



Maintenance of wetland plant communities: the role of the seed bank in regeneration of native plants

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ABSTRACT

Exotic grasses have been introduced into wetlands and can compete with native plants due to their high tolerance of flood and dry periods. Flooding can facilitate seed dispersal of exotic species and reduce the diversity of native species. We compared two grasslands to assess whether seed banks can maintain the diversity of native plants in wetlands with introduced exotic plants. We recorded a total of 136 species and a predominance of annual plants in the seed bank and vegetation together. The seed bank had high species diversity independently of the dominance of the exotic *Urochloa humidicola* in the vegetation. The seed banks of the native and cultivated grasslands differed significantly with a positive correlation for aquatic plants in the native grassland and negative correlation in the cultivated grassland. The seed bank revealed potential to maintain the diversity of native species in the cultivated grassland since the flood and dry seasons promoted the presence of distinct species in the seed bank, but lower richness in the vegetation reflects a dependence on the germination stage. The seasonality of flood and dry periods influences distinct growth forms, increasing the diversity of the seed bank and the vegetation.

Keywords: exotic plants, life cycle, grasslands, growth forms, seasonal savanna

Introduction

Wetlands are composed of a diversity of perennial grasses and annual herbs, which vary in abundance according to flood and drought periods (Touzard *et al.* 2002). The Brazilian Pantanal is dominated by open fields under periodical floods from local rains and river overflow (Pott & Silva 2015). The seasonality is a determining factor in the establishment of the vegetation due to the direct effects of soil moisture on germination and establishment of seedlings (Baskin & Baskin 2014). The variations in water regime can change over seasons and influence the formation of seasonal communities of distinct plants (Casanova & Brock 1990;

Harwell & Havens 2003). During the flood season, the vegetation is structured by submerged and floating aquatic macrophytes (Pott & Pott 2004; Bao *et al.* 2018a), and as the water recedes, the grassland becomes drained, and the vegetation is rapidly dominated by emergent species from the seed bank (Bao *et al.* 2017).

Grasses have high representation in these wetlands and coexist with the other groups of plants over the seasons (Bao *et al.* 2014; 2015; 2017; 2018a; Pott & Silva 2015; Souza *et al.* 2016). The predominance of grasses, however, makes these areas ideal for grazing activities. The search for species resistant and able to compete with aquatic plants during floods leads to the introduction of exotic grasses in natural grasslands worldwide (Bossuyt *et al.* 2006; Fisher *et*

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al. 2009; Ma *et al.* 2012). In the Pantanal, the introduction of *Urochloa humidicola*, utilized as grazing for cattle, became recurrent due to its ability to tolerate flooding (Mattos *et al.* 2005; Souza *et al.* 2006; Bao *et al.* 2020) and high regrowth and vegetative propagation potential (Michelan *et al.* 2010). The morphology of its diaspores (with palea and glume well coupled) provides slow absorption of water, allowing it to stay dormant in the field for extended periods (Montorio *et al.* 1997). Widespread dispersal of *U. humidicola* can lead to increased dominance in the community at the expense of native species in the vegetation (Bao *et al.* 2015). However, for the seed bank, although it can store seeds of exotic plants, the seasonal floods can act in favor of maintaining diversity, bringing seeds from local native plants and neighboring areas (Bao *et al.* 2014).

The dispersal of seeds and the formation of the seed banks dominated by exotic species are a great concern in wetlands, as connected waterways can act as corridors increasing the spread of the species through hydrochory (Nathan & Muller-Landau 2000), finally modifying the local scale and patterns of the native plant community (Whittaker *et al.* 2001). Wetlands and hydrologic connectivity within and among wetland areas can facilitate changes in the composition and diversity of the vegetation by providing dispersal corridors (Middleton 2002), and modify the composition of the local seed banks (Boedeltje *et al.* 2002; Baldwin *et al.* 2010).

In a microcosms experiment with five aquatic macrophytes (*Sagittaria guayanensis*, *Limncharis flava*, *Hydrocleys parviflora* and *Pontederia subovata*) we showed that the presence of aquatic macrophytes can increase the mortality of *U. humidicola* (c. 70 %) under three months, due to decreased of luminosity (Bao *et al.* 2020). In this sense, it is important to verify the distribution and abundance of aquatic macrophytes within the seed bank in grasslands considering how plant species invasion alters the vegetation and the seed bank. For this study, we compared the vegetation and the seed bank of seasonally flooded grassland dominated by the exotic *U. humidicola* and another composed of native grasses. The following hypotheses guided this research:

The seed bank does not differ in richness and abundance between native and cultivated grasslands. We believe that the maintenance of these variables occurs by annual plants present in the soil in both grasslands (contrasting life cycles). The seed bank and the vegetation do not present similarity: independently of the grassland or seasonal period, the seed bank has greater diversity, due to local seeds and neighboring areas that accumulate over the years. In the seed bank, the growth forms of aquatic and amphibious plants have higher distribution in native grasslands and terrestrial forms in cultivated grasslands. However, in the vegetation, we expect a positive correlation of terrestrial forms in both grasslands. We believe that the history of cultivation (over 15 years) of *U. humidicola* in cultivated grasslands can be

decreasing the presence of aquatic macrophytes in the seed bank (contrasting growth forms).

Materials and methods

Study area

The present study was carried out in the sub-region of Abobral, Pantanal, Mato Grosso do Sul (Central-West Brazil, Fig. 1A). The climate of the region is tropical sub-humid, with a mean annual temperature of 26 °C and an average annual rainfall of 1100 mm (Allem & Valls 1987; Silva & Abdon 1998). The Brazilian Pantanal is regulated by an annual flood pulse, the seasonality in this region is marked by well-defined periods of rain/flood (between December and May) and dry (between July and November), with pluvial and fluvial fluctuations, with maximum (7.34 m) and minimum level (2.37 m) of the Miranda river (data collected at Base de Estudos do Pantanal - BEP, between 2005 and 2015, Fig.1B). The ground level can vary between 1 to 60 cm (Allem & Valls 1987; Silva & Abdon 1998). Such variation of topography added to the different sites of hydrological regime form permanent and periodically flooded zones (Pott & Silva 2015).

To examine the effect of seasonality on the grassland over time, we conducted four samplings on the hydrophases (dry/2013-2014 and flood/2014-2015) of the Pantanal: two at the end of the dry period (September) and two at the end of the flood period (July) (Fig.1B). These native grasslands are traditionally utilized as pastures and were partially replaced by cultivated grassland using the exotic *Urochloa humidicola* (Rendle Morrone & Zuloaga (Poaceae). This species was first introduced 15 years ago.

Samplings were made in eight seasonal ponds, distant 1 km between each other: four located in a cultivated grassland dominated by the exotic *U. humidicola* and the others four in native grassland (Fig. 1A). To achieve the widest amplitude in capture of seeds and species richness, in each seasonal pond we set three transects according to the flood level: one placed in the middle of the pond (low), one on the pond edge (mid) and another most external to the pond (high), keeping a distance between them ca. 10 m horizontally and ca. 30 cm vertically (Fig. 1C). The transects were established using as reference the watermark of the flood level on fence poles and arboreal plants, and the points were marked in the first year of the study, at the end of flooding, when seasonal ponds are formed (*cf.* Bao *et al.* 2014).

Vegetation and seed bank sampling

For analysis of the established vegetation, we performed a sampling of plant cover using the method of the percentage of species present in the study area (*e.g.* Dolle & Schmidt 2009). In each transect, we sampled five random replicates for evaluation of plant cover, totaling 1 sample per pond.



Within a delimited area of 0.50 x 0.50 m, we made the visual estimate of the percentage cover of each species, and for more precise estimates each quadrat was subdivided with strings into quarters, and the observation was always made by the same person.

In each sampling quadrat of plant cover, we took three soil samples, each with 20 x 20 cm and 3 cm deep, with a shovel (cf. Bao *et al.* 2014). Each soil sample was submitted to a distinct method of evaluation of the seed bank. To increase seed sampling accuracy we used three methods: Method I –seedling emergency in the greenhouse (for knowledge of viable seeds) – we spread the soil samples in plastic trays (30 cm x 30 cm x 10 cm), over a 2 cm layer of sterilized washed sand under ambient temperature, the seedlings of germinated seeds were counted, identified and removed, to avoid competition from new seedlings (Thompson *et al.* 1997). Method II – manual counting of seeds (to determine the total number of seeds in the sediment) – for this, we washed the soil through a set of sieves with three mesh sizes (0.25 mm, 0.35 mm and 0.50 mm) to trap seeds of distinct sizes (Bonis *et al.* 1995; Mcfarland & Shafer 2011), the retained seeds were fixed in alcohol 50% and preserved

and, in the laboratory, the seeds were counted and identified under a stereoscopic microscope; Method III –submerged trays with soil to check the emergence of aquatic macrophyte seedlings (for the knowledge of the aquatic community) – seedling emergence was determined by spreading soil samples in plastic trays (30 cm x 30 cm x 10 cm) and then samples were submerged in tanks under 90 cm of water (flood) for three months (we removed filamentous algae when necessary).

The identification of the species was made by comparison with specimens in the Herbarium CGMS of Universidade Federal de Mato Grosso do Sul (UFMS), consulting specialized books (e.g. Pott & Pott 1994; Pott & Pott 2000; Kissmann & Groth 1992; 1995; 1997) and identification manuals (e.g. Gil & Bove 2006; Groth 1983; Kaul 1978; 1985; Souza & Giulletti 2014), and collaboration from specialists on plants of the Pantanal. Species were presented according to APG IV- Angiosperm Phylogeny Group (2016) and Smith *et al.* (2006) for Lycophytes. We classified species germinated from the seed bank according to their life cycle (perennial or annual) and growth form (aquatic, amphibious and terrestrial) (cf. Pott & Pott 1994; Pott & Pott 2000).

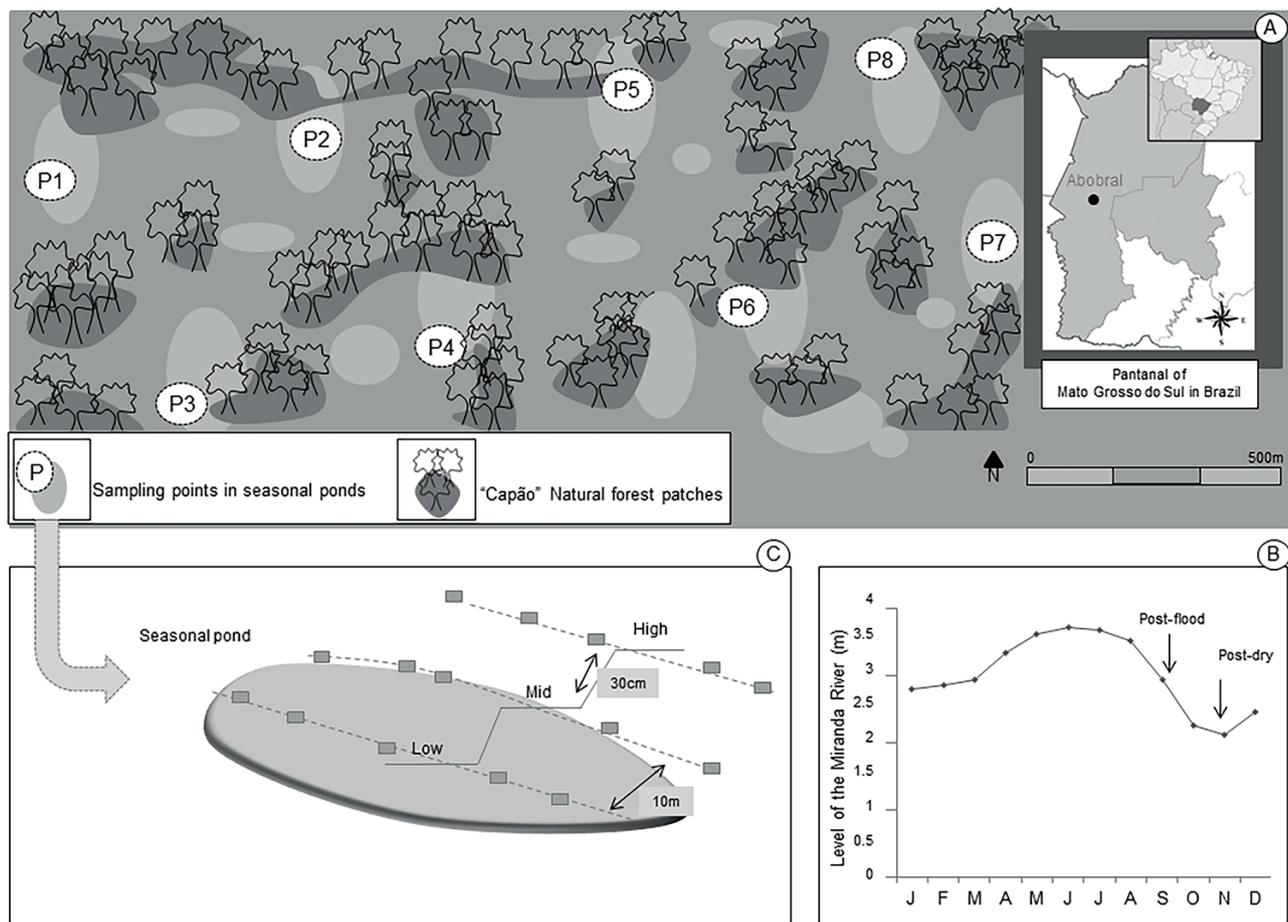


Figure 1. Seasonally flooded grassland in the Pantanal wetland (Central-West Brazil). (A) Sampling points including eight seasonal ponds (P1, P2, P3 and P4 in grassland dominated by *U. humidicola*, and P5, P6, P7 and P8 in native grassland), (B) representation of the transects following the topographic levels (low, mid and high) in each sampled pond, with five random samples, (C) mean monthly level of the Miranda River, arrows showing the sampled seasonal periods (dry and flood), between the years 2005-2015.

Statistical analysis

For the first hypothesis, with richness and abundance data, we used the mean number of individuals of each species in the two-seasonal flood-dry cycles and calculated the total sum of abundance per sampling plot. For the first hypothesis, to describe the plant community, with richness and abundance values as response variables, we constructed a two-way ANOVA model with grassland type (native and cultivated) and life cycle (annual and perennial plants) as predictors.

For the second hypothesis, the data of species abundance and relative cover in the seed bank and the vegetation in each grassland type and seasonal period were ordinated by Non-Metric Multidimensional Scaling (NMDS), utilizing the Bray-Curtis distance. To decide how many solutions of NMDS would be utilized as dependent variables in a Multivariate Analysis of Variance (MANOVA), we compared r^2 values from linear regression of original values of the matrix of similarity with that obtained from ordination in one, two, or three solutions. The best solution had the highest r^2 value with the lowest value of stress. However, for graphical visual performance on compositional distribution between the seed bank and vegetation vs seasonal period (flood and dry) and grassland type (native and cultivated), we chose to use two-dimensional solution. MANOVA was used to determine if there were significant mean differences in a set of data through Pillai-Trace statistics. In addition, the similarity among sampled sites according to the floristic composition of soil seed bank and vegetation (data of grassland types and seasonal periods) were determined using the Similarity Percentage. We utilized ANOVA to compare effects of native and cultivated grasslands, and seasonal periods upon species relative abundance of seeds and relative cover. Finally, the species diversity of the vegetation and seed bank was calculated using the Shannon diversity index to evaluate the effect of seasonal periods (flood and dry) on diversity in each grassland type (native and cultivated). The analysis of variance (One-Way ANOVA) and the Tukey test were applied to verify significant mean differences.

Finally, for the third hypothesis, we applied analyses of redundancy (RDA) to examine if the growth forms (aquatic, amphibious and terrestrial) are related to the distribution of species composition of the seed bank and the vegetation between native and cultivated grassland. To select the growth forms for the analysis, we considered the germination and ecological requirements of the plant species to become established during the flood and dry season (analysed together). The significance tests of RDAs were done by an analysis of variance (Two-Way ANOVA). All analyses were in R environment (R Development Core Team 2020), using the packages BiodiversityR (Kindt & Coe 2005), vegan (Oksanen *et al.* 2017), permute (Simpson 2016) and lattice (Deepayan 2008).

Results

Floristic

We recorded 136 species in the plant community, 120 species in the native grassland (33 exclusives) and 103 species in the cultivated grassland dominated by *U. humidicola* (12 exclusives). Most species were in the Poaceae family (24 species), followed by Cyperaceae (16), Leguminosae (11), Asteraceae, Euphorbiaceae and Malvaceae (eight), Alismataceae and Plantaginaceae (seven each). Together these represented over 50 % of the species found in this community (Tab. S1 in supplementary material).

Of the 120 species present in the seed bank 60 % annuals and 40 % were perennials. The richness of life cycles in the seed bank between grasslands types did not differ (ANOVA: $F_{4,15}=214.310$, $p=0.217$, Fig. 2A). The abundance of annual species in the seed bank was significantly higher compared to perennials (ANOVA: $F_{4,15}=423.333$, $p<0.001$, Fig. 2B), but did not differ between native and cultivated grasslands (ANOVA: $F_{4,15}=28.128$, $p=0.341$, Fig. 2B). The five species of highest abundance in the seed bank in both grasslands were annual plants: *Hyptis brevipes* (10.467 seeds), *Richardia grandiflora* (8.962), *Rotala ramosior* (8.298), *Ludwigia octovalvis* (8105) and *Helanthis tenellum* (5766).

Of the 104 species in the vegetation 60 % were annuals and 40 % were perennials. In the seed bank, annual species had the highest richness in native grassland (51 spp.), differing in richness as for perennial species (ANOVA: $F_{4,15}=62.10$, $p<0.001$, Fig. 2C) and grassland type (ANOVA: $F_{4,15}=50.59$, $p<0.001$, Fig. 2C). For vegetation cover, we did not detect differences between life cycle (ANOVA: $F_{4,15}=6.135$, $p=0.0234$, Fig. 2D) or type of grassland (ANOVA: $F_{4,15}=11.560$, $p=0.351$, Fig. 2D). The five species with the highest average cover in both types of grasslands were the grasses *Urochloa humidicola* (53.4 %), *Digitaria fuscescens* (52.1 %), *Axonopus purpusii* (42.2 %), *Reimarochloa acuta* (41.2 %) and *Paspalum alnum* (31.2 %).

Similarity and diversity

The similarity between the seed bank and the vegetation in the native and cultivated grassland was under 50 % when seasonality was analysed separately. In flood and dry seasonal periods, it was 49 % and 47 % in native grassland and, 39 % and 27 % in cultivated grassland, respectively (Fig. 3).

In the flood season, the seed bank composition differed from the vegetation in both grassland types; native (MANOVA: Pillai-Trace = 0.087; $F_{2,242}$, $p<0.001$, Fig. 3A) and cultivated (MANOVA: Pillai-Trace = 0.175; $F_{2,242}$, $p<0.001$, Fig. 3B). In both grasslands, there was higher species diversity in the seed bank ($p<0.001$, Tab. 1). The individual contribution of each species in the similarity between seed bank and vegetation was below 2 %. In native grassland,



Bacopa myriophylloides (1.54 %), *Rotala ramosior* (1.32 %), *Bacopa australis* (1.21 %) and *Helanthis tenellum* (1.02 %), were the most similar species; and in cultivated, *R. ramosior* (1.92 %), *Cyperus surinamensis* (1.33 %), *C. subsquarrosus* (1.30 %) and the exotic *U. humidicola* (1.25 %).

In the dry season no similarity was detected in native (MANOVA: Pillai-Trace = 0.0867; $F_{2,242}$, $p < 0.001$, Fig. 3C) and cultivated grassland (MANOVA: Pillai-Trace = 0.0921, $F_{2,242}$, $p < 0.001$, Fig. 3d). The most similar species in native grassland were *D. fuscescens* (7.1 %), *R. grandiflora* (9.3 %), *A. purpusii* (9.8 %) and *Borreria eryngioides* (10 %), and in cultivated, *Isoetes pedersennii* (5.2 %), *U. humidicola* (5.5 %), *L. octovalvis* (6.2 %) and *Euploca filiformis* (7.1 %).

To verify the absence of species that could be in the vegetation during the flood or dry seasonal periods, we made an analysis together (dry + flood). Despite the seed bank and the vegetation having increased their similarity to 57% in native and 45% in cultivated grassland, they continued to differ significantly in both grasslands, native (MANOVA: Pillai-Trace = 0.434, $F_{2,242}$, $p < 0.001$) and cultivated (MANOVA: Pillai-Trace = 0.460, $F_{2,242}$, $p < 0.001$). The index of

species diversity increased; nevertheless the diversity in the seed bank remained superior in both grasslands ($p < 0.001$, Tab. 1), without effect of the seasonality.

Correlation of the growth forms with the seed bank and vegetation

Groups of plants were selected to explain how distinct growth forms (aquatic, amphibious and terrestrial) were related to species distribution between grasslands. In the seed bank, there was a clear split of native and cultivated grasslands (Fig. 4A). There was a positive correlation in aquatic plants (41.3%) in native grassland (91.08 seeds), but negative in cultivated (52.96 seeds). The opposite occurred with terrestrial plants, being positive for cultivated (142.98 seeds) and negative for the native grasslands (110.61 seeds). Aquatic and terrestrial plants were inversely correlated to both grasslands (ANOVA: $F_{3,17} = 17.883$, $p < 0.001$, Fig. 4A). Nevertheless, in terms of diversity, the seed bank was similar between the native and cultivated grasslands (Tab. 1). The amphibious species were abundant in both

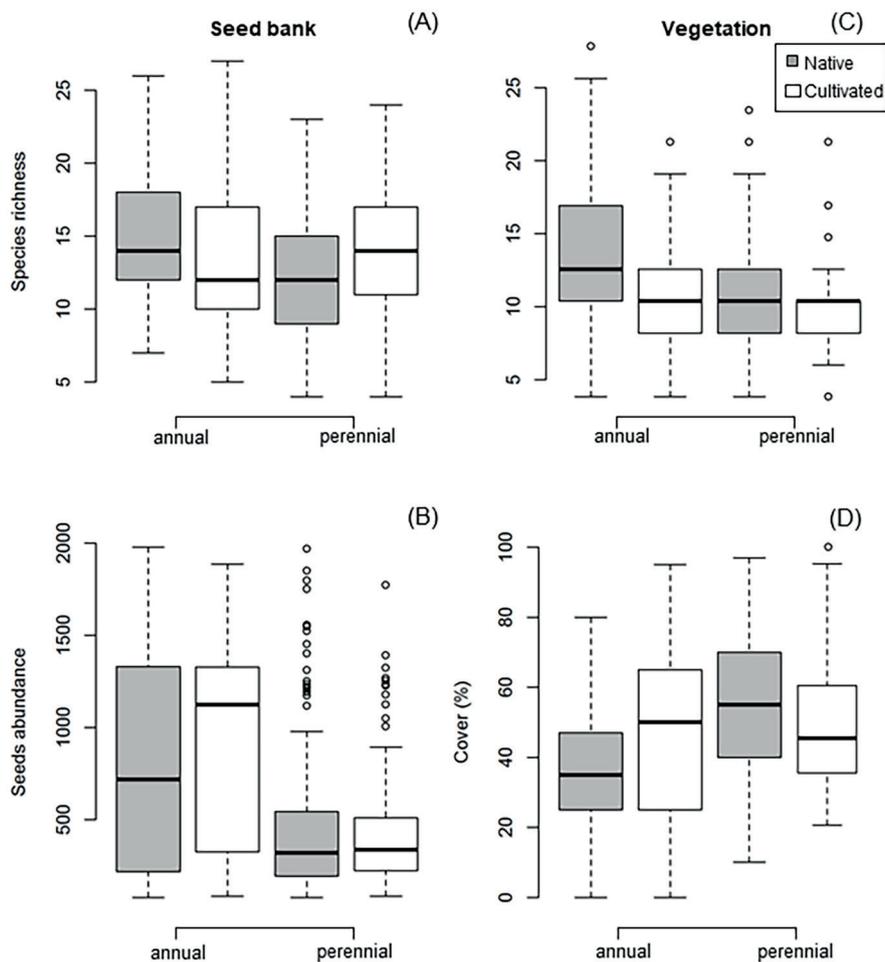


Figure 2. Occurrence of annual and perennial species regarding richness (A) and mean abundance of seeds (B), species richness (C) and mean vegetation cover (D), between native and cultivated grassland in the seed bank and in the vegetation, in the Pantanal wetland (Central-West Brazil).

grassland types; the species *Isoetes pedersenii* (13.1%), *Rotala ramosior* (12%), *E. minima* (10.4%), *Bacopa australis* and *Schoenoplectiella supina* (5% each) correlated positively (Fig.4A).

In the vegetation there was no separation of grassland types. The occurrence of terrestrial plants (52.2%) was positively related to the axis RDA 2 including the higher composition of the plants present in cultivated grassland, differing from amphibious (28.7%) and aquatic plants

(20.9%) (ANOVA: $F_{3,17}=2.917$, $p<0.001$, Fig. 4B). The grasses *U. humidicola* (15.2%), *A. purpusii* (9.3%), *D. fuscescens* (7.4%), *R. acuta* (6.6%), *Cynodon dactylon* (6.1%), *P. alnum* (5.5%) and of the emergent *R. grandiflora* and *Diodia kuntzei* (5% each), *H. brevipes*, *R. ramosior* and *Croton trinitatis* (4% each) were the most influential species in the distribution of the species, enhancing the similarity between native and cultivated grassland (Fig.4B).

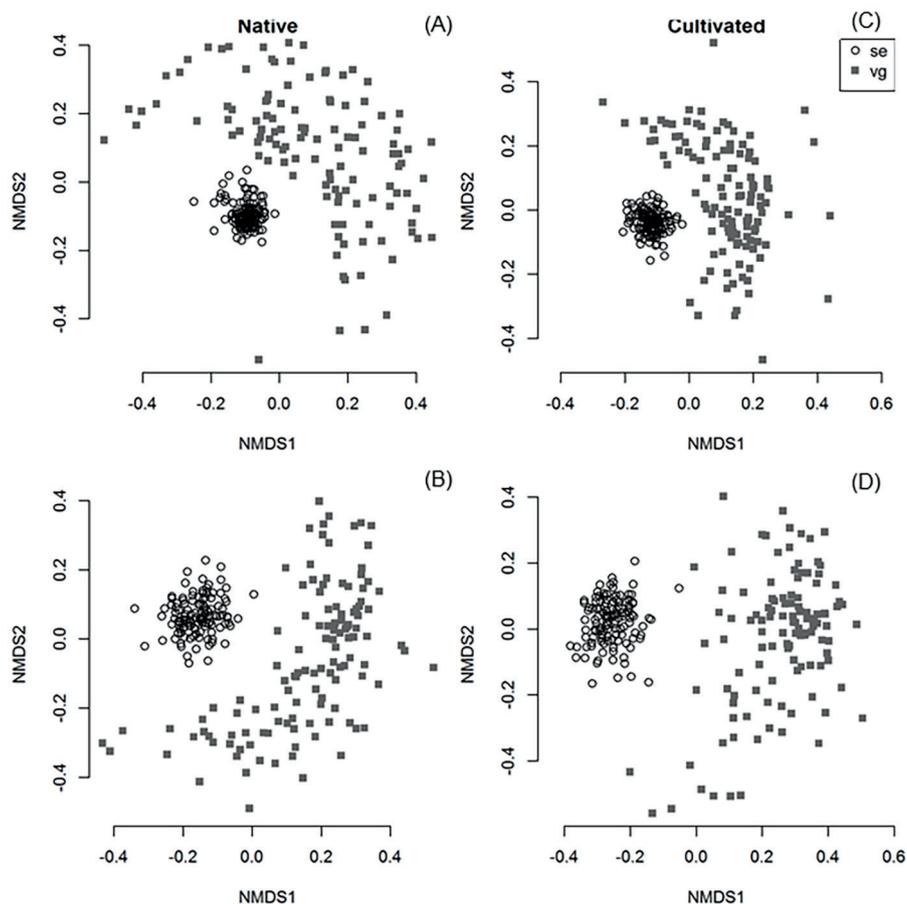


Figure 3. Ordination by non-metric multidimensional scaling (NMDS) of species similarity (Bray-Curtis index), calculated from the abundance and relative cover of species in the seed bank (se) and in the vegetation (vg), in native grassland in (A) flood and (B) dry seasonal periods and grassland dominated by *U. humidicola* in (C) flood and (D) dry seasonal periods, in the Pantanal wetland (Central-West Brazil).

Table 1. Analysis of variance of the Shannon diversity index between the seed bank and the vegetation (SE ± mean), in native and cultivated grassland in the flood and the dry seasonal periods (Central-West Brazil).

Grassland		Vegetation	Seed bank	Df	F	P
Native	Season					
	Flood	0.5060 ± 1.2559	0.4341 ± 2.7781	1	508	0.001
	Dry	0.3896 ± 1.2721	0.4158 ± 2.4228	1	408	0.001
	flood+dry	0.7561 ± 1.8770	0.4514 ± 2.5773	2	876	0.001
	Residuals			223		
Cultivated	Season					
	Flood	0.3420 ± 1.3826	0.4720 ± 2.6279	1	592	0.001
	Dry	0.4089 ± 1.2411	0.3285 ± 2.3431	1	630	0.001
	flood+dry	0.7448 ± 1.9342	0.4225 ± 2.5605	2	962	0.001
	Residuals			223		



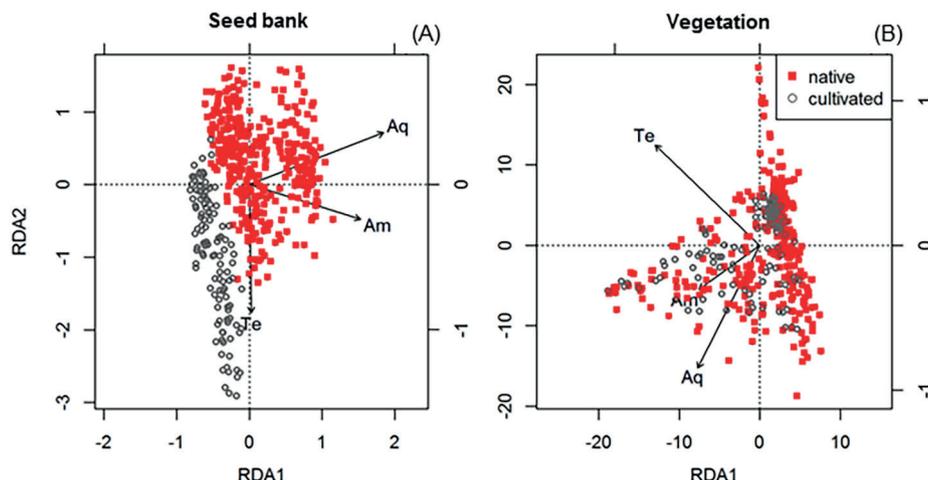


Figure 4. Redundancy Analysis (RDA) of the distribution of distinct growth forms in the (A) seed bank and (B) in the vegetation of the plots of native and cultivated grassland (Central-West Brazil). The ordination was based on data of abundance and relative cover of the species. Aq = aquatic; Am = amphibious and Te = terrestrial.

Discussion

Floristics

The characteristics of the vegetation and the seed bank were studied in grasslands with native and cultivated grasses. The predominance of annual species in the seed bank and the vegetation indicates high turnover promoted by the seasonal environments in the vegetation. The seasonal effect can be the main source of similarity between types of grasslands. The highest richness and abundance in the seed bank was also observed in other floodable grasslands due to a large production of annual seeds tolerating the flood periods (Brock *et al.* 2003; Ma *et al.* 2012). Such tolerance of the seeds makes the seed banks one of the primary sources of maintenance of wetland diversity (Ge *et al.* 2013).

In seasonal grasslands, when waters recede and fields begin to dry, annual species are the first to germinate (Bao *et al.* 2014; 2018b), then several native and exotic grasses start (Bao *et al.* 2015; 2018a). In contrast, in the flood season, the aquatic plants that were waiting for more moisture compose the vegetation (Agra & Ne'eman 2012). This dynamics of vegetation is only possible due to the persistent seed bank that offers higher resilience to the environment (Brock 2011). Thereby, such areas under recurrent floods tend to present higher proportion of annual species in the seed banks and lower similarity with the established vegetation.

The lower species richness in vegetation compared with the seed bank can be due to the high mean plant cover of perennial grasses in native grassland (ca. 55%) and cultivated with dominant *U. humidicola* (ca. 70%). In grasslands, the dominance of a species leads to reduced germination of species with germinative characteristics below the dominant one (Myers *et al.* 2005). This fact can explain the high richness of annual plants in the vegetation, where such

species are initial colonizers (Scott & Morgan 2012), present fast germination and reproduction, independently on the stressing environmental conditions (McPeck & Peckarsky 1998). However, the perennial species tend to have late germination and show low seed production (Gillespie & Voltaire 2017), which caused low occurrence of perennial species in the seed bank.

Similarity and diversity

Our results show that regardless of the dominance of *U. humidicola*, the seed bank and the vegetation are not similar. The higher diversity of the seed bank during flood seasons assures the survival of several growth forms. Seed banks are known to contain more species richness and diversity than the vegetation properly (Touzard *et al.* 2002; Ma *et al.* 2012; Yang & Li 2013), as they accumulate seeds for many years (Holzel & Otte 2004). Seed longevity in wetlands is attributed to species-specific germination characteristics (Leeuwen *et al.* 2014; Baskin & Baskin 2014).

The vegetation can be limited by the effect of grazing (not evaluated in this study) and by environmental filters, such as flooding (Myers & Harms 2009; Bao *et al.* 2015), which promotes loss of species in certain times of the year (Bao *et al.* 2015). Several terrestrial species without tolerance to submersion drop out the vegetation during the flood season (Yang & Li 2013), e.g., *Eragrostis articulata*, *E. bahiensis*, *Panicum repens* and *Paspalum alnum* (present in the seed bank in the flood period, [Tab. S1 in supplementary material](#)). In contrast, the opposite occurs in the dry period, when the mortality of strictly aquatic plants is due to an intolerance to desiccation (Blindow *et al.* 2016), e.g., *Cabomba furcata*, *Heteranthera limosa* and *Limnocharis flava* (abundant in the seed bank during the dry period, [Tab. S1 in supplementary material](#)). In this grassland, the species trade-off between seasonal periods only occurred in the vegetation. The seed bank had a similar species composition in both periods. The

seed bank can remain with high richness and abundance for years, which can be the primary source of maintenance in wetlands.

The differences between vegetation and seed bank are maintained by the higher diversity of the seed bank. It is an efficient regeneration mechanism rich in annual and perennial species that may not exhaust by germination, which is conferred to wetlands areas by the species turnover from the dynamics of flood and dry (Capon *et al.* 2015). In this way, the seed bank acts as the primary receptor for species (seed income) whilst the vegetation reflects a small part of the hidden community according to environmental conditions. This gives grasslands the resilience needed to withstand floods and competition with exotic species.

Correlation of the seed bank and vegetation in relation to growth forms

The positive correlation of the distribution of aquatic plant seeds in native grassland may indicate that they have a high seed rain and rapid germination. The similarity in requirements of resources for germination becomes favorable (McPeck & Peckarsky 1998), in addition to the presence of aquatic plants in the vegetation that increases the income of seeds by dispersal and, consequently, increase the abundance of the seed bank of aquatic macrophytes (Metzner *et al.* 2017).

The negative correlation of aquatic plants seeds on cultivated grassland indicates that a low flow of this growth form is occurring, either for failures in dispersal from nearby grasslands (Miao *et al.* 2016), or for the low cover of these species in the vegetation, which reduces the income from seed rain (Metzner *et al.* 2017). The dominance of exotic grass in the vegetation can suppress the growth of submerged macrophytes and leaves of free-floating, due to the reduction of light and nutrients, and can increase soil temperature (Gopal & Goel 1993; Ot'ahel'ová *et al.* 2011). Furthermore, the seeds and aerial parts of *U. humidicola* present allelopathic activity (Souza Filho *et al.* 2005), which may be inhibiting the germination of aquatic plants, but there are no studies to prove this. In rice fields, it can be observed that where the water extract of roots, stems leaves inhibits the germination of the macrophyte *Heteranthera limosa* (Ebana *et al.* 2001).

The lowest abundance of aquatic plants in cultivated grassland is worrying, since they are economically utilized in the control of exotic plants for their capacity to tolerate either flooded or dry soils, in the form of amphibious plants (Barrett *et al.* 1993), especially by limiting the light they promote with floating leaves (Bao *et al.* 2020). However the role of the seed bank in the communities of aquatic plants still presents research gaps, given the frequent initial colonization of temporary wetlands requiring a diverse seed bank (Elsey-Quirk & Leck 2015). Despite the lower distribution of aquatic plants in cultivated grassland, it did not alter the diversity of the seed bank.

Conclusion

The seed bank demonstrated the potential to predict the richness and abundance of species wetlands, with the higher presence of annual species reflecting the leading composition seed banks in wetlands areas. The seed bank has greater diversity, mainly due to the greater abundance of aquatic and amphibian plants, present in native grasslands. In this case, it was evident that there is a loss of aquatic macrophytes in the cultivated grasslands, which can become particularly important in the formulation of plans to control *U. humidicola* invasion in native grasslands and neighboring areas, and preserving the Pantanal native plant community.

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