Anais da Academia Brasileira de Ciências (2015) 87(4): 2081-2090
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
http://dx.doi.org/10.1590/0001-3765201520140555
www.scielo.br/aabc

Floristic and structural patterns in South Brazilian coastal grasslands

LUCIANA S. MENEZES[1], SANDRA C. MÜLLER[1,2] and GERHARD E. OVERBECK[1,3]

[1]Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Agronomia, 91501-970 Porto Alegre, RS, Brasil
[2]Departamento de Ecologia, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Agronomia, 91501-970 Porto Alegre RS, Brasil
[3]Departamento de Botânica, Universidade Federal do Rio Grande do Sul, Av. Bento Gonçalves, 9500, Agronomia, 91501-970 Porto Alegre, RS, Brasil

Manuscript received on October 17, 2014; accepted for publication on February 5, 2015

ABSTRACT

The natural vegetation of Southern Brazil's coastal region includes grasslands formations that are poorly considered in conservation policy, due to the lack of knowledge about these systems. This study reports results from a regional-scale survey of coastal grasslands vegetation along a 536 km gradient on southern Brazil. We sampled 16 sites along the coastal plain with 15 plots (1 m²) per site. All sites were grazed by cattle. We estimated plant species cover, vegetation height, percentage of bare soil, litter and manure, and classified species according to their growth forms. We found 221 species, 14 of them exotic and two threatened. The prostate grasses: *Axonopus* aff. *affinis*, *Paspalum notatum* and *P. pumilum* were among the most important species. Prostrate graminoids species represented the most important vegetation cover, followed by cespitose grasses. Vegetation height, bare soil, litter and manure were similar among all areas, highlighting the homogeneity of sampling sites due to similar management. In comparison to other grasslands formations in Southern Brazil, the coastal grasslands presented rather low species richness. The presence of high values for bare soil at all sampling sites indicates the need to discuss management practices in the region, especially with regard to the intensity of livestock grazing.

Key words: Pampa biome, Campos, conservation, grazing, sandy soil.

INTRODUCTION

Coastal landscapes currently are among the most degraded environments in the world (UNEP 2006). This degradation is related to the fact that most of the population worldwide lives close to the coastline and explores natural resources from coastal environments. This is also true for Brazil, where about 74 million people, or 40% of the population, live in coastal zones (Marroni and Asmus 2013). The Brazilian shoreline extends 7500 km in length and encompasses very distinct environments. Throughout this region, conservation problems have been pointed out for a large diversity of ecosystems, such as saltmarshes (Isacch et al. 2006), foredunes (Seeliger 2003), wetlands (Diegues 1999) and Atlantic forest (Rigueira et al. 2013). However, little or no attention has been directed to the grassland landscapes. In the coastal plain of the state of Rio Grande do Sul, in the South of Brazil, about 5700 km² of grasslands remain, distributed in a strip of 622 km in length and 80

Correspondence to: Luciana da Silva Menezes
E-mail: luciana.menezes@ufrgs.br

km in width along the coastline, equivalent to 13% of grasslands that are still present in the state (Cordeiro and Hasenack 2009).

As pointed out by Overbeck et al. (2013), grasslands have not been considered a conservation priority in southern Brazil, despite losses in cover of more than 50%, high biodiversity (concerning plants and animals, see e.g. Boldrini 2009 and Bencke 2009) and important ecosystem services offered by them. The situation of costal grasslands is not different. The National Coastal Management Program (GERCO, acronym in Portuguese) is the principal political basis for protection of the coastal environments in Brazil (Marroni and Asmus 2013). However, it is mostly focused on management of water resources such as lagoons, rivers and wetlands, especially those located in the northern part of Brazil, where most research is performed (Diegues 1999). No policies for protecting coastal grasslands have been developed by GERCO or other agencies so far. Furthermore, the management guidelines in the conservation units that exist in the region (National Park of Lagoa do Peixe, State Park of Itapeva and Ecological Station Taim) focus mainly on wetlands, sand dunes and Restinga forest, and do not aim at preserving grasslands, and even less so on processes that shape and maintain them, e.g. cattle grazing (see also Pillar and Vélez 2010). In fact, at the moment, the limited number of studies and the lack of data impede the evaluation of the conservation state of the costal grasslands.

Here we present results from a regional-scale survey of grassland fragments in the coastal plain of southern Brazil, providing for the first time a more comprehensive knowledge of this vegetation type in the coastal landscape. We explore vegetation structure and diversity of coastal grasslands, in terms of species richness, species composition and growth forms, also identifying exotic and threatened species. We aim to characterize the grassland formations in the region in a comprehensive way in addition to assessing whether floristic characteristics of the coastal grasslands reflect signs of degradation.

MATERIALS AND METHODS

Study Region

The survey was carried out on 16 sites distributed along a 536 km gradient along Brazil's southern coast (Fig. 1), from latitude 28°S to 33°S. Potential sample sites were selected based on satellite imagery, with main criteria minimum size of grassland areas of 3 ha and presence of natural grassland (i.e. cultivated grasslands were not considered). Sites with high water levels in the soil (i.e., wetlands) were excluded after inspection in the field. Sites were selected as to represent four discrete subregions in southern Brazil (three in the state of Rio Grande do Sul and one in the southern Santa Catarina state), based on similarity of climatic conditions (Table I). Climate in the region is classified as Cfa subtropical humid (Peel et al. 2007).

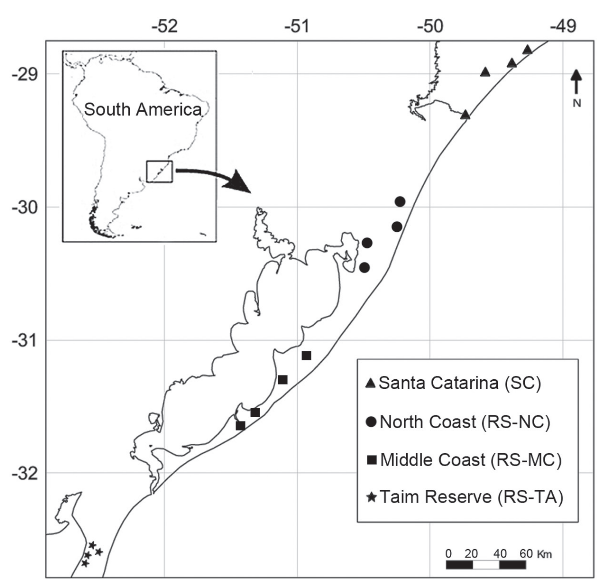

Figure 1 - Location of the 16 sampling sites and classification into four climatically defined subregions in the South Brazilian coastal plain.

TABLE I
Geographical location and main climatic variables for each of the 16 sample sites in the South Brazilian's coastal plain. Precipitation and temperature are annual averages for a series of 50 years (Hijmans et al. 2005).

Subregion	Site	Latitude(S)	Longitude(W)	Municipality	Precip.(mm)	Temp. (°C)
SC	SC1	28°49’49.0”	49°15’48.2”	Balneário Rincão	1341	19.4
	SC2	28°55’55.6”	49°22’50.5”	Conventos	1313	19.2
	SC3	28°59’11.7”	49°35’14.8”	Araranguá	1321	19.1
	SC4	29°18’19.3”	49°43’56.2”	Passo de Torres	1397	18.8
NC	NC1	29°57’20.7”	50°13’40.4”	Osório	1499	18.8
	NC2	30°08’55.3”	50°15’09.3”	Cidreira	1487	18.8
	NC3	30°16’00.8”	50°28’33.9”	Palmares do Sul	1484	18.8
	NC4	30°27’08.5”	50°29’46.0”	Palmares do Sul	1462	18.7
MC	MC1	31°06’52.3”	50°56’00.4”	Mostardas	1381	18.5
	MC2	31°17’40.5”	51°06’40.6”	Tavares	1360	18.5
	MC3	31°32’37.2”	51°19’11.8”	Bojuru	1326	18.4
	MC4	31°38’37.7”	51°25’53.3”	Bojuru	1308	18.4
TA	TA1	32°32’27.3”	52°32’36.8”	Sta. Vitória do Palmar	1227	17.7
	TA2	32°35’31.7”	52°29’33.9”	Sta. Vitória do Palmar	1220	17.7
	TA3	32°36’54.1”	52°34’43.0”	Sta. Vitória do Palmar	1220	17.7
	TA4	32°40’42.2”	52°35’40.5”	Sta. Vitória do Palmar	1216	17.6

Soils in the region were formed in the Quaternary period (Villwock and Tomazelli 1998). The influence of different sedimentary depositional environments (Lagoonal and Aeolian) caused the formation of different soil types in the region. Organosoil, Gleysoil and Planossoil were formed mainly by Lagoonal deposition processes, with predominance of clay and organic matter. Plinthosoil, Spodosoil and Neosoil, formed by Aeolian deposition processes, present predominance of sand (soil classifications following Santos 2013).

Vegetation Sampling

Sampling was performed during southern hemisphere spring and summer in 2012 and 2013. Species' composition data was obtained in 15 plots of one square meter per site, randomly distributed. In each plot, all vascular plant species were identified and had their cover estimated according to Londo's decimal scale (Londo 1976). Characterization of species' composition at each site considered mean species' cover within the 15 plots. Plant samples were collected for posterior taxonomic identification whenever necessary. Classification of species into families followed Stevens (2001), nomenclature of species follows Boyle et al. (2013). In addition to estimation of species cover, we measured vegetation structural attributes: mean vegetation height, estimated cover of litter, manure and bare soil.

Data Analyses

Species richness of grasslands was explored using average species richness per site (in 15 plots), considering shared and exclusive species, and mean species richness per plot (1m²). For exploring general patterns of species composition we ran a principal coordinate analysis (PCoA), based on chord distance, using the matrix of species mean cover per site. Due to the high dominance of few species and high importance of bare soil, only species with relative cover higher than 1% were considered for the ordination analysis.

Additionally, we tested for differences in species composition between subregions with a randomization test, using chord distance as resemblance measure. Subregions were also compared regarding the parameters: vegetation height, total vegetation cover, bare soil, litter and manure with the assistance of randomization tests, using Euclidian distance and 999 permutations. All analyses were performed using the software MULTIV (Pillar 1997).

Species were characterized according to their growth forms into: erect (cespitose) graminoid herb (EGH), prostrate graminoid herb (PGH), erect herb (ERH), prostrate herb (PTH), rosulate herb (ROH), herbaceous vine (VIH), woody vine or lianna (VIW), subshrub (SSH), shrub (SHR) and succulent leaf species (CRA).

For each subregion the most important species were recorded by calculating relative cover (RC), relative frequency (RF) and the importance value index (IVI), according to Mueller-Dombois and Ellenberg (1974). We also identified naturalized or exotic species, according to the checklist of exotic species for the Pampa biome (Fonseca et al. 2013) and the list of Brazilian flora website (http://floradobrasil.jbrj.gov.br/). Extinction risk and vulnerability of the species was checked in the current Red List of Threatened Plant Species for the state (Rio Grande do Sul 2003).

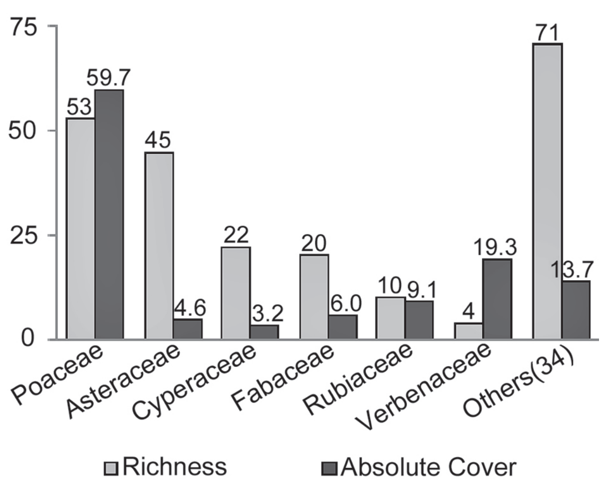

Figure 2 - Richness of species and total vegetation cover per family, recorded in 16 sites distributed in four subregions in grasslands of the South Brazilian coastal plain.

RESULTS

A total of 221 taxa of vascular plants were identified to the species level, four individuals could only be identified to the genus or family level. Of the total 225 records, 23.5% belonged to Poaceae family, 20% to Asteraceae, 9.7% to Cyperaceae and 8.9% to Fabaceae family (Fig. 2). Even though other families also presented high richness, most of the plant cover was formed by species from the Poaceae family. The relatively high absolute cover of Verbenaceae is partly the consequence of a specific situation at one of the TA sites. A complete list of species occurrence with indication of the five most important species (higher IVI), growth forms and endangerment status is presented in the supplementary material (Table SI, available only in the online version).

The highest species richness was found for the subregion NC, where we recorded 137 species. The other subregions presented similar richness values, with 113 species in SC and TA subregions, and 105 in MC.Most of the species were shared between one or more subregion (Fig. 3). A total of 39 species (18% of total species number) were common to all subregions. Poaceae contributed most to this number, with 12 species, followed by Asteraceae

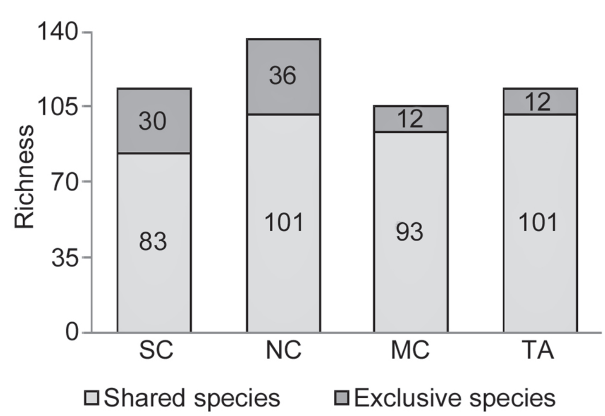

Figure 3 - Species richness per subregion registered for the grasslands of southern Brazilian coastal plain, indicating the number of exclusive species and number of species that were shared between two or more subregions.

and Cyperaceae, both with five species common to all subregions. Average species number per plot (1 m²) was 13.5, and the highest value was at site NC3 (22 species per plot), lowest mean value was at SC3 (7.9).

The first two axes of the PCoA (Fig. 4) together, explained 60% of the total variation. The first ordination axis, separated sites with high cover of *Axonopus* aff. *affinis* Chase and *Andropogon lateralis* Ness, to the left side, whereas areas with high coverage of *Paspalum notatum* Alain ex Flüggé and *Paspalum pumilum* Nees were separated to the right side. Along the second axis, sites with the presence of the exotic species *Brachiaria brizantha* (Hochst. ex A. Rich.) Stapf. and the ruderal species *Phyla nodiflora* (L.) Greene (in the positive portion) were separated from sites with the presence of the tussock species *Sorghastrum setosum* (Griseb.) Hitchc. and *Andropogon selloanus* Hack (in the negative portion).

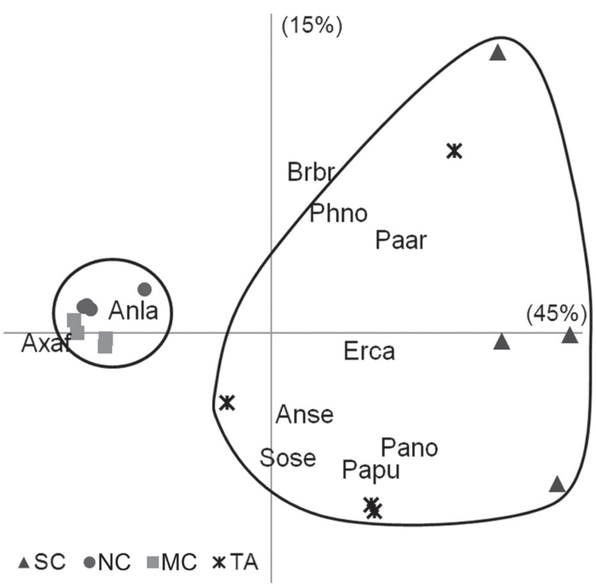

Figure 4 - Principal coordinate ordination diagram showing the first two axes. Only species with higher correlations to the axes are shown (corr.>0.4). Symbols represent the subregions and continuous lines delimit groups of sampling units that were similar in species composition (ρ<0.05). Axaf: *Axonopus* aff. *affinis*; Anla: *Andropogon lateralis*; Anse: *A. selloanus*; Brbr: *Brachiaria brizantha*; Erca: *Eragrostis cataclasta*; Paar: *Paspalum arenarium*; Pano: *P. notatum*; Papu: *P. pumilum*; Phno: *Phylla nodiflora*; Sose: *Sorghastrum setosum*.

The Poaceae species *Axonopus* aff. *affinis* was the most important species for the majority of the areas, representing almost half of total cover at MC sites. *P. notatum* also had an important role in species composition of the coastal grasslands, together with other species of the genus Paspalum, such as *Paspalum arenarium* Schrad., *P. pumilum* and *Paspalum lepton* Schult..

The subregions NC/MC differed from SC/TA, resulting in two groups of sites, clearly separated along the first ordination axis (Fig. 4). Sites belonging to the subregions NC and MC were situated close together in the ordination diagram, and thus did not present significant differences in species composition (ρ=0.2), which might be expected due to their geographical proximity. Nonetheless, the sites in the SC and TA subregions did not present significant difference in species composition either (ρ=0.09), despite their geographical distance.

The structural parameters of the coastal grassland vegetation were quite similar among areas (Table II). Only two parameters were significantly different: mean vegetation cover was higher in the MC subregion, when compared to SC subregion, and litter cover was higher in the SC and TA subregions when compared to MC subregion.

Only two threatened species were recorded: *Gomphrena perennis* L., classified as vulnerable (VU), registered at five sites (NC1, SC1, SC4, LN1 and TA2); and the endangered (EN) species *Laurembergia tetrandra* (Schott ex Spreng.) Kanitz, occurring on the TA2 site.

We registered 14 exotic/naturalized species that together accounted for about 6% of total species cover for the entire survey. Among these were some species with invasive potential, such as *Eragrostis plana* Nees, *Cynodon dactylon* (L.) Pers. and *B. brizantha. C. dactylon* was extremely widespread especially in the southern areas (TA), occurring

Table II
Structural parameters of coastal grasslands sampled in four different subregions in the South Brazilian's coastal plain. Table II shows the mean values of the 60 plots per subregion and the respective standard deviation. Different letters represent significant difference between subregions (ρ<0.05).

	SC	NC	MC	TA
Vegetation height (cm)	5.8 (±1.2)	6.3 (±1.6)	6.0 (±1.3)	6.3 (±2.4)
Vegetation cover (%)	62.8 (±11.9)^{a}	73.0 (±17.6)^{ab}	79.8 (±5.6)^{b}	78.5 (±11.3)^{ab}
Bare soil cover (%)	19.9 (±13.6)	19.0 (±13.4)	13.7 (±5.4)	7.8 (±9.2)
Litter cover (%)	18.9 (±5.7)^{a}	8.9 (±3.3)^{ab}	7.7 (±1.1)^{b}	14.0 (±5.0)^{a}
Manure cover (%)	0.7 (±0.7)	0.9 (±0.6)	1.4 (±0.6)	2.2 (±1.0)

in 22 of the 60 plots and covering about 4.5% of the four TA areas.Furthermore, many ruderal species, which are characteristic for disturbed environments, were recorded, such as *Digitaria connivens* (Trin.) Henrard, *Cenchrus echinatus* L., *Cardionema ramosissima* (Weinm.) A.Nelson and J.F.Macbr. and *Phyla nodiflora*. Particularly very frequent, *C. ramosissima*, was registered in 10 of the 16 sites.

As to growth forms, the grasslands in all four subregions were dominated by prostrate graminoid herbs (Fig. 5), which include the species *A.* aff. *affinis*, *P. notatum*, *P. arenarium*, *P. pumilum* and *P. lepton*. Erect or cespitose grasses (EGH) also played an important role in the communities, with high frequency especially of *Eragrostis cataclasta* Nicora, *A. lateralis* and *S. setosum*.

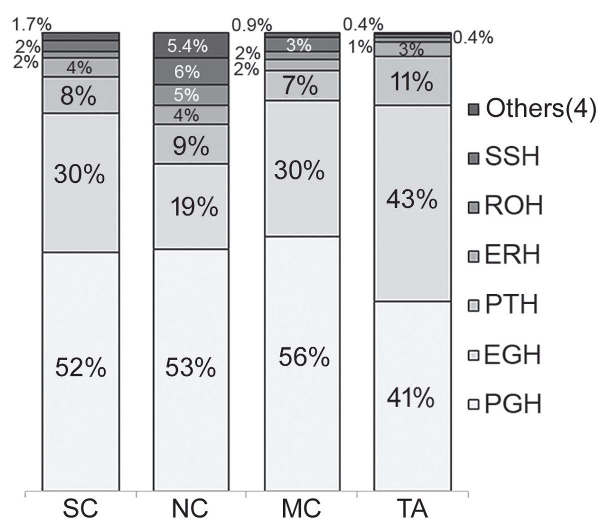

Figure 5 - Percentage of cover of species growth form in the four subregions. Growth forms are: EGH - erect (cespitose) graminoid herb; PGH - prostrate graminoid herb; ERH - erect herb; PTH - prostrate herb; ROH - rosulate herb; VIH - herbaceous vine; VIW - woody vine or liana; SSH – subshrub; SHR – shrub; and CRA - succulent leaf.

DISCUSSION

We sampled 16 areas of grassland vegetation along a latitudinal gradient of the South Brazilian coast, where we recorded 221 species distributed in 40 botanical families. The most important families were Poaceae, Asteraceae, Cyperaceae and Fabaceae, which corresponds to the general pattern of the South Brazilian grasslands, however, with higher occurrence of Cyperaceae. This is considered as characteristic for the coastal grasslands (Boldrini 2009), in contrast to other regions in the state, where Fabaceae takes this position. Cyperaceae species have characteristics that favor their establishment in non-consolidated sandy soils, such as the presence of well-developed underground structures (Boldrini 2009). Furthermore, the species of the Cyperaceae family are known for establishing well in humid areas and act as weeds invaders of crops (Simpson et al. 2011). These characteristics may facilitate their establishment and spread in coastal grasslands due to the high percentage of bare soil and abundance of wetlands in this region.

When compared to other grasslands formations of southern Brazil, the strikingly lower plant species richness in the coastal grasslands becomes evident. We found, on average, only 13.5 species per plot (1m²). For grasslands on the granitic hills in Porto Alegre, in contrast, different studies reported 20.7 spp/m² (Setubal and Boldrini 2012), 27 spp/m² (Dresseno and Overbeck 2013) and 27.1 spp/m² (Ferreira et al. 2010), i.e. considerably higher numbers. The lower plant species richness of the coastal grasslands is likely related to the nature of the substrate (sand depositions, i.e. rather limiting conditions) and the relative uniformity of soils and climate along the entire gradient. Likely, the recent geological formation of the entire coastal region (Villwock and Tomazelli 1998), also contributes to the lower richness values. The region was colonized from adjacent regions, which explains ample distribution patterns of many species (most species were found in two or more subregions) and low endemism. Boldrini (2009) indicated only six endemic species in the coastal grasslands, while in the highlands grasslands, for example, the latest estimates account for 296 cases of endemism (Iganci et al. 2011). In comparison to previous studies conducted at single locations of the coastal plain, similar richness values as found herein per subregion (117 spp.) were those found by Garcia and Boldrini (2007) 138 spp. and Ferreira and Setubal (2009) 123 spp.

Species with high potential for vegetative spread and a prostrate habitus, covered most of the sampling sites, such as the grasses *Axonopus* aff. *affinis* and *Paspalum notatum*. Those two species have already been mentioned as being representative of coastal grasslands, especially in drier areas (Boldrini et al. 2008, Ferreira and Setubal 2009). *Ischaemum minus* and *P. pumilum*, were also found with high coverage in our survey. These species have been pointed out as important species in humid areas in the coastal grasslands (Garcia and Boldrini 2007). Prostrate species generally have structures adequate for colonization of open soil, such as rhizome and stolons, and can cover this type of environment relatively easily.

The limiting availability of resources in the coastal environments provide conditions to which few species are well adapted (Crawford 2008), and these well adapted species seem to be quite successful in colonizing such environments. Clonal spread, i.e. production of new individuals by the growing of new ramets, has been suggested as particularly advantageous in less favorable environments (Honnay and Bossuyt 2005). Additionally, high cover of prostrate grasses is also a consequence of high levels of cattle grazing. These plants, characterized by rapid resource acquisition and fast substitution of leaves consumed by cattle, can be considered as indicative of high grazing pressure (Cruz et al. 2010). At high grazing pressure, the dominance of grasses with this strategy leads to the relatively homogenous vegetation structure (Nabinger et al. 2009).

Overgrazing has been identified as a major cause of degradation in grasslands around the world (D'Odorico et al. 2013). One of the signals that a grassland is suffering overgrazing is a sparse and short vegetation cover, due to constant and strong grazing activity, animal trampling, wallowing and grazing. In the sampled coastal grasslands, the percentage of bare soil accounted for more than 30% of total cover in some areas (mean values presented in Table II). However, it is difficult to evaluate the problem of overgrazing in the studied coastal grasslands, as the exact stocking rate could not be estimated. The relatively little cover of manure in all sites (Table II) indicates that cattle grazing may not be the main source of high percentages of open soil, instead it seems to be a natural characteristic of the region in consequence of the sandy substrate.

The high proportion of bare soil facilitates the colonization by exotic and ruderal species. In the ordination analysis, the grouping of sites NC/MC and TA/SC is influenced by two sites from TA and SC subregions with conspicuously different floristic composition, with presence of exotic and ruderal species, such as *B. brizantha* and *P. nodiflora*. One of the sites in TA subregion (TA3) seems altered by past agricultural use, indicated by the high cover values of *Phyla nodiflora* (Verbenaceae), with about 20% of total vegetation cover. The total number of exotic species found in our study was rather low, and only *Cynodon dactylon* reached higher abundance level. Many of the exotic species deliberately introduced in the Pampa biome are for forage use (Fonseca et al. 2013). In our study, this is the case of *Melinis minutiflora* P.Beauv. and *B. brizantha*. *Eragrostis plana* is a Poaceae species that has high invasive capacity, can reach dominance and reduce local biodiversity as well as grassland productivity (Reis and Coelho 2000). In our survey, *E. plana* was found only at one site, but all the costal grasslands have been considered as vulnerable environment for the invasion of this species (Barbosa et al. 2013) which can be found along roadsides practically along the entire gradient, making monitoring of the possible spread of this exotic invasive species important.

A comparatively low plant species richness, a large percentage of bare soil, high dominance and high coverage of prostrate species are the most striking characteristics of the coastal grasslands on southern Brazil. In other formations of the Brazilian Campos, these features might be interpreted as a sign of degradation – for the coastal grasslands however, they seem typical, related to the limiting characteristics of marginal environments, as a consequence of the soil features of the region. However, we should keep in mind that the management of grassland, e.g. high cattle loads, as well as past agricultural use, can promote changes in grassland structure. In the case of two sites, in the SC and TA subregions, a legacy of degradation is evident by conspicuously different floristic characteristics of the vegetation, which might indicate low resilience of these grasslands to severe disturbances such as land use change.

From the data of our survey we can conclude that the remaining areas of coastal grassland vegetation, preserve their characteristic floristic composition and structure. Nonetheless, just as in other regions of the South Brazilian grasslands, it seems necessary to set more appropriate management goals for coastal grassland vegetation, e.g. lower stocking rates of cattle (Carvalho and Batello 2009). Preservation of the remaining fragments of this landscape, i.e. prevention of their transformation to other land use, thus, should be the core of a conservation strategy for grasslands in the South Brazilian coastal plain. A basis for this would be a zoning plan for different types of land use that could be developed in the course of the National Coastal Management Plan (Brazil 1988).

ACKNOWLEDGMENTS

Special thanks go to Daniel Galiano for helping with contacts of property owner, and to the property owners for the permit to work on their lands. We are also grateful to the fieldwork team from the Grassland Vegetation Lab (LEVCamp/UFRGS). LSM was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES). SCM was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

RESUMO

A vegetação natural da região costeira sul brasileira inclui formações campestres que são pouco consideradas nas políticas de conservação, devido a falta de conhecimento sobre estes ecossistemas. Esse estudo reporta resultados de um levantamento em escala regional da vegetação campestre costeira ao longo de um gradiente de 536 km no sul do Brasil. Amostramos 16 áreas ao longo da planície costeira com 15 parcelas (1m²) por área. Todas as áreas eram pastejadas por gado. Estimamos cobertura de espécies de plantas, altura da vegetação, porcentagem de solo descoberto, mantilho e esterco, e classificamos as espécies de acordo com suas formas de crescimento. Encontramos 221 espécies, 14 dessas exóticas e duas ameaçadas. As gramas prostradas: *Axonopus* aff. *affinis*,

Paspalum notatum e *P. pumilum* estavam entre as espécies mais importantes. Espécies de gramíneas prostradas representaram a cobertura vegetal mais importante, seguidas por gramas cespitosas. Altura da vegetação, solo descoberto, mantilho e esterco foram similares entre todas as áreas, destacando a homogeneidade das áreas amostrais devido ao manejo similar. Em comparação com outras formações campestres no sul do Brasil, os campos costeiros apresentaram riqueza de espécies bastante baixa. A presença de altos valores de solo descoberto em todas as áreas amostrais indica a necessidade de discutir as práticas de manejo na região, especialmente no que diz respeito a intensidade de pastejo do gado.

Palavras-chave: bioma Pampa, Campos, conservação, pastejo, solo arenoso.

REFERENCES

BARBOSA FG, PILLAR VD, PALMER AR AND MELO AS. 2013. Predicting the current distribution and potential spread of the exotic grass Eragrostis plana Nees in South America and identifying a bioclimatic niche shift during invasion. Austral Ecol 38: 260-267.

BENCKE GA. 2009. Diversidade e conservação da fauna dos Campos do Sul do Brasil. In: Pillar VDP, Müller SC, Castilhos ZMS and Jacques AVÁ (Eds), Campos Sulinos Conservação e uso sustentável da biodiversidade. MMA: Brasília, p. 101-121.

BOLDRINI II. 2009. A flora dos campos do Rio Grande do Sul. In: Pillar VDP, Müller SC, Castilhos ZMS and Jacques AVÁ (Eds), Campos Sulinos Conservação e uso sustentável da biodiversidade. MMA: Brasília, p. 63-77.

BOLDRINI II, TREVISAN R AND SCHNEIDER AA. 2008. Estudo florístico e fitossociológico de uma área às margens da lagoa Armazém, Osório, Rio Grande do Sul, Brasil. Rev Bras Biociências 6: 355-367.

BOYLE B ET AL. 2013. The taxonomic name resolution service: an online tool for automated standardization of plant names. BMC Bioinformatics 14: 1-16.

BRAZIL. 1988. Lei No7.661, de 16 de maio de 988: Plano Nacional de Gerenciamento Costeiro. Available at: http://www.planalto.gov.br/ccivil_03/leis/l7661.htm.

CARVALHO PCF AND BATELLO C. 2009. Access to land, livestock production and ecosystem conservation in the Brazilian Campos biome: The natural grasslands dilemma. Livest Sci 120: 158-162.

CORDEIRO JLP AND HASENACK H. 2009. Cobertura vegetal atual do Rio Grande do Sul. In: Pillar VDP, Müller SC, Castilhos ZMS and Jacques AVÁ (Eds), Campos Sulinos Conservação e uso sustentável da biodiversidade. MMA: Brasília, p. 285-299.

CRAWFORD RM. 2008. Plants at the Margin: Ecological Limits and Climate Change. Cambridge University Press: Cambridge, 478 p.

CRUZ P, QUADROS FLF, THEAU JP, FRIZZO A, JOUANY C, DURU M AND CARVALHO PCF. 2010. Leaf Traits as Functional Descriptors of the Intensity of Continuous Grazing in Native Grasslands in the South of Brazil. Rangel Ecol Manag 63: 350-358.

DIEGUES AC. 1999. Human populations and coastal wetlands: conservation and management in Brazil. Ocean Coast Manag 42: 187-210.

D'ODORICO P, BHATTACHAN A, DAVIS KF, RAVI S AND RUNYAN CW. 2013. Global desertification: Drivers and feedbacks. Adv Water Resour 51: 326-344.

DRESSENO ALP AND OVERBECK GE. 2013. Structure and composition of a grassland relict within an urban matrix : potential and challenges for conservation. Iheringia Sér Bot 68: 59-71.

FERREIRA PMA, MÜLLER SC, BOLDRINI II AND EGGERS L. 2010. Floristic and vegetation structure of a granitic grassland in Southern Brazil. Rev Bras Botânica 33: 21-36.

FERREIRA PMA AND SETUBAL RB. 2009. Florística e fitossociologia de um campo natural no município de Santo Antônio da Patrulha, Rio Grande do Sul, Brasil. Rev Bras Biociências 7: 195-204.

FONSECA CR, GUADAGNIN DL, EMER C, MASCIADRI S, GERMAIN P AND ZALBA SM. 2013. Invasive alien plants in the Pampas grasslands: a tri-national cooperation challenge. Biol Invasions 15: 1751-1763.

GARCIA EN AND BOLDRINI II. 2007. Estado de conservação de um campo alterado na Planície Costeira, Rio Grande do Sul. Rev Bras Biociências 5: 1044-1046.

HIJMANS RJ, CAMERON SE, PARRA JL, JONES PG AND JARVIS A. 2005. Very high resolution interpolated climate surfaces for global land areas. Int J Climatol 25: 1965-1978.

HONNAY O AND BOSSUYT B. 2005. Prolonged clonal growth: escape route or route to extinction? Oikos 108: 427-432.

IGANCI JRV, HEIDEN G, MIOTTO STS AND PENNINGTON RT. 2011. Campos de Cima da Serra: the Brazilian Subtropical Highland Grasslands show an unexpected level of plant endemism. Bot J Linn Soc 167: 378-393.

ISACCH JP, COSTA CSB, RODRIGUEZ-GALLEGO L, CONDE D, ESCAPA M, GAGLIARDINI DA AND IRIBARNE OO. 2006. Distribution of saltmarsh plant communities associated with environmental factors along a latitudinal gradient on the south-west Atlantic coast. J Biogeogr 33: 888-900.

LONDO G. 1976. The decimal scale for releves of permanent quadrats. Vegetatio 33: 61-64.

MARRONI EV AND ASMUS ML. 2013. Historical antecedents and local governance in the process of public policies building for coastal zone of Brazil. Ocean Coast Manag 76: 30-37.

MUELLER-DOMBOIS D AND ELLENBERG H. 1974. Aims and methods of vegetation ecology. John Wiley: New York, 574 p.

NABINGER C, FERREIRA ET, FREITAS AK, CARVALHO PCF AND SANT'ANNA DM. 2009. Produção animal com base no campo nativo: aplicações de resultados de pesquisa. In: Pillar VDP, Müller SC, Castilhos ZMS and Jacques AVÁ (Eds), Campos Sulinos Conservação e uso sustentável da biodiversidade. MMA: Brasília, p. 175-198.

OVERBECK GE ET AL. 2013. Restorarion Ecology in Brazil - Time to Step Out of the Forest. Nat Conserv 11: 92-95.

PEEL MC, FINLAYSON BL AND MCMAHON TA. 2007. Updated world map of the Koppen-Geiger climate classification. Hydrol Earth Syst Sci 11: 1633-1644.

PILLAR VDP. 1997. Multivariate exploratory analysis and randomization testing with MULTIV. Coenoses 12: 145-148.

PILLAR VDP AND VÉLEZ E. 2010. Extinção dos Campos Sulinos em Unidades de Conservação : um Fenômeno Natural ou um Problema Ético? Nat Conserv 8: 84-86.

REIS JCL AND COELHO RW. 2000. Controle Do Capim-Annoni-2 Em Campos Naturais e Pastagens. Embrapa clima temperado Circ Técnica. EEMBRAPA Clima Temperado: Pelotas.

RIGUEIRA DMG, ROCHA PLB AND MARIANO-NETO E. 2013. Forest cover, extinction thresholds and time lags in woody plants (Myrtaceae) in the Brazilian Atlantic Forest: resources for conservation. Biodivers Conserv 22: 3141-3163.

RIO GRANDE DO SUL. 2003. Decreto Estadual No42.099 de 01 de janeiro de 2003. Available at: http://www.fzb.rs.gov.br/downloads/index.htm

SANTOS HG. 2013. Sistema brasileiro de classificação de solos. 3ª ed., EMBRAPA: Brasília, 323 p.

SEELIGER U. 2003. Response of southern Brazilian coastal foredunes to natural and human-induced disturbance. J Coast Res 35: 51-55.

SETUBAL RB AND BOLDRINI II. 2012. Phytosociology and natural subtropical grassland communities on a granitic hill in southern Brazil. Rodriguésia 63: 513-524.

SIMPSON DA, YESSON C, CULHAM A, COUCH CA AND MUASYA AM. 2011. Climate change and Cyperaceae. In: Hodkinson T, Jones M, Waldren S and Parnell J (Eds), Climate change, ecology and systematics. Cambridge University Press: London, p. 439-456.

STEVENS PF. 2001. Angiosperm Phylogeny Website. Version 12, July 2012 [and more or less continuously updated since]. Available at: http://www.mobot.org/MOBOT/research/APweb/.

UNEP. 2006. Marine and coastal ecosystems and human wellbeing: A synthesis report based on the findings of the Millennium Ecosystem Assessment. UNEP, 76 p.

VILLWOCK JA AND TOMAZELLI LJ. 1998. Holocene Coastal Evolution in Rio Grande do Sul, Brazil. In: Rabassa J and Salemme M (Eds), Quaternary of South America and Antartic Peninsula. A. A. Balkema: Rotterdam, p. 283-296.

SUPPLEMENTARY MATERIAL

TABLE SI - Species presence in four subregions of South Brazil coastal grasslands, the five most important species in each subregion (higher IVI) are in bold and identified from 1º to 5º. Growth forms are: EGH - erect (cespitose) graminoid herb; PGH - prostrate graminoid herb; ERH - erect herb; PTH - prostrate herb; ROH - rosulate herb; VIH - herbaceous vine; VIW - woody vine or liana; SSH – subshrub; SHR – shrub; and CRA - succulent leafs species. Origin refers to exotic species (E) or naturalized (N), as in the list of [1]Brazilian flora checklist and [2]Pampa exotic species checklist. Threatened species, following the list of Rio Grande do Sul (2003) are identified with *.