Brasília: Ministério do Meio Ambiente, 2005. p.383-399.

SANO, E.E.; SILVA, E.T.J.B.; BEZERRA, H.S. Mapeamento e quantificação de áreas remanescentes do Cerrado através de um sistema de informações geográficas. **Sociedade e Natureza**, v.13, p.47-62, 2001.

SÃO PAULO. Secretaria do Meio Ambiente de São Paulo. **Cerrado**: Bases para a conservação e uso sustentável das áreas de Cerrado do Estado de São Paulo. São Paulo: SEMA, 1997. 184p. (Série PROBIO/SP).

SATO, M.N.; MIRANDA, H.S. Mortalidade de plantas lenhosas do Cerrado *sensu stricto* submetidas a diferentes regimes de queima. In: MIRANDA, H.S.; SAITO, C.H.; DIAS, B.F.S. (Ed.). **Impactos de queimadas em áreas de cerrado e restinga.** Brasília: Universidade de Brasília, 1996. p.102-111.

SHIDA, C.N.; PIVELLO, V.R. O desafio da conservação dos recursos naturais na região: o contexto do Cerrado Pé-de-Gigante como fragmento: conseqüências. In PIVELLO, V.R.; VARANDA, E.M. (Orgs). **O Cerrado Pé-de-Gigante: Ecologia e Conservação**. São Paulo: Secretaria do Meio Ambiente, 2005. p.267-272.

SILVA, J.M.C.; BATES, J.M. Biogeographic patterns and conservation in the South American Cerrado: a Tropical Savanna Hotspot. **BioScience**, v.52, p.225-233, 2002.

SOUZA, S.C.P.M.; DURIGAN, G.; MELO, A.C.G. Impacto do gado sobre a regeneração do Cerrado em área invadida por braquiária (*Urochloa decumbens* (Stapf.) R.D. Webster) em Assis, SP. In: 57º CONGRESSO NACIONAL DE BOTÂNICA, Gramado, 2006. Anais. SBB/UFRGS. CDRom (Resumo 489).

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