UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
INSTITUTO DE BIOCIÊNCIAS
PROGRAMA DE PÓS-GRADUAÇÃO EM BOTÂNICA

EFEITO DE DIFERENTES INTENSIDADES DE PASTEJO AO BANCO DE SEMENTES DO SOLO EM CAMPOS NO SUL DO BRASIL

EFFECT OF DIFFERENT GRAZING INTENSITIES ON THE SOIL SEED BANK IN NATURAL GRASSLAND

Graziela Har Minervini Silva

Orientador: Prof. Dr. Gerhard Ernst Overbeck
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Dissertação apresentada ao Programa de Pós-Graduação em Botânica como um dos requisitos para a obtenção do grau de Mestre em Botânica pela Universidade Federal do Rio Grande do Sul.

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AGRADECIMENTOS

Fazer este trabalho foi um grande desafio em todos os sentidos e, ao concluí-lo, posso afirmar consegui superar e agregar novos conhecimentos. Entretanto, tudo isso foi possível com a importante contribuição de várias pessoas, aos quais eu dedico meus agradecimentos:

Ao meu orientador, professor Gerhard Overbeck, por todo o apoio, dedicação, gentileza, paciência e disponibilidade para ajudar em todos os momentos. Vielen Dank!

Pelo auxílio em campo, em casa de vegetação, com identificações, troca de idéias e materiais, agradeço aos colegas do Laboratório Levcamp, Ecoqua, Leveg e Forrageiras e aos professores Ilsi Boldrini, Sílvia Miotto e Carlos Nabinger.

À Mariana Vieira pelo extenso compartilhamento de informações e trabalhos sobre banco de sementes.

À Felícia Fischer por compartilhar os dados do seu trabalho de mestrado na EEA.

Ao órgão financiador da bolsa de estudos, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), ao Programa de Pós-Graduação em Botânica da Universidade Federal do Rio Grande do Sul e ao Programa de Pesquisas Ecológicas de Longa duração (PELD).

Ao Miguel Dall'Agnol pela disponibilização do espaço em casa de vegetação do Departamento de Plantas Forrageiras e Agrometeorologia.

Aos meus pais, irmãs, madrinha, sobrinhos e demais familiares que, de certa forma, me ajudaram a conquistar uma das minhas grandes realizações na vida. E por sempre que era necessário, me levarem para regar as "minhas graminhas".

Ao meu namorado, Fábio Carrion, companheiro e ouvinte em todos os momentos desta jornada acadêmica, me confortando sempre que possível.

Enfim, a todos que, de algum modo, contribuíram para a realização desta dissertação. Muito obrigada, sintam-se todos abraçados!

SUMÁRIO

RESUMO

Os ecossistemas campestres co-evoluíram com distúrbios como a herbivoria e o fogo. Assim, estes fatores são importantes no surgimento e manutenção de características da comunidade, podendo modificar os processos de sucessão. Em áreas perturbadas, as sementes que persistem no solo participam da regeneração natural. Diante da alta taxa de conversão dos campos nativos no sul do Brasil em áreas de uso intensivo (lavoura ou plantios de espécies arbóreas), bem como do manejo pastoril com alta pressão animal, aumenta o interesse em estudos relacionados ao banco de sementes do solo (BSS), buscando compreender a sua função nas comunidades vegetais e na regeneração de áreas degradadas. O conhecimento já existente sobre BSS em biomas campestres do hemisfério sul ainda é incipiente. Grande parte dos trabalhos feitos em campos sul-americanos compararam o BSS entre áreas de vegetação pastejadas e áreas abandonadas, sendo poucos os que utilizaram diferentes intensidades de pastejo, apesar de efeitos claros de diferentes intensidades de pastejo sobre a composição e estrutura da vegetação. Em vista disto, foi avaliado, neste trabalho, o BSS em um experimento em campo submetido a diferentes intensidades de pastejo, em duas estações (primavera e outono), utilizando o método de emergência de plântulas. Também foi feito o levantamento da vegetação estabelecida para avaliar a similaridade com o BSS. Em total, foram encontradas 103 espécies no BSS e 162 na vegetação estabelecida. No BSS, a porcentagem de espécies de caráter ruderal foi alta. Diferenças significativas em termos de densidade e riqueza do BSS foram encontradas somente entre o tratamento com maior intensidade de pastejo e os demais. De forma geral, a semelhança entre o BSS e a vegetação estabelecida foi baixa. Assim, estes resultados indicam que o BSS tem um papel limitado na recuperação da vegetação campestre típica após distúrbios mais severos e que, aparentemente, a intensidade do manejo não tem um impacto muito grande para o BSS. Apesar disso, o BSS é importante pelo armazenamento das características naturais dos ambientes, agregando funções à regeneração da comunidade vegetal.

Palavras-chave: Campos Sulinos, dinâmica da comunidade vegetal, degradação, pastagens, potencial de recuperação, Bioma Pampa.

ABSTRACT

Grassland ecosystems co-evolved with disturbances such as fire and herbivory, and these factors are important for emergence and maintenance of community features areas. After disturbances, the seeds that persist in the soil contribute to regeneration processes. However, increasing conversion of natural grasslands into areas of intensive use (agriculture and exotic tree plantations), as well as overgrazing make the study of the regeneration of grassland vegetation after these severe disturbances an important research topic. Our knowledge on the role of the soil seed bank (SSB) in grassland biomes in the southern hemisphere still is incipient. The majority of studies realized in South American grassland compared the SSB between grazed and abandoned areas, and few consider different intensities of grazing, despite clear effects of different grazing intensities on vegetation composition and structure. In view of this, in this study, the SSB was evaluated in a grassland experiment under different intensities of grazing in two seasons (spring and autumn), using the seedling emergence method. In spring, a survey of the established vegetation was conducted to evaluate the similarity with the SSB. In total, we found 103 species in the SSB and 162 in established vegetation. The SSB was mostly composed of ruderal species. Grass species dominant in aboveground vegetation were largely absent in the SSB. Significant differences regarding SSB richness and density were only found between the treatment with higher intensity of grazing and the others, and overall composition did not differ among treatments. In general, the similarity between the SSB and established vegetation was low. Our results indicate that the SSB has a limited role in the recovery of natural grassland vegetation after more severe disturbances. Apparently, the intensity of management does not have a very large impact on the SSB or on the similarity between SSB and established vegetation. Nevertheless, the SSB is important for storage the natural characteristics of environments, adding functions to the regeneration of the plant community.

Key words: Campos Sulinos, plant community dynamics, degradation, grasslands, recovery potential, Pampa Biome.

INTRODUÇÃO

O banco de sementes do solo (BSS) é um reservatório viável de sementes armazenadas no solo (THOMPSON e GRIME, 1979, ROBERTS, 1981), ainda não germinadas, mas potencialmente capazes de substituir as plantas que desapareceram devido à sua morte natural ou distúrbios (BAKER, 1989). HARPER (1977) se refere ao banco como "a memória" de populações de plantas, pois, ao longo de décadas, podem preservar genótipos que não estão mais presentes na vegetação estabelecida. A composição do BSS é oriunda da dispersão de propágulos provenientes da comunidade local e de áreas adjacentes (GASPARINO *et al.*, 2006) e varia muito de acordo com a composição florística da vegetação estabelecida e das características reprodutivas e fisiológicas das espécies, bem como com uma série de fatores ambientais.

A permanência das sementes no banco é definida por fatores fisiológicos, como germinação e dormência, e por fatores ambientas, como, por exemplo, disponibilidade de água, luz e predadores (GARWOOD, 1989). Entre estes fatores, a dormência garante com que as sementes não germinem enquanto o ambiente estiver sob condições adversas em determinados períodos (CARMONA, 1996). O BSS pode ser classificado de acordo com a sua persistência no solo (BAKER, 1989): (i) transitório, quando formado por sementes que permanecem no solo por menos de ano após a dispersão dos propágulos, (ii) persistente em curto prazo, quando composto por sementes que permanecem viáveis por até cinco anos após a dispersão, (iii) persistente em longo prazo, quando as sementes permanecem viáveis no solo por mais de cinco anos. Em contraste com a classificação do banco de sementes nestas três categorias, THOMPSON *et al.* (1997) propôs uma categorização baseada na distribuição vertical de sementes no solo e na presença das espécies do BSS na vegetação estabelecida. Conforme esta classificação, considera-se como BSS transitório o formado por espécies presentes somente na vegetação estabelecida ou no estrato superior do solo. Já o BSS persistente em curto prazo é composto por sementes presentes na camada superior do solo. O BSS persistente em longo prazo é formado por sementes em quantidade maior ou igual na camada inferior do solo, em relação à camada superior.

Entre os métodos empregados para estimar a densidade de sementes estão o método da emergência ou a contagem direta de sementes (ROBERTS, 1981, SIMPSON *et al.*, 1989). O primeiro, feito em casa de vegetação, avalia a quantidade das sementes viáveis no solo em base das plântulas que conseguiram se estabelecer durante um determinado período. Tem como desvantagem o longo período necessário para garantir a germinação da maior parte das sementes contidas no solo, o tempo de desenvolvimentos da planta até o estágio reprodutivo, em caso de espécies de identificação difícil. E também limitações em termos de logística, esforço amostral e espaço para o desenvolvimento do experimento. Além do fato de uma (desconhecida) parte do BSS possa não vir a germinar (por ex., por causa de necessidades fisiológicas específicas para a quebra da dormência) e assim não sendo incluída no levantamento (SIMPSON *et al.*, 1989). Já o método de contagem direta de sementes, indica resultados rápidos, contudo, demanda um conhecimento prévio da morfologia das sementes, além da não exclusão das sementes inviáveis e a possibilidade de não incluir sementes muito pequenas.

Nos ecossistemas campestres, espécies que dependem da propagação sexual geralmente possuem uma densidade um pouco maior de sementes no solo em comparação com aquelas que apresentam regeneração vegetativa. Estas espécies, cuja permanência na comunidade após sofrer distúrbios depende do rebrote a partir de gemas, possuem, geralmente, um pequeno BSS (MEDEIROS, 2000).Fatores como a herbivoria (por ex., pastejo por grandes herbívoros) e o fogo representam um papel importante no surgimento e manutenção de características e organização da comunidade campestre (BAZZAZ, 1983). Atuam como agentes que promovem mudanças na riqueza, diversidade e dominância das espécies (HARETCHE e RODRÍGUEZ, 2006), podendo modificar os processos de sucessão (KINUCAN e SMEINS, 1992). As sementes que persistem no solo, após distúrbios, como a herbivoria, podem definir o rumo da sucessão secundária e as diferenças entre banco de sementes e a vegetação estabelecida (THOMPSON, 2000). Portanto, o BSS é um componente importante da dinâmica da vegetação, por caracterizar-se como agente na regeneração natural de áreas perturbadas, e uma estratégia de sobrevivência das espécies ao longo do tempo (MAIA *et al.*, 2006).

Diante do aumento dos distúrbios causados pela conversão de áreas campestres naturais em áreas de uso intensivo pelo sobrepastejo e pela monocultura, que consequentemente utiliza agrotóxicos, a ação antrópica torna-se cada vez mais preocupante, devido à perda de biodiversidade destes ambientes. Em busca de compreender como agem as dinâmicas sucessionais, visando auxiliar na conservação destes espaços, surge o grande interesse em estudos relacionados com BSS, em busca de respostas para questões que ainda não foram completamente entendidas, como, por exemplo, a função que o BSS exerce nas comunidades vegetais e na regeneração de áreas degradadas e os resultados aos efeitos de distúrbios bióticos e abióticos (MEDEIROS, 2000).

O conhecimento já existente sobre o BSS em biomas campestres do hemisfério sul, como nos Campos Sulinos (GARCIA, 2009) ou em ambientes de Savana (ANDERSON *et al.*, 2012), ainda são incipientes. Ainda são relativamente poucas as fisionomias campestres em regiões tropicais e subtropicais ao qual o BSS foi estudado. Grande parte dos trabalhos feitos para Campos Sulinos e sul-americanos compararam o BSS entre áreas de vegetação pastejadas e excluídas do pastoreio (OESTERHELD e SALA, 1990, BOCCANELLI e LEWIS, 1994, GHERMANDI, 1997, BERTILLER e ALOIA, 1997, FUNES *et al.,* 2001 e 2003, MÁRQUEZ *et al.*, 2002, MAYOR *et al.*, 2003, HARETCHE e RODRÍGUEZ, 2006, ETCHEPARE e BOCCANELLI, 2007, BUSSOA e BONVISSUTO, 2009,GIANACCINI *et al.*, 2009, LOYDI *et al.*, 2012). No entanto, são poucos os estudos que utilizaram diferentes intensidades de pastejo (FAVRETO *et al.*, 2000, MARCO e PÁEZ, 2000, MORICI *et al.*, 2009).

O presente trabalho visa a contribuir para o melhor conhecimento sobre o banco de sementes dos Campos Sulinos. Mais especificamente, pretendemos avaliar o efeito de diferentes intensidades de pastejo sobre o banco de semente em uma área de campo nativo. Para tanto, foi desenvolvido o seguinte artigo, a ser submetido para a revista “Grass and Forage Science” (estrato B1 no Webqualis/Biodiversidade): “Effect of different grazing intensities on the soil seed bank in natural grassland.”

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Article: Effect of different grazing intensities onthe soil seed bank in natural grassland

Abstract

The study of the soil seed bank (SSB) is important for a better understanding of vegetation dynamics and regeneration of plant communities after disturbance. Grazing is one of the principal factors that determine the composition and structure of grassland vegetation, however, the relation of the soil seed bank to grazing has been poorly investigated. The objective of this study was to compare the effects of four different grazing intensities on total density, richness and abundance of the SSB in subtropical grasslands in southern Brazil. The composition of the SSB was evaluated on the basis of ten samples of soil collected from each of four treatments at two sampling dates (spring and autumn), in two layers (0-5 and 5-10cm), using the method of seedling emergence. A quantitative survey of the vegetation was conducted to verify the similarity of the composition SSB with established vegetation. We recorded a total of 103 species in the SSB, distributed in 22 families. Seed density was higher in the treatment with high degree of grazing compared to those with intermediate or low intensity grazing. Of the 162 species identified in the vegetation, 71 also occurred in the SSB, the majority of these perennials. Graminoids showed a higher contribution in vegetation when compared to SSB. Species with a caespitose habit increased their proportion in the SSB gradually with increasing grazing intensity. The intensity of management apparently does not have a very large impact on the SSB, which is composed mainly of species of more ruderal character. Altogether, the SSB seems to be of minor importance for vegetation recovery after disturbances in the studied system.

Key words: Campos Sulinos, plant community dynamics, degradation, grasslands, recovery potential, Pampa Biome.

Introduction

Grazing is one of the main factors that determine the composition and structure of grassland vegetation due to direct and often selective consumption of plant biomass and in consequence of impacts on soil characteristics, e.g. by trampling(KINUCAN and SMEINS, 1992, GASPARINO *et al.*, 2006). In regions where climatic conditions allow the development of forest vegetation, dynamics and the very maintenance of grasslands are associated to herbivory or fire (BOND, 2005, PILLAR and VÉLEZ, 2010). These processes are of high importance for the emergence and organization of the grassland community (BAZZAZ, 1983), acting as agents promoting changes in richness, diversity and species dominance (HARETCHE and RODRÍGUEZ, 2006) and, possibly, modifying successional processes (KINUCAN and SMEINS, 1992).

In the subtropical grasslands in southern Brazil (OVERBECK *et al.*, 2007), differences in grazing intensity promote strong changes in the composition in terms of species and functional groups (CRUZ *et al.*, 2010). At intermediate levels of forage offer, i.e., at intermediate stocking and thus grazing levels, vegetation structure is heterogeneous and composed of plants with contrasting habit. Intensively grazed patches are formed by species of low size and dominated by stoloniferous and/or rhizomatous grasses. Within this matrix, tussock grasses and often subshrubs and shrubs characterize less intensively grazed patches. Preference of cattle for the low-growing grasses creates a positive feedback mechanism that stabilizes this structure. Due to the this structural complexity, intermediate levels of grazing lead to higher diversity and species richness as well as pasture productivity (NABINGER *et al.,* 2009). The adjustment of cattle numbers to forage availability is a key element for maintenance of grassland physiognomies and for sustainable use of grasslands for livestock production. However, although not being the most productive, overgrazing is a recurring problem in the region (JACQUES and NABINGER, 2006).

A remarkable characteristic of grassland communities is their high resilience to disturbances, i.e., the capacity for regeneration of vegetation after disturbance by fire or grazing (OVERBECK, *et al.* 2005, GARAGORRY, 2012), as long as these factors have been important in the evolution of the systems (MILCHUNAS *et al.*, 1988). In the Campos Sulinos, the presence of underground organs and the ability of regrowth from below-ground gems (bud bank) allows quick regrowth after and thus regeneration of vegetation after disturbance (OVERBECK *et al.*, 2005, FIDELIS *et al.,* 2014). However, the presence of dense soil seed banks (SSB) in grasslands in southern Brazil has also been shown (review in GARCIA, 2009), even though it had been suggested that the density of SSB in tropical systems are minor compared with temperate ecosystem (SKOGLUND, 1992).

While the effect of different intensities of grazing on vegetation in South American subtropical grassland, as sketched above, is well known(e.g., NABINGER *et al.*, 2009, CRUZ *et al.*, 2010, LEZAMA *et al.*, 2014). However, very little is known about effects of grazing on the soil seed bank (SSB). The vast majority of work done in the region compared the SSB in grazed areas to those without any management, i.e., abandonment (OESTERHELD and SALA, 1990, BOCCANELLI and LEWIS, 1994,GHERMANDI, 1997, BERTILLER and ALOIA, 1997,FUNES *et al.,* 2001 e 2003,MÁRQUEZ *et al.*, 2002, MAYOR *et al.*, 2003,HARETCHE and RODRÍGUEZ, 2006, ETCHEPARE and BOCCANELLI, 2007, BUSSOA and BONVISSUTO, 2009,GIANACCINI *et al.*, 2009, LOYDI *et al.*, 2012). In general, these studies demonstrate an increase of the SSB density under grazing. Few studies have evaluated the effects of different grazing intensities, and these do not always compare the SSB with established vegetation (FAVRETO *et al.*, 2000, MARCO and PÁEZ, 2000, MORICI *et al.*, 2009). In other regions under tropical or subtropical climate, the question of the effect of different grazing intensities on the SBB likely has not received much attention. Work in savannas is mostly related to the effects of fire on the SSB (SCOTT *et al.*, 2010, WILLIAMS *et al.*, 2005, WRIGHT and CLARKE, 2009), but also considers the abandonment of grazing and management (FRIEND *et al.*, 1997, LUNT, 1997, MCIVOR *et al.*, 2005). Knowledge of the SSB under different grazing intensities, on the other hand, may be important for a better understanding of the potential of vegetation recovery after overgrazing and, in a broader context, contribute to the understanding of vegetation resilience.

The purpose of this study was to compare different grazing intensities regarding (i) species composition, richness and abundance of the SSB (ii) similarity between composition of above-ground vegetation and the SSB and (iii) types of SSB according to their persistence in soil (transient or persistent), (iv) phytosociological parameters of established vegetation and soil compaction, correlated to the composition of SSB and (v) plant strategies. We hypothesized that the composition of the SSB varies with different grazing intensities for areas with higher grazing intensity, we expected with a higher density and high dominance of species with ruderal character. Further, we expected higher similarity between SSB and established vegetation under higher grazing intensities, as these ruderal species that dominate the SSB should find better conditions to establish in the more open vegetation.

Materials and methods

Study area

The study was conducted in an area of 52 ha of natural rangelands inthe Central Depression of Rio Grande do Sul, in the Agronomic Experimental Station of the Federal University of Rio Grande do Sul (30º 05'S and 51° 40'W), average elevation 46 m above sea level). Climate in the region is Cfa, humid subtropical with hot summer, according to the Köppen classification, Average total annual rainfall amounts to1.440 mm (BERGAMASCHI *et. al*, 2003). Average monthly temperatures range from 9 to 25 °C and average daily solar radiation from 200 to 500cal/cm^2 (BERGAMASCHI and GUADAGNIN, 1990). Dominant soil type is typical Dystrophic Red Argissoil of clayish-loamy texture derived from granite (AMADO *et. al*, 2000). Grasslands and riparian forests are characteristic original vegetation types in the region. Grassland vegetation consists mainly of species of the families Poaceae, Fabaceae, Cyperaceae, Rubiaceae and Apiaceae (BOLDRINI, 1993).

The study was conducted in the area of an experiment of continuous grazing with beef cattle, in practice since 1986. The vegetation is subjected to grazing treatments involving adjustment of levels of forage allowance. The treatments consistof different forage offers (FO) or combinations of different FO in the course of the year, totaling 14 experimental units ranging between 3 and 5 hectares, with a total of seven treatments with two replications each. In the present study, were utilized only the treatments with 4%, 8%, 12% and 16% of FO (4, 8, 12 and 16 kg dry matter/100 kg live weight gain/day) throughout the year, with two replications under similar relief conditions, totaling 8 experimental units. We excluded low areas with wet grasslands. The FO was calculated on the basis of total dry matter in the pasture (SOARES *et al*., 2005, for details see also NABINGER *et al.,* 2009).

Soil sampling for seed bank

For the analysis of the seed bank, we used the seedling emergence method (ROBERTS, 1981). Soil was collected in two seasons, spring (October 2012) and autumn (March 2013), to permit evaluation of transient and persistent components of the seed bank. Collection of soil was done by a manual auger (diameter: 5 cm, length: 10cm). In each experimental unit, soil was collected at 5 points (sampling units) per paddock, corresponding to ten samples for each of the four treatments. Sampling points correspond to permanently established plots within the LTER (PELD) Campos Sulinos project. Minimum distance between sampling points was 50m, the distance to fences (adjacent treatments) 20m. The soil sampled was divided into upper (0-5 cm) and lower layer (5-10 cm). At each point, four sub-samples were taken and mixed to compose a sample. Subsequently, the soil was allowed to dry at room temperature for 7 days.

Germination and seedling count

For each sampling point, 50% of the total volume of soil collected (per layer) was mixed with the same volume of vermiculite, to maintain moisture in the sample. Samples were distributed in aluminum trays (capacity 700 ml volume), forming a layer of soil about 2 cm thick. The experiment was conducted in a greenhouse at the Faculty of Agronomy, Department of Forage Plants and Agrometeorology, UFRGS. To monitor contamination from the seed rain, trays with sterile soil were distributed randomly between the trays with collected soil. Germination was observed for one year, for each of the two sampling dates. Emergent seedlings were counted and removed weekly. At least one individual of each species was transplanted into a larger container, where it remained until the reproductive stage for taxonomic identification.

Established vegetation survey

To analyze the similarity between seed bank and established vegetation, a quantitative survey of the vegetation was conducted in spring of 2012. At the points where the soil had been collected for the seed bank study, vegetation was surveyed in plots of 1 m^2. All species present were identified and had their absolute coverage by using a decimal scale (LONDO, 1976). Species that could not be identified in situ were collected for later identification in the Laboratory Studies on Grassland Vegetation, Department of Botany, Institute of Biosciences (UFRGS). Scientific names of species were verified by help of the Taxonomic Name Resolution Service (TNRS) (BOYLE et al., 2013). For all species phytosociological parameters (relative frequency, RF, relative abundance, RAbu, and importance value index, IVI=RF+RAbu) were calculated, per treatment. In addition to species cover, we also recorded, in each plot, vegetation height (calculated from five measured values) and percentage of open soil, litter, cattle manure and standing dead biomass, to correlate them with the results for the SSB.

Soil compaction

To estimate soil compaction in the areas with different grazing intensities, we used an impact penetrometer, which measures the resistance to penetration, expressed in kg/cm^2. We measured soil compaction up to 20 cm, with 3 repetitions of the process in each sample unit (at the same points where the soil had been collected for the seed bank and established vegetation survey). For the analysis, we used the average of these measures per sample unit value.

Data Analysis

Number of seeds per sampling unit was converted into number ofseeds per square meter, multiplying the number of seedlings by a coefficient based on the sampled surface area of the soil in each sample. Species found in the SSB were classified according to the following functional attributes: Life cycle (perennial and non-perennial) (BURKART, 1969), growth forms (caespitose graminoids, prostrate graminoids, erect forbs, prostrate forbs, rosulate forbs, subshrubs) (SETUBAL, 2010) and persistence in soil (persistent or transient). The classification regarding persistence was adapted from BAKER (1989), considering species that appeared in the SSB of both sampling periods as persistent and those that emerged in only one of them as transient. Additionally, we considered the classification by THOMPSON *et. al* (1997), based on the vertical distribution of seeds in the soil and the presence of species in the established community. According to this classification, the transient BSS consists of species present only in the established vegetation or upper layer of the soil. Persistent short-term BSS is composed of seeds present in the upper soil layer. Persistent long-term BSS has equal or greater amount of seed in the bottom layer of the soil, in relation to the upper layer.

For comparison of data between treatments, analysis of variance with randomization testing was performed, using Euclidean distance as dissimilarity measure and 1.000 iterations. This analysis was applied to: (i) data on density and species richness (species number per plot), using data from the upper and lower layer separately and together, (ii) soil compaction between treatments, (iii) parameters describing established vegetation.

To determine the main trends of variation in the composition and abundance of species in the seed bank in the four treatments (considering the lower and upper layer together), principal coordinate analysis (PCoA) was used, based on Chord distance. Significance of the ordination axes was assessed by bootstrapping (PILLAR, 1999).

To quantify the similarity of vegetation and seed bank for each treatment, Soerensen’s similarity was calculated, both on the plot and treatment level. The values obtained for plot were compared between treatments by analysis of variance with randomization test using the Euclidean distance as similarity measure and 1.000 iterations.

For all analyses we used the program MULTIV (PILLAR, 1999).Due to the large distance between sampling units (minimum of 50m), we considered them as independent for purposes of analyzes involving hypothesis testing.

Results

Characteristics of the soil seed bank

A total of 103 taxa was registered in the SSB, distributed in 22 botanical families, highlighting Asteraceae, Poaceae, Cyperaceae and Hypoxidaceae with the higher number of species (Appx. 1). Using the classification proposed by BAKER (1989), 63% of the species found were classified as having a persistent and 37% as a transitional seed bank. According to the classification by Thompson *et al.* (1997), 34% of the species collected in spring belong to the transitional SSB, 52% of persistent short term and 16% of persistent long term, for the collection of spring. From the samples collected in autumn, 42% belonged to the transitional SSB, 52% to the persistent short term and 6% to the persistent long term SSB (Appx. 2). The most important growth form in terms of species number was that of caespitose graminoids (grasses, sedges and rushes), with 33% of species, followed by rosulate forbs and erect forbs, with 17% and 15% of species. Regarding life cycle, 73% of species were perennials.

83 species were found in the spring SSB and 84 in the autumn SSB. The most abundant families were Asteraceae, for the first sampling and Poaceae for the second date (Fig. 1). The opposite occurred concerning species richness per family: 16 Asteraceae species were identified in the spring SSB and 20 in autumn, while for Poaceae, 19 taxa were collected in the first and 14 for the second sampling. *Gamochaeta coarctata*, *Hypoxis decumbens*, *Hydrocotyle exigua*, *Piptochaetium montevidense* and *Sisyrinchium micranthum* were the most abundant species in the two samples (Fig. 2).

Multivariate analysis of variance (MANOVA) of SSB data, in both samples, revealed significant differences among 4% and other treatments and between 8% and 16%.

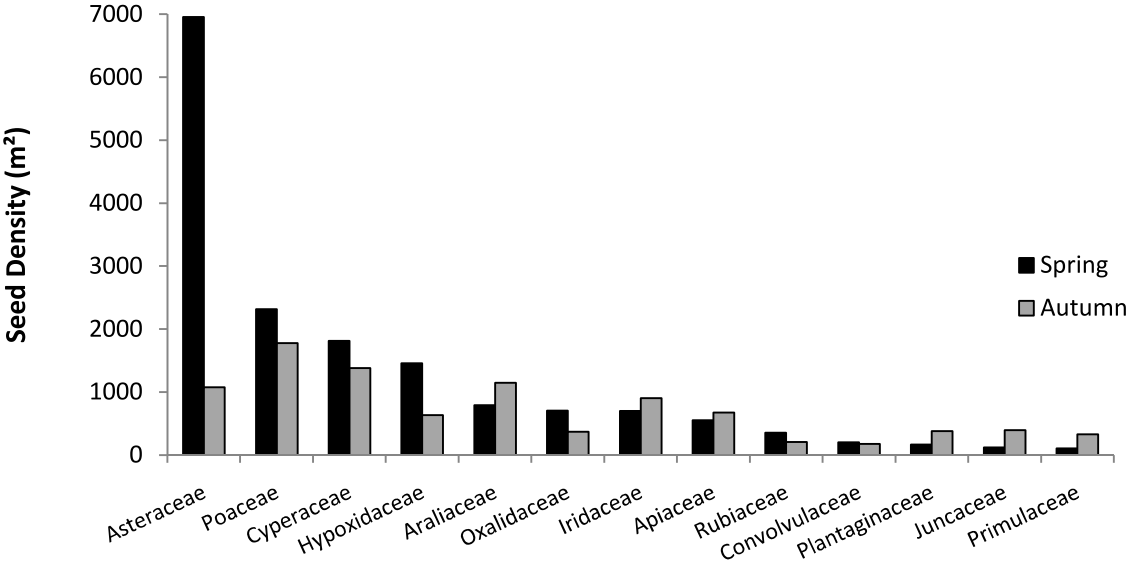
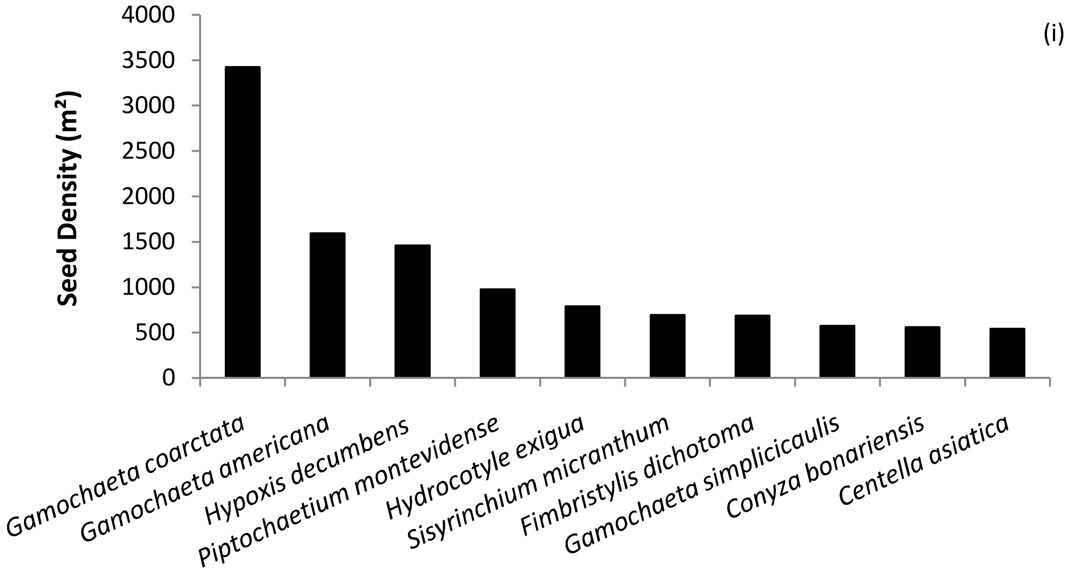


Figure 1. Families that presented the highest values of abundance in soil seed bank, considering all grazing intensities.



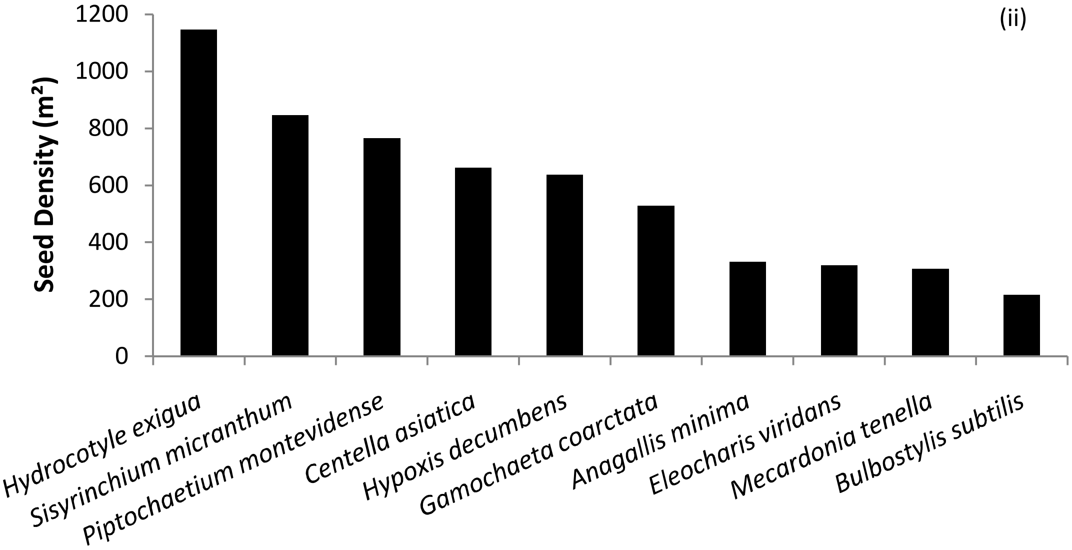


Figure 2. Most abundant species in the seed bank of spring (i) and autumn (ii).

Density and richness differed significantly between the two sampling layer in spring and autumn, with higher values in the upper layer (Fig. 3 and 4).

In the spring SSB and considering the four treatments, a total of 2.578 seedlings (16.420 seedlings/m^2), was recorded 67% of them in the upper layer. Treatment 4% showed higher seedling density, considering the lower/upper layer separated and both together, compared to the other three treatments. Between treatments 8%, 12% and 16%, no significant differences were found (Fig. 3). As torichness, significant differences were only found between treatments 4% and 12%, both considering the two layers separately and together (Fig. 4).

In the autumn SSB, we sampled a total of 1.526 seedlings (9.720 seedlings/m^2), considering the four treatments, with 75% found in the upper layer. Treatment 8% had higher seed density (in the lower layer and considering both layers together), and 4% had higher seed density in the upper layer, compared with the other three treatments. No significant differences existed between treatments regarding other pair-by-pair comparisons of density or the comparisons regarding species richness.

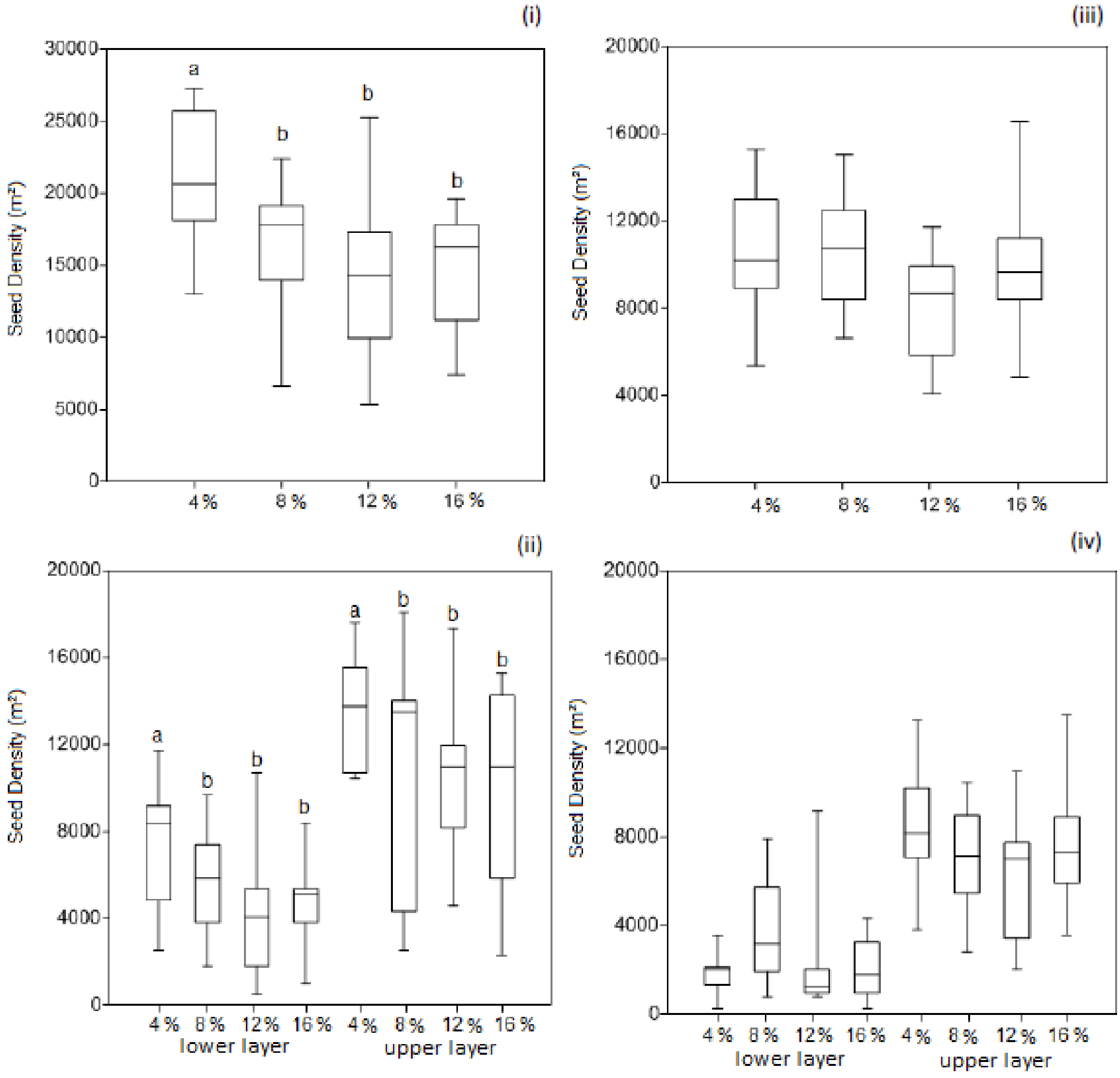


Figure 3. Seed density (seedlings/m^2) per treatment: (i) total of both layers and (ii) lower/upper layer, spring seed bank; (iii) total of both layers and (iv) lower/upper layer, autumn seed bank. Different letters indicate significant differences between variables.

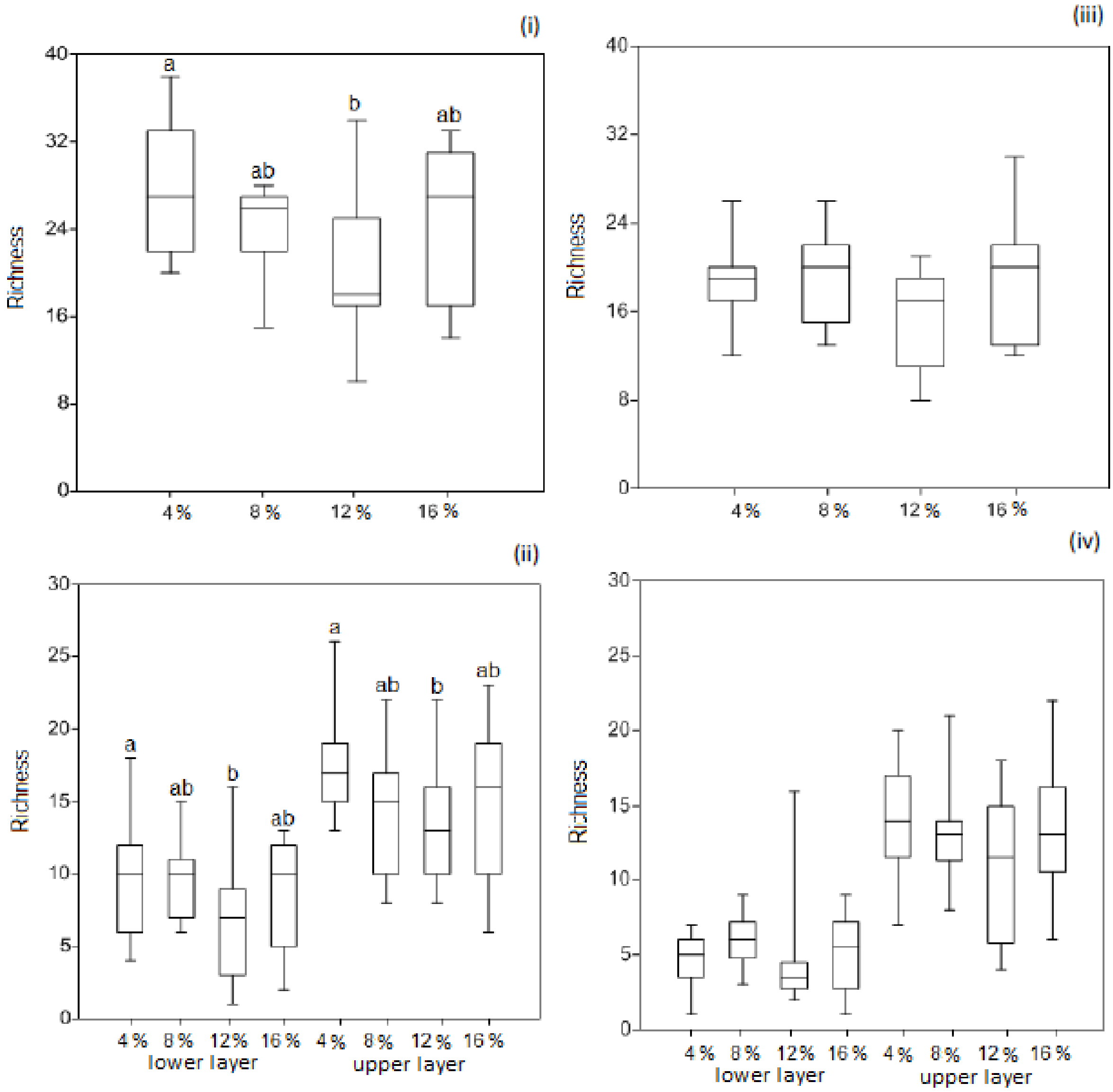


Figure 4. Richness per treatment: (i) total of both layers and (ii) lower/upper layer, spring seed bank; (iii) total of both layers and (iv) lower/upper layer, autumn seed bank. Different letters indicate significant differences between variables.

In the PCoA diagram of the SSB composition data, the treatments were not separated clearly and explanation of the axes was weak (axis 1: 19.7%, axis 2: 13.2%, for the ordination of SSB spring, Figure 5; 12.8% and 14.9%, for the Ordination of the SSB autumn, figure not shown). Nonetheless, sampling units in the 4% treatment were separated from and grouped more clearly in comparison to the other treatments, a result also seen in analyses of variance with randomization test for density and species richness.

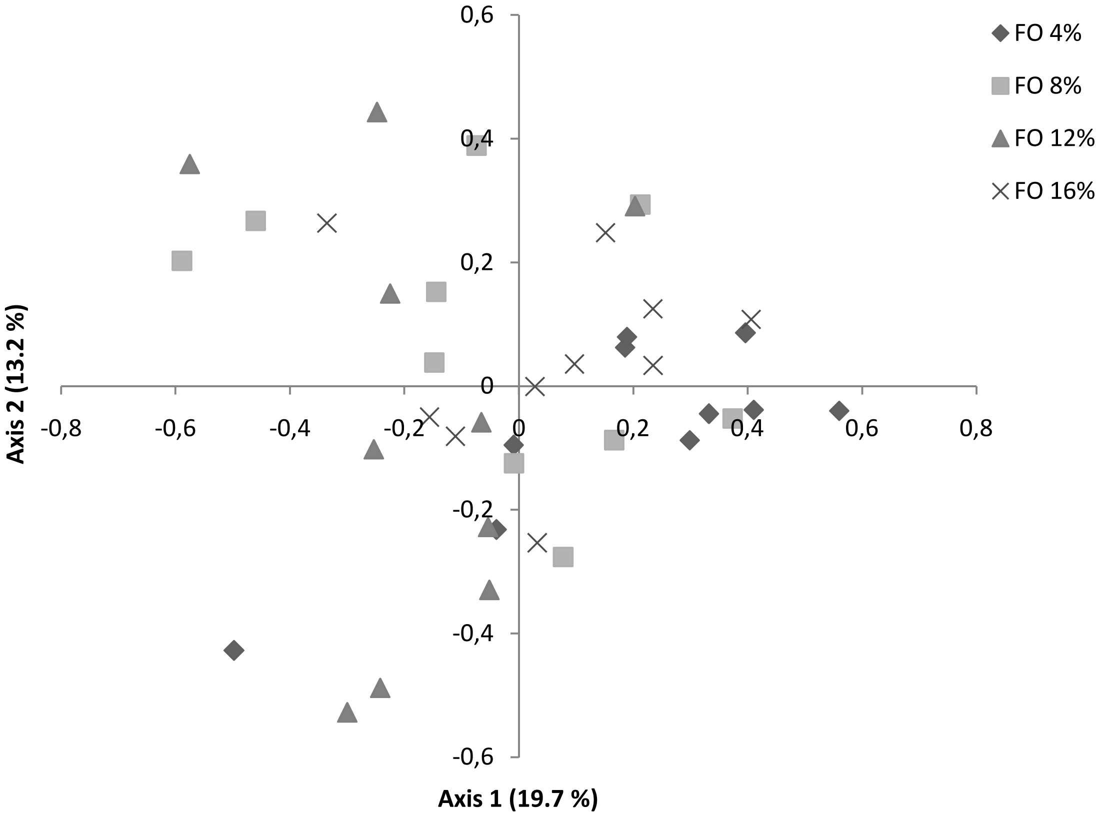


Figure 5. Ordination diagram (PCoA) of spring seed bank composition between four treatments. Symbols represent the treatments with different forage offers (FO).

Survey of the established vegetation

In the quantitative survey of established vegetation, conducted in spring 2012, 162 species were found in the full data set (all four treatments, 10 sampling units each), distributed in35 families. *Andropogon lateralis*, *Paspalum notatum*, *Eryngium horridum* and *Piptochaetium montevidense*, showed the highest importance value index (IVI), highlighted in Table 1 and Appx. 3.

Table 1. Species that showed the highest values of importance (IVI) in the quantitative survey of established vegetation.

Species	4%			8%			12%			16%		
	RF	RAbu	IVI	RF	RAbu	IVI	RF	RAbu	IVI	RF	RAbu	IVI
Eryngium horridum Malme	0.26	0.09	0.35	2.36	12.8	15.2	3.15	11.8	15	3.14	11.7	14.8
Andropogon lateralis Nees	1.59	2.3	3.89	2.95	18.2	21.2	3.5	11.5	15	3.92	21	25
Paspalum notatum Alain ex Flüggé	2.65	19.6	22.2	1.18	2.63	3.81	2.8	7.48	10.3	2.35	1.55	3.9
Piptochaetium montevidense (Spreng.) Parodi	2.65	7.66	10.3	0.29	0.08	5.29	3.5	6.26	9.76	3.14	3.95	7.09

Treatment 4% showed the highest cover of cattle manure and open soil, indicating the high grazing pressure. However, for both variables, only differences between the 4% treatment to 8% and 16% were significant. Cover of standing dead biomass and average height were higher in areas with lower grazing pressure, decreasing as grazing pressure increased; significant differences existed between all treatments except between 8 and 12% (Table 3).

Table 2. Means and standard deviations values of variables describing vegetation established features of the grassland in the different treatments. Different letters indicate significant differences between variables.

	4%	8%	12%	16%
Open Soil	0.97±0.77 a	0.44±0.31 b	0.67±0.64 ab	0.35±0.22 b
Cattle Manure	0.31±0.35a	0.06±0.16b	0.15±1.00ab	0.06±0.94 b
Dead Biomass	0.29±0.38 a	0.90±0.16 b	1.21±0.83 b	2.10±0.74 c
Alture	3.12±1.17 a	12.08±8.78 b	12.8±10.17 b	16.02±10.02 b
Litter	0.55±0.38	1.00±0.24	0.57±0.34	0.87±0.87

In the ordination diagram of vegetation data (abundances), the treatments were separated clearly (axis 1: 30.7%, axis 2: 15.2%) (Fig. 6). A division between higher greater (4 and 8%) and lower (12 and 16%) grazing intensities can be observed along the first ordination axes. Along the second axis, the 4% and 8%treatments showed the least dispersion.

Multivariate analysis of variance (MANOVA) of vegetation data revealed significant differences among all treatments, except between 12 and 16%.

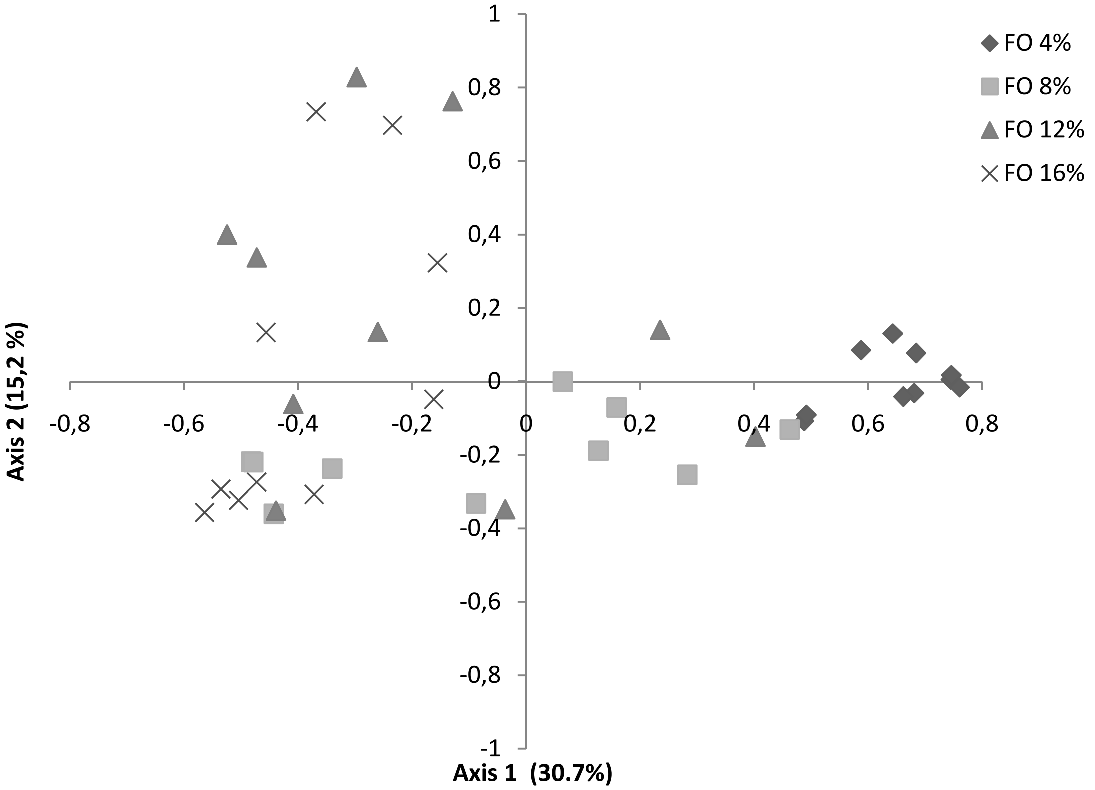


Figure 6. Ordination diagram (PCoA) of established vegetation composition between four treatments. Symbols represent the treatments with different forage offers (FO).

Comparison of seed bank with established vegetation

Of the 162 species identified in the survey of established vegetation, 71 species also occurred in the SSB and 91 were found only in the established vegetation. The SSB contained 34 exclusive species not found in the plots used for vegetation sampling (Appx. 2). The Soerensen similarity index (Qs) when compared between grazed treatments showed similar values for both the SSB spring and for the autumn. Similarity between the SSB and established vegetation was highest for the 4% treatment, considering the set of all sample units. Comparing the values of Qs per plot between treatments by analysis of variance with randomization test, data from the spring sampling showed significant differences between treatments 4% and 8% (p=0.022), 8% and 12% (p=0.002) 12 and 16% (p=0.044), and 16% was the treatment with the highest similarity with the vegetation. For data from the autumn sampling no significant differences were found, and 4% was the treatment with the highest similarity with the vegetation (Table 3).

Table 3. Comparison of species composition between established vegetation and seed bank per treatments: Number of exclusive and shared species and Soerensen index for both sampling period. Different letters indicate significant differences between variables (only for spring SSB data).

	4%		8%		12%		16%	
	Spring	**Autumn**	**Spring**	**Autumn**	**Spring**	**Autumn**	**Spring**	**Autumn**
Shared species between established vegetation and SSB	30	29	30	29	25	25	26	22
Number of species exclusively in established vegetation	63	60	73	66	68	62	63	62
Number of species exclusively in SSB	37	21	22	22	23	27	28	24
Soerensen (per treatment)	40,00%	41,73%	38,71%	39,73%	35,46%	35,97%	36,36%	33,85%
Soerensen (per sampling unit)	18,16% a	21,63%	23,40% b	18,19%	13,34% a	16,77%	23,94% ab	20,18%

Regarding life cycle, most of the species found in the SSB and in established vegetation were perennials (Tables 1 and 2). However, if we consider the abundance of species, plants with a non-perennial cycle of life has a much greater importance in the SSB compared with established vegetation (Fig. 7).

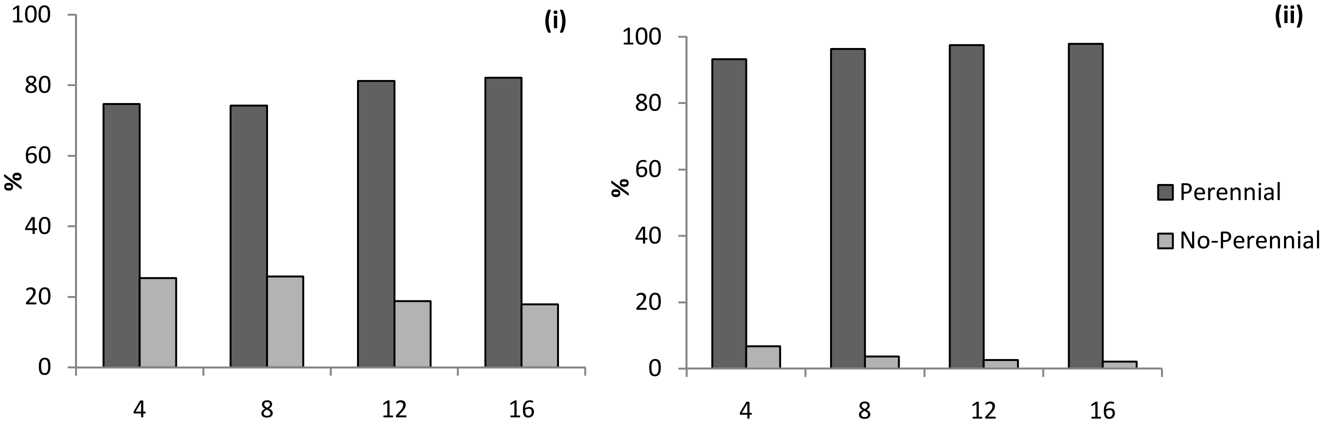


Figure 7. Percentage of abundance according to life cycle. (i) Soil seed bank and (ii) Established vegetation.

Species with a caespitose graminoids growth form gradually increased their proportion with the decrease in grazing intensity, both in the SSB as in vegetation. However, their contribution in terms of abundance was much higher in the vegetation. The percentage of prostrate grass species is lower compared to other forms of growth in both surveys, but the vegetation is observed that there is decrease as you increase the offer of forage. Also, both in the SSB and the vegetation, the percentage of prostrate forbs species decreased from the 4% to the 16% treatment. The proportion of rosulate species is higher in the seed bank and in the standing vegetation decreases with decreasing grazing intensity. The same was observed for erect and prostrate forbs, appearing in a higher percentage in the SSB and decreasing with decreasing intensity of grazing on vegetation as much in the bank. The SSB and vegetation showed low abundance of subshrubs, with similar values between treatments in vegetation, while values decreased with the increase of the FO SSB (Fig. 8).

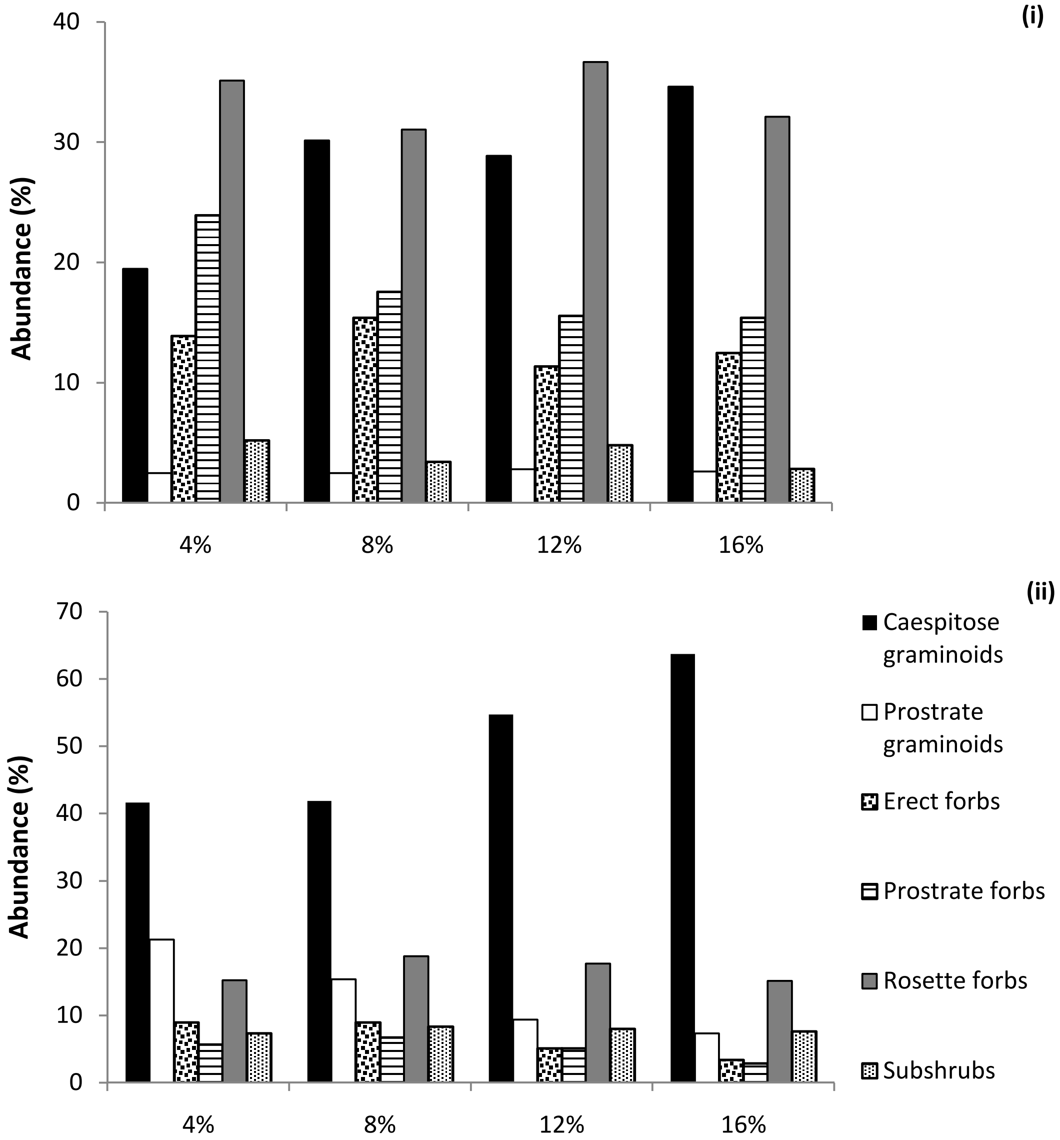


Figure 8. Percentage of abundance according to growth forms. (i) Soil seed bank and (ii) Established vegetation.

Soil compaction

Soil compaction, i.e., resistance to penetration, decreased within creasing stocking rate. The means values of soil compaction (kg/cm^2) were 8.75, 7.36, 6.71 and 6.03 for the treatments 4%, 8%, 12% and 16%, respectively. There was a significant difference between treatment 4% and the other treatments ($p < 0.05$).

Discussion

Composition, density and richness of SSB in areas with different grazing intensities

In this study, the seed density was higher in the treatment with higher grazing pressure (FO 4%) compared to the other treatments, as also demonstrated by MARCO and PÁEZ (2002) and MORICI *et al.* (2009) in the Argentinian Pampa province. This is mainly a consequence of the higher percentage of ruderal species that are characteristic of areas with disturbance intensity, with fast development cycle and high seed production (GRIME, 1979). Despite high grazing levels contribution of these species in the vegetation likely results in high pressure of seeds and thus higher abundance in the sampling units. Moreover, in consequence of increased grazing pressure, cover of tussock grasses in this treatment is very low, which implies in lower vegetation height and more open soil. This may increase the possibility of entry of seeds of these species into the seed bank. Examples of these plants, found in large numbers in areas with heavy grazing, are *Hypoxis decumbens*, *Hydrocotyle exigua* and species from several genera of the Asteraceae, principally rosulate species such as *Gamochaeta* spp., *Chevreulia* spp. and *Chaptalia* spp. (AZAMBUJA FILHO, 2013). These ruderal species have a small stature and, therefore avoid consumption by cattle, which should lead to high reproduction and dispersal.

As cattle grazes more selectively under higher forage allowance (NABINGER *et al.*, 2009), i.e. increasingly in the treatments of 8%, 12% and 16%, plants with higher palatability are consumed. This favors presence of less palatable plants in the vegetation, allowing the formation of large tussocks of caespitose grasses and, consequently, high cover values of these species, e.g. in the case of *Andropogon* *lateralis*. Vegetation becomes more heterogeneous than in the high grazing treatment and becomes increasingly dominated by tussock grasses, subshrubs and unpalatable species such as *Eryngium* spp. as grazing pressure reduces (BOLDRINI and EGGERS, 1996, MCIVOR *et al.*, 2005, OVERBECK *et al.*, 2007, NABINGER *et al.*, 2009). Lower consumption of tussock species in treatments with high FO leads to a greater accumulation of dry biomass, which could hinder the entry of soil seed (MARCO and PAEZ, 2002), despite the lower compaction by trampling. Additionally, the contribution of the species that form a larger SSB (the ruderal species see above) in the community is reduced. Nonetheless, these species still have a high contribution to the SSB.

Characteristics of the SSB compared with other studies

In surveys in wet grasslands in the South Brazilian coastal plain, GARCIA (2005) found 104 species and 57.001 seedlings/m^2 and VIEIRA (2013) of 61.796 seedlings/m^2 and 114 species (similar total sampling effort in terms of number of samples and same sampling depth as in our study). While SSB richness was quite similar in our study when compared to these previous finding, seed bank density was much lower, as species from the Cyperaceae and Juncaceae, species of high importance in wet grasslands areas and at the same time species that are characterized by high seed production, were of minor importance in the vegetation we studied. Nonetheless, and despite the low contribution in aboveground vegetation, in our study, Cyperaceae was the third family in terms of density in the SSB. In general, the richness and the density found in our work seem to be quite typical for dry grasslands of Southeastern South America, such as those studied by MÁRQUEZ *et al*. (2002), FUNES *et al*. (2001 and 2003) and HARETCHE and RODRÍGUEZ (2006). SKOGLUND (1992), in a review study also indicated low density values for dry tropical ecosystems (e.g.in savannas: average of 3.000-5.500 seeds/m^2). Although a broad range of factors, such as abiotic factors linked to soil or topography, the vegetation itself and the processes that determine it, as well as the sampling method used for SSB assessment, may influence the results of these studies, the contrast between areas with drier and more humid soil conditions becomes clearly evident and apparently can be generalized for the region of the Campos Sulinos, even with the rather small number of available studies to date.

In this study, the number of perennial species was significantly higher compared to non-perennial, both in vegetation and in the bank. This result is in agreement with those from other studies conducted in South American grasslands (BOCCANELLI and LEWIS 1994, MÁRQUEZ *et al.* 2002, MAIA *et al.*, 2004, GARCIA, 2005, FELDMAN *et. al*, 2007). Nevertheless, the participation of non-perennial species was considerably higher in the SSB, and exactly these species depend on the SSB for their regeneration. As previously discussed, this increased participation is due to the fact that most of these species are ruderal, such as *Anagallis minima*, *Conyza bonariensis* and *Gamochaeta simplicicaulis*, among others.

Sampling periods and persistent/ transient components

In our study, significant differences in SSB parameters between treatments were only found for the data from the spring sampling, and only between 4% and the remaining treatments. As for the sampling of autumn, there were no differences between treatments and the total density was considerably lower than that in spring (40%). In many SSB studies, the highest densities occur in autumn when the seeds are incorporated into the soil after dispersal of propagules developed in spring and summer. Since the collection was made at the end of March, i.e. early autumn, the seeds released from the plants during summer seem not to have been incorporated into the SSB so far.

In regard to the classification of the seed as its persistence in soil, we concluded that the SSB is mostly composed of species with a persistent seed bank, i.e., of species that occurred in both samples. BERTILLER and ALOIA (1996) claimed that species with persistent SSB colonize habitats disturbed by grazing more successfully compared to transient species and MARQUÉZ *et al.* (2002) noted that the grazing caused an increase in the percentage of species with persistent seed bank, which could be explained by the movement of soil caused by trampling of livestock, which would favor the burial of seeds.

In regard to the classification of the seed as its persistence in soil, we concluded that the SSB is mostly composed of species with a persistent seed bank, both for classification of BAKER (1989) and THOMPSON *et al.* (1997). BERTILLER and ALOIA (1996) claimed that species with persistent SSB colonize habitats disturbed by grazing more successfully compared to transient species and MARQUÉZ *et al.* (2002) noted that the grazing caused an increase in the percentage of species with persistent seed bank, which could be explained by the movement of soil caused by trampling of livestock, which would favor the burial of seeds.

Nonetheless, in regions were the seed bank remains rather poorly studied in total, such as in the Campos Sulinos region, studies over longer periods of time are necessary. BAKER (1989), for instance, considers the SSB as persistent when composed of seeds that remain viable for up to five years after the dispersion. However, it is necessary to extend the time tracking method of seedling emergence for over 1 year. In view of this, other methods can also be useful in classifying species regarding their seed bank type, such as the one proposed by THOMPSON *et al.* (1997), using a categorization from estimates based on depth distribution and the presence of the species in the SSB established vegetation. This method allows the categorization is made from only one collection soil, in spring or fall, in a shorter time period of the experiment. Moreover, it takes into account the comparison with established vegetation, including the analysis of the dynamics and composition of the study area. However, such data are still very scarce for the region of the Campos Sulinos, which still leads to limitations regarding our understanding of the SSB.

Relation of SSB with established vegetation

When considering the paddock as a whole, similarity between established vegetation and SSB obviously was higher, as all species found within a paddock were included in the comparison. The Soerensen similarity index showed rather similar values when comparing the treatments, being slightly higher in the treatment with the higher grazing intensity. However, when evaluated on the level of sampling units, similarity was low. As in other studies (LUNT, 1997, FRIEND *et al.*, 1997, GHERMANDI, 1997, FUNES *et al.,* 2001 e 2003, FELDMAN *et. al,* 2007, HARETCHE and RODRÍGUEZ, 2006), it was observed that the predominant species in the established vegetation, such as *Paspalum notatum* and *Andropogon lateralis*, to indicate only the two main grasses, were not present in the bank or appeared only in very low numbers. An exception to the rule was *Piptochaetium montevidensis*, a species or ruderal/opportunistic character (HERINGER and JAQUES, 2002) and one of the species with the highest importance in vegetation and also abundant in the SSB. The lack of dominant grasses in the SSB has been pointed out in other studies conducted in the region (e.g. FRIEND *et al.*, 1997, MAIA *et al*., 2004, HARETCHE and RODRÍGUEZ, 2006, VIEIRA, 2013). These species, adapted to grazing and/or fire, are abundant and long-lived, i.e. mortality should be low, and thus there seems to be no necessity for them to form a large soil seed bank (MEDEIROS, 2000). However, this also means that after more severe disturbances that implies in destruction of rhizomes, they likely will not re-establish readily.

Conclusions and Implications

Our study points out high richness but dominance of ruderal species in the SSB on the one hand, absence of those species that show highest abundances in the established vegetation on the other hand, corroborating studies that show that the SSB has a limited role in the recovery of typical vegetation typical after more severe disturbances and specifically after longer periods of overgrazing. Additionally, we confirm the difference in seed bank density between humid and mesic grasslands

Apparently, the intensity of management does not have a very large impact on the SSB, in contrast to our initial hypothesis. Not only the treatment with high grazing pressure, but all treatments were dominated by ruderal species. The results of this study have implications beyond the question whether effects of overgrazing can be easily reverted or not. As discussed for wet grasslands in southern Brazil (VIEIRA, 2013), our study indicates that recovery from the SSB likely will be of limited importance in grassland areas that have been affected by severe disturbances (e.g. implementation of other land uses), as the dominant species seem to rely on vegetative recovery from underground storage organs (e.g., OVERBECK and PFADENHAUER, 2007, FIDELIS, 2014). Long-term studies on seed band, bud bank and vegetation dynamics are needed to better assess the vegetation dynamics in relation to different types of management.

Acknowledgements

We thank Miguel Dall'Agnol the availability of greenhouse space in the Department of Agrometeorology and Forage Plants at UFRGS. For assistance in field and greenhouse work and with plant identification, we thank members of the Laboratory for the Study of Grassland Vegetation UFRGS and especially Ilsi Iob Boldrini. We thank Felícia Fischer for sharing the data of vegetation, and students in the Ecology and Botany Graduate Programs at UFRGS for the help in the vegetation surveys. This project received support from CNPq (558282/2009-1).

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Appendix

Appendix1. Seed bank density per m² per area during spring and autumn seasons. Given are mean values for each area. * Indicates ruderal species (based on own observations and knowledge of botanists and agronomist in the region).

			Spring				Autumn			
Family	**Species**	**Cycle life**	**4%**	**8%**	**12%**	**16%**	**4%**	**8%**	**12%**	**16%**
Amaranthaceae	*Pfaffia tuberosa* Hicken *	perennial	0	0	0	0	0	0	0	76
Amaryllidaceae	*Nothoscordum bivalve* (L.) Britton	perennial	0	0	0	25	0	0	0	0
	Nothoscordum montevidense Beauverd	perennial	0	0	0	0	0	25	25	76
Apiaceae	*Centella asiatica* (L.) Urb. *	perennial	688	306	510	433	1146	255	510	739
	Cyclospermum leptophyllum (Pers.) Sprague ex Britton & P. Wilson *	annual	0	0	0	0	25	0	0	0
	Eryngium horridum Malme *	perennial	0	25	0	25	0	0	25	0
Araliaceae	*Hydrocotyle exigua* Malme *	perennial	1580	866	408	306	994	1783	815	535
Asteraceae	*Aster squamatus* (Spreng.) Hieron. *	perennial	0	0	25	0	51	0	25	0
	Baccharis trimera (Less.) DC. *	perennial	0	0	0	0	0	0	178	0
	Chaptalia exscapa (Pers.) Baker *	perennial	0	0	0	0	0	0	0	25
	Chaptalia piloselloides (Vahl) Baker *	perennial	25	0	0	0	0	0	25	0
	Chevreulia sarmentosa (Pers.) S.F. Blake *	perennial	0	51	0	127	51	76	25	0
	Conyza bonariensis (L.) Cronquist *	annual	637	459	611	535	25	76	0	0
	Elephantopus mollis Kunth *	perennial	0	0	0	0	0	0	0	25
	Erechtites valerianifolius (Link ex Spreng.) DC. *	annual	76	306	51	76	0	0	0	25
	Eupatorium squarrulosum Hook. & Arn.	perennial	0	0	0	0	0	0	51	25
	Facelis retusa (Lam.) Sch. Bip. *	annual	51	51	25	25	0	25	0	25
	Galinsoga parviflora Cav. *	annual	25	0	0	25	0	0	0	0
	Gamochaeta americana (Mill.) Wedd. *	biannual or perennial	1529	1376	1936	1070	51	51	204	153
	Gamochaeta coarctata (Willd.) Kerguélen *	biannual or perennial	4917	2191	1987	2318	866	357	255	637
	Gamochaeta filaginea (DC.) Cabrera *	perennial	102	25	0	0	0	0	0	0

	Gamochaeta pensylvanica (Willd.) Cabrera *	biannualorperennial	917	153	433	382	0	153	0	0
	Gamochaeta simplicicaulis (Willd. ex Spreng.) Cabrera *	annual	815	1045	280	153	0	0	25	0
	Micropsis spathulata (Pers.) Cabrera	annual	0	0	0	0	153	0	25	0
	Pterocaulon rugosum (Vahl) Malme *	perennial	408	204	25	0	0	51	0	0
	Senecio leptolobus DC. *	annual or biannual	0	25	0	0	51	0	0	0
	Senecio madagascariensis Poir. *	annual or biannual	25	0	0	0	255	0	0	0
	Senecio selloi (Spreng.) DC. *	annual	0	0	0	0	0	25	76	0
	Soliva sessilis Ruiz & Pav. *	annual	51	0	0	0	76	25	0	0
Campanulaceae	*Lobelia hederacea* Cham.	perennial	0	25	0	0	0	25	0	0
	Wahlenbergia linarioides (Lam.) A. DC. *	perennial	0	0	0	25	25	178	0	178
Convolvulaceae	*Dichondra macrocalyx* Meisn. *	perennial	0	0	0	0	0	0	25	76
	Dichondra sericea Sw. *	perennial	280	229	102	127	153	51	127	178
	Evolvulus sericeus Sw.	perennial	25	0	0	51	25	0	25	51
Cyperaceae	*Abildgaardia ovata* (Burm. f.) Kral	perennial	25	0	0	0	0	0	0	0
	Bulbostylis subtilis M.G. López	annual	51	102	127	102	306	204	0	357
	Carex sp.	perennial	0	0	0	0	0	76	25	0
	Carex phalaroides Kunth	perennial	25	0	25	102	25	25	25	51
	Cyperus aggregatus (Willd.) Endl.	perennial	76	0	0	0	51	102	127	76
	Cyperus hermaphroditus (Jacq.) Standl.	perennial	0	0	0	51	0	0	0	0
	Cyperus lanceolatus (Poir.) C.B. Clarke	perennial	25	0	25	127	0	0	0	0
	Cyperus sp. 2	perennial	0	0	0	0	0	0	0	51
	Cyperus sp.1	perennial	0	0	0	0	0	306	25	25
	Eleocharis viridans Kük. ex Osten	perennial	25	153	204	76	357	306	127	255
	Fimbristylis autumnalis (L.) Roem. & Schult.	annual	0	102	127	102	204	153	25	51
	Fimbristylis dichotoma (L.) Vahl	annual	688	637	560	637	255	178	127	178
	Kyllinga brevifolia Rottb.	perennial	306	178	433	255	178	153	102	280
	Kyllinga odorata Vahl	perennial	204	306	153	204	102	127	153	76
	Rhynchospora barrosiana Guagl.	perennial	102	357	127	25	0	0	51	0
	Rhynchospora brittonii Gale	perennial	0	0	0	76	0	0	0	0

	Rhynchospora tenuis Willd. ex Link	perennial	0	51	0	76	0	0	0	0
Droseraceae	*Drosera brevifolia* Pursh	annual	0	127	76	76	0	0	0	0
Euphorbiaceae	*Euphorbia serpens* Kunth	annual	0	0	0	0	25	0	0	0
Fabaceae	*Desmanthus virgatus* (L.) Willd.	perennial	25	25	0	25	25	25	0	0
	Desmodium incanum (Sw.) DC.	perennial	0	0	0	0	25	0	0	0
	Trifolium polymorphum Poir.	perennial	0	0	25	0	0	0	0	0
Hypoxidaceae	*Hypoxis decumbens* L.	perennial	637	1299	1783	1197	153	637	866	892
Iridaceae	*Sisyrinchium micranthum* Cav.	annual	1070	739	408	331	815	1172	739	662
	Sisyrinchium ostenianum Beauverd	annual	0	25	0	0	153	25	25	25
Juncaceae	*Juncus capillaceus* Lam.	perennial	102	25	76	102	280	280	76	204
	Juncus dichotomus Elliott	perennial	0	0	0	0	0	25	0	0
	Juncus microcephalus Kunth	perennial	51	25	25	76	25	204	51	433
Linaceae	*Cliococca selaginoides* (Lam.) C.M. Rogers & Mildner *	perennial	51	0	0	0	25	0	0	0
Malvaceae	*Krapovickasia flavescens* (Cav.) Fryxell	perennial	0	0	0	25	0	0	0	0
	Sida rhombifolia L.	perennial	0	25	0	0	0	0	0	0
Oxalidaceae	*Oxalis brasiliensis* G. Lodd.	perennial	408	0	229	76	153	76	102	102
	Oxalis conorrhiza Jacq.	perennial	866	204	229	255	127	178	76	76
	Oxalis eriocarpa DC.	perennial	25	0	0	0	0	51	25	25
	Oxalis lasiopetala Zucc.	perennial	102	127	102	178	76	204	25	153
	Oxalis perdicaria (Molina) Bertero	perennial	0	0	25	0	0	0	25	0
Plantaginaceae	*Mecardonia tenella* (Cham. & Schltdl.) Pennell *	perennial	153	76	51	153	408	255	153	408
	Plantago tomentosa Lam. *	perennial	51	0	0	102	76	0	25	0
	Scoparia dulcis L. *	perennial	25	0	0	51	102	51	51	0
Poaceae	*Andropogon lateralis* Nees	perennial	0	0	0	0	25	25	51	25
	Axonopus affinis Chase	perennial	153	229	0	51	76	51	51	0
	Chascolytrum poomorphum (J. Presl) L. Essi, Longhi-Wagner & Souza-Chies	perennial	0	0	0	0	0	0	0	51
	Chascolytrum rufum (J. Presl) Matthei	perennial	0	0	0	25	25	0	102	382
	Chascolytrum subaristatum (Lam.) Desv.	perennial	0	25	25	0	0	0	0	0
	Dichanthelium sabulorum (Lam.) Gould & C.A. Clark	perennial	25	204	153	357	51	255	25	102

	Digitaria violascens Link *	annual	25	102	51	204	102	76	102	51
	Eleusine tristachya (Lam.) Lam. *	perennial	0	25	51	0	0	0	0	0
	Elionurus candidus (Trin.) Hack.	perennial	0	51	25	255	0	0	0	0
	Eragrostis lugens Nees	perennial	25	0	76	127	25	127	102	25
	Eragrostis neesii Trin. *	annual or biannual	331	51	51	229	331	153	229	102
	Mnesithea selloana (Hack.) de Koning & Sosef	perennial	0	102	51	76	51	51	51	0
	Paspalum plicatulum Michx.	perennial	0	0	25	0	25	0	204	76
	Paspalum pumilum Nees	perennial	25	0	25	0	0	0	0	0
	Piptochaetium montevidense (Spreng.) Parodi	perennial	994	1096	1096	713	535	790	943	560
	Setaria parviflora (Poir.) Kerguélen *	perennial	25	51	0	25	0	0	0	0
	Sporobolus indicus (L.) R. Br. *	perennial	25	0	0	0	0	0	25	76
	Steinchisma hians (Elliott) Nash	perennial	76	255	204	535	76	127	51	127
	Stipa juergensii Hack.	perennial	51	0	0	0	0	0	0	0
	Stipa nutans Hack.	perennial	0	25	51	51	0	76	280	102
	Trachypogon spicatus (L. f.) Kuntze	perennial	25	25	0	0	0	0	0	0
Polygalaceae	*Polygala australis* A.W. Benn.	annual	0	25	25	0	102	76	76	0
Primulaceae	*Anagallis minima* (L.) E.H.L. Krause	annual	280	153	0	0	739	153	255	178
Rubiaceae	*Borreria eryngioides* Cham. & Schltdl. *	perennial	0	0	0	0	51	0	0	25
	Galium hirtum Lam. *	annual	331	153	127	76	0	25	76	0
	Galium richardianum (Gillies ex Hook. & Arn.) Endl. ex Walp.	perennial	25	25	280	255	0	153	153	255
	Richardia brasiliensis Gomes *	perennial	51	25	51	0	25	25	0	0
	Richardia humistrata (Cham. & Schltdl.) Steud. *	perennial	0	0	0	0	0	25	0	0
	Richardia stellaris (Cham. & Schltdl.) Steud. *	perennial	25	0	0	0	0	25	0	0
Verbenaceae	*Verbena litoralis* Kunth *	perennial	51	0	0	0	25	0	0	0

Appendix 2. List of species in the vegetation present in the established vegetation, SSB spring and autumn and vertical distribution of seeds in the bank.

Family	Species	Established vegetation	Spring		Autumn	
			Lower	Upper	Lower	Upper
Acanthaceae	*Justicia reitzii* Leonard	x				
	Ruellia hypericoides (Nees) Lindau	x				
	Ruellia morongii Britton	x				
	Stenandrium diphyllum Nees	x				
Amaranthaceae	*Gomphrena graminea* Moq.	x				
	Pfaffia tuberosa Hicken	x				x
	Nothoscordum bivalve (L.) Britton		x	x		
	Nothoscordum Kunth	x			x	x
	Nothoscordum montevidense Beauverd	x				
Apiaceae	*Centella asiatica* (L.) Urb.	x	x	x	x	x
	Cyclospermum leptophyllum (Pers.) Sprague ex Britton & P. Wilson	x				x
	Eryngium ciliatum Cham. & Schltdl.	x				
	Eryngium elegans Cham. & Schltdl.	x				
	Eryngium horridum Malme	x		x		x
Apocynaceae	*Oxypetalum capitatum* Mart.	x				
Araliaceae	*Hydrocotyle exigua* Malme	x				
Aristolochiaceae	*Aristolochia sessilifolia* (Klotzsch) Duch.	x				
Asteraceae	*Acmella* sp.	x				
	Aspilia montevidensis (Spreng.) Kuntze	x				
	Aster squamatus (Spreng.) Hieron.		x	x	x	x
	Baccharis cognata DC.	x				
	Baccharis trimera (Less.) DC.	x			x	x
	Chaptalia exscapa (Pers.) Baker	x				x
	Chaptalia mandonii Burkart	x				
	Chaptalia piloselloides (Vahl) Baker	x	x	x		x

	Chaptalia runcinata Kunth	x				
	Chevreulia acuminata Less.	x				
	Chevreulia sarmentosa (Pers.) S.F. Blake	x	x	x		x
	Conyza primulifolia (Lam.) Cuatrec. & Lourteig	x				
	Conyza bonariensis (L.) Cronquist		x	x	x	x
	Elephantopus mollis Kunth	x				x
	Erechtites valerianifolius (Link ex Spreng.) DC.			x		x
	Eupatorium squarrulosum Hook. & Arn.	x				x
	Facelis retusa (Lam.) Sch. Bip.	x	x	x		x
	Galinsoga parviflora Cav.		x	x		
	Gamochaeta americana (Mill.) Wedd.	x	x	x	x	x
	Gamochaeta coarctata (Willd.) Kerguélen	x	x	x	x	x
	Gamochaeta filaginea (DC.) Cabrera			x		
	Gamochaeta pensylvanica (Willd.) Cabrera		x	x	x	x
	Gamochaeta simplicicaulis (Willd. ex Spreng.) Cabrera		x	x		x
	Hypochaeris albiflora (Kuntze) Azevêdo-Gonç. & Matzenb.	x				
	Hypochaeris megapotamica Cabrera	x	x	x	x	x
	Hypochaeris radicata L.	x				
	Micropsis spathulata (Pers.) Cabrera	x				x
	Orthopappus angustifolius (Sw.) Gleason	x				
	Pterocaulon angustifolium DC.	x				
	Pterocaulon rugosum (Vahl) Malme		x	x		x
	Senecio brasiliensis (Spreng.) Less.	x				
	Senecio heterotrichius DC.	x				
	Senecio leptolobus DC.	x		x		x
	Senecio madagascariensis Poir.	x	x			x
	Senecio selloi (Spreng.) DC.	x			x	x
	Solidago L.	x				
	Soliva sessilis Ruiz & Pav.	x		x	x	x
	Stenachaenium campestre Baker	x				

	Chrysolaena flexuosa (Sims) H. Rob.	x				
	Vernonanthura nudiflora (Less.) H. Rob.	x				
Campanulaceae	*Lobelia hederacea* Cham.	x	x	x		x
	Wahlenbergia linarioides (Lam.) A. DC.			x	x	x
Caryophyllaceae	*Cerastium glomeratum* Thuill.	x				
Cistaceae	*Helianthemum brasiliense* (Lam.) Pers.	x				
Commelinaceae	*Commelina diffusa* Burm. f.	x				
	Commelina erecta L.	x				
Convolvulaceae	*Dichondra macrocalyx* Meisn.	x			x	x
	Dichondra sericea Sw.	x	x	x	x	x
	Evolvulus sericeus Sw.	x	x	x		x
Cyperaceae	*Abildgaardia ovata* (Burm. f.) Kral	x		x		
	Bulbostylis capillaris (L.) C.B. Clarke	x				
	Bulbostylis subtilis M.G. López		x	x	x	x
	Carex phalaroides Kunth	x		x	x	x
	Carex sp.				x	x
	Cyperus lanceolatus (Poir.) C.B. Clarke			x		
	Cyperus aggregatus (Willd.) Endl.			x	x	x
	Cyperus hermaphroditus (Jacq.) Standl.		x	x		
	Cyperus sp. 1				x	x
	Cyperus sp.				x	
	Eleocharis viridans Kük. ex Osten	x	x	x	x	x
	Fimbristylis autumnalis (L.) Roem. & Schult.		x	x	x	x
	Fimbristylis dichotoma (L.) Vahl	x	x	x	x	x
	Kyllinga brevifolia Rottb.		x	x	x	x
	Kyllinga odorata Vahl	x	x	x	x	x
	Rhynchospora barrosiana Guagl.		x	x		x
	Rhynchospora brittonii Gale			x		
	Rhynchospora sp.	x				
	Rhynchospora tenuis Willd. ex Link	x	x	x		

Droseraceae	*Drosera brevifolia* Pursh			x		
Euphorbiaceae	*Euphorbia selloi* (Klotzsch & Garcke) Boiss.	x				
	Euphorbia serpens Kunth					x
	Tragia bahiensis Müll. Arg.	x				
Fabaceae	*Chamaecrista* Moench	x				
	Clitoria nana Benth.	x				
	Desmanthus virgatus (L.) Willd.	x	x	x	x	x
	Desmodium incanum (Sw.) DC.	x				x
	Galactia marginalis Benth.	x				
	Galactia pretiosa Burkart	x				
	Macroptilium prostratum (Benth.) Urb.	x				
	Pomaria pilosa (Vogel) B.B. Simpson & G.P. Lewis	x				
	Pomaria stipularis (Vogel) B.B. Simpson & G.P. Lewis	x				
	Stylosanthes leiocarpa Vogel	x				
	Stylosanthes montevidensis Vogel	x				
	Trifolium polymorphum Poir.	x	x			
Hypoxidaceae	*Hypoxis decumbens* L.	x	x	x	x	x
Iridaceae	*Cypella* sp.	x				
	Herbertia pulchella Sweet	x				
	Sisyrinchium micranthum Cav.	x	x		x	x
	Sisyrinchium ostenianum Beauverd	x	x	x	x	x
	Sisyrinchium sellowianum Klatt	x				
Juncaceae	*Juncus capillaceus* Lam.	x	x	x	x	x
	Juncus dichotomus Elliott					x
	Juncus microcephalus Kunth		x	x	x	x
Lamiaceae	*Peltodon longipes* Kunth ex Benth.	x				
	Scutellaria racemosa Pers.	x				
Linaceae	*Cliococca selaginoides* (Lam.) C.M. Rogers & Mildner	x	x			x
Lythraceae	*Cuphea glutinosa* Cham. & Schltdl.	x				
Malvaceae	*Krapovickasia flavescens* (Cav.) Fryxell	x		x		

	Sida rhombifolia L.		x	x		
Melastomataceae	Tibouchina gracilis (Bonpl.) Cogn.	x				
Myrtaceae	*Psidium salutare var. mucronatum* (Cambess.) Landrum	x				
Orchidaceae	*Habenaria parviflora Lindl.*	x				
	Orchidaceae	x				
	Skeptrostachys arechavaletanii	x				
Oxalidaceae	*Oxalis brasiliensis* G. Lodd.	x	x	x		x
	Oxalis conorrhiza Jacq.	x		x	x	x
	Oxalis eriocarpa DC.	x	x	x		x
	Oxalis lasiopetala Zucc.	x		x	x	x
	Oxalis perdicaria (Molina) Bertero	x	x			x
Passifloraceae	*Piriqueta suborbicularis* (A. St.-Hil. & Naudin) Arbo	x				
	Turnera sidoides L.	x				
Plantaginaceae	*Mecardonia tenella* (Cham. & Schltdl.) Pennell	x		x	x	x
	Plantago myosuros Lam.	x				
	Plantago tomentosa Lam.	x		x		x
	Scoparia dulcis L.			x	x	x
Poaceae	*Andropogon sp.*	x				
	Andropogon lateralis Nees	x			x	x
	Andropogon selloanus (Hack.) Hack.	x				
	Andropogon ternatus (Spreng.) Nees	x				
	Andropogon virgatus Desv. ex Ham.	x				
	Aristida filifolia (Arechav.) Herter	x				
	Aristida flaccida Trin. & Rupr.	x				
	Aristida jubata (Arechav.) Herter	x				
	Aristida laevis (Nees) Kunth	x				
	Aristida venustula Arechav.	x				
	Axonopus affinis Chase	x		x	x	x
	Axonopus fissifolius (Raddi) Kuhlm.	x				
	Bothriochloa laguroides (DC.) Herter	x				

	Chascolytrum uniolae (Nees) L. Essi, Longhi-Wagner & Souza-Chies	x				
	Calamagrostis alba (J. Presl) Steud.	x				
	Chascolytrum poomorphum (J. Presl) L. Essi, Longhi-Wagner & Souza-Chies	x				x
	Chascolytrum rufum (J. Presl) Matthei			x	x	x
	Chascolytrum subaristatum (Lam.) Desv.	x		x		
	Danthonia cirrata Hack. & Arechav.	x				
	Dichanthelium sabulorum (Hitchc. & Chase) Gould	x	x	x	x	x
	Digitaria violascens Link	x	x	x	x	x
	Eleusine tristachya (Lam.) Lam.			x		
	Elionurus candidus (Trin.) Hack.	x	x	x		
	Eragrostis lugens Nees		x	x	x	x
	Eragrostis neesii Trin.	x	x	x	x	x
	Eragrostis plana Nees	x				
	Melica brasiliana Ard.	x				
	Mnesithea selloana (Hack.) de Koning & Sosef	x	x			x
	Paspalum dilatatum Poir.	x				
	Paspalum nicorae Parodi	x				
	Paspalum notatum Alain ex Flüggé	x				
	Paspalum paucifolium Swallen	x				
	Paspalum plicatulum Michx.	x	x	x		x
	Paspalum pumilum Nees	x	x	x		
	Paspalum sp.	x				
	Paspalum umbrosum Trin.	x				
	Piptochaetium bicolor (Vahl) E. Desv.	x				
	Piptochaetium montevidense (Spreng.) Parodi	x	x	x	x	x
	Piptochaetium stipoides (Trin. & Rupr.) Hack. ex Arechav.	x				
	Saccharum angustifolium (Nees) Trin.	x				
	Setaria parviflora (Poir.) Kerguélen	x		x		

	Setaria setosa (Sw.) P. Beauv.	x				
	*Schizachyrium tenerum*Nees	x				
	Sorghastrum sp.	x				
	Sporobolus indicus (L.) R. Br.	x		x		x
	Steinchisma hians (Elliott) Nash	x	x	x	x	x
	Stipa juergensii Hack.			x		
	Stipa nutans Hack.	x	x	x	x	x
	Stipa setigera J. Presl	x				
	Trachypogon spicatus (L. f.) Kuntze		x	x		
Polygalaceae	*Polygala australis* A.W. Benn.	x	x			x
Primulaceae	*Anagallis minima* (L.) E.H.L. Krause		x		x	x
Rubiaceae	*Borreria eryngioides* Cham. & Schltdl.	x			x	x
	Spermacoce verticillata L.	x				
	Borreria dasycephala (Cham. & Schltdl.) Bacigalupo & E.L. Cabral	x				
	Galianthe fastigiata Griseb.	x				
	Galium hirtum Lam.	x	x	x		x
	Galium richardianum (Gillies ex Hook. & Arn.) Endl. ex Walp.	x	x	x	x	x
	Richardia brasiliensis Gomes	x			x	x
	Richardia grandiflora (Cham. & Schltdl.) Steud.	x				
	Richardia humistrata (Cham. & Schltdl.) Steud.	x		x		x
	Richardia stellaris (Cham. & Schltdl.) Steud.	x		x	x	
Verbenaceae	*Glandularia marrubioides* (Cham.) Tronc.	x				
	Verbena litoralis Kunth		x	x		x
	NI	x				

Appendix 3. Species identified in established vegetation survey (per treatment) and phytosociological parameters of the species: relative frequency (RF), relative abundance (RAur) and importance value index (IVI).

Family	Species	Cycle life	4%			8%			12%			16%		
			RF	RAbu	IVI	RF	RAbu	IVI	RF	RAbu	IVI	RF	RAbu	IVI
Acanthaceae	*Justicia reitzii* Leonard	perennial	0	0	0	0	0	0	0.35	0.09	0.44	0	0	0
	Ruellia hypericoides (Nees) Lindau	perennial	1.85	0.6	2.45	2.06	0.59	2.66	0	0	0	0	0	0
	Ruellia morongii Britton	perennial	2.65	0.85	3.5	1.18	1.02	2.2	1.4	0.7	2.09	2.75	0.6	3.35
	Stenandrium diphyllum Nees	perennial	0.26	0.09	0.35	0.29	0.08	0.38	0.35	0.09	0.44	0	0	0
Amaranthaceae	*Gomphrena graminea* Moq.	perennial	0.26	0.09	0.35	0.29	0.08	0.38	0	0	0	0	0	0
	Pfaffia tuberosa Hicken	perennial	1.06	0.34	1.4	0.59	0.85	1.44	1.75	0.43	2.18	1.18	0.26	1.43
Amaryllidaceae	*Nothoscordum montevidense* Beauverd	perennial	1.06	0.34	1.4	0	0	0	0	0	0	0	0	0
	Nothoscordum sp.	perennial	0	0	0	0	0	0	0.35	0.09	0.44	0	0	0
Apiaceae	*Centella asiatica* (L.) Urb.	perennial	1.32	4.26	5.58	1.18	0.34	1.52	1.75	1.22	2.97	2.75	1.98	4.72
	Cyclospermum leptophyllum (Pers.) Sprague ex Britton & P. Wilson	perennial	2.12	0.68	2.8	1.47	0.42	1.9	0.35	0.09	0.44	0	0	0
	Eryngium ciliatum Cham. & Schltdl.	perennial	2.38	8.51	10.9	1.18	1.02	2.2	0.35	0.43	0.78	0.39	0.09	0.48
	Eryngium elegans Cham. & Schltdl.	perennial	0	0	0	0	0	0	0.7	0.96	1.66	0.39	0.09	0.48
	Eryngium horridum Malme	perennial	0.26	0.09	0.35	2.36	12.8	15.2	3.15	11.8	15	3.14	11.7	14.8
Apocynaceae	*Oxypetalum capitatum* Mart.	perennial	0	0	0	0	0	0	0	0	0	0	0	0
Araliaceae	*Hydrocotyle exigua* Malme	perennial	0.53	0.17	0.7	0.59	0.17	0.76	0	0	0	0	0	0
Aristolochiaceae	*Aristolochia sessilifolia* (Klotzsch) Duch.	perennial	0.53	0.17	0.7	1.18	0.34	1.52	0.7	0.17	0.87	0	0	0
Asteraceae	*Acmella* sp.	perennial	1.06	0.68	1.74	1.18	0.68	1.86	0	0	0	0	0	0
	Aspilia montevidensis (Spreng.) Kuntze	perennial	2.65	1.53	4.18	0.29	0.08	0.38	2.45	0.61	3.06	0.78	0.17	0.96
	Baccharis cognata DC.	perennial	0	0	0	0.29	0.08	0.38	0.35	0.09	0.44	0	0	0
	Baccharis trimera (Less.) DC.	perennial	0.53	0.94	1.47	0	0	0	2.45	2.87	5.32	1.96	1.2	3.16
	Chaptalia exscapa (Pers.) Baker	perennial	1.85	0.6	2.45	0.29	0.08	0.38	0.35	0.09	0.44	0.78	0.17	0.96
	Chaptalia mandonii Burkart	perennial	0	0	0	0.29	0.08	0.38	0.35	0.09	0.44	0	0	0

	Chaptalia piloselloides (Vahl) Baker	perennial	0	0	0	0	0	0	0	0	0	0	0	0
	Chaptalia runcinata Kunth	perennial	1.59	0.51	2.1	0.29	0.08	0.38	0.7	0.17	0.87	0	0	0
	Chevreulia acuminata Less.	perennial	0.53	0.17	0.7	1.77	0.51	2.28	1.05	0.26	1.31	0.78	0.17	0.96
	Chevreulia sarmentosa (Pers.) S.F. Blake	perennial	1.59	0.51	2.1	1.47	0.42	1.9	0.7	0.17	0.87	0.39	0.09	0.48
	Chrysolaena flexuosa (Sims) H. Rob.	perennial	0.26	0.09	0.35	1.18	0.34	1.52	0.35	0.09	0.44	0	0	0
	Conyza primulifolia (Lam.) Cuatrec. & Lourteig	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0	0	0
	Elephantopus mollis Kunth	perennial	0	0	0	0.88	0.25	1.14	1.4	0.35	1.75	0.39	0.43	0.82
	Eupatorium ascendens Sch. Bip. ex Baker	perennial	0	0	0	0.59	0.17	0.76	0	0	0	0	0	0
	Facelis retusa (Lam.) Sch. Bip.	annual	1.06	0.34	1.4	1.18	0.34	1.52	1.4	0.35	1.75	0.39	0.09	0.48
	Gamochaeta americana (Mill.) Wedd.	biannual or perennial	0	0	0	0.59	0.17	0.76	1.05	0.26	1.31	0.78	0.17	0.96
	Hypochaeris albiflora (Kuntze) Azevêdo-Gonç. & Matzenb.	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0	0	0
	Hypochaeris megapotamica Cabrera	perennial	2.38	1.45	3.83	2.95	1.53	4.48	3.15	1.83	4.97	3.53	1.12	4.65
	Hypochaeris radicata L.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
	Micropsis spathulata (Pers.) Cabrera	annual	2.12	1.45	3.56	0.88	0.25	1.14	2.45	1.3	3.75	2.75	0.95	3.69
	Orthopappus angustifolius (Sw.) Gleason	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0.39	0.43	0.82
	Pterocaulon angustifolium DC.	perennial	0.53	0.17	0.7	0.29	0.08	0.38	1.4	0.35	1.75	0.39	0.09	0.48
	Senecio brasiliensis (Spreng.) Less.	annual	0.26	0.09	0.35	0	0	0	0.35	0.09	0.44	0	0	0
	Senecio heterotrichius DC.	annual	0	0	0	0.59	0.17	0.76	0.35	0.09	0.44	0	0	0
	Senecio leptolobus DC.	annual	1.06	0.68	1.74	0.29	0.42	0.72	0	0	0	0.78	0.52	1.3
	Senecio madagascariensis Poir.	annual	0.53	0.17	0.7	0.88	0.59	1.48	0	0	0	0	0	0
	Senecio selloi (Spreng.) DC.	annual	0.26	0.09	0.35	0	0	0	1.75	1.13	2.88	0.78	0.95	1.73
	*Solidago chilensis*Meyen	perennial	0	0	0	1.18	0.34	21.2	0	0	0	0.39	0.09	0.48
	Soliva sessilis Ruiz & Pav.	annual	1.85	0.6	2.45	0	0	0	0	0	0	0	0	0
	Stenachaenium campestre Baker	perennial	0	0	0	0.59	1.27	1.86	0	0	0	0	0	0
	Vernonanthura nudiflora (Less.) H.	perennial	1.59	1.53	3.12	2.36	1.69	4.05	3.15	2.17	5.32	2.35	0.52	2.87

	Rob.													
Campanulaceae	*Lobelia hederacea*Cham.	perennial	0	0	0	0.88	0.25	1.14	0	0	0	0.39	0.09	0.48
Caryophyllaceae	*Cerastium glomeratum* Thuill.	annual	0.79	0.26	1.05	1.77	1.61	3.38	0.7	0.17	0.87	0	0	0
Cistaceae	*Helianthemum brasiliense* (Lam.) Pers.	perennial	1.85	0.6	2.45	2.06	0.59	2.66	0.7	0.17	0.87	0	0	0
Commelinaceae	*Commelina diffusa* Burm. f.	perennial	0.26	0.09	0.35	0	0	0	0	0	0	1.18	0.26	1.43
	Commelina erecta L.	biannual or perennial	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
Convolvulaceae	*Dichondra macrocalyx* Meisn.	perennial	0.26	0.09	0.35	1.47	0.76	2.24	1.05	0.26	1.31	0	0	0
	Dichondra sericea Sw.	perennial	0.26	0.09	0.35	0.29	0.08	0.38	2.1	2	4.1	2.75	0.6	3.35
	Evolvulus sericeus Sw.	perennial	2.38	0.77	3.15	2.06	0.59	2.66	2.45	0.61	3.06	1.96	0.43	2.39
Cyperaceae	*Abildgaardia ovata* (Burm. f.) Kral	perennial	0.26	0.09	0.35	0.29	0.08	5.29	0	0	0	0	0	0
	Bulbostylis capillaris (L.) C.B. Clarke	annual	0.53	0.17	0.7	0.29	0.08	0.38	0	0	0	0	0	0
	Carex phalaroides Kunth	perennial	1.06	0.34	1.4	0	0	0	0.7	0.17	0.87	1.57	0.69	2.26
	Eleocharis viridans Kük. ex Osten	perennial	0.26	0.09	0.35	0.29	0.08	0.38	0.35	0.09	0.44	0.39	0.86	1.25
	Fimbristylis dichotoma (L.) Vahl	annual	0.53	0.17	0.7	0	0	0	0	0	0	0	0	0
	Kyllinga odorata Vahl	perennial	0	0	0	0.29	0.08	0.38	0.7	0.17	0.87	0.39	0.09	0.48
	Rhynchospora sp.	perennial	0	0	0	0.29	0.08	5.29	0	0	0	0	0	0
	Rhynchospora tenuis Willd. ex Link	perennial	0	0	0	0	0	0	0	0	0	0	0	0
Euphorbiaceae	*Euphorbia selloi* (Klotzsch & Garcke) Boiss.	perennial	0.26	0.09	0.35	0.29	0.08	0.38	0	0	0	0.39	0.09	0.48
	Tragia bahiensis Müll. Arg.	perennial	0.26	0.09	0.35	0.59	0.17	10.6	0.35	0.09	0.44	0.39	0.09	0.48
Fabaceae	*Chamaecrista repens* (Vogel) H.S. Irwin & Barneby	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0.78	0.17	0.96
	Clitoria nana Benth.	perennial	1.85	0.6	2.45	0.88	0.25	15.9	0.7	0.17	0.87	0	0	0
	Desmanthus virgatus (L.) Willd.	perennial	0.53	0.17	0.7	2.06	0.93	3	0	0	0	0.39	0.09	0.48
	Desmodium incanum (Sw.) DC.	perennial	2.12	1.02	3.14	1.77	1.19	2.96	2.8	1.74	4.54	2.35	1.55	3.9
	Galactia marginalis Benth.	perennial	0.53	0.17	0.7	0	0	0	0.35	0.09	0.44	0.39	0.09	0.48
	Galactia pretiosa Burkart	perennial	0	0	0	0	0	0	0.35	0.09	0.44	0	0	0
	Macroptilium prostratum (Benth.) Urb.	perennial	0.79	0.26	1.05	0	0	0	0	0	0	0	0	0

	Pomaria pilosa (Vogel) B.B. Simpson & G.P. Lewis	perennial	0	0	0	0.59	0.17	0.76	0.35	0.87	1.22	0	0	0
	Pomaria stipularis (Vogel) B.B. Simpson & G.P. Lewis	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0	0	0
	Stylosanthes leiocarpa Vogel	perennial	1.59	0.85	2.44	1.18	0.34	1.52	0.35	0.09	0.44	0	0	0
	Stylosanthes montevidensis Vogel	perennial	0.53	0.17	0.7	0	0	0	1.75	0.43	2.18	1.57	0.34	1.91
	Trifolium polymorphum Poir.	perennial	0.26	0.09	0.35	0	0	0	0.35	0.09	0.44	0	0	0
Hypoxidaceae	*Hypoxis decumbens* L.	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0	0	0
Iridaceae	*Cypella* sp.	perennial	1.32	0.43	1.75	0	0	0	0.7	0.17	0.87	0.78	0.17	0.96
	Herbertia pulchella Sweet	perennial	1.06	0.68	1.74	0.88	0.59	35.9	0.35	0.09	0.44	1.96	0.43	2.39
	Sisyrinchium micranthum Cav.	annual	2.12	0.68	2.8	0.59	0.17	0.76	0.35	0.09	0.44	1.18	0.26	1.43
	Sisyrinchium ostenianum Beauverd	annual	1.06	0.34	1.4	0	0	0	0	0	0	0	0	0
	Sisyrinchium sellowianum Klatt	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0.39	0.09	0.48
Juncaceae	*Juncus capillaceus* Lam.	annual	1.59	0.51	2.1	0	0	0	1.05	0.26	1.31	0.39	0.09	0.48
Lamiaceae	*Peltodon longipes* Kunth ex Benth.	perennial	0.53	0.17	0.7	1.77	0.51	2.28	0	0	0	0.39	0.09	0.48
	Scutellaria racemosa Pers.	annual	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
Linaceae	*Cliococca selaginoides* (Lam.) C.M. Rogers & Mildner	perennial	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
Lythraceae	*Cuphea glutinosa* Cham. & Schltdl.	annual	0.26	0.43	0.69	0	0	0	0	0	0	0	0	0
Malvaceae	*Krapovickasia flavescens* (Cav.) Rfyxell	perennial	0.26	0.09	0.35	0.59	0.17	0.76	0	0	0	0.39	0.09	0.48
Melastomataceae	*Tibouchina gracilis* (Bonpl.) Cogn.	perennial	0	0	0	0.59	0.17	0.76	0.7	0.17	0.87	0.78	0.17	0.96
Myrtaceae	*Psidium salutare var. mucronatum* (Cambess.) Landrum	perennial	0	0	0	1.47	1.53	3	0	0	0	0.39	0.09	0.48
Orchidaceae	*Habenaria parviflora* Lindl.	perennial	0.79	0.26	1.05	0.59	0.51	1.1	0.35	0.09	0.44	0	0	0
	Orchidaceae	perennial	0.26	0.09	0.35	0	0	0	0	0	0	0	0	0
	Skeptrostachys arechavaletanii (Barb. Rodr.) Garay	perennial	0.53	0.17	0.7	0	0	0	0	0	0	0	0	0
Oxalidaceae	*Oxalis brasiliensis* G. Lodd.	perennial	0	0	0	1.47	0.42	1.9	0.7	0.17	0.87	1.18	0.26	1.43
	Oxalis conorrhiza Jacq.	perennial	1.59	0.51	2.1	1.18	0.34	1.52	0.35	0.09	0.44	0.39	0.09	0.48
	Oxalis eriocarpa DC.	perennial	2.12	1.02	3.14	1.18	0.34	1.52	0.35	0.09	0.44	0.39	0.09	0.48
	Oxalis lasiopetala Zucc.	perennial	1.06	0.34	1.4	0.59	0.17	0.76	0.7	0.17	0.87	0.78	0.17	0.96

	Oxalis perdicaria (Molina) Bertero	perennial	1.06	0.34	1.4	0.29	0.08	5.29	0.35	0.09	0.44	0	0	0
Passifloraceae	*Piriqueta suborbicularis* (A. St.-Hil. & Naudin) Arbo	perennial	0.53	0.17	0.7	0.29	0.08	0.38	0.35	0.09	0.44	0	0	0
	Turnera sidoides L.	perennial	0.26	0.09	0.35	1.18	0.68	41.2	0	0	0	0	0	0
Plantaginaceae	*Mecardonia tenella* (Cham. & Schltdl.) Pennell	perennial	0	0	0	0.29	0.08	0.38	0.35	0.09	0.44	0.39	0.43	0.82
	Plantago myosuros Lam.	annual	0.26	0.09	0.35	0.88	0.25	1.14	0	0	0	0	0	0
	Plantago tomentosa Lam.	perennial	1.59	0.51	2.1	0.88	0.25	1.14	0.7	0.17	0.87	0	0	0
Poaceae	*Andropogon lateralis* Nees	perennial	1.59	2.3	3.89	2.95	18.2	21.2	3.5	11.5	15	3.92	21	25
	Andropogon selloanus (Hack.) Hack.	perennial	0	0	0	0.29	0.42	0.72	0.7	0.17	0.87	0	0	0
	Andropogon ternatus (Spreng.) Nees	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0	0	0
	Andropogon virgatus Desv. ex Ham.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.43	0.82
	*Andropogon*sp.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.86	1.25
	Aristida filifolia (Arechav.) Herter	perennial	0	0	0	0.29	0.08	5.29	1.05	6.17	7.22	2.35	7.47	9.83
	Aristida flaccida Trin. & Rupr.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.43	0.82
	Aristida jubata (Arechav.) Herter	perennial	0	0	0	0	0	0	0.7	3.48	4.18	0.39	1.72	2.11
	Aristida laevis (Nees) Kunth	perennial	0	0	0	0	0	0	2.45	12.3	14.7	1.57	8.59	10.2
	Aristida venustula Arechav.	perennial	0.79	0.26	1.05	0.59	0.93	1.52	2.1	1.22	3.32	0.78	0.95	1.73
	Axonopus affinis Chase	perennial	1.85	1.28	3.13	2.36	2.46	147	1.4	1.83	3.22	1.96	5.24	7.2
	Axonopus fissifolius (Raddi) Kuhlm.	perennial	0	0	0	0.88	2.2	3.09	0	0	0	0	0	0
	Bothriochloa laguroides (DC.) Herter	perennial	0	0	0	0.59	0.17	0.76	0.35	0.09	0.44	0	0	0
	Calamagrostis alba (J. Presl) Steud.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
	Chascolytrum poomorphum (J. Presl) L. Essi, Longhi-Wagner & Souza-Chies	perennial	0	0	0	1.47	0.42	1.9	0	0	0	0.39	0.09	0.48
	Chascolytrum subaristatum (Lam.) Desv.	perennial	0.26	0.09	0.35	0	0	0	1.4	0.7	2.09	3.53	1.12	4.65
	Chascolytrum uniolae (Nees) L. Essi, Longhi-Wagner & Souza-Chies	perennial	0	0	0	0	0	0	0.35	0.09	0.44	0	0	0
	Danthonia cirrata Hack. & Arechav.	perennial	0	0	0	0	0	0	1.05	0.26	1.31	0	0	0
	Dichanthelium sabulorum (Lam.)	perennial	0.26	0.09	0.35	0.59	0.17	0.76	3.15	0.78	3.93	3.14	3.35	6.49

	Gould & C.A. Clark													
	Digitaria violascens Link	annual	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
	Elionurus candidus (Trin.) Hack.	perennial	0	0	0	0	0	0	0	0	0	1.18	2.75	3.93
	Eragrostis neesii Trin.	annual or biannual	0.53	0.17	0.7	0.29	0.08	0.38	0	0	0	0	0	0
	Eragrostis plana Nees	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0	0	0
	Melica brasiliana Ard.	perennial	2.12	0.68	2.8	2.36	1.69	4.05	0	0	0	0	0	0
	Mnesithea selloana (Hack.) de Koning & Sosef	perennial	0.79	0.26	1.05	0.29	0.08	0.38	0	0	0	1.18	0.26	1.43
	Paspalum dilatatum Poir.	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0.39	0.09	0.48
	Paspalum nicorae Parodi	perennial	0	0	0	2.06	12.8	14.9	0	0	0	0	0	0
	Paspalum notatum Alain ex Flüggé	perennial	2.65	19.6	22.2	1.18	2.63	3.81	2.8	7.48	10.3	2.35	1.55	3.9
	Paspalum paucifolium Swallen	perennial	2.38	18.7	21.1	2.06	2.37	4.44	0.7	0.52	1.22	0	0	0
	Paspalum plicatulum Michx.	perennial	0	0	0	0	0	0	2.45	1.74	4.19	2.75	2.06	4.81
	Paspalum pumilum Nees	perennial	0	0	0	0	0	0	0	0	0	0.78	0.52	1.3
	Paspalum umbrosum Trin.	perennial	0	0	0	0	0	0	0.7	0.52	1.22	0	0	0
	*Paspalum*sp. L.	perennial	0	0	0	0.29	0.08	0.38	0.35	0.09	0.44	0	0	0
	Piptochaetium bicolor (Vahl) E. Desv.	perennial	0	0	0	2.65	4.92	7.57	0	0	0	0	0	0
	Piptochaetium montevidense (Spreng.) Parodi	perennial	2.65	7.66	10.3	0.29	0.08	5.29	3.5	6.26	9.76	3.14	3.95	7.09
	Piptochaetium stipoides (Trin. & Rupr.) Hack. ex Arechav.	perennial	0	0	0	0.29	0.08	0.38	0.35	0.09	0.44	0.78	0.17	0.96
	Saccharum angustifolium (Nees) Trin.	perennial	2.65	3.06	5.71	0	0	0	1.05	0.26	1.31	0.78	0.17	0.96
	Schizachyrium tenerum Nees	perennial	0	0	0	0	0	0	0.7	3.91	4.61	0.39	0.43	0.82
	Setaria parviflora (Poir.) Kerguélen	Annual	1.06	0.34	1.4	1.77	0.51	2.28	1.4	0.7	2.09	0.78	0.17	0.96
	Setaria vaginata Spreng.	perennial	0	0	0	1.18	0.34	1.52	0	0	0	0.39	0.43	0.82
	Sorghastrum sp.	perennial	0	0	0	0.88	0.25	1.14	0	0	0	0.39	0.09	0.48
	Sporobolus indicus (L.) R. Br.	perennial	0.26	0.09	0.35	0.29	0.42	0.72	0	0	0	0	0	0
	Steinchisma hians (Elliott) Nash	perennial	0	0	0	0	0	0	1.05	0.26	1.31	2.35	0.86	3.21
	Stipa nutans Hack.	perennial	0	0	0	0.29	0.08	0.38	0.7	0.17	0.87	0.39	0.09	0.48

	Stipa setigera J. Presl	perennial	0	0	0	0.59	0.17	10.6	1.05	0.61	1.66	1.57	3.61	5.18
Polygalaceae	*Polygala australis* A.W. Benn.	annual	2.38	0.77	3.15	0	0	0	1.05	0.26	1.31	0	0	0
Rubiaceae	*Borreria dasycephala* (Cham. & Schltdl.) Bacigalupo & E.L. Cabral	perennial	0.26	0.85	1.12	2.06	3.98	6.05	0	0	0	0	0	0
	Borreria eryngioides Cham. & Schltdl.	perennial	0	0	0	0	0	0	0	0	0	0.39	0.09	0.48
	Galianthe fastigiata Griseb.	perennial	0.53	0.51	1.04	0	0	0	0	0	0	0.39	0.09	0.48
	Galium hirtum Lam.	annual	0	0	0	0.29	0.08	0.38	0.7	0.17	0.87	0	0	0
	Galium richardianum (Gillies ex Hook. & Arn.) Endl. ex Walp.	perennial	0.53	0.17	0.7	0.59	0.51	1.1	0.7	0.17	0.87	2.35	0.52	2.87
	Richardia brasiliensis Gomes	perennial	0	0	0	0.29	0.08	0.38	0	0	0	0.39	0.09	0.48
	Richardia grandiflora (Cham. & Schltdl.) Steud.	perennial	0	0	0	0	0	0	0.35	0.09	0.44	0	0	0
	Richardia humistrata (Cham. & Schltdl.) Steud.	perennial	0	0	0	1.77	1.19	2.96	1.05	0.26	1.31	1.18	0.26	1.43
	Richardia stellaris (Cham. & Schltdl.) Steud.	perennial	2.65	1.53	4.18	0	0	0	0.35	0.09	0.44	0.39	0.09	0.48
	Spermacoce verticillata (L.) G. Mey.	perennial	0	0	0	0.88	0.59	1.48	0.35	0.09	0.44	0.78	0.17	0.96
Verbenaceae	*Glandularia marrubioides* (Cham.) Tronc.	perennial	1.06	0.34	1.4	0.29	0.08	0.38	0	0	0	0	0	0
—	NI	—	0	0	0	0.59	0.17	0.76	0.7	0.17	0.87	0	0	0

CONSIDERAÇÕES FINAIS

Os resultados do nosso estudo demonstram que as diferenças entre as intensidades de pastejo causam poucas mudanças ao banco de sementes no solo (BSS), ao contrário do que se observa na vegetação estabelecida, aonde estrutura e composição variam consideravelmente entre tratamentos. As diferenças no BSS foram observadas principalmente entre o tratamento 4% em relação às demais, devido às diferenças no consumo da biomassa vegetal entre a maior e as menores intensidades de pastejo, o que se reflete na estrutura da vegetação.

De acordo com outros estudos, as áreas com distúrbio apresentam maior densidade e riqueza em comparação às commanejo menos intensivo ou quase abandonadas. Estes parâmetros também se mostraram mais baixos em comparação a estudos feitos em áreas com maior umidade, devido à estrutura e composição da vegetação estabelecida, mas semelhantes a trabalhos feitos em campos secos.

A metodologia pela emergência de plântulas mostrou-se eficiente, sendo importante para identificação correta das plantas vegetais ao nível de espécies e melhor avaliação da classificação quanto a sua persistência no solo.

O estudo do BSS continua uma área difícil e certamente existem limitações e incertezas no que diz respeito dos métodos, fazendo se necessário uma padronização da metodologia. Entre as dificuldades, encontram-se a necessidade de um acompanhamento por um longo tempo, principalmente para avaliação quanto à persistência no solo e desenvolvimento das estruturas reprodutivas para identificação correta das espécies. Além do risco de que algumas sementes não germinarem, devido à falta o estímulo certo para a quebrada da dormência.

Portanto, o trabalho contribui para um melhor conhecimento sobre o BSS e os processos que o determinam, agregando mais informações às conclusões já vistas em outros trabalhos sobre o tema.

Para futuros trabalhos, se sugere como estudo complementar a análise do banco de meristemas (*bud bank*), já que é comum em ambientes campestres espécies com regeneração vegetativa e como efeito do distúrbio age sobre cada banco e se há semelhança nos resultados. Além disso, um trabalho de revisão abrangendo os estudos de banco de sementes já feitos para os biomas campestres de ecossistemas campestres nas regiões tropicais ou subtropicais parece algo que será importante, considerando a escassez de estudos e o fato que muito do conhecimento geral sobre o BSS é originário do hemisfério norte.