EFFECTS OF INVASIVE SPECIES ON FOREST RESTORATION IN SOUTH-EAST BRAZIL

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Abstract: This research aimed to investigate some restoration techniques to facilitate recovery of cerrado disturbed areas. Over two years the stem height of ten reintroduced species were checked, as well as the effect of frost damage on native species. The richness and abundance of natural regeneration were also evaluated. The results suggest grass removal as an important technique to accelerate the spontaneous succession and the growth of reintroduced species.

Keywords: tropical forest; invasive species; reafforestation; spontaneous succession; growth; frost damage; colonization; Cerrado biome.

Introduction

Restoring an ecosystem requires a previous understanding of recovery dynamics. In Brazil, planting nursery-grown tree seedlings has been the most utilized technique to restore forests (Sampaio et al, 2007) but knowledge about the reintroduced species is still insufficient and the cost of this activity very high. The Cerrado covers more than 2 million km^2 and inspite of its richness, it is possibly the most threatened tropical savanna in the world due to deforestation, fire, and invasive grasses (Duringan et al, 2007; Pivello et al, 1999; Silva & Bates, 2002). The goals of this study were to determine the effect of invasive grasses on native species and verify the potential of spontaneous succession and planting in aiding the recovery of a disturbed cerrado.

Materials and methods

This project was conducted in a disturbed area of cerrado located in the Municipal Botanical Garden of Bauru, in South-east Brazil (22°20'30''S; 49°00'30''W). The climate in the region is tropical with a well-defined wet and dry season (Cwa-Köppen classification). The studied area was formerly covered by forest-like cerrado, but the frequent occurrence of fire followed by grass invasion eliminated most of this vegetation. Among the grasses the African *Urochloa brizantha* (Hochst. ex A. Rich.) R.D. Webster was favored by the increase of light and quickly dominated the area. Five months after a fire two plots, one adjacent to the cerrado forest and another near the Vargem Limpa river were established. In each of the plots four 12.5 x 12.5-m adjacent smaller plots were set up, resulting in 1250m^2. ***Planting***: 92 individuals of 10 cerrado species were planted on a 2 x 3-m grid in four 12.5 x 12.5-m plots (2 next to the forest and 2 near the river). Among the chosen species 5 were pionners (*Gochnatia polymorpha*

(Less.) Cabr., *Tibouchina stenocarpa* (Schr. & Mart. ex DC.), *Croton urucurana* Baill., *Cecropia pachystachya* Trec., *Inga uruguensis* Hooker at Arnolt) and 5 were non-pionner species (*Luehea grandiflora* Mart., *Platypodium elegans* Vog., *Copaifera langsdorffii* Desf., *Tabebuia aurea* (Manso) Benth.& Hook. F ex S. Moore, and *Pseudobombax longiflorum* A. Robyns). The stem height of all plants was measured every three months over the course of two years. *Grass removal*: during the second year grasses were cut six times using hoes in all four 12.5 x 12.5-m plots. *Spontaneous succession*: the new woody regenerating plants were quantified in all plots seven times during two years. *Data analysis*: to check the efficiency of grass removal in increasing growth and regeneration, the data were analyzed using a two-factor repeated measures analysis of variance (ANOVA). The first factor, grass removal, was defined by the four treatment groups: 1) grass removal; 2) planting and grass removal; 3) planting and 4) control. The second factor, time, was defined by nine points. Adjustments to the analysis were made according to the Greenhouse-Geisser method. If a significant interaction between grass removal and time was evident, treatment effects were also examined using Tukey adjustments for multiple comparisons.

Results and discussion

Spontaneous succession: in ten months we recorded 1132 regenerating individuals (9,056 ind.ha^{-1}) and 22 species (Table 1). Most of individuals were shrubs (55.55%), followed by trees (22.27%) and herbs (22.18%). Anemochory was the predominant dispersion syndrom (55.55%) due mainly to dominance by *Baccharis dracunculifolia* DC. Among the trees authocory and zoochory were the most important syndroms but considering the frequency of vegetative reproduction in cerrado (Sampaio *et al*, 2007) and the disturbance history it is possible that many of these plants originated by resprouting. *B. dracunculifolia* was the most abundant species (4,760 ind.ha^{-1}), followed by *Solanum americanum* Mill (1,920 ind.ha^{-1}) and *Mabea fistulifera* Mart. (1,336 ind.ha^{-1}), all found in frequently perturbed areas. *B. dracunculifolia* is a widespread perennial shrub which develops rapidly and can be potentially used in restoration programs as a successful colonizer of poor and acid soils (Gomes & Fernandes, 2002). 80.8% of regenerating plants were recorded in the plots where the grasses were removed. In fact *Urochloa brizantha* is very competitive against native plants and once established it can changes the environment quickly and severely. The intense fragmentation of cerrado, much to the detriment of pastures and agriculture, increases the edge effects and favors the dissemination of invasive grasses representing a real threat to the biodiversity (D'Antonio & Vitousek, 1992; Pivello et al, 1999). In São Paulo State African grasses were recorded in 72% of 81 cerrado fragments. These species are considered the most common disturbance factor and a potential intensifier of wildfires as a result of their flammable biomass (Durigan et al, 2007).

Planting: an unusual frost which occurred during three days in the end of July 2000 seriously damaged many species that were not adapted to these climate conditions. As a consequence, the mean stem height decreased in all the treatments and from January 2001 the species started to regrow (Figure 1). Time and grass removal had an interactive effect on stem height ($F_{[6,121]}$ = 5.24, p = 0,0001). The Tukey comparisons indicate a significant difference between the treatments 1 x 3 (p=0.0006) and 3 x 4 (p=0.0012) but no difference between 2 x 3 (p=0.14). Only in the plots where the grasses were removed did species showed a positive growth (treatment 2, p = 0.02; treatment 3, p< 0.001). The species present in plots near the river showed a higher but not significant difference in mean stem height, probably related to the differences in edaphic (fertility, humidity...) and microclimatic conditions (humidity, temperature...). *Gochnatia polymorpha* (Less.) Cabr. was not very affected by the frost and had the highest mean stem growth (1.96 ± 0.91m) in two years. Most species had their aerial parts destroyed after July, in particular, *Tibouchina stenocarpa* which lost 79% of its height, *Cecropia pachystachya* (-73%) and *Croton urucurana* (-61%), the more injuried species. In despite of this, these species recovered in the following months and had a mean stem growth of 0.26 ± 0.78, 0.50 ± 1.33m and 0.35 ± 2.10, respectively. As expected, the non-pionner species showed a even slower mean growth (*Tabebuia aurea* = -0.06m ± 0.28m; *Copaifera langsdorffii* = 0.13 ± 0.44m and *Pseudobombax longifolium* = 0.14 ± 0.36m) and they are recommended just for areas that need to be enriched.

Table 1. Woody species surveyed in a regenerating cerrado during two years. Bauru Botanical Garden, Brazil.

Families	**Regenerating species**	**Number of individuals**	**Habit**	**Dispersal syndrome**
Asteraceae	*Baccharis dracunculifolia* DC.	595	Shrub	Anemochoric
Solanaceae	*Solanum americanum* Mill.	240	Herb	Zoochoric
Euphorbiaceae	*Mabea fistulifera* Mart.	167	Tree	Authocoric
Fabaceae	*Copaifera langsdorffii* Desf.	41	Tree	Zoochoric
Fabaceae	*Senna* sp	37	-	-
Verbenaceae	*Aegiphila lhotskiana* Cham.	13	Tree	Zoochoric
Fabaceae	*Bauhinia* sp	10	-	-
Ulmaceae	*Trema micrantha* (L.) Blume	6	Tree	Zoochoric
Euphorbiaceae	*Manihot tripartita* (Spreng.) Mull.Arg.	3	Shrub	Zoochoric
Arecaceae	*Syagrus flexuosa* (Mart.) Becc.	3	Tree	Zoochoric
Fabaceae	*Acosmium subelegans* (Mohlenbr.) Yakovlev	3	Tree	Anemochoric
Fabaceae	*Dimorphandra mollis* Benth.	3	Tree	Zoochoric
Myrtaceae	Indeterminate	2	-	-
Moraceae	*Brosimum gaudichaudii* Trécul.	1	Shrub	Zoochoric
Malpighiaceae	*Byrsonima intermedia* A. Juss.	1	Shrub	Zoochoric
Cecropiaceae	*Cecropia pachystachya* Trécul	1	Tree	Zoochoric
Bignoniaceae	*Cybistax antisyphilitica* Mart.	1	Tree	Anemochoric
Malvaceae	*Pavonia sp*	1	-	-
Vochysiaceae	*Qualea grandiflora* Mart.	1	Tree	Anemochoric
Combretaceae	*Terminalia brasiliensis* (Cambess. ex A. St.-Hil.) Eichler	1	Tree	Anemochoric
Caryocaraceae	*Caryocar brasiliense* Camb.	1	Tree	Zoochoric
Polygonaceae	*Coccoloba mollis* Casar.	1	Shrub	Zoochoric
	Total	**1132**		

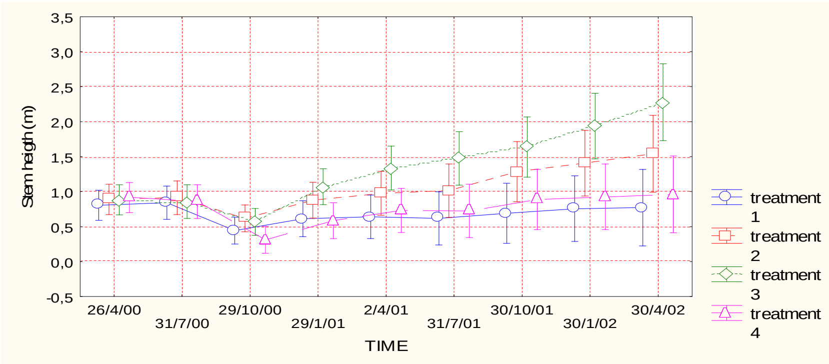

Figure 1. Mean stem height of reintroduced species according to the time. Treatments 1 = No grass removal (near the forest); 2 = Grass removal (near the forest); 3 = Grass removal (near the river) and 4 = No grass removal (near the river).

Conclusions

Manual removal of *Urochloa brizantha* can increase the growth and the spontaneous succession in cerrado vegetation, probably by reducing competition and stimulating germination and the sprouting of regenerating plants. Among the introduced species *Gochnatia polymorpha* showed the greatest growth even under frost conditions and is recommended to be used in similar restoration programs. Considering the costs of planting we suggest this technique be applied only for non-sprouting species or in low resilience areas. Otherwise the removal of disturbance factors, like exotic grasses, is enough to accelerate the cerrado natural regeneration.

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