Neotropical Biology and Conservation
5(1):3-9, january-april 2010
© by Unisinos - doi: 10.4013/nbc.2010.51.01

Comparison between grassland communities with and without disturbances

Comparação de comunidades campestres com e sem influência de distúrbios

Ronei Baldissera[1]
roneibaldissera@yahoo.com.br

Leila Fritz[2]
leilafritz@gmail.com

Rita Rauber[3]
ritarauber@yahoo.com.br

Sandra C. Müller[3]
sandra.muller@ufrgs.br

Resumo

O manejo do campo com pastejo e fogo é considerado um dos principais fatores determinantes da fisionomia e composição de ecossistemas campestres. Nesse sentido, pode-se esperar que distúrbios intermediários, não frequentes e/ou intensos, nem ausentes, contribuam para aumentar a diversidade das comunidades campestres pelo relaxamento da exclusão competitiva. O presente estudo analisou o efeito da exclusão de distúrbios em campos do Planalto Sul Brasileiro, no Rio Grande do Sul. Dois campos foram amostrados: um excluído de distúrbios há 16 anos e outro com ocorrência de distúrbios (fogo e pastejo). Em cada área foram utilizadas seis parcelas de 1m2. Dentro de cada parcela foi analisada a composição, a riqueza e a equabilidade da vegetação com base em medidas de cobertura das espécies. A análise dos dados revelou que o campo com distúrbios apresentou maior riqueza e maior equabilidade. Verificou-se diferença na composição das espécies que ocorreram nos dois tipos de campo, com diminuição da dominância de plantas cespitosas no campo com distúrbios. Além disso, as parcelas foram mais homogêneas na área com distúrbios, mostrando baixa substituição das espécies, apesar de elevada riqueza. Conclui-se que a dominância de plantas cespitosas no campo excluído tende a suprimir outras plantas herbáceas, diminuindo a riqueza e a equabilidade. A presença de distúrbios, contudo, mantém as cespitosas com menor tamanho, o que propicia condições para o desenvolvimento de outras espécies herbáceas.

Palavras-chave: manejo de campo, fogo, pastejo, distúrbio intermediário.

Abstract

Grassland management with fire and grazing is considered one of the main factors determining plant physiognomy and composition in grassland ecosystem. In that sense, it is thought that intermediate disturbances, neither high frequent and/or intense, nor absent, could enhance grasslands diversity by diminishing the competitive exclusion. Therefore, the present study evaluated the effect of disturbance exclusion over grassland plant communities in Plateau region of Southern Brazil. Two grasslands were sampled: one excluded of disturbances over the past 16 years, and other with fire and grazing disturbances. Six plots (1m^2) were sorted inside each area. Inside each plot, plant species composition was described, while plant richness and evenness were assessed based on cover proportion of each species. The data analysis showed that the grassland without

[1] Laboratório de Ecologia de Populações e Comunidades, Programa de Pós-Graduação em Ecologia. Universidade Federal do Rio Grande do Sul – UFRGS, Av. Bento Gonçalves 9500, 91540-000, Porto Alegre, RS, Brasil.
[2] Laboratório de Microbiologia, Universidade do Vale do Rio dos Sinos – UNISINOS. Av. Unisinos, 950, 93022-000, São Leopoldo, RS, Brasil.
[3] Laboratório de Ecologia Quantitativa e Vegetal, Programa de Pós-Graduação em Ecologia, Universidade Federal do Rio Grande do Sul – UFRGS, Av. Bento Gonçalves 9.500, 91540-000, Porto Alegre, RS, Brasil.

disturbances presented higher richness and evenness. Furthermore, there were differences in the species composition between the grasslands, with less tussock dominance in the disturbed grassland. In addition, plots' compositions were more homogeneous in areas submitted to disturbances, despite of the high richness. It is concluded that dominant tussock grasses in the grassland without disturbances suppressed many forbs, leading to reducing the species richness and evenness. On the other hand, the presence of disturbances limits the tussocks growth allowing the development of other forbs species.

Key words: grassland management, fire, cattle grazing, intermediate disturbance.

Introduction

Estimates about the number of phanerophytes species in Southern Brazil grassland ecosystems indicate the presence of *ca.* 3,000 to 4,000 species (Boldrini, 1997; Klein, 1975). In spite of this great diversity, conservation polices of these ecosystems are not adequate with only 0.05% of grasslands inside full protected areas in Rio Grande do Sul State (RS) (Overbeck *et al*., 2007). In Southern Brazil, grassland physiognomies occur mainly in the Southern half of RS, corresponding to Pampa biome (Brazilian biome's classification: IBGE, 2004), but they also occur associated with South Brazilian Plateau forest formations, especially in Northern half of RS and in Santa Catarina State, forming mosaics with Araucaria Forest (Mixed Ombrophyllus Forest). In this region, grasslands are known as Altitude Grasslands or Mountain Summit Grasslands ("Campos de Cima da Serra") and are part of the Atlantic Forest biome (Teixeira *et al*., 1986; Overbeck *et al*., 2007). These grasslands physiognomies of Southern Brazil are referred here as *Campos* or just grasslands.

Under the present climatic conditions in Southern Brazil, a major factor determining the physiognomy and floristic composition of grasslands is the management with fire and grazing, either combined or not, aiming mainly beef cattle production. Cattle production on native grasslands is still one of the main economic activities at Campos regions of Southern Brazil (Pillar and Quadros, 1997; Pillar *et al*., 2006). However, there is a thin line to achieve a sustainable grazing regime, so that the balance between foraging production, biodiversity, and soil protection must be considered in grassland management (Heringer and Jacques, 2002b; Jacques, 2003; Pillar *et al.*, 2006).

In many grassland ecosystems fire increases the species richness, which can peak few years after a fire event. This greater richness can be achieved by the presence of great numbers of opportunistic, pioneer, annual and perennial species (Vogl, 1974; McIntyre *et al*., 2003), or by the development of interstitial species, mainly little herbs, that are able to grow due to the opening of dominant grasses canopy (Overbeck *et al*., 2006). Changes in floristic composition (Eggers and Porto, 2004; Heringer and Jacques, 2002a), forage production (Heringer and Jacques, 2002b), and soil characteristics (Heringer *et al*., 2002; Jacques, 2003) have been recorded in studies approaching management effects in RS grasslands areas. However, experimental studies on fire management effects in natural Campos vegetation mainly associated to the intensity, frequency and time of burning are still scarce (Overbeck *et al*., 2005, 2007).

Therefore, disturbances associated to fire and grazing may be important to the maintenance of the structure and diversity of natural open ecosystems if they are not very frequent and/or intense. In that sense, it could be expected to record an increase in species diversity due to the decreasing dominance of one or more species – strong competitors that tend to competitively exclude other species –, and the increasing spatial heterogeneity (Connell and Slatyer, 1977). Therefore, the present study preliminarily investigate the effect of disturbance exclusion (fire and grazing) on a grassland plant community, considering species composition, richness and evenness, by comparing an area with present disturbances and another without them for the past 16 years. Main hypothesis is that the area with disturbances could present greater plant species diversity and a distinct floristic composition considering the area without the disturbances.

Methods

Study area

The area without disturbances is located inside the Pró-Mata Research and Conservation Center (CPCN Pró-Mata) in the municipality of São Francisco de Paula (*ca.* 900 m.a.s.l.) under the coordinates 29°28'S e 50°13'W. The CPCN Pró-Mata has a total area of 4,500 ha showing a natural mosaic of Araucaria Forest and grasslands (Oliveira and Pillar, 2004). Grassland areas are excluded of burning and grazing since 1993. Due to disturbance exclusion, it is observed the accumulation of plant biomass (a dense layer of grasses with *ca.* 1 m height) in the areas once covered by low grasslands as well as an encroachment of woody species, shrubs (mainly *Baccharis uncinela*; Asteraceae) and pioneer forest trees (such as *Araucaria angustifolia* and *Myrsine lorentziana*) into the grasslands (Oliveira and Pillar, 2004; Overbeck *et al*., 2005). The area with disturbances is a nearby cattle farm, which usually manages native grassland vegetation with cattle grazing and supposedly fire (Figure 1). The climate is temperate, mesothermic and superhumid, with mean annual temperature of 14.5 °C, and mean annual rainfall of *ca.* 2,250 mm (Nimer, 1989).

Data collection

Inside each one of the grassland areas, six plots of 1 m^2 distant *ca.* 10 m of each other were sorted. Cover of all plant species was recorded in each plot and whenever possible they were identified to species or genus level. Aboveground species cover was estimated using a scale method of percentage intervals (adapted from Mueller-Dombois and Ellenberg, 1974) as follows: 1 = <1% cover; 2 = 1 to 5%; 3 = 5 to 12.5%; 4 = 12.5 to 25%; 5 = 25 to 50%; and 6 = 50 to 100%.

Data analysis

A matrix of species cover by sampling units (plots) was organized. To compare the grassland community areas with and without disturbances with respect to the floristic composition, multivariate analyses were performed utilizing the software MULTIV (Pillar, 2004). A dissimilarity matrix between sampling units using chord distance index (Podani, 2000) was calculated to evaluate the floristic composition variation (MANOVA) between both grasslands by a randomization test (1,000 iterations). Using the same distance matrix, a Principal Coordinate Analysis was done to visualize the distribution pattern of sampling units according to species cover values with the ordination axes being tested for stability by bootstrap method (Pillar, 1999).

Richness and evenness of both grassland community areas were individually compared by one-way analysis of variance (ANOVAs) via randomization tests (1,000 iterations). Evenness was estimated with the Pielou Index (J = H'/ln S; where H' is the Shannon Index value, ln is the natural logarithm, and S is the sampling unit species richness) (Magurran, 1988). In order to visualize the species abundance distribution patterns of the two communities, two rank-abundance curves were done based on the logarithm of species relative cover values (Magurran, 1988).

Figure 1. Photograph showing the grassland without disturbances (left side), in the CPCN Pró-Mata, and the grassland with disturbances (right side) in São Francisco de Paula, Rio Grande do Sul (photo by Ronei Baldissera).

Results

Species richness and floristic cover patterns

A total of 49 plant species was counted in the two grasslands (Table 1). Richness in the grassland with disturbances was significantly greater (mean 23 ± 1.24 standard error) than the richness in the grassland without disturbances (9.67 ± 1.69) (SS = 533.33; P = 0.01; Figure 2).

The grass *Andropogon lateralis* presented the greater general relative cover value (58.89%), and also presented the greater relative cover in each one of the grasslands (Table 1), although its performance was more prominent in the grassland without disturbances (40.85% *versus* 18.05% in the area with disturbances). Taking into account only exclusive species, *Eryngium horridum* was the species with greater relative cover in the grassland without disturbances (11.27%), while *Rhynchospora flexuosa* presented greater cover in the grassland with disturbances (13.53%). Evenness in the grassland without disturbances (0.8 ± 0.01) was significantly lower than in the grassland with disturbances (0.91 ± 0.01) (SS = 0.035; P = 0.003; Figure 2). In the grassland without disturbances *Andropogon lateralis* showed a relative cover *ca.* 3.5 fold greater than the species with the second major relative cover (*Eryngium horridum*). On the other hand, in the grassland with disturbances, the cover of *A. lateralis* was only 1.3 fold greater than the cover of the second species (*Rynchospora flexuosa*), and only 2.4 fold greater than the cover of the third species (*Paspalum plicatulum*) (Figure 3).

Floristic composition

The MANOVA showed a significant difference between the two grassland floristic compositions (SS = 1.57;

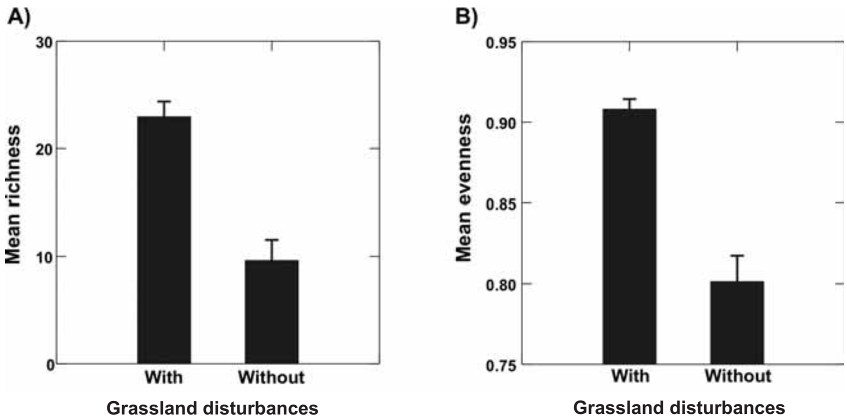

Figure 2. Mean richness (species.m-2) ± standard error (A) and mean evenness (Pielou Index) ± standard error of plant species (B) sampled in grassland areas with and without disturbances in São Francisco de Paula, Rio Grande do Sul.

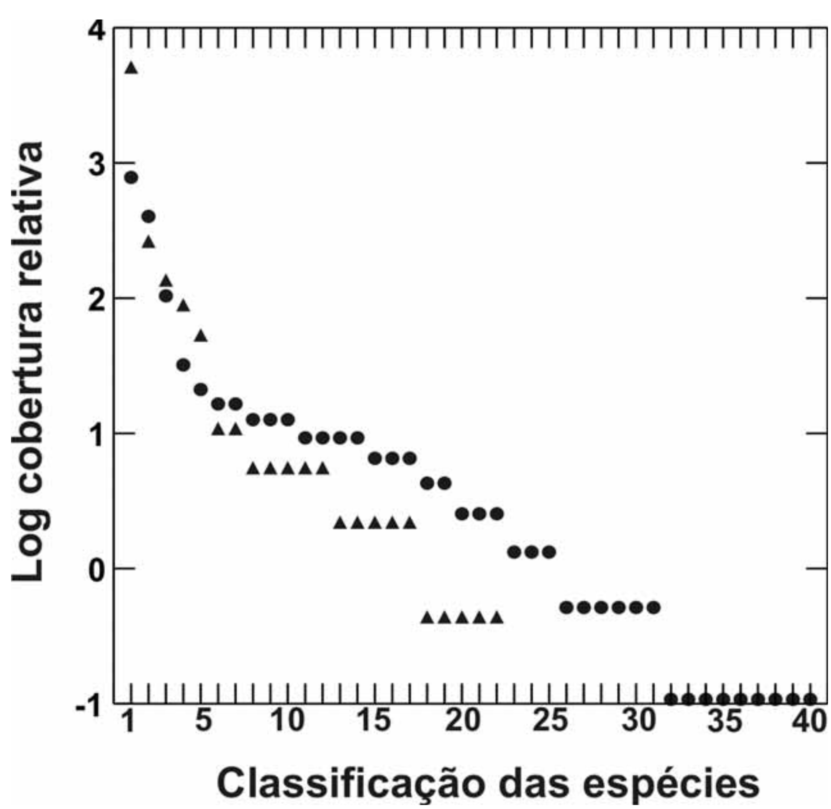

Figure 3. Rank abundance curves of relative cover of species sampled in grassland areas with disturbances (circles) and without disturbances (triangles) in São Francisco de Paula, Rio Grande do Sul. See Table 1 to the respective species rank abundance.

P = 0.003). The difference can be clearly observed along the first axis of the dispersion diagram of ordination analysis (Figure 4). The first ordination axis explained 52.8% of variation and it was significantly stable by bootstrap test (P = 0.077). Plots of the grassland with disturbances were kept together on the left side of ordination axis 1 (Figure 4). Species that best described the composition of the samples of grassland with disturbances were *Rynchospora flexuosa*, *Trichocline catharinensis*, *Sysirinchium* sp. and *Paspalum plicatulum* (Figure 4).

The most part of grassland without disturbances composition was characterized by the dominance of *A. lateralis* (Table 1, Figure 4). However, it was observed a variation in species composition along the second ordination axis. Two plots were separated from the others by the presence of *Eryngium horridum*, which occupied great part of these sampling units because of its size in the excluded grassland areas.

Discussion

Concordant with the expectations, differences were found in the two community structures. Grassland with disturbances presented the greatest species richness and evenness, and the species composition of each community was also different.

The greatest species richness and evenness found in the grassland with disturbances could be a combined result of the exclusion of strong competitive species and of the increasing spatial and nutrient availability (*e.g.* light). The latter characteristic could allow high establishment rates of disturbed plots by opportunistic species, while the former characteristic could allow a small local extinction by the lack (or continuous delayed) of competitive exclusion process, which could prevent the dominance of most efficient species in resource exploitation in the latter stages of succession (Connell and Stalyer, 1977; Overbeck *et al*., 2005). In the present study, this statement is justified by the extremely increase in the cover of *A. lateralis* in the grassland without disturbances with consequently decrease of local species richness and evenness. Similar pattern of the *A. lateralis* grass was verified by Pott (1974), who found that its relative cover in grasslands without disturbance was 5.8%, while in the presence of grazing disturbance, it was only 2.4%.

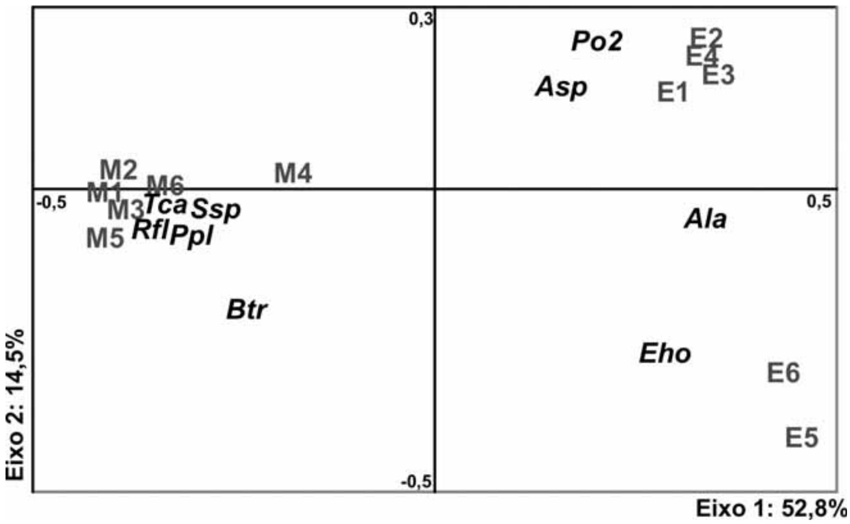

Figure 4. Ordination diagram based on Principal Coordinates Analysis of sampling units in grassland areas without (E) and with disturbances (M) described by 49 plant (morpho-) species. The species more correlated with the first and second ordination axes are disposed proportionally in the diagram. Abbreviations: *Rfl, Rynchospora flexuosa; Tca, Trichocline catharinensis; Ssp, Sysirinchium* sp.*; Ppl, Paspalum plicatulum; Btr, Baccharis trimera; Asp, Aristida sp.; Po2, Poaceae* sp.2*; Ala, Andropogon lateralis; Eho, Eryngium horridum.*

In the present study, although not all species were identified, we found 27 exclusive species of the grassland with disturbances. The presence of Asteraceae species, like the now surveyed *Vernonia* spp., *Chaptalia runcinata* and *Trichocline catharinensis*, have been as well stand out in disturbed grasslands in comparison to areas where fire disturbance was longer excluded in a granitic hill around Porto Alegre region (Morro Santana) (Overbeck *et al*., 2005, 2006; Fidelis *et al*., 2007). Such kinds of species present a rosette growing form demanding space and great luminosity (canopy opening) to a proper development. Fidelis *et al*. (2007) named the presence of xylopodium and others belowground structures of reserve that are forming a bud bank, as an important feature explaining this pattern because such plant species are able to resprouting after the loss of aerial biomass. Therefore, they support well fire and grazing disturbance in spite of the frequently loss of some aboveground biomass. Besides these species, some Cype raceae species were also found only in the disturbed grassland plots, underlining *R. flexuosa* that should have had an advantage by the decreasing of the tussock species cover like *A. lateralis* and *Sorghastrum setosum*, which obtain very high sizes in excluded grasslands.

Analyzing the individual cover of the three most frequent Poaceae in the two grasslands, *A. lateralis*, *Schizachyrium tenerum* and *Axonopus ciccus*, it could be observed that the proportional cover difference between the two environments remains the same. It may indicate that, as time passes, some pioneer species, although perennial, could be able to survive, grow and inhibit the growth of other species present in early post-disturbance phases (Connell and Slatyer, 1977). That fact also suggests a great regeneration ability of native vegetation in Southern Brazil grasslands, showing resilient communities adapted to the current fire and grazing regimes (Overbeck *et al*., 2005). Grasses are pointed like the plant family most adapted to burn, mainly because of the quickly regeneration ability after disturbance (Vogl, 1974; Coutinho, 1994; Trindade and Rocha, 2002; Pelaez *et al*., 2003). According to Bond and Midgley (1995), grasses evolved under the influence of burn, they are highly flammable, and by being the main fire fuel, they eliminate neighbor plants (even for a moment) and reoccupy rapidly the space. This is due to the continuous growth of intercalary meristems at the base of leaves and to new tillers arising from protected meristems underground or in the base of persistent leave sheaths (Bond and Wilgen, 1996), which also favors them under continuous grazing. However, it could suggest the importance of disturbance frequency and/or the intensity (magnitude) to the observed changes in species composition and structure (Pickett and White, 1985; Pucheta *et al*., 1998). Sampling units of grassland with disturbances were closed together in the dispersion diagram outpointing a higher spatial homogeneity in the community composition (smaller β-diversity) with the supremacy of resistant species, while plots with less frequent or intensive disturbances tend to show a greater heterogeneity. Such a feature could lead to patch mosaic vegetation with different community structures and compositions. Nevertheless, as time since disturbance exclusion increases the tendency of dominance, big sized tussock plants increase as well, stabilizing and once again homogenizing the grassland community (Overbeck *et al*., 2005).

Hence, in order to maintain a high local diversity (α-diversity) with spatial heterogeneity (β-diversity), the disturbances upon grassland vegetation should be at the intermediate level, not so frequent and intense to limit plant community to the presence of species extremely tolerant to disturbances (opportunistic and ruderal) nor completely absents to result in the predominance of tussock grasses. The high diversity observed in the grassland with fire and grazing seems to emphasize the importance of intermediate disturbance conditions to grassland communities. Moreover, the completely absence of

Table 1. List of species (taxa), their respective families and relative cover values (%) surveyed in grassland areas with disturbances and without disturbances in São Francisco de Paula, Rio Grande do Sul.

Family	Species (taxa)	With disturbances	Without disturbances
Apiaceae	*Eryngium horridum*	11.268	-
Poaceae	*Sorghastrum setosum*	2.1127	-
Poaceae	Poaceae sp.2	2.1127	-
Poaceae	*Dichanthelium sabulorum*	2.1127	-
Poaceae	*Aristida* sp.	1.4085	-
Asteraceae	Asteraceae sp.	0.7042	-
Poaceae	Poaceae sp.1	0.7042	-
Poaceae	*Axonopus* cf. *argentinus*	0.7042	-
Asteraceae	*Chevreulia acuminata*	0.7042	-
Cyperaceae	*Rhynchospora flexuosa*	-	13.534
Poaceae	*Paspalum plicatulum*	-	7.5188
Asteraceae	*Trichocline catharinensis*	-	3.7594
Rubiaceae	*Galium humile*	-	3.3835
Polygalaceae	*Polygala brasiliensis*	-	3.0075
Cyperaceae	*Rhynchospora barrosiana*	-	2.6316
Iridaceae	*Sisyrinchium* sp.	-	2.2556
Asteraceae	*Baccharis cultrata*	-	2.2556
Cyperaceae	*Bulbostylis sphaerocephalus*	-	1.8797
Asteraceae	*Chaptalia runcinata*	-	1.5038
Poaceae	*Briza uniole*	-	1.5038
Asteraceae	*Calea phyllolepis*	-	1.1278
Poaceae	*Schizachyrium spicatum*	-	1.1278
Poaceae	*Paspalum dilatatum*	-	0.7519
Apiaceae	*Hydrocotyle exigua*	-	0.7519
Asteraceae	*Chevreulia sarmentosa*	-	0.7519
Cyperaceae	*Cyperus aggregatus*	-	0.7519
Cyperaceae	*Bulbostylis* sp.	-	0.7519
Asteraceae	*Vernonia* sp.	-	0.3759
Asteraceae	*Vernonia nudiflora*	-	0.3759
Poaceae	*Andropogon ternatus*	-	0.3759
-	Ni 1	-	0.3759
-	Ni 2	-	0.3759
Cyperaceae	*Killinga odorata*	-	0.3759
Melastomataceae	*Tibouchina* sp.	-	0.3759
Poaceae	Poaceae sp.3	-	0.3759
Poaceae	*Stipa* sp.	-	0.3759
Poaceae	*Andropogon lateralis*	40.845	18.045
Poaceae	*Schizachyrium tenerum*	8.4507	3.3835
-	Bryophyta sp.	7.0423	1.1278
Poaceae	*Axonopus ciccus*	5.6338	2.6316
Poaceae	*Briza poaemorpha*	2.8169	2.2556
Asteraceae	*Eupatorium ascendens*	2.8169	1.8797
Asteraceae	*Baccharis trimera*	2.1127	4.5113
Melastomataceae	*Tibouchina gracilis*	2.1127	3.0075
Polygalaceae	*Polygala australis*	1.4085	1.5038
Euphorbiaceae	Euphorbiaceae sp.	1.4085	3.0075
Asteraceae	*Lucilia acutifolia*	1.4085	2.6316
Asteraceae	*Chaptalia integerrima*	1.4085	2.6316
Orchidaceae	*Habenaria* sp.	0.7042	0.7519

fire and grazing disturbances on *Campos* vegetation in the Plateau region of Rio Grande do Sul gives conditions to the dynamic of Araucaria Forest expansion (Behling and Pillar, 2007), which could result in small regional diversity (γ-diversity) due to the predominance of forest systems in the landscape.

Acknowledgements

We would like to thank Pró-Mata staff (PUC-RS) that provides the field infrastructure to this research. One anonymous reviewer made valuable comments on the manuscript.

References

BEHLING, H.; PILLAR V.D. 2007. Late Quaternary vegetation, biodiversity and fire dynamics on the Southern Brazilian highland and their implication for conservation and management of modern Araucaria forest and grassland ecosystems. *Philosophical Transactions Royal Society B,* **362**:243-251.

BOLDRINI, I.I. 1997. Campos do Rio Grande do Sul: caracterização fisionômica e problemática ocupacional *Boletim do Instituto de Biociências UFRGS,* **56**:1-39.

BOND, W.J.; MIDGLEY, J.J. 1995. Kill thy neighbour: an individualistic argument for the evolution of flammability. *Oikos,* **73**:79-85.

BOND, W.J.; WILGEN, B.W. van. 1996. *Fire and plants*. London, Chapman & Hall, 263 p.

CONNELL, J.H.; SLATYER, R.O. 1977. Mechanisms of succession in natural communities and their role in community stability and organization. *American Naturalist,* **111**:1119-1144.

COUTINHO, L.M. 1994. O uso do fogo em pastagens naturais brasileiras. *In*: J.P. PUIGNAU (ed.), *Utilizacion y manejo de pastizales.* Montevideo, IICA-PROCISUR, p. 159-168.

EGGERS, L.; PORTO, M.L. 1994. Ação do fogo em uma comunidade campestre secundária, analisada em bases fitossociológicas. *Boletim do Instituto de Biociências da UFRGS,* **53**:1-88.

FIDELIS, A.; MÜLLER, S.C.; PILLAR, V.D.; PFADENHAUER, J. 2007. Efeito do fogo na ecologia de populações de herbáceas e arbustos dos campos sulinos. *Revista Brasileira de Biociências,* **5**(supl. 1):303-305.

HERINGER, I.; JACQUES, A.V.A. 2002a. Composição florística de uma pastagem natural submetida a queima e manejos alternativos. *Ciência Rural,* **32**:315-321.

HERINGER, I.; JACQUES, A.V.A. 2002b. Qualidade da forragem de pastagem nativa sob distintas alternativas de manejo. *Pesquisa Agropecuária Brasileira,* **37**:399-406.

HERINGER, I.; JACQUES, A.V.A.; BISSANI, C.A.; TEDESCO, M. 2002. Características de um latossolo vermelho sob pastagem natural sujeita à ação prolongada do fogo e de práticas alternativas de manejo. *Ciência Rural,* **32**:309-314.

IBGE, 2004. *Mapa da vegetação do Brasil e Mapa de biomas do Brasil*. IBGE. Available at: http://www.ibge.gov.br; accessed on 03/03/2009.

JACQUES, A.V.A. 2003. A queima das pastagens naturais - efeitos sobre o solo e a vegetação. *Ciência Rural,* **33**:177-181.

KLEIN, R.M. 1975. Southern Brazilian phytogeographic features and the probable influence of Upper Quaternary climate changes in the floristic distribution. *Boletim Paranaense de Geociências,* **33**:67-88.

MAGURRAN, A.E. 1988. *Ecological diversity and its measurement*. New South Wales, Royal Society University Research Fellow and University College of North Wales, 256 p.

McCINTYRE, S.; HEARD, K.M.; MARTIN, T.G. 2003. The relative importance of cattle grazing in subtropical grasslands: does it reduce or enhance plant biodiversity? *Journal of Applied Ecology,* **40**:445-457.

MUELLER-DOMBOIS, D.; ELLENBERG, H. 1974. *Aims and methods of vegetation ecology*. New York, John Wiley, 547 p.

NIMER, E. 1990. Clima. *In*: IBGE (org.). *Geografia do Brasil*: *Região Sul*. Rio de Janeiro, IBGE, p. 151-187.

OLIVEIRA, J.M.; PILLAR, V.D. 2004. Vegetation dynamics on mosaics of Campos and Araucaria forest between 1974 and 1999 in Southern Brazil. *Community Ecology* **5**:197-202

OVERBECK, G.E.; MÜLLER, S.C.; PILLAR, V.D.; PFADENHAUER, J. 2005. Fine-scale post-fire dynamics in South Brazilian subtropical grassland. *Journal. Vegetation Science,* **16**:655-664.

OVERBECK, G.E.; MÜLLER, S.C.; PILLAR, V.D.; PFADENHAUER, J. 2006. Floristic composition, environmentral variation and species distribution patterns in burned grassland in Southern Brazil. *Brazilian Journal of Biology,* **66**:1073-1090.

OVERBECK, G.E.; MÜLLER, S.C.; FIDELIS, A.; PFADENHAUER, J.; PILLAR, V.D.; BLANCO, C.C.; BOLDRINI, I.I.; BOTH, R.; FORNECK, E.D. 2007. Brazil's neglected biome: The South Brazilian Campos. *Perspectives in Plant Ecology, Evolution and Systematics,* **9**:101-116.

PELAEZ, D.V.; BOO, R.M.; ELIA, O.R.; MAYOR, M.D. 2003. Effect of fire on growth of three perennial grasses from central semi-arid Argentina. *Journal of Arid Environments,* **55**:657-673.

PICKETT, S.T.A.; WHITE, P. 1985. *The Ecology of Natural Disturbance and Patch Dynamics.* Orlando, Academic Press, 472 p.

PILLAR, V.D.; QUADROS, F.L.F. 1997. Grassland-forest boundaries in Southern Brazil. *Coenose,* **12**:119-126.

PILLAR, V.D. 1999. The bootstrap ordination reexamined. *Journal of Vegetation Science,* **10**:895-902.

PILLAR, V.D. 2004. *MULTIV: Multivariate exploratory analysis, randomization testing and bootstrap resampling. User´s Guide v. 2.3.10.* Porto Alegre, Departamento de Ecologia, UFRGS. Avaliable at: http://ecoqua.ecologia.ufrgs.br; accessed on: 05/01/2009.

PILLAR, V.D.; BOLDRINI, I.I.; HASENACK, H.; JACQUES, A.V.A.; BOTH, R.; MÜLLER, S.C.; EGGERS, L.; FIDELIS, A.T.; SANTOS, M.M.G.; OLIVEIRA, J.M.; CERVEIRA, J.; BLANCO, C.C.; JONER, F.; CORDEIRO J.L.; PINILLOS GALINDO, S.M. 2006. *In:* WORKSHOP ESTADO ATUAL E DESAFIOS PARA A CONSERVAÇÃO DOS CAMPOS, Porto Alegre, 2006. UFRGS, 24 p. Avaliable at: http://ecoqua.ecologia.ufrgs.br; accessed on: 01/04/2009.

PODANI, J. 2000. *Introduction to the Exploration of Multivariate Biological Data*. Leiden, Backuys Publishers, 407 p.

POTT, A. 1974. *Levantamento ecológico da vegetação de um campo natural sob três condições: pastejado, excluído e melhorado*. Porto Alegre, Dissertação Mestrado, PPGAg/UFRGS, 177 p.

PUCHETA, E.; CABIDO, M.; DÍAZ, S.; FUNES, G. 1998. Floristic composition, biomass, and aboveground net plant production in grazed and protected sites in a mountain grassland of central Argentina. *Acta Oecologica*, **19**:97-105.

TEIXEIRA, M.B.A.; COURDA METO, A.B.; PASTORE, U.; RANGEL FILHO, A.L.R. 1986. Vegetação. *In*: IBGE (org.), *Levantamento de recursos naturais*. Rio de Janeiro, IBGE, v. 33.

TRINDADE, J.P.P.; ROCHA, M.G.da 2002. Rebrotamento de capim caninha (*Andropogon lateralis* Ness) sob o efeito de pastejo e fogo. *Ciência Rural,* **32**:141-146.

VOGL, R.J. 1974. Effects of fire on *grasslands. In:* T.T. KOZLOWSKI; C.E. AHLGREN (eds.), *Fire and ecosystems*. Madison, Academic, p. 139-182.

Submitted on August 21, 2009
Accepted on January 5, 2010