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ARTICLE

Floristic diversity in areas of sandy soil grasslands in Southwestern Rio Grande do Sul, Brazil

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ABSTRACT: (Floristic diversity in areas of sandy soil grasslands in Southwestern Rio Grande do Sul, Brazil). Extensive natural grasslands areas in southwestern Rio Grande do Sul occur on sandy soils, which are susceptible to the sandy patch process. This process leads to the formation of large sandy patches, which constitutes a large-scale environmental problem. In grassland areas undergoing sandy patch processes in Alegrete, Manoel Viana and São Francisco de Assis municipalities, we recorded the occurrence of 343 species, 195 genera and 52 botanical families, with two new records for Rio Grande do Sul State (*Eragrostis articulata* (Schrank) Nees and *Eragrostis leucosticta* Nees ex Döll) and one for Brazil (*Croton lorentzii* Müll. Arg. ex Griseb.). The families with higher specific richness were Asteraceae, Poaceae, Fabaceae, Euphorbiaceae, Cyperaceae, Rubiaceae and Myrtaceae. From the whole species set, 19 species show a restricted distribution area, seven of these are exclusive to Rio Grande do Sul's grasslands and 16 are considered as extinction threatened.
Key words: sandy patch process, grassland species, threatened species, restrict occurrence.

RESUMO: (Diversidade florística dos campos em áreas de solos arenosos do sudoeste do Rio Grande do Sul, Brasil). Extensas áreas de campo do sudoeste do Rio Grande do Sul ocorrem sobre solos arenosos, suscetíveis ao processo de arenização. Esse processo conduz à formação de grandes manchas de areia, constituindo um problema ambiental de grande escala. Em campos, com o processo de arenização nos municípios de Alegrete, Manoel Viana e São Francisco de Assis, foi registrada a ocorrência de 343 espécies, 195 gêneros e 52 famílias botânicas, com duas novas citações para o estado do Rio Grande do Sul (*Eragrostis articulata* (Schrank) Nees e *Eragrostis leucosticta* Nees ex Döll) e uma para o Brasi (*Croton lorentzii* Müll. Arg. ex Griseb). As famílias com maior riqueza foram Asteraceae, Poaceae, Fabaceae, Euphorbiaceae, Cyperaceae, Rubiaceae e Myrtaceae. Do total de espécies, 19 apresentam área de dispersão restrita, sendo sete exclusivas dos campos do Rio Grande do Sul e 16 consideradas ameaçadas de extinção.
Palavras-chave: arenização, espécies campestres, espécies ameaçadas, ocorrência restrita.

INTRODUCTION

Plant landscapes are largely determined by soil, relief and climate conditions (Kern 1991). However, although climatic conditions in the South-Brazilian region are typical of forest-covered regions, extensive grassland-covered areas occur. The distribution of the South-Brazilian extant flora is not in agreement with present climate conditions, such as with the annual rainfall and temperature data (Kern 1991), being grasslands the prevailing formations in areas that have wet climate conditions, favoring the forest expansion (Behling *et al.* 2005). These grasslands, formations that had prevailed since 22 thousand years before the present, consist in relictual evidences of a dryer early climate that changed into a more humid one after 5170 years before the present (Behling *et al.* 2005). The existence of plants with attributes related to arid environments is relictual evidence of these changes and of the resulting vegetation adaptation (Marchiori 1995).

In the present time, grasslands are distributed in determined spots of the landscape due to the spatial variation of soil type and water-retaining capacity, usually with above-average water shortage (Cunha 1992).

In Rio Grande do Sul State (RS), grasslands are included in two biomes: Pampa (southern and western halves of the state) and Mata Atlântica (northeastern area, associated to *Araucaria* forests). These grasslands present high floristic diversity, with ca. 3000 spermatophytes (Boldrini 2002), and few grassland regions in the world have diversity such as the one found in the Brazilian subtropics.

The grasslands of RS southwestern region, inserted on Pampa biome, show deep, sandy and permeable soils, where the sandy patch process takes place (Suertegaray 1995, 1998). The sandy patch process is the result of wet climate processes reworking sandstone or superficial sandy deposits through the constant mobility of the sediments. Consequently, the vegetation of extensive areas of these grasslands is buried or removed, leading to the formation of sand-covered areas that are designated as sandy patches (Suertegaray 1995, 1998, Verdum 2004). Therefore, it is a natural process, and its expansion is the consequence of nature dynamics and inadequate use of the ecosystem, particularly through intensive grazing

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(Suertegaray 1995, 1998). Starting from the decade of 1970, with the implementation of the mechanized extensive monoculture and the consequent reduction in grazing areas, there was an increase in the number of areas undergoing sandy patch process (Verdum 2004). Nowadays, spots undergoing sandy patch process occur in Alegrete, Cacequi, Itaqui, Maçambará, Manoel Viana, Quaraí, Rosário do Sul, São Borja, São Francisco de Assis and Unistalda municipalities (Suertegaray *et al.* 2001).

These grasslands, locally named as "campo limpo", show a flat landscape distinguished by the presence of smooth hills and testimonial (tabular) hills, with sandstone substratum (Verdum 2004). With xeromorphic attributes derived from strong edaphic influences, these grasslands have witnessed a semiarid period that underwent a humidification that started in the Mid Holocene (Kern 1991, Suertegaray 1995, 1998, Medeiros *et al*. 1995). Vegetation is characterized by species with abundant hairiness in leaves, flowers and other organs, flowers in large and/or colorfull inflorescences, presence of volatile oils that grant a strong scent to their green organs, short leaves and the presence of xylopodium or other subterraneous organs (Lindman 1906).

The sandy patch process, alongside the surge in agriculture, the reduction of graze-destined areas, the growing implementation of cultivated forests and the flexible use of environmental laws has progressively contributed to the reduction of biological diversity in grassland formations. The destruction of the Pampa biome is no longer a threat, but a reality, because ca. 50% of the original vegetation cover has been destroyed or deeply altered (Hasenack *et al.* 2007).

The present paper aimed to describe the floristic diversity of natural sandy soil grassland areas in the southwest of Rio Grande do Sul state, at Alegrete, Manoel Viana and São Francisco de Assis municipalities.

MATERIAL AND METHODS

The study site, located in the southwest of RS State, between the latitudes 29°00'S and 31°00'S and the longitudes 54°30'W and 58°45'W, is characterized by the occurrence of sandy patches. The study covered natural grassland areas present in sandy soils with traces of sandy patch process, with and without cattle grazing, at Alegrete, Manoel Viana and São Francisco de Assis municipalities (Fig. 1).

According to Köppen classification, climate in the region is Cfa type, with 1400 mm mean annual rainfall (Nimer 1979). However, rainfall is poorly distributed, with the occurrence of reduced rainfall periods interposed by heavy rains, often concentrated in only one day (Freitas *et al.* 2009). The region shows great hydric limitation due to the atmosphere high evaporative uptake, mainly between November and February (Berlato *et al.* 2006). During this period, the probability of hydric deficiency (relationship between rainfall and evapotranspiration) is 41% in November, rising up to 60% in December and decreasing to 47% and 36% in January and February, respectively (Leivas *et al.* 2006). Mean annual temperature is 14.3°C in winter and 26.3°C in summer (Nimer 1979), while maximum and minimum absolutes can reach 40ºC and -4ºC, respectively (Cordeiro & Soares 1975).

The landscape is smoothly rippled, permeated by flat areas, configuring a surface of unconsolidated arenous deposits cradled over the Botucatu Formation sandstone. The flat areas contrast with the silicified sandstone plateaus in the regional landscape (Suertegaray 1995, 1998). The soil, classified as a typical Ortic Quartzarenic Neosol (Streck *et al.* 2008), shows arenous and silt-arenous texture, acid pH, lack of phosphor and potassium, aluminum surplus (Verdum 2004), strong natural limitations in fertility, high erosion susceptibility and low cation-exchanging capacity (Azevedo & Kaminski 1995). Besides that, the soil shows water-retaining difficulties, which leads to hydric shortage even in short dry periods (Klamt & Schneider 1995).

For the floristic survey, field expeditions were

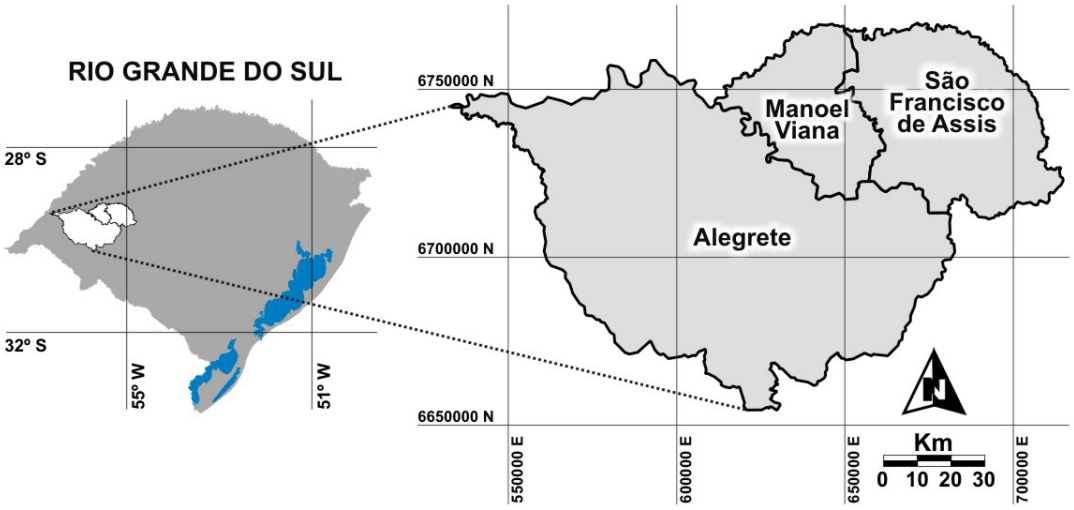

Figure 1. Location of Alegrete, Manoel Viana and São Francisco de Assis municipalities in southwestern Rio Grande do Sul, Brazil.

conducted between 2006 and 2009, covering all months. We collected fertile botanic material of the phanerogamous species present in the grassland areas, including herbs, vines, shrubs and trees occuring in scattered patterns along the grasslands. The collected material was herborized, identified and included in the ICN Herbarium collection of the Biosciences Institute of Universidade Federal do Rio Grande do Sul (UFRGS). Botanical families were considered according to APG II (2003). Some species were identified in the field but were not included in the herbarium collection, because they were in vegetative phase. Furthermore, we added to our floristic list the species found in a survey carried out in a grassland area at São Francisco de Assis municipality during 2004 and 2005. The collected botanical material for this previous survey can be found in the HVAT herbarium (Vale do Taquari Herbarium) of the Natural Sciences Museum, Univates Universitary Center, Lajeado municipality, RS.

RESULTS AND DISCUSSION

Floristic diversity

In the floristic survey, 343 species were found, pertaining to 194 genera and 52 botanical families (angiosperms and gymnosperms) (Table 1). Families with the highest species richness were Asteraceae (77 species), Poaceae (58 species), Fabaceae (31 species), Euphorbiaceae (15 species), Cyperaceae and Rubiaceae (11 species each) and Myrtaceae (10 species) (Fig. 2). Besides these families, Malvaceae (nine species), Amaranthaceae, Apocynaceae and Convolvulaceae (eight species each) also stand out. The eleven families (21.2%) with the highest species richness correspond to 71.6% of the total species number. Of all the families, 21 (40.4%) are represented by only one species, and eight by two species. The genera with the highest species number were *Eupatorium*, *Baccharis*, *Eragrostis*, *Senecio*, *Vernonia*, *Aristida*, *Axonopus*, *Croton*, *Eryngium*, *Oxalis*, *Paspalum*, *Eugenia*, *Pterocaulon* and *Sisyrinchium* (Fig. 3).

For the South-Brazilian grasslands, Boldrini (2002) pointed out Asteraceae (ca. 600 species), Poaceae (400 species) and Fabaceae (150 species) as the most representative families. In the present survey, besides these families, other ones such as Apocynaceae, Euphorbiaceae and Myrtaceae figure among the most species-rich families, making these grasslands floristically different from the remaining grasslands in southern Brazil.

Previous studies focusing on the grassland vegetation distributed in other areas of RS, when compared to our results, indicate differences in floristic composition, mainly concerning the most numerous families (Boldrini & Eggers 1996, Boldrini *et al.* 1998, Boldrini *et al.* 2008). The floristic inventory of the grassland vegetation at São Pedro hill, which presents the higher proportions of dry grassland formations at the granitic hills of Porto Alegre municipality (RS), pointed out the occurrence of 497 native species pertaining to 66 botanical families. Considering the dry gassland areas, the most representative families were Asteraceae (97 spp.), Poaceae (63 spp.), Fabaceae (44 spp.), Rubiaceae (16 spp.), Verbenaceae (13 spp.), Apiaceae (11 spp.), Malvaceae and Cyperaceae (10 spp.) (Setúbal & Boldrini 2009). In these studies, the families Apocynaceae, Euphorbiaceae and Myrtaceae, when represented, showed reduced species number.

The reason for the existing differences in floristic composition between the sandy soil grasslands and the grasslands covering other areas of RS state may be the result of adaptations to edaphic and climatic factors existing in the first ones since dryer climatic times, when grasslands were the prevailing formations in the region. Nowadays, these formations are predominatly found on soils of low fertility, high acidity and high susceptibility to hydric and aeolian erosion, associated to high probability of hydric shortage, summer rains and extreme temperatures. Besides that, the direct anthropic action, through cattle treading and grazing, contributes for the selection of grassland species (Boldrini & Eggers 1996).

There is a certain similarity between the most numerous botanical families at the Cerrado biome and at the sandy soil grasslands of RS. In a study accomplished by Silva *et al.* (2002) at Parque Estadual da Serra de Caldas Novas, Goiás state, Apocynaceae and Myrtaceae figured between the families with highest species number. Tannus & Assis (2004), studying the floristic composition of a Cerrado area at Itapiranga region, São Paulo state, verified that Euphorbiaceae and Myrtaceae were among the richest families. Such resemblance may also be the consequence of climatic and edaphic conditions found at the Cerrado region (rainy periods followed by dry ones, light temperatures during the year and intemperized soils with lack of nutrients and high aluminum concentration) (Klink & Machado 2005).

Studies concerning sandy soil grasslands at RS state are scarce. Trindade *et al.* (2008) evaluated the floristic composition of grassland areas located at the edge of 11 sandy patches at São Francisco de Assis, Manoel Viana and Alegrete municipalities, registering the occurrence of 53 species and 16 families. The most representative families were Poaceae, Asteraceae and Fabaceae. Rovedder *et al*. (2005) also evaluated the floristic composition in the edges and in the core of a sandy patch in a grassland area at Alegrete municipality, southwestern RS, identifying the occurrence of 42 species and 13 families, with Poaceae as the richest family, followed by Fabaceae, Rubiaceae, Asteraceae and Myrtaceae. Euphorbiaceae and Cyperaceae registered few species, probably because the survey focused on edges and cores of sandy patches, whereas our survey encompassed all the sandy soil grassland area. Freitas *et al.* (2009), in a floristic and phytosociological survey of a grassland undergoing sandy patch process at São Francisco de Assis municipality, registered the occurrence of 102 species

Table 1. Families and species of sandy soil grasslands in southwestern Rio Grande do Sul state, with respective vouchers.

Family/Species	Voucher
ACANTHACEAE	
Justicia axillaris (Nees) Lindau	*Freitas s.n.* (HVAT1444)
Stenandrium diphyllum Nees	*Freitas 576* (ICN)
Stenandrium dulce (Cav.) Nees	*Freitas s.n.* (HVAT1721)
Ruellia bulbifera Lindau	*Freitas 579* (ICN)
Ruellia sp.	*Freitas 645* (ICN)
ALLIACEAE	
Nothoscordum bonariense (Pers.) Beauverd	*Freitas 386* (ICN)
AMARANTHACEAE	
Alternanthera hirtula (Mart.) R.E. Fr.	*Bruisma 002* (ICN)
Alternanthera praelonga A. St.-Hil.	*Bruisma 069* (ICN)
Froelichia tomentosa (Mart.) Moq.	*Freitas 055* (ICN)
Gomphrena celosioides Mart.	*Mundeleski 020* (ICN)
Gomphrena graminea Moq.	*Freitas 096* (ICN)
Gomphrena perennis L.	*Freitas 378* (ICN)
Pfaffia gnaphaloides (L. f.) Mart.	*Freitas 056* (ICN)
Pfaffia tuberosa (Sprengel) Hicken	*Freitas 335* (ICN)
ANACARDIACEAE	
Schinus weinmannifolius Engl.	*Freitas 656* (ICN)
APIACEAE	
Apium leptophyllum (Pers.) F. Muell. ex Benth.	*Freitas 365* (ICN)
Centella hirtella Nannf.	*Freitas 649* (ICN)
Eryngium ciliatum Cham. & Schltdl.	*Freitas 451* (ICN)
Eryngium elegans Cham. & Schltdl.	*Freitas 091* (ICN)
Eryngium eriophorum Cham. & Schltdl.	*Mundeleski 051* (ICN)
Eryngium horridum Malme	*Bruisma 008* (ICN)
Eryngium nudicaule Lam.	*Freitas 413* (ICN)
APOCYNACEAE	
Asclepias campestris Vell.	*Freitas 387* (ICN)
Asclepias mellodora A. St.-Hil.	*Freitas 652* (ICN)
Blepharodon lineare (Decne.) Decne.	*Freitas 637* (ICN)
Macrosiphonia longiflora (Desf.) Müll. Arg.	*Freitas 087* (ICN)
Oxypetalum glomeratum E. Fourn.	*Freitas 516* (ICN)
Oxypetalum sp.	*Freitas 333* (ICN)
Oxypetalum solanoides Hook. & Arn.	*Freitas 417* (ICN)
Tabernaemontana australis Müll. Arg.	*Freitas 385* (ICN)
ARECACEAE	
Butia lallemantii Deble & Marchiori	*Freitas 098* (ICN)
ARISTOLOCHIACEAE	
Aristolochia sessilifolia (Klotzsch) Duch.	*Freitas 415* (ICN)
ASTERACEAE	
Acanthospermum australe (Loefl.) Kuntze	*Freitas 392* (ICN)
Achyrocline marchiorii Deble	*Muller s.n.* (ICN152811)
Achyrocline satureioides (Lam.) DC.	*Freitas 283* (ICN)
Ambrosia tenuifolia Spreng.	*Bruisma 063* (ICN)
Aspilia montevidensis (Spreng.) Kuntze	*Freitas 080* (ICN)
Asteropsis megapotamica (Spreng.) Marchesi, Bonifacino & Sancho	*Mundeleski 040* (ICN)
Baccharis albolanosa A.S. Oliveira & Deble	*Freitas 506* (ICN)
Baccharis coridifolia DC.	*Freitas 489* (ICN)
Baccharis dracunculifolia DC.	*Bruisma 048* (ICN)
Baccharis leptophylla DC.	*Freitas 287* (ICN)
Baccharis multifolia A.S.Oliveira, Deble & Marchiori	*Bruisma 051* (ICN)
Baccharis pseudotenuifolia Malag.	*Mundeleski 032* (ICN)
Baccharis punctulata DC.	*Bruisma 051* (ICN)
Baccharis riograndensis Malag. & J.E. Vidal	*Mundeleski 022* (ICN)
Baccharis trimera (Less) DC.	*Freitas s.n.* (HVAT1479)
Calea clematidea Baker	*Freitas 513* (ICN)
Calea uniflora Less.	*Freitas 101* (ICN)
Centhratherum camporum (Hassl.) Malme	*Freitas 514* (ICN)
Chaptalia integerrima (Vell.) Burk.	*Freitas 501* (ICN)
Chaptalia nutans (L.) Pol.	*Freitas 288* (ICN)
Chaptalia sinuata (DC.) Baker	*Heberle s.n.* (ICN157298)
Chevreulia sarmentosa (Pers.) S.F. Blake	*Freitas 556* (ICN)
Conyza bonariensis var. *microcephala* (Cabrera) Cabrera	*Freitas 448* (ICN)
Conyza primulifolia (Lam.) Cuatrec. & Lourteig	*Bruisma 064* (ICN)
Elephantopus mollis Kunth	*Freitas s.n.* (HVAT1385)
Eupatorium angusticeps Malme	*Freitas 180* (ICN)
Eupatorium calyculatum Hook. & Arn.	*Freitas 641* (ICN)
Eupatorium commersonii (Cass.) Hieron.	*Freitas 509* (ICN)
Eupatorium inulifolium Kunth	*Freitas 493* (ICN)
Eupatorium laevigatum Lam.	*Bruisma 049* (ICN)
Eupatorium macrocephalum Less.	*Bruisma 062* (ICN)
Eupatorium squarrulosum Hook. & Arn.	*Bruisma 042* (ICN)
Eupatorium subhastatum Hook. & Arn.	*Freitas 099* (ICN)
Eupatorium tanacetifolium Gillies ex Hook. & Arn.	*Freitas 562* (ICN)
Eupatorium tweedianum Hook. & Arn.	*Mundeleski 041* (ICN)
Facelis retusa (Lam.) Sch. Bip.	*Freitas 397* (ICN)
Gamochaeta americana (Mill.) Wedd.	*Heberle s.n.*(ICN157277)
Gamochaeta falcata (Lam.) Cabrera	*Freitas 329* (ICN)
Gamochaeta spicata Cabrera	*Freitas 391* (ICN)

Table 1. cont.

Family/Species	Voucher
Gochnatia cordata Less.	*Freitas 508* (ICN)
Hieracium commersonii Monnier	*Freitas 559* (ICN)
Hypochaeris chillensis (Kunth) Britton	*Heberle s.n.* (ICN157310)
Hypochaeris megapotamica Cabrera	*Freitas 618* (ICN)
Hysterionica filiformis (Spreng.) Cabrera	*Freitas 553* (ICN)
Isostigma peucedanifolium (Spreng.) Less.	*Freitas 624* (ICN)
Lucilia acutifolia (Poir.) Cass.	*Bruisma 018* (ICN)
Lucilia nitens Less.	*Freitas 400* (ICN)
Mikania thapsoides DC.	*Freitas 496* (ICN)
Mikania trachypleura B. L. Rob.	*Freitas 426* (ICN)
Noticastrum acuminatum (DC.) Cuatrec.	*Freitas 502* (ICN)
Noticastrum diffusum (Pers.) Cabrera	*Bruisma 041* (ICN)
Noticastrum gnaphalioides (Baker) Cuatrec.	*Freitas 086* (ICN)
Orthopappus angustifolius (Sw.) Gleason	*Freitas 168* (ICN)
Pterocaulon alopecuroides (Lam.) DC.	*Freitas 174* (ICN)
Pterocaulon angustifolium DC.	*Freitas 178* (ICN)
Pterocaulon lorentzii Malme	*Freitas 108* (ICN)
Pterocaulon polypterum (DC.) Cabrera	*Freitas 640* (ICN)
Senecio brasiliensis (Spreng.) Less. var. *brasiliensis*	*Freitas s.n.* (HVAT1636)
Senecio cisplatinus Cabrera	*Freitas 020* (ICN)
Senecio grisebachii var. *schyzotus* Cabrera	*Freitas s.n.* (HVAT1633)
Senecio leptolobus DC.	*Freitas 014* (ICN)
Senecio oxyphyllus DC.	*Freitas 021* (ICN)
Senecio riograndensis Matzenbacher	*Freitas s.n.* (HVAT1557)
Senecio selloi (Spreng.) DC.	*Freitas 568* (ICN)
Solidago chilensis Meyen	*Mundeleski 037* (ICN)
Soliva pterosperma (Juss.) Less.	*Freitas 435* (ICN)
Stenachaenium riedelii Baker	*Freitas 548* (ICN)
Tagetes osteni Hicken	*Bruisma 066* (ICN)
Trixis pallida Less.	*Freitas 511* (ICN)
Trixis praestans (Vell.) Cabrera	*Freitas 574* (ICN)
Trixis verbascifolia (Gardner) S.F. Blake	*Freitas 492* (ICN)
Vernonia brevifolia Less.	*Freitas 370* (ICN)
Vernonia cognata Less.	*Freitas 176* (ICN)
Vernonia macrocephala Less.	*Freitas 436* (ICN)
Vernonia megapotamica Spreng.	*Freitas 507* (ICN)
Vernonia nudiflora Less.	*Freitas 267* (ICN)
Vernonia sellowii Less.	*Spellmeier 094* (ICN)
BORAGINACEAE	
Euploca salicoides (Cham.) J.I.M. Melo & Semir	*Freitas 646* (ICN)
Cordia verbenacea DC.	*Freitas 557* (ICN)
BRASSICACEAE	
Lepidium aletes J.F. Macbr.	*Freitas 577* (ICN)
BROMELIACEAE	
Dyckia vicentensis T. Strehl	*Freitas 390* (ICN)
CACTACEAE	
Cereus hildmannianus K. Schuman	*Freitas 650* (ICN)
Echinopsis oxygona (Link) Zucc.	*Freitas 626* (ICN)
Parodia ottonis (Lehmann) N. P. Taylor	*Freitas 587* (ICN)
Frailea cataphracta (Dams) Britton & Rose	Sem testemunho
CAMPANULACEAE	
Lobelia hederacea Cham.	*Freitas 518* (ICN)
Wahlenbergia linarioides (Lam.) A. DC.	*Freitas 456* (ICN)
CARYOPHYLLACEAE	
Cardionema ramosissima (Weinm.) A. Nelson & J.F. Macbr.	*Freitas 035* (ICN)
Cerastium commersonianum DC.	*Freitas 011* (ICN)
Paronychia brasiliana DC.	*Freitas 357* (ICN)
Polycarpon tetraphyllum (L.) L.	*Freitas s.n.* (HVAT1637)
Silene gallica L.	*Heberle s.n.* (ICN157287)
Stellaria media (L.) Vill.	*Freitas 332* (ICN)
CISTACEAE	
Helianthemum brasiliense (Lam.) Pers.	*Heberle s.n.* (ICN157286)
COMMELINACEAE	
Commelina erecta L.	*Freitas 424* (ICN)
Commelina rufipes var. *glabrata* (D.R.Hunt) Faden & D.R. Hunt	*Freitas 079* (ICN)
Tradescantia umbraculifera Hand.-Mazz.	*Freitas 657* (ICN)
CONVOLVULACEAE	
Cuscuta xanthochortos Mart.	*Freitas 078* (ICN)
Dichondra sericea Swartz	*Freitas 434* (ICN)
Evolvulus glomeratus Nees & C. Mart.	*Freitas 423* (ICN)
Evolvulus sericeus Swartz	*Santos s.n.* (ICN148690)
Evolvulus sericeus f. *pedunculatus* Ooststr.	*Freitas 069* (ICN)
Ipomoea kunthiana Meisn.	*Freitas 615* (ICN)
Ipomoea malvaeoides var. *lineariloba* Hallier	*Freitas 449* (ICN)
Ipomoea nitida Griseb.	*Freitas 616* (ICN)
CYPERACEAE	
Bulbostylis capillaris var. *elatior* Osten	*Freitas 351* (ICN)
Bulbostylis major Palla	*Freitas 659* (ICN)
Bulbostylis sphaerocephala (Boeck.) C.B. Clarke	*Freitas 289* (ICN)
Carex phalaroides Kunth	*Freitas 552* (ICN)

Table 1. cont.

Family/Species	Voucher
Carex sororia Kunth	*Freitas 500* (ICN)
Cyperus aggregatus (Willd.) Endl.	*Freitas 272* (ICN)
Cyperus sp.	*Spellmeier 090* (ICN)
Kyllinga odorata Vahl	*Heberle s.n.* (ICN157276)
Kyllinga vaginata Lam.	*Freitas 376* (ICN)
Lipocarpha humboldtiana Nees	*Freitas 175* (ICN)
Rhynchospora rugosa (Vahl) Galé	*Heberle s.n.* (ICN157275)
DROSERACEAE	
Drosera brevifolia Pursh	*Freitas 550* (ICN)
ERICACEAE	
Agarista eucalyptoides (Cham. & Schltdl.) G. Don	*Freitas 639* (ICN)
EUPHORBIACEAE	
Acalypha communis Müll. Arg.	*Freitas 427* (ICN)
Croton echinulatus (Griseb.) Croizat	*Freitas 555* (ICN)
Croton glandulosus L.	*Freitas 200* (ICN)
Croton lorentzii Müll. Arg. ex Griseb.	*Bruisma 006* (ICN)
Croton parvifolius Müll. Arg.	*Schneider 1581* (ICN)
Croton subpannosus Müll. Arg. ex Griseb.	*Freitas 049* (ICN)
Euphorbia caecorum Mart. ex Boiss.	*Freitas 422* (ICN)
Euphorbia papillosa A. St.-Hil.	*Freitas 349* (ICN)
Euphorbia selloi (Klotzsch & Garcke) Boiss.	*Freitas 082* (ICN)
Euphorbia sp.	*Freitas 663* (ICN)
Jatropha isabelliae Müll. Arg.	*Freitas 377* (ICN)
Manihot sp.	*Freitas 564* (ICN)
Sapium haematospermum Müll. Arg.	*Santos s.n.* (ICN156290)
Sebastiania hispida var. *graciliramea* Pax & K. Hoffm.	*Freitas 092* (ICN)
Sebastiania hispida var. *interceedens* (Müll. Arg.) Pax	*Freitas 445* (ICN)
FABACEAE	
Aeschynomene histrix var. *incana* (Vogel) Benth.	*Freitas 044* (ICN)
Arachis burkartii Handro	*Freitas 402* (ICN)
Chamaecrista flexuosa (L.) E. Greene var. *flexuosa*	*Spellmeier 089* (ICN)
Chamaecrista repens (Vogel) H.S. Irwin & Barneby	*Bruisma 005* (ICN)
Chamaecrista rotundifolia (Pers.) Greene	*Freitas 189* (ICN)
Clitoria nana Benth.	*Freitas 188* (ICN)
Crotalaria tweediana Benth.	*Freitas 421* (ICN)
Desmanthus virgatus (L.) Willd.	*Freitas 443* (ICN)
Desmanthus sp.	*Muller s.n.* (ICN159196)
Desmodium barbatum (L.) Benth.	*Freitas 638* (ICN)
Desmodium incanum DC.	*Santos s.n.* (ICN148691)
Eriosema tacuaremboense Arechav.	*Freitas 094* (ICN)
Galactia benthamiana Micheli	*Freitas 623* (ICN)
Galactia gracillima Benth.	*Freitas 648* (ICN)
Lupinus albescens Hook. & Arn.	*Freitas 317* (ICN)
Lupinus bracteolaris Desr.	*Freitas 595* (ICN)
Lupinus lanatus Benth.	*Heberle s.n.* (ICN158799)
Macroptilium heterophyllum (Humb. & Bonpl. ex Willd.) Maréchal & Baudet	*Bruisma 072* (ICN)
Macroptilium prostratum (Benth.) Urb.	*Freitas 116* (ICN)
Mimosa bifurca Benth.	*Freitas 575* (ICN)
Pomaria pilosa (Vogel) B.B. Simpson & G.P. Lewis	Sem testemunho
Rhynchosia corylifolia Mart. ex Benth.	*Freitas 084* (ICN)
Rhynchosia lineata Benth.	*Freitas 085* (ICN)
Senna pillifera (Vogel) H.S. Irwin & Barneby	*Freitas 455* (ICN)
Senna scabriuscula (Vogel) H. S. Irwin & Barneby	*Lima s.n.* (ICN151412)
Stylosanthes guianensis var. *subviscosa* Benth.	*Spellmeier 099* (ICN)
Stylosanthes montevidensis Vogel	*Freitas 383* (ICN)
Stylosanthes sp.	*Freitas s.n.* (HVAT1402)
Vigna peduncularis var. *clitorioides* (Mart. ex Benth.) Maréchal, Mascherpa & Stainier	*Freitas 617* (ICN)
Zornia reticulata Sm.	*Freitas 393* (ICN)
Zornia sp.	*Freitas 596* (ICN)
GESNERIACEAE	
Sinningia stricta (Hook. & Arn.) Wiehler	*Freitas 642* (ICN)
HYPERICACEAE	
Hypericum connatum Lam.	*Freitas 177* (ICN)
IRIDACEAE	
Cypella herbertii Kook.	*Bruisma 057* (ICN)
Sisyrinchium hasslerianum Baker	*Freitas 356* (ICN)
Sisyrinchium micranthum Cav.	*Freitas 322* (ICN)
Sisyrinchium ostenianum Beauv.	*Heberle s.n.* (ICN159211)
Sisyrinchium vaginatum Spreng.	*Freitas 573* (ICN)
JUNCACEAE	
Juncus capillaceus Lam.	*Lima s.n.* (ICN157268)
Juncus scirpoides Lam.	*Spellmeier 110* (ICN)
LAMIACEAE	
Hesperozygis ringens Benth.	*Bruisma 007* (ICN)
Hyptis mutabilis (Rich.) Briq.	*Freitas 494* (ICN)
Marsypianthes chamaedrys (Vahl) Kuntze	*Santos s.n.* (ICN159202)
Marsypianthes hassleri Briq.	*Freitas 062* (ICN)
Peltodon longipes Kunth ex Benth.	*Mundeleski 055* (ICN)
Salvia ovalifolia A. St.-Hil.	*Freitas 498* (ICN)

Table 1. cont.

Family/Species	Voucher
LAURACEAE	
Ocotea pulchella (Nees) Mez	*Heberle s.n*. (ICN158803)
LOGANIACEAE	
Spigelia stenophylla Progel	Sem testemunho
LYTHRACEAE	
Cuphea racemosa (L.f.) Spreng.	*Bruisma 060* (ICN)
MALPIGHIACEAE	
Galphimia sp.	*Freitas 605* (ICN)
Heteropterys sp.	*Freitas 446* (ICN)
MALVACEAE	
Ayenia mansfeldiana (Herter) Herter & Cristobal	*Spellmeier 092* (ICN)
Hochreutinera hasslerana (Hochr.) Krapov.	*Freitas 171* (ICN)
Krapovickasia flavescens (Cav.) Fryxell	*Freitas 043* (ICN)
Krapovickasia urticifolia (A. St.-Hil.) Fryxell	*Freitas 660* (ICN)
Sida rhombifolia L.	*Freitas 037* (ICN)
Sida vespertina Ekman	*Mundeleski 058* (ICN)
Sida viarum A. St.-Hil.	*Bruisma 014* (ICN)
Sida sp.	*Freitas 619* (ICN)
Waltheria douradinha A. St.-Hil.	*Freitas 064* (ICN)
MELASTOMATACEAE	
Tibouchina gracilis (Bonpl.) Cogn.	*Bruisma 067* (ICN)
MOLLUGINACEAE	
Mollugo verticillata L.	*Freitas 431* (ICN)
MORACEAE	
Dorstenia brasiliensis Lam.	*Freitas 416* (ICN)
MYRTACEAE	
Blepharocalyx salicifolius (Kunth) O. Berg	*Freitas 653* (ICN)
Campomanesia aurea O. Berg.	*Freitas 352* (ICN)
Eugenia arenosa Mattos	*Freitas 581* (ICN)
Eugenia hiemalis Cambess.	*Freitas 572* (ICN)
Eugenia pitanga (O. Berg) Kiaersk.	*Freitas* 105 (ICN)
Eugenia plurisepala Barb. Rodr. ex Chodat & Hassl.	*Freitas 042* (ICN)
Hexachlamys humilis O. Berg	*Freitas 319* (ICN)
Myrcia verticillaris O. Berg	*Freitas 265* (ICN)
Myrceugenia campestris (DC.) D. Legrand & Kausel	*Freitas 644* (ICN)
Psidium luridum (Spreng.) Burret	*Freitas 197* (ICN)
ONAGRACEAE	
Ludwigia sericea (Cambess.) Hara	*Spellmeier 111* (ICN)
Oenothera molissima L.	*Freitas 419* (ICN)
OROBANCHACEAE	
Agalinis communis (Cham. & Schltdl.) D'Arcy	*Freitas 661* (ICN)
Buchnera longifolia Kunth	*Freitas 613* (ICN)
OXALIDACEAE	
Oxalis lasiopetala Zucc.	*Freitas 488* (ICN)
Oxalis conorrhiza Jacq.	*Freitas 560* (ICN)
Oxalis eriocarpa DC.	*Freitas 009* (ICN)
Oxalis hispidula Zucc.	*Freitas s.n.* (HVAT1529)
Oxalis perdicaria (Molina) Bertero	*Freitas 490* (ICN)
PLANTAGINACEAE	
Angelonia integerrima Spreng.	*Freitas 077* (ICN)
Plantago tomentosa Lam.	*Freitas 394* (ICN)
Scoparia ericacea Cham. & Schltdl.	*Freitas 389* (ICN)
Scoparia montevidensis (Kuntze) R.E. Fr.	*Freitas 551* (ICN)
POACEAE	
Agrostis montevidensis Spreng. ex Nees var. *montevidensis*	*Bruisma 059* (ICN)
Andropogon lateralis Nees	*Spellmeier 085* (ICN)
Andropogon selloanus (Hackel) Hackel	*Freitas 053* (ICN)
Andropogon ternatus (Spreng.) Nees	*Freitas 440* (ICN)
Aristida circinalis Lindm.	*Freitas 274* (ICN)
Aristida condylifolia Caro	*Spellmeier 091* (ICN)
Aristida filifolia (Arechav.) Herter	*Muller s.n.* (ICN153139)
Aristida glaziowii Hack. ex Henrard	*Freitas 277* (ICN)
Aristida jubata (Arechav.) Herter	*Freitas 109* (ICN)
Axonopus affinis Chase	*Freitas s.n.* (HVAT1639)
Axonopus argentinus Parodi	*Freitas 342* (ICN)
Axonopus fissifolius (Raddi) Kuhlm.	*Freitas 344* (ICN)
Axonopus siccus (Nees) Kuhlm.	*Freitas 182* (ICN)
Axonopus suffultus (Mikan ex Trin.) Parodi	*Santos s.n.* (ICN148682)
Briza subaristata Lam.	*Freitas 569* (ICN)
Cenchrus echinatus L.	*Freitas s.n.* (HVAT1723)
Cynodon dactylon (L.) Pers.	*Mundeleski 027* (ICN)
Dichanthelium sabulorum (Lam.) Gould et C.A. Clark var. *sabulorum*	*Freitas 345* (ICN)
Digitaria ciliaris (Retz.) Koeler	*Freitas 491* (ICN)
Digitaria eriantha subsp. *pentzii* (Stent) P.D.F.Kok	*Mundeleski 040* (ICN)
Digitaria insularis (L.) Fedde	*Freitas 437* (ICN)
Eleusine tristachya (Lam.) Lam.	*Mundeleski 028* (ICN)
Elionurus sp.	*Freitas 338* (ICN)
Eragrostis articulata (Schrank) Nees	*Freitas 051* (ICN)
Eragrostis bahiensis Schrad. ex Schult.	*Freitas s.n.* (HVAT1473)

Table 1. cont.

Family/Species	Voucher
Eragrostis curvula (Schrad.) Nees	*Freitas 314* (ICN)
Eragrostis leucosticta Nees ex Döll	*Freitas 089* (ICN)
Eragrostis lugens Nees	*Freitas 347* (ICN)
Eragrostis mexicana (Hornem.) Link subsp. *mexicana*	*Freitas 263* (ICN)
Eragrostis neesii Trin.	*Freitas 047* (ICN)
Eragrostis plana Nees	*Freitas 186* (ICN)
Eragrostis polytricha Nees	*Freitas 275* (ICN)
Eustachys distichophylla (Lag.) Nees	*Freitas 531* (ICN)
Eustachys retusa (Lag.) Kunth	*Freitas 075* (ICN)
Gymnopogon spicatus (Spreng.) Kuntze	*Freitas 280* (ICN)
Leptocoryphium lanatum (Kunth) Nees	*Freitas 268* (ICN)
Melica eremophila M. A. Torres	*Freitas 504* (ICN)
Melinis repens (Willd.) Zizka	*Freitas 012* (ICN)
Microchloa indica (L. F.) P. Beauv.	*Freitas s.n.* (HVAT1562)
Panicum olyroides Kunth	*Freitas 602* (ICN)
Panicum tricholaenoides Steud.	*Freitas 102* (ICN)
Pappophorum macrospermum Roseng., B.R. Arrill. & Izag.	*Freitas 264* (ICN)
*Paspalum lepton S*chult. (= Paspalum nicorae Parodi)	*Freitas 033* (ICN)
Paspalum notatum Flüggé	*Freitas 185* (ICN)
Paspalum plicatulum Michx.	*Freitas 312* (ICN)
Paspalum polyphyllum Nees ex Trin.	*Freitas 534* (ICN)
Paspalum stellatum Humb. & Bonpl. ex Flüggé	*Freitas 497* (ICN)
Piptochaetium montevidense (Spreng.) Parodi	*Freitas 346* (ICN)
Poa lanigera Nees	*Freitas 561* (ICN)
Schizachyrium imberbe (Hack.) A. Camus	*Freitas 594* (ICN)
Schizachyrium microstachyum (Desv. ex Ham.) Roseng. B.R. Arrill. & Izag.	*Santos s.n.* (ICN152719)
Schizachyrium spicatum (Spreng.) Herter	*Freitas 036* (ICN)
Schizachyrium sp.	*Freitas 660* (ICN)
Setaria parviflora (Poir.) Kerguélen	*Freitas 066* (ICN)
Sporobolus indicus (L.) R. Br. var. *indicus*	*Freitas s.n.* (HVAT1466)
Steinchisma hians (Elliott) Nash	*Freitas s.n.* (HVAT1406)
Stipa melanosperma J. Presl	*Freitas 313* (ICN)
Trachypogon montufarii (Kunth) Nees var. *montufarii*	*Freitas 337* (ICN)
Vulpia australis (Nees ex Steud.) C. H. Blom	*Heberle s.n.* (ICN157283)
PODOCARPACEAE	
Podocarpus lambertii Klotzsch ex Endl.	*Freitas 103* (ICN)
POLYGALACEAE	
Monnina cuneata A. St.-Hil.	*Freitas 592* (ICN)
Monnina tristaniana A. St.-Hil.	*Mundeleski 052* (ICN)
Polygala molluginifolia A. St.-Hil. & Moq.	*Mundeleski 056* (ICN)
Polygala pulchella A. St.-Hil. & Moq.	*Freitas 578* (ICN)
PORTULACACEAE	
Portulaca grandiflora Hook.	*Freitas 208* (ICN)
Portulaca sp.	*Freitas 432* (ICN)
RUBIACEAE	
Galianthe fastigiata Griseb.	*Spellmeier 123* (ICN)
Galium atherodes Spreng.	*Bruisma 061* (ICN)
Galianthe verbenoides (Cham. & Schlcht.) Griseb.	*Fleig 138* (ICN)
Mitracarpus megapotamicus (Spreng.) Kuntze	*Freitas 167* (ICN)
Richardia brasiliensis Gomes	
Richardia humistrata (Cham. & Schltdl) Steud.	*Freitas 371* (ICN)
Richardia stellaris (Cham. & Schltdl.) Steud.	*Freitas 398* (ICN)
Spermacoce brachystemonoides Cham. & Schltdl.	*Freitas 040* (ICN)
Spermacoce poaya A. St.-Hil.	*Freitas 425* (ICN)
Spermacoce tenella Kunth	*Freitas 520* (ICN)
Staelia thymoides Cham. & Schltdl.	*Santos s.n.* (ICN159144)
RUTACEAE	
Zanthoxylum rhoifolium Lam.	*Freitas 654* (ICN)
SAPOTACEAE	
Chrysophyllum marginatum (Hook. & Arn.) Radlk.	*Freitas 535* (ICN)
SOLANACEAE	
Calibrachoa thymifolia (A. St.-Hil.) Stehmann & Semir	*Freitas 107* (ICN)
Petunia integrifolia Schinz & Thell.	*Bruisma 054* (ICN)
Solanum americanum Mill.	*Freitas 285* (ICN)
Solanum hasslerianum Chodat	*Freitas 038* (ICN)
TURNERACEAE	
Piriqueta suborbicularis (A. St.-Hil. & Naudin) Arbo	*Freitas 519* (ICN)
Turnera sidoides subsp. *integrifolia* (Griseb.) Arbo	*Heberle s.n.* (ICN159199)
VERBENACEAE	
Aloysia gratissima (Gillies & Hook.) Tronc.	*Freitas 173* (ICN)
Glandularia peruviana (L.) Small	*Freitas 583* (ICN)
Glandularia tenera (Spreng.) Cabrera	*Freitas 010* (ICN)
Glandularia thymoides (Cham.) N. O'Leary	*Freitas 503* (ICN)
Lantana camara L.	*Freitas 571* (ICN)
Lippia arechavaletae Moldenke	*Freitas 081* (ICN)
Verbena litoralis Kunth.	*Mundeleski 044* (ICN)
VIOLACEAE	
Hybanthus bicolor (A. St.-Hil.) A. St.-Hil. & Baill.	*Freitas 045* (ICN)

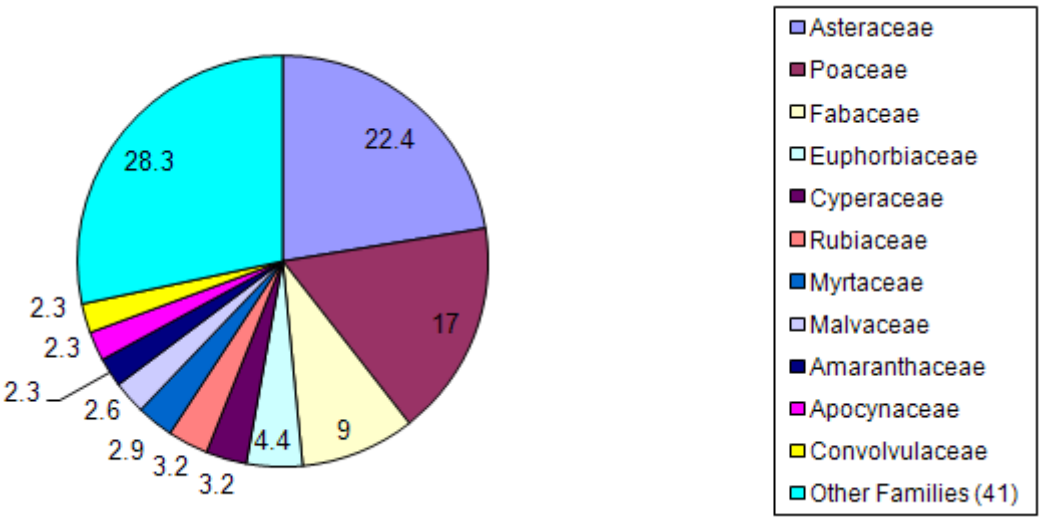

Figure 2. Percentual distribution of the families with higher richness values in sandy soil grasslands at Alegrete, Manoel Viana and São Francisco de Assis municipalities, RS.

distributed in 25 families. Among the richest families were Poaceae (29 species), Asteraceae (18 species) and Myrtaceae (six species).

Some species found in the study area are more resistant, surviving the soil removal or the sand burying processes: *Croton subpannosus*, *Elionurus* sp., *Eugenia pitanga*, *E. plurisepala*, *E. arenosa*, *Hexachlamys humilis*, *Psidium luridum*, *Paspalum lepton (= Paspalum nicorae)*, *P. notatum* and *Vernonia brevifolia*.

Paspalum lepton and *P. notatum* are prostrate rhizomatous species, which allows their vegetative propagation when exposed to cattle treading. Besides that, they show resistance to sand burying processes when the sand is wind-driven. Both species are abundant in grassland areas undergoing sandy patch process where grazing is present. Besides these species, *Elionurus* sp., commonly known as 'capim-limão' ('lemon-grass') (Fig. 4A), *Vernonia brevifolia* (Fig. 4B) and *Croton subpannosus* (Fig. 4C, 4D) where frequently observed at edges and cores of sandy patches, evidencing resistance to erosive and sand burying processes. *Vernonia brevifolia* shows a well developed lignified base, favouring its survival in adverse environments such as the sandy patches.

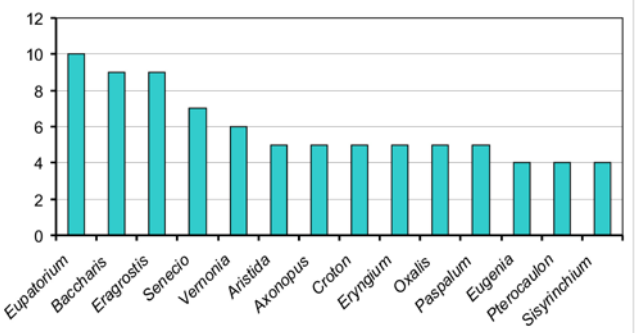

Figure 3. Genera with higher species richness, with the respective species number, of the sandy soil grasslands at Alegrete, Manoel Viana and São Francisco de Assis municipalities, RS.

Senecio cisplatinus (Fig. 5A, 5B) is another species with marked presence in the grassland areas of southwerstern RS. It frequently occurs in edges and cores of sandy patches, and was scarcely found in areas not undergoing sandy patch process. Due to the presence of wax, sand grains lifted by the wind adhere to the plant's aerial structure. On the other hand, *Senecio selloi* (Fig. 5C, 5D), also frequent in these grasslands, was observed only in grassland areas distant from the sandy patches, showing no evident resistance to the sandy patch process.

Due to the abundance of individuals in their populations, *Vernonia macrocephala* (Fig. 5E, 5D) and *Axonopus argentinus* also stand out in the study area. Both species are frequent, constituting large populations and covering broad grassland areas.

Myrtaceae species, especially *Hexachlamys humilis* (Fig. 6A), *Eugenia arenosa* (Fig.6B, 6C), *E. pitanga* (Fig.6D) and *E. plurisepala* (Fig.6E), probably favoured by their deep roots and coriaceous leaves, survive amidst sandy patches. They were frequently observed in spots with sparse vegetation cover (Fig.6F).

Other species showed potential for regeneration of grassland areas undergoing sandy patch process. Among them, *Acanthospermum australe* (Fig. 7A, 7B) and *Lupinus albescens* (Fig. 7C, 7D) deserve special attention. The first, due to its capacity to grow on small sand mounds, contributes to the stabilization of the sandy patch process. The latter, occurring only in the grasslands of RS state in Brazil (Pinheiro & Miotto 2001), has been mentioned as an alternative to sandy patch revegetation. It shapes dense populations in areas undergoing advanced sandy patch process (Fig. 7E, 7F), acting as a natural colonizer of this environment, which verifies its adaptation to the region's unfriendly edaphic conditions (Rovedder *et al.* 2005). This species

shows high potencial for use in recuperation initiatives concerning degraded areas, due to its high seed production and ease in occupying opened communities. Besides these, *Panicum tricholaenoides*, *Pappophorum macrospermum* and *Paspalum polyphyllum* are cespitose-rhizomatous grasses common in sandy areas, contributing for sand fastening.

Among the species registered for the study site, according to Schneider (2007) and Souza & Lorenzi (2005) nine are naturalized: *Cardionema ramosissima*, *Cerastium commersonianum* (Fig. 8A), *Polycarpon tetraphyllum*, *Silene gallica*, *Stellaria media*, *Digitaria ciliaris*, *Digitaria eriantha* subsp. *pentzii*, *Eragrostis plana* and *Melinis repens*. Among these, *Eragrostis plana* is also characterized as an invasive plant, probably the most aggressive one in RS state due to its high capacity of seed production, allowing dispersion to great distances (Schneider 2007). *Melinis repens* is also mentioned by the author as one of the most aggressive species in the state's herbaceous flora.

New records

Among the species found in the area, *Croton lorentzii* (Fig. 8B) appears as a new record for Brazil. It is a shrub with distribution records for central and NE Argentina and for Uruguay (Burkart & Bacigalupo 2005). In the study area, the species was found in grasslands undergoing sandy patch process at São Francisco de Assis

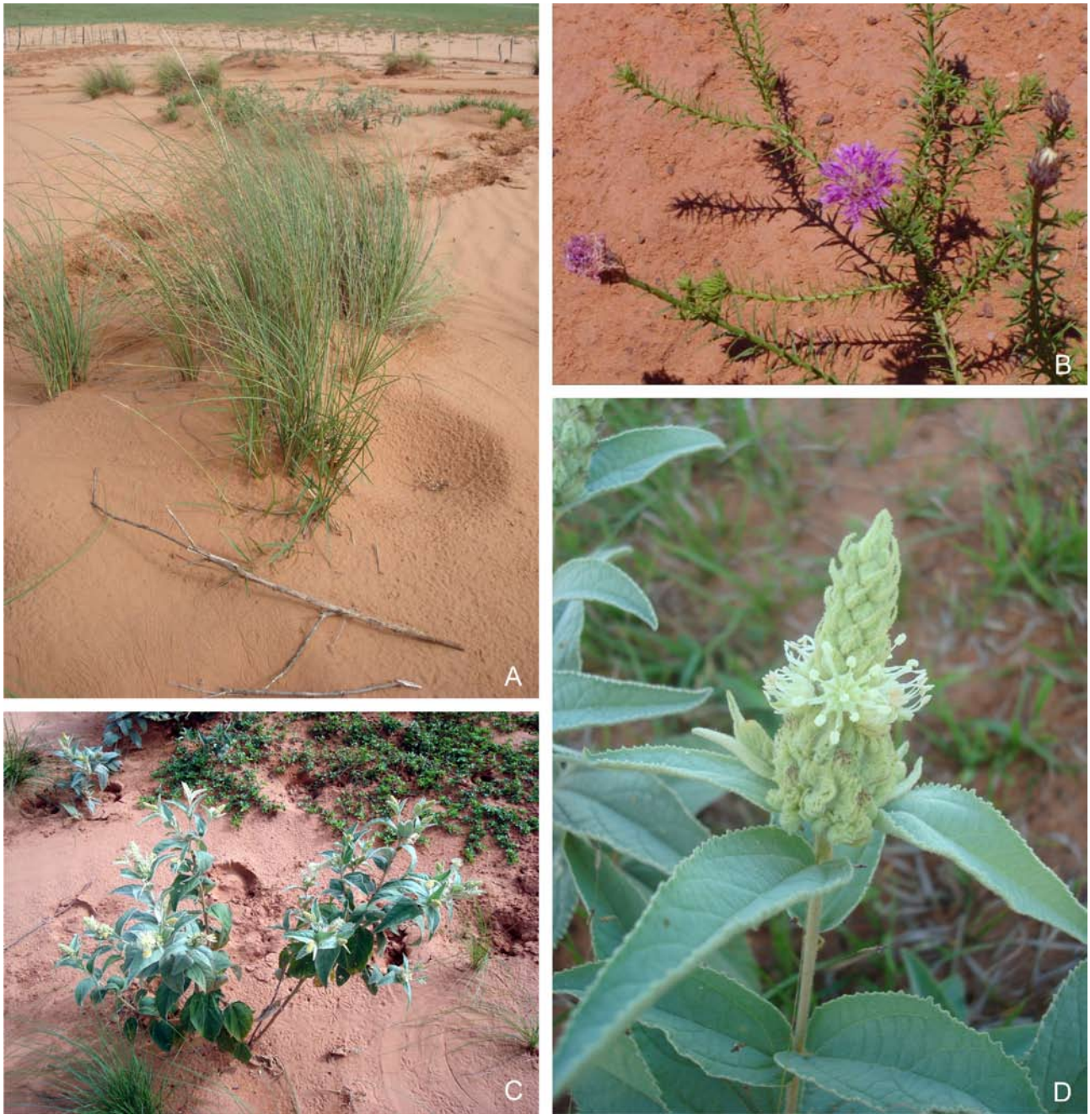

Figure 4. Species frequently found at edges and cores of sandy patches. A. *Elionurus sp.*. B. *Vernonia brevifolia*. C. *Croton subpannosus* (habit). D. *C. subpannosus* (inflorescence detail).

Figure 5. A, B. *Senecio cisplatinus*, occurring in the areas most severely hit by the sandy patch process. C, D. *Senecio selloi*, occurring in grassland portions still untouched by the sandy patch process. E. *Vernonia macrocephala*, represented by a high number of individuals in a grassland area at São Francisco de Assis municipality. F. *V. macrocephala* inflorescence.

municipality, Taquari district, Passo do Nagel locality.

Eragrostis articulata and *Eragrostis leucosticta* appear as new records for RS state. *E. articulata*, an annual cespitous grass is recorded for Argentina, Bolivia, Brazil and Paraguay. In Brazil it is recorded for many states and so that its southernmost record is for Paraná state. The rocky fields and the cerrado are the predominant habitats for this species (Boechat & Longhi-Wagner 2001). In the study area, it was found in dry and sandy grasslands undergoing sandy patch process, at Manoel Viana municipality, Lajeado locality. *E. leucosticta*, a cespitous perennial grass, has occurrence records for many states to Brazil, as a typical species of the cerrado biome (Boechat & Longhi-Wagner 2001). In the study area, it was collected in dry and sandy grasslands undergoing sandy patch process, at Alegrete municipality, Cerro do Tigre locality.

Figure 6. A. *Hexachlamys humilis*. B. *Eugenia arenosa*. C. *E. arenosa* individuals in a grassland areas undergoing sandy patch process at Jacaquá, São Francisco de Assis municipality. D. *Eugenia pitanga*. E. *E. plurisepala*. F. Grassland area with sandy patch process in Jacaquá, São Francisco de Assis, with specimens of *E. pitanga*, *E. arenosa* and *H. humilis*.

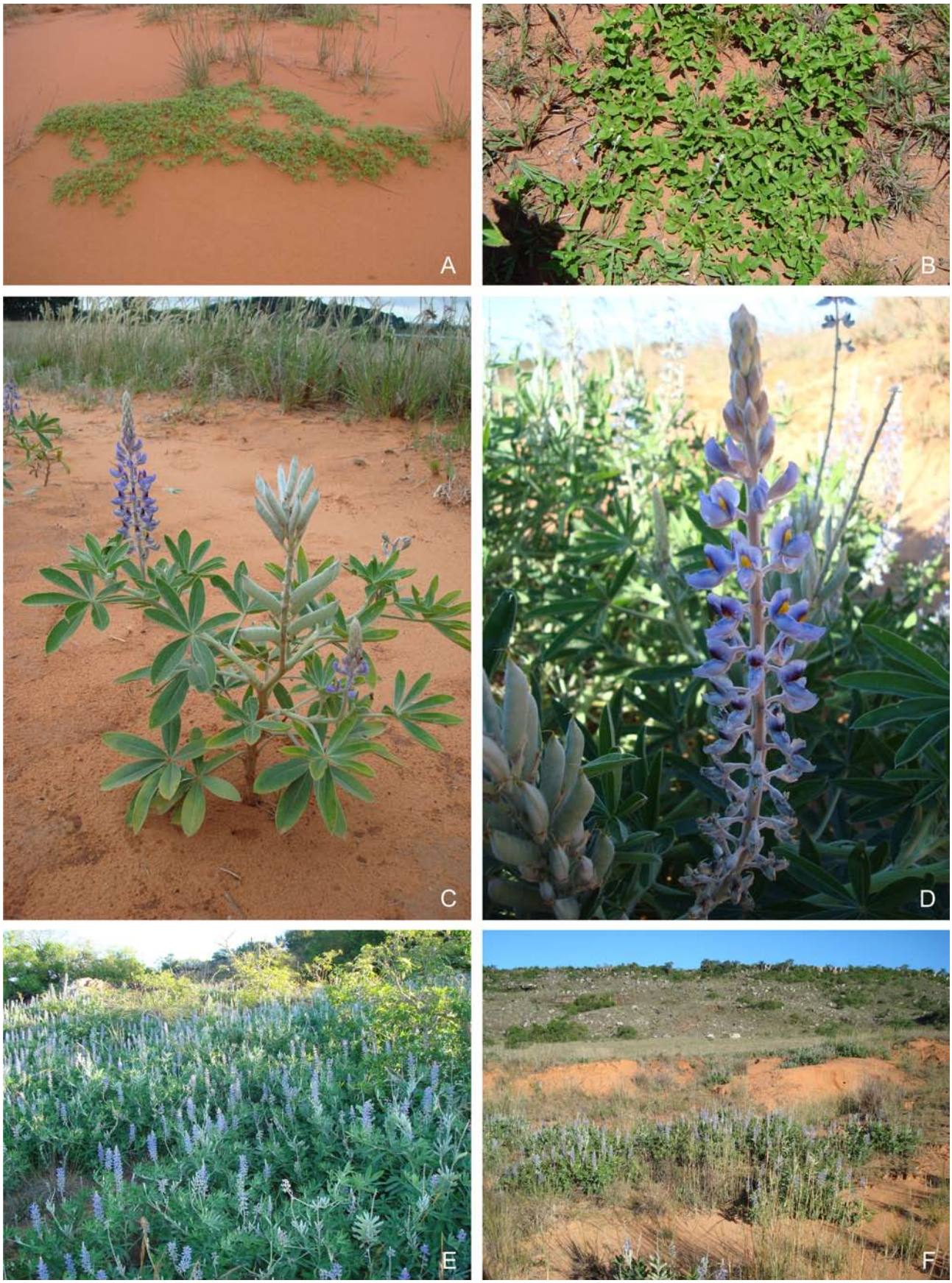

Figure 7. Species with potential attributes for recovering of grassland areas undergoing sandy patch process. A. *Acanthospermum australe* on exposed sand. B. *A. australe* in the edge of a sandy patch at São Francisco de Assis municipality. C. *Lupinus albescens* (habit). D. *L. albescens* inflorescence. E, F. *L. albescens* individuals in a grassland area undergoing sandy patch process at Cerro do Tigre locality, Alegrete municipality.

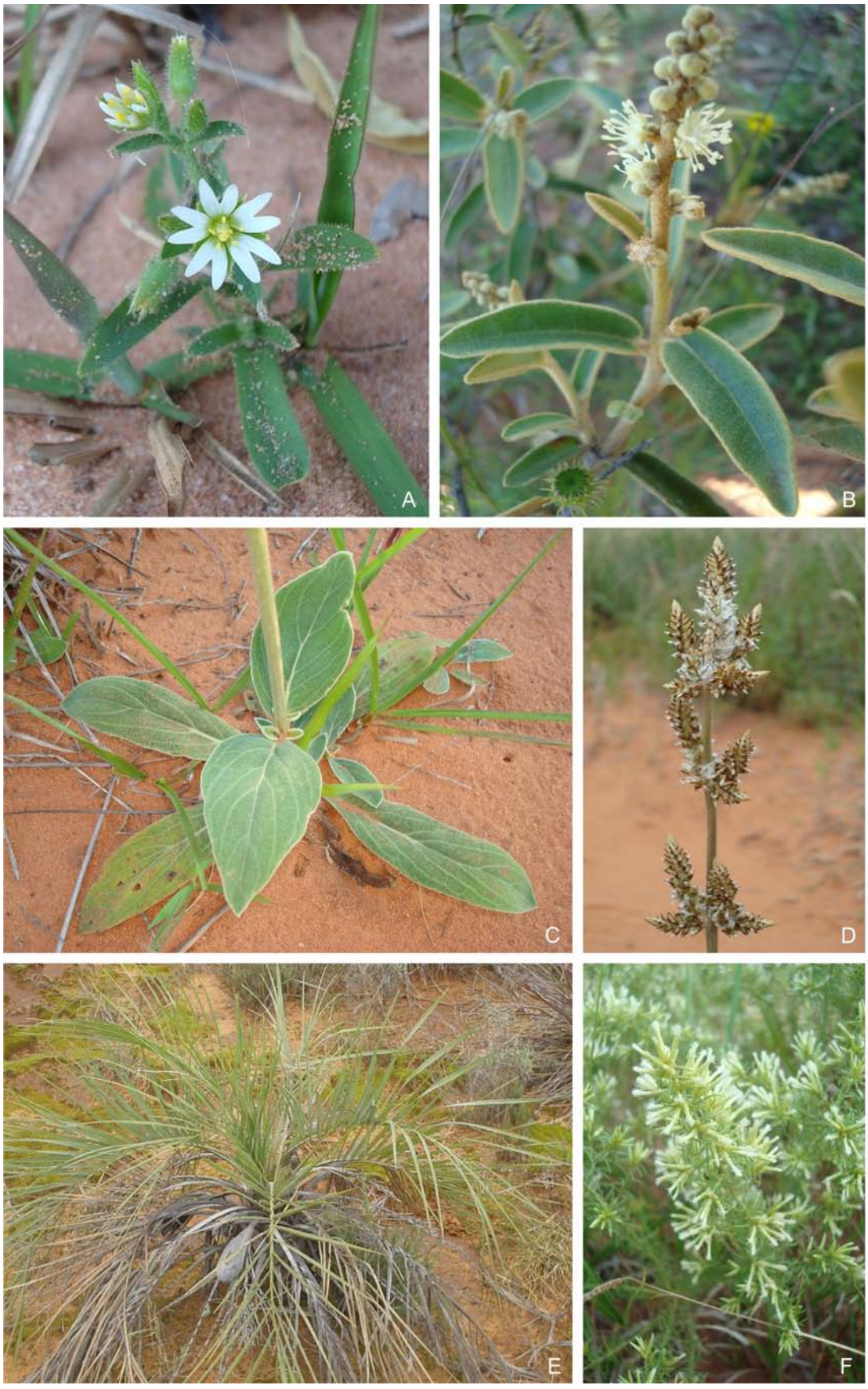

Figure 8. A. *Cerastium commersonianum*, exotic species naturalized in Brazil. B. *Croton lorentzii*, new record for Brazil, found at São Francisco de Assis municipality, Taquari district, Passo do Nagel locality. C. *Froelichia tomentosa*, cited as extinction threatened, frequently observed in the study area. D. *F. tomentosa* (inflorescence). E. *Butia lallemantii,* exclusive to the sandy grasslands found in the southwestern RS state. F. *Baccharis multifolia*, exclusive to the sandy grasslands found in the southwestern RS state.

Table 2. Extinction-threatened species of Rio Grande do Sul state with records for grassland areas undergoing sandy patch process at Alegrete, Manoel Viana and São Francisco de Assis municipalities.

Family/Species	Threat rank
AMARANTHACEAE	
Alternanthera hirtula (Mart.) R.E. Fr.	Endangered
Alternanthera praelonga A. St.-Hil.	Critically endangered
Froelichia tomentosa (Mart.) Moq.	Critically endangered*
Gomphrena graminea Moq.	Vulnerable
Gomphrena perennis L.	Vulnerable
Pfaffia gnaphaloides (L. f.) Mart.	Vulnerable
ASTERACEAE	
Eupatorium angusticeps Malme	Probably extinct
Gochnatia cordata Less.	Endangered
Trixis pallida Less.	Endangered
CACTACEAE	
Echinopsis oxygona (Link) Zucc.	Vulnerable
Parodia ottonis (Lehmann) N. P. Taylor	Vulnerable
LAMIACEAE	
Hesperozygis ringens Benth.	Endangered
MALVACEAE	
Hochreutinera hasslerana (Hochr.) Krapov.	Vulnerable
Waltheria douradinha A. St.-Hil.	Vulnerable
MORACEAE	
Dorstenia brasiliensis Lam.	Vulnerable
MYRTACEAE	
Eugenia arenosa Mattos	Endangered

* Species not cited in the Final List of the Threatened Flora – RS (State decree nº 42.099; December 31st 2002).

Threatened and restricted species

Fifteen taxa found in the study area (Table 2) are included in the Final List of the Threatened Flora – RS (State decree nº 42.099; December 31st 2002).: eight are categorized as 'vulnerable', five as 'endangered', one as 'critically endangered' (*Alternanthera praelonga*) and one as 'probably extinct' (*Eupatorium angusticeps*) (SEMA 2003). *Eupatorium angusticeps* was found in only one grassland area, in a population with few individuals. Beside these species, *Froelichia tomentosa* (Fig. 8C, 8D) was cited by Marchioretto *et al.* (2005) as 'critically endangered'. However, this species was frequently observed in all the areas studied, chiefly in grassland areas heavily affected by the sandy patch process.

From all the species, 20 show a restricted distributional area (Table 3). Of these, seven are exclusive to the sandy grasslands found in the southwestern RS state: *Butia lallemantii* (Fig. 8E), *Achyrocline marchiorii*, *Baccharis albolanosa*, *B. multifolia* (Fig. 8F), *B. riograndensis*, *Senecio riograndensis* and *Hesperozygis ringens*. Among the families with higher number of restricted species, Asteraceae stands out with 11 species.

Butia lallemantii, also known as 'butiá-anão' due to its reduced height, is among the species that stand out in sandy patches. The species occurs only in the sandy grasslands of southwestern RS, where it usually constitutes populations with large number of individuals, standing out in the landscape (Fig. 9A) (Deble & Marchiori 2006). It was observed in several grassland areas among the surveyed municipalities, where we also found strong interaction between the species and the local fauna.

Achyrocline marchiorii is mentioned as endemic to the 'Campanha Gaúcha" region (the southwest of RS state), where it dwells in sandy and rocky grasslands (Deble 2005). In the study area, it was found only at Cerro o Tigre farm, Alegrete municipality, the same place where the species' type was collected.

Baccharis albolanosa, to the present moment, has occurrence records only for the sandy grasslands of the southwestern RS state, at Manoel Viana and São Francisco de Assis municipalities (Oliveira & Deble 2006). In the grassland areas surveyed during the present study, the species was collected only in an area located near the state road RS 377, km 351.

Baccharis multifolia is another species that, until this moment, is mentioned only for the southwest region of RS state, in sandy grassland areas (Oliveira & Marchiori 2006). The species was observed at Alegrete municipality, Cerro do Tigre locality, and at São Francisco de Assis municipality, Joaquim Paz farm, where its population is numerous, dominating all the grassland area during the blooming phase (Fig. 9C).

Baccharis riograndensis is considered endemic to RS, with occurrence recorded for dry or rocky grasslands, notedly in the southernmost half of the state (Heiden & Schneider 2008). In the study area, the species was found in a grassland undergoing sandy patch process at São Francisco de Assis municipality, Joaquim Paz farm.

Senecio riograndensis is recorded only for the RS state, in coastal grasslands, Central Depression, Campanha and Planalto Médio regions (Matzenbacher 1996). Only a small population was found in a grassland area undergoing sandy patch process at São Francisco de Assis municipality, near Cerro da Esquina locality.

Table 3. Restricted species registered for grassland areas in southwestern RS State.

Family/Species	Geographic distribution
APIACEAE	
Eryngium ciliatum	Uruguay and dry grasslands of RS state (Central Depression, Missões and Campanha regions).
ARECACEAE	
Butia lallemantii	Exclusive to sandy soil grasslands of southwestern RS.
ASTERACEAE	
Achyrocline marchiorii	Endemic to sandy and rocky grasslands of the Campanha Gaúcha region.
Asteropsis megapotamica	Sandy and rocky grasslands of RS state and Uruguay.
Baccharis albolanosa	Sandy soil grasslands of southwestern RS.
Baccharis multifolia	Sandy soil grasslands of southwestern RS.
Baccharis riograndensis	Endemic to RS, in dry or rocky grasslands, especially in the state's southernmost half.
Gochnatia cordata	RS, in sandy soil grasslands, Uruguay and NE Argentina up to Entre Ríos province.
Hysterionica filiformis	Southern Brazil, Uruguay and NE Argentina.
Noticastrum acuminatum	Sandy soil grasslands and coastal dunes in southern Brazil, Uruguay and NE Argentina.
Noticastrum diffusum	Dry and rocky grasslands of southern Brazil, Uruguay and central/NE Argentina.
Senecio cisplatinus	Sandy patches in RS, Uruguay and NE Argentina.
Senecio riograndensis	Endemic to RS, in Coastal grasslands, Central Depression, Campanha and Planalto Médio regions.
CONVOLVULACEAE	
Ipomoea malvaeoides var. *lineariloba*	Dry grasslands of RS, Paraguay, Argentina and Uruguay.
Ipomoea nitida	RS (Missões and Campanha regions) and Argentina.
EUPHORBIACEAE	
Croton lorentzii	Central/NE Argentina and Uruguay. In Brazil, is found in southwestern RS.
FABACEAE	
Lupinus albescens	Uruguay (W), Argentina and Paraguay. In Brazil, only in RS (Litoral, Campanha and Missões regions).
LAMIACEAE	
Hesperozygis ringens	Endemic to the southern grasslands of RS (Serra do Sudeste and Missões regions).
MYRTACEAE	
Myrcia verticillaris	Clean and stony grasslands of Uruguay and RS (Campanha, Central Depression, Missões and Serra do Sudeste regions).
POACEAE	
Pappophorum macrospermum	Sandy soil grasslands of Central/N Uruguay, southern RS and NE Argentina.

Besides being present in the threatened flora list, *Hesperozygis ringens* (Fig. 9B) is endemic to the grasslands of RS, with distribution in the Serra do Sudeste and the south of the Missões, in sandy and rocky soils at Caçapava do Sul, Alegrete and São Francisco de Assis municipalities. Successive cleaning and burning of pastures, associated with the low gene flow between populations, led the species to the threatened list (Fracaro 2006). In the study area, only two populations were observed, and they were in greatly separated grassland areas (ca. 30 km from each other), which may complicate or even block gene flow between them.

The remaining species considered restricted (Tab. 3) reach grassland areas in RS state, Argentina, Uruguay and, occasionally, Paraguay. Among them, *Asteropsis megapotamica* (Fig. 9D, 9E) is restricted to the sandy soil grasslands of RS and rocky grasslands of Uruguay, where it dwells between scattered shrubs and *Butia paraguayensis* (Barb. Rodr.) L.H. Bailev (Bonifacino *et al.* 2009). In the study site, it was found in sandy soils at Manoel Viana municipality, among shrubs, cespitous grasses and *Butia lallemantii*. *Gochnatia cordata* grows on sandy soils in RS state, Paraguay, Uruguay and NE Argentina as far as Entre Ríos province (Burkart 1974). Sobral (2003) mentioned *Myrcia verticillaris* as restricted to the clean and stony grasslands of Uruguai and RS state. *Eryngium ciliatum* is described as endemic to Uruguay and to the dry and graminous grasslands of RS, in the Depressão Central, Missões e Campanha regions (Rambo 1957, Irgang 1974). *Ipomoea malvaeoides* var. *lineariloba* (Fig. 9F), restricted to sandy grasslands in RS, also has registers for Paraguay, Argentina and Uruguay. On the other hand, *Ipomoea nitida* occurs in Argentina and Brazil, being restricted to RS state in the latter (Ferreira 2009). In our survey, both species of *Ipomoea* were found at only one location. *Pappophorum macrospermum* is restricted to the sandy grasslands of northern Uruguay, southern RS and northeastern Argentina (Corrientes province) (Pensiero 1986).

The grasslands from southwestern RS have a peculiar flora with significant number of species, including several threatened and endemic species. In addition, many of them present morpho-physiological adaptations that allow their survival in the extreme local environmental conditions.

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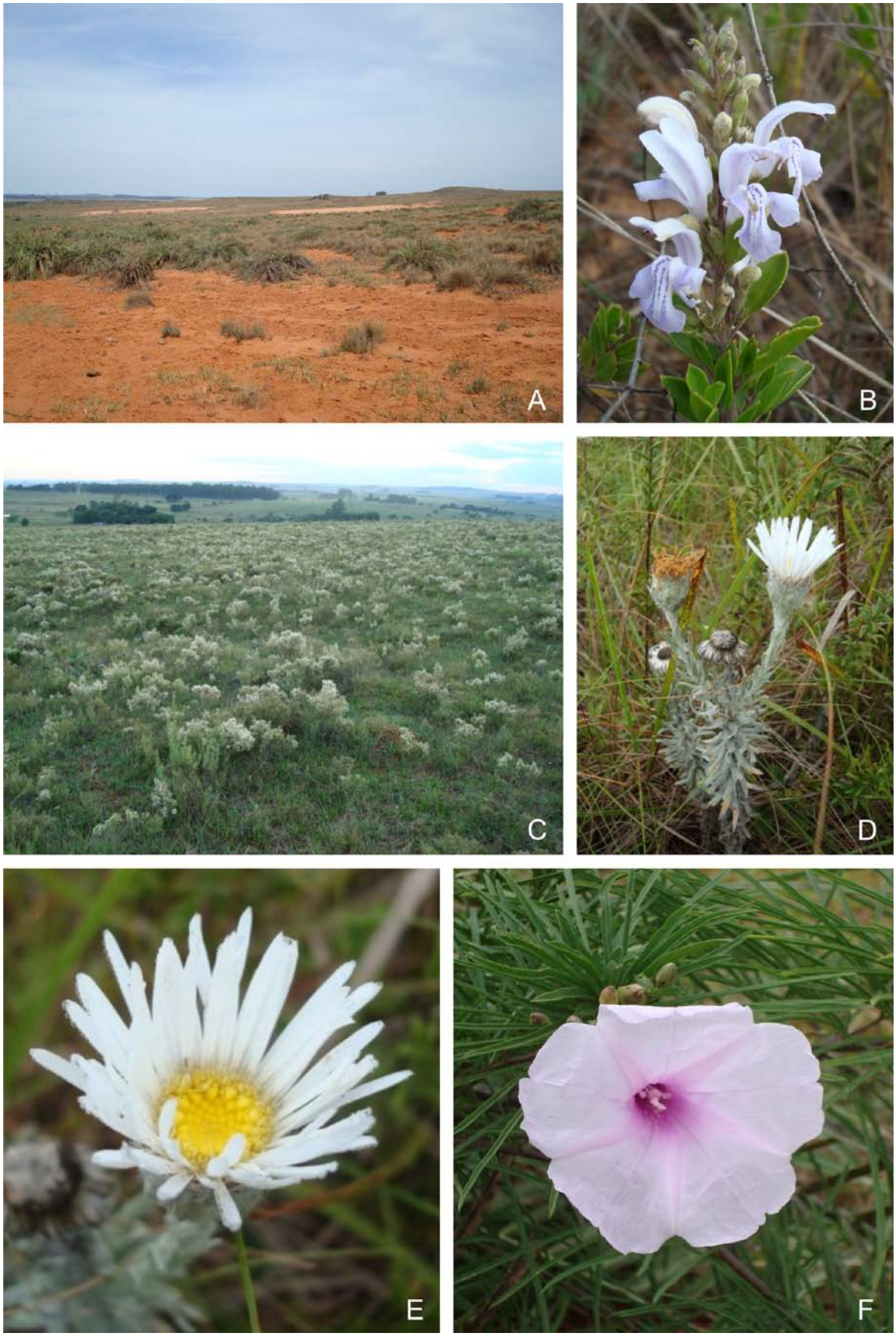

Figure 9. A. *Butia lallemantii* specimens in a sandy patch at Manoel Viana municipality. B. *Hesperozygis ringens*, endemic to the grasslands of RS. C. Grassland area at São Francisco de Assis municipality with a large population of *Baccharis multifolia*. Species with restrict occurrence: D. *Asteropsis megapotamica* (habit). E. *A. megapotamica* (inflorescence). F. *Ipomoea malvaeoides* var. *lineariloba*.

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