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

FLORA CAMPESTRE RARA, ENDÊMICA E AMEAÇADA DOS MORROS GRANÍTICOS DE PORTO ALEGRE, RIO GRANDE DO SUL, BRASIL

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ORIENTAÇÃO: DRA. ILSI IOB BOLDRINI

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DISSERTAÇÃO APRESENTADA AO PROGRAMA DE PÓS-GRADUAÇÃO EM BOTÂNICA DA UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL COMO PARTE DOS REQUISITOS PARA A OBTENÇÃO DO TÍTULO DE MESTRE EM BOTÂNICA.

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“Se, a princípio, a ideia não é absurda, então não há esperança para ela”

Albert Einstein

SUMÁRIO

RESUMO

Os campos cobrem 62,2% do Rio Grande do Sul, o estado mais austral do Brasil, e encontram-se fortemente alterados devido a ações humanas que removem ou descaracterizam sua cobertura vegetal original. No Estado, essas formações estão presentes em dois biomas: o Pampa, na metade sul, e a Mata Atlântica, na porção norte. As maiores extensões contínuas cobertas por fisionomias campestres encontram-se no primeiro. Os campos naturais presentes na cidade de Porto Alegre encontram-se restritos à cadeia de morros graníticos presentes na região. Esses morros estão rodeados por uma matriz urbana, configurando, portanto, formações vegetacionais completamente disjuntas. Os táxons presentes nesses locais estão submetidos a altos níveis de ameaça, em decorrência da crescente expansão urbana. Este trabalho objetivou a avaliação do estado de conservação dos campos presentes nos morros graníticos de Porto Alegre, bem como das populações de 19 espécies campestres selecionadas pelo seu alto grau de raridade, fragmentação e ameaça. Muitas dessas espécies são consideradas endêmicas na literatura, em diferentes escalas geográficas. Assim sendo, foi também realizada uma revisão do histórico de uso do conceito de endemismo aplicado à flora, bem como a sugestão de uso de uso de categorias padronizadas, para que seja possível a futura utilização de bases de dados de endemismo vegetal em iniciativas de conservação. Por fim, utilizando dados de distribuição de certos táxons, revisão de literatura e análise de padrões de endemismo levando em conta unidades florísticas, e não políticas, é sugerido que se reconheça os campos subtropicais presentes no Sul do Brasil, Uruguai e Argentina como uma unidade florística, um bioma Pampa transnacional, em um senso mais amplo do que o atualmente aceito, refletindo a co-ocorrência de táxons existente.

Introdução Geral

No globo terrestre, as formações campestres em senso amplo (incluindo savanas, vegetação arbustiva e tundra) cobrem 52,5 milhões de quilômetros quadrados, o que corresponde a 40,5% da superfície da Terra, excluindo-se Groenlândia e Antártida (Suttie *et al.* 2005). Na América do Sul, os campos cobrem cerca de 3,5 milhões de quilômetros quadrados, ou 350 milhões de hectares (Burkart 1975). No Brasil, os campos naturais cobrem 13.656.000 hectares (IBGE 2006), se concentram na região sul do país e foram as formações dominantes na região durante o Pleistoceno recente, sendo sua distribuição atual interpretada como um indício de um clima anterior mais seco e frio (Behling 2002; Bredenkamp *et al.* 2002).

Os campos são as formações fitoecológicas predominantes no Rio Grande do Sul (RS), cobrem 62,2% da superfície do Estado (Cordeiro & Hasenack 2009) e se distribuem em dois biomas brasileiros distintos: Pampa e Mata Atlântica (IBGE 2004). Esta divisão dos campos presentes no Estado em dois biomas distintos reflete a classificação de províncias fitogeográficas proposta em Cabrera & Willink (1980). Classificações mais antigas da vegetação do Brasil (Teixeira *et al.* 1986) incluíam os campos sulinos em duas regiões fitoecológicas: savanas e estepes. Como apontado por Overbeck *et al.* (2007), os termos savana e estepe são inapropriados para definir a vegetação campestre presente no Sul do Brasil. O termo *campo*, utilizado historicamente na região (Overbeck *et al.* 2007; Suertegaray & Silva 2009), corresponde ao termo *subtropical grassland* utilizado em formações semelhantes (Behling 2002, Focht & Pillar 2003, Overbeck *et al*. 2007).

No Estado, as formações campestres apresentam elevada riqueza de espécies, além da presença de diversos táxons considerados endêmicos (Boldrini 2002). Boldrini (2009) aponta a ocorrência de cerca de 2.200 espécies campestres no Estado, distribuídas nos biomas Pampa e Mata Atlântica. A alta diversidade biológica encontrada no Estado está, em grande parte, atrelada à grande variabilidade geológica, topográfica, de pluviosidade, de temperatura e de disponibilidade de água no solo (Boldrini 2009). Rambo (1954) chama a atenção para a riqueza e a importância ecológica da flora campestre sul-brasileira, apontando que somente as espécies herbáceas de Asteraceae presentes na região são mais numerosas do que toda a sua flora arbórea. Aguiar *et al.* (1986) destacam que, no que diz respeito à flora dos morros de Porto Alegre, o número de espécies campestres é geralmente mais do que o dobro do número de espécies florestais. Considerando-se a totalidade da flora campestre do RS (ca. 2.200 espécies), 213 espécies são consideradas ameaçadas de extinção (SEMA 2002; atualização nomenclatural em Boldrini 2009). Dentre os táxons ameaçados, 85 ocorrem no bioma Mata Atlântica, 146 no bioma Pampa e 28 são comuns a ambos.

O componente florístico que caracteriza fisionomicamente as formações campestres são as gramíneas (Poaceae). Todavia, em termos de contribuição de riqueza específica, Asteraceae apresenta valores semelhantes à Poaceae (Overbeck *et al.* 2006, Cervi *et al* 2007, Kozera 2008, Boldrini 2009). Além dessas famílias, Fabaceae, Cyperaceae e Rubiaceae são importantes contribuintes da flora dos campos do RS.

Inserida no bioma Pampa, a região que compreende a cidade de Porto Alegre e suas circunvizinhanças, por estar localizada próxima ao paralelo 30º S, apresenta elevada relevância sob o ponto de vista florístico, tendo em vista a conhecida transição de floras e formações vegetacionais que ocorre nesta região do subtrópico austral (Waechter 2002; Cabrera & Willink 1980). A região está inserida em um local de transição entre três das províncias biogeográficas apresentadas por Cabrera & Willink (1980) para a América do Sul (Províncias Atlântica, Paranense e Pampeana), bem como em um local de intersecção das quatro províncias geomorfológicas presentes no Estado: a Depressão Periférica, a Planície Costeira, o Sistema Lagunar e o Escudo Cristalino (Hasenack *et al*. 1998). Por caracterizar uma zona de convergência de formações geológicas e florísticas distintas, a região apresenta um conjunto de espécies vegetais bastante diverso.

A cadeia de morros graníticos presente na cidade de Porto Alegre consiste no limite nordeste da extensão do Escudo Cristalino Sul-rio-grandense. Concomitantemente a este limite geológico, muitas espécies de distribuição relativamente ampla (Norte do Uruguai, Argentina e Rio Grande do Sul, por exemplo) têm seu limite norte de distribuição na região, como *Schlechtendalia luzulifolia* Less.. A cobertura vegetal natural dessas formações graníticas é basicamente composta por mosaicos de formações campestres e arbóreas, sendo conhecida pela presença de diversas espécies raras e endêmicas (Aguiar *et al.* 1986; Boldrini *et al.* 1998; Brack *et al.* 1998; Rambo 1954). Rambo (1954) salienta a importância que a cadeia de morros graníticos de Porto Alegre pode ter apresentado como um conjunto de refúgios para as espécies vegetais da região durante os períodos de transgressão marinha que se estenderam até as proximidades do final do Terciário. Esta hipótese explicaria em parte a distribuição peculiar de algumas das espécies que ocorrem nesses locais.

Os morros de Porto Alegre ainda atuam como refúgios em relação à expansão urbana. Por configurarem um relevo de difícil acesso, que oferece dificuldades ao estabelecimento de construções, essas formações abrigam os últimos remanescentes de vegetação natural da capital, pois a cobertura vegetal das áreas planas da região encontra-se completamente descaracterizada (Hasenack 2008). Historicamente, os morros graníticos foram alvos de extração madeireira (Rambo 1956, Saint-Hillaire 1987) e, posteriormente, de exploração de minérios (Porto Alegre 1975). A segunda atividade persiste até o presente, sendo que a permissão para instalação e ampliação de pedreiras na região ainda é assegurada pelo poder público.

Apesar de constituírem um componente paisagístico e ecológico fundamental da região de Porto Alegre, os morros são contemplados em apenas três unidades de conservação:

o Parque Natural Morro do Osso (127 ha), a Reserva Particular do Patrimônio Natural Costa do Cerro (8 ha) e a Reserva Biológica do Lami (21 ha no morro Ponta do Cego). Segundo Setúbal (2006), a área total dos morros graníticos incluída em Unidades de Conservação é de aproximadamente 56 ha, o que corresponde a apenas 0,45% da área que essas formações ocupam.

Estudos envolvendo a flora campestre da região de Porto Alegre são em sua maioria voltados para inventários florísticos ou análises estruturais. Uma extensa lista florística para a região, tanto de espécies herbáceas quanto arbóreas, pode ser encontrada em Rambo (1954). Todavia, atualizações nomenclaturais e de sinonimizações são necessárias na lista apresentada. Além disso, a cobertura original da vegetação da região sofreu drásticas mudanças desde os levantamentos de Rambo (1954), a maioria delas advindas da urbanização. O trabalho mais abrangente envolvendo as formações graníticas de Porto Alegre é o de Aguiar *et al.* (1986), que consiste em uma lista florística preliminar com 867 táxons específicos e infra-específicos, de formações florestais e campestres, para 10 dos morros graníticos presentes na região. Boldrini *et al.* (1998) realizaram um levantamento florístico e estrutural da vegetação campestre do Morro da Polícia, uma das formações graníticas da região. Overbeck et al. (2006), em trabalho realizado em outro morro granítico, analisaram a composição florística do campo, relacionando-a a fatores ambientais e distúrbios. Setúbal & Boldrini (no prelo) trabalharam nos campos do Morro São Pedro, listando cerca de 497 espécies, destacando as endêmicas e ameaçadas. Ferreira *et al.* (no prelo) realizaram estudo estrutural e florístico das formações campestres do Morro do Osso.

São raros os trabalhos enfocando a flora campestre ameaçada e endêmica da região de Porto Alegre. Setúbal & Boldrini (in press) identificam, dentre as espécies campestres presentes no Morro São Pedro, as ameaçadas de extinção. Não há registro de estudos sobre o estado de conservação das populações das espécies endêmicas, raras e ameaçadas presentes nos morros graníticos de Porto Alegre, assim como não há estudos sobre o estado de conservação das formações campestres neles presente. Tendo em vista a importância dos táxons raros e endêmicos para a conservação (Lira *et al*. 2002; Hobohm 2003; Davila-Aranda *et al.* 2004), e a possível relação positiva entre altos níveis de endemismo e riqueza específica (Lamoreux *et al.* 2006), estudos sobre sua distribuição e estado de conservação são fundamentais. Estudos sobre estes aspectos das populações de espécies categorizadas como ameaçadas são necessários para que se possa tomar decisões embasadas sobre exclusão de listas ou mudança de categoria de ameaça dos táxons.

A definição dos táxons como ameaçados, raros e endêmicos apresenta diferentes níveis de dificuldade para cada conceito. Espécies ameaçadas são de fácil definição, uma vez que já estão inseridas em alguma categoria de ameaça por trabalhos anteriores, além de estarem presentes em listas estaduais e federais (SEMA 2003; MMA 2008). Definir uma espécie como rara, em senso estrito, dependeria de estudos quali-quantitativos que denotassem uma baixa freqüência do táxon na área de estudo. Análise da distribuição das coletas e conhecimento de campo são, também, ferramentas válidas para definir a raridade de um táxon. Identificar um táxon como endêmico é o processo mais complicado e dependente de interpretações. Embora muitos trabalhos de taxonomia envolvendo táxons campestres façam uma análise crítica das suas distribuições, não há um padrão para definir um táxon como endêmico. Como apontado por Simon & Hay (2003), endemismo é um conceito relativo, que se refere à abrangência geográfica dos organismos. Desde o início da utilização do conceito para a distribuição de táxons vegetais (De Candolle 1855; Engler 1882), existe a idéia da ocorrência de múltiplos tipos de endemismo (Wherry 1944; Stebbins & Major 1965), partindo-se do princípio que endemismo é um fenômeno biológico (Kruckenberg & Rabinowitz 1985; Simon & Hay 2003; Lavergne *et al.* 2004). Tendo em vista a importância dos endemismos para a conservação, muitas vezes atuando como indicadores de locais com alta diversidade (Hobohm 2003; Lamoreux *et al.* 2006), ou mesmo na definição de áreas prioritárias para a conservação (Pressey *et al.* 1994), é de fundamental importância o estabelecimento de padrões universais para a definição dos diferentes tipos de endemismo.

Este trabalho será dividido em dois capítulos, cada um correspondendo a um artigo científico independente. No primeiro, serão apresentadas as listas de espécies raras, ameaçadas e endêmicas presentes nos morros graníticos de Porto Alegre, acompanhadas de descrições das espécies, suas distribuições e do seu atual estado de conservação. Mapas de distribuição das populações em cada morro estudado também serão apresentados, além de descrições de cada morro, com comentários sobre seus estados de conservação e sugestões sobre iniciativas de conservação a serem tomadas futuramente. No segundo capítulo, será apresentada uma revisão da utilização dos conceitos de endemismo, com a sugestão de uso padronizado de determinadas categorias de endemismo, exemplificadas com táxons campestres presentes no Rio Grande do Sul. O primeiro artigo será submetido à Revista Brasileira de Biociências, e o segundo à Conservation Biology.

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CAPÍTULO 1

FRAGMENTED GRANITIC GRASSLANDS WITHIN AN URBAN LANDSCAPE: RARE, ENDEMIC AND EXTINCTION-THREATENED SPECIES AS A CONSERVATION TOOLS

PEDRO M.A. FERREIRA, ROBBERSON B. SETUBAL, ILSI I. BOLDRINI

ARTIGO A SER SUBMETIDO À REVISTA BRASILEIRA DE BIOCIÊNCIAS

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Abstract – (Fragmented granitic grasslands within an urban landscape: rare, endemic and extinction-threatened species as conservation tools). Grassland formations cover 62.2% of Rio Grande do Sul, the southernmost Brazilian state, with a total species richness of ca. 2.200 species. At Porto Alegre city, the state capital, natural vegetation cover was almost completely removed by the historical urbanization process, and the last remnants are restricted to a granitic hill chain present at the region. These hills cradle a unique floristic composition, due to a convergence of geological formations and floristic influences. We evaluated the conservation status of grasslands present at nine granitic hills and 19 rare, endemic and extinction-threatened grassland species. We present species descriptions, distribution maps, current and suggested threat categories according to IUCN criteria and conservation status of species and grassland formations at each hill, in order to provide a framework for future conservation actions. Based on our results, the implementation of three Conservation Units is suggested, in order to prevent further fragmentation and biodiversity loss. Finally, based on revision of species distributions, we emphasize the need to acknowledge the subtropical grasslands present at southern Brazil, Uruguay and Argentina as a floristic unit, a transnational Pampa Biome in a broader sense than it is presently known.

Key words – conservation, environment, subtropical grasslands, habitat fragmentation, conservation units, Pampa biome.

Resumo – (Campos graníticos fragmentados em uma paisagem urbana: espécies raras, endêmicas e ameaçadas como ferramentas de conservação). Formações campestres cobrem 62,2% do Rio Grande do Sul, o estado mais austral do Brasil, com uma riqueza específica total de ca. 2.200 espécies. Na cidade de Porto Alegre, a capital do Estado, a cobertura de vegetação natural foi removida quase completamente pelo processo histórico de urbanização, e os últimos remanescentes estão restritos à cadeia de morros graníticos presentes na região. Esses morros abrigam uma composição florística única, devido a uma convergência de formações geológicas e influências florísticas. Nós avaliamos o estado de conservação dos campos presentes em nove morros graníticos e de 19 espécies campestres raras, endêmicas e ameaçadas de extinção. São apresentadas descrições das espécies, mapas de distribuição, categorias de ameaça atuais e sugeridas de acordo com os critérios propostos pela IUCN e o estado de conservação das espécies e dos campos presentes em cada morro, tendo como objetivo disponibilizar uma base de dados para futuras ações de conservação. Com base nos resultados obtidos, a implantação de três Unidades de Conservação é sugerida, visando à prevenção de maior fragmentação e perda de biodiversidade. Finalmente, com base na revisão da distribuição de espécies, é enfatizada a necessidade de se reconhecer os campos subtropicais presentes no Sul do Brasil, Uruguai e Argentina como uma unidade florística, um bioma Pampa transnacional, em um senso mais amplo do que o atualmente aceito.

Palavras-chave – Conservação, ambiente, campos subtropicais, fragmentação de hábitats, unidades de conservação, bioma Pampa.

Introduction

Subtropical grasslands, also known as *campos* in Brazil (Behling 2002, Focht & Pillar 2003, Overbeck *et al.* 2007), were the dominant formations in Southern Brazilian landscape during late Pleistocene, and its present distribution can be interpreted as a remnant of a drier and cooler climate in the region (Behling 2002, Bredenkamp *et al.* 2002). In Rio Grande do Sul (RS), the southernmost Brazilian state, *campos* grasslands are the dominant formations, covering 62.2% of the state's area (Cordeiro & Hasenack 2009). According to IBGE (2004), these formations occur in two separate Biomes within RS limits: the Pampa Biome and the Mata Atlântica Biome (Brazilian Atlantic Forest). The first one covers ca. 2/3 of the state, encompassing its southern region as far as the borderline between Brazil and Uruguay. The latter is located at the northern section of the state, mostly at high altitudes, showing limited distribution in RS state but a broader one in Brazil.

Inserted in the Pampa Biome, there is a chain of granitic hills that surrounds Porto Alegre city, the state's capital. Natural vegetation cover in the region, largely removed by urban expansion, finds shelter in these hills, which cradle the last remnants of original vegetation cover in a large area dominated by urban landscape. Natural grassland vegetation remnants are predominantly distributed at hilltops and northern slopes, while forests usually dominate southern slopes or moister areas (Rambo 1954). These granitic hills are inserted at the western limit of the Coastal Plain of Rio Grande do Sul, a formation produced during Pleistocene and Holocene ocean transgression times, thus configuring the western limit of these transgression events (Tomazelli *et al*. 2000).

This chain is the northeastern limit of the South Brazilian Crystalline Shield, an ancient granite-based geological formation distributed between the center and the southwestern portions of the State, extending as far as the northern parts of Uruguay.

Accordingly, many species with distributional ranges encompassing this region have their northern distributional limit at the granitic hills of Porto Alegre region (e.g. *Schlechtendalia luzulifolia* Less. and *Moritzia ciliata* (Cham.) DC.). Moreover, there are records of several rare and endemic species for these formations (Rambo 1954, Aguiar *et al.* 1986, Boldrini *et al.* 1998, Brack *et al.* 1998), and this could be related to three reasons: (1) the region configures an intersection point of four different structural provinces, namely the Crystalline Shield, the Peripheral Depression, the bottom of the Seashore Plain and the Lagoon System (Hasenack & Weber 1998), (2) the granitic hills could have acted as a refuge, sheltering populations during ocean transgression periods (Rambo 1954) and (3) proximity to the latitude of 30^{o}S, and the transitional point for floras that it represents in the austral subtropics (Cabrera & Willink 1980; Waechter 2002). Therefore, the uniqueness and richness of the granitic hill's flora is related to a convergence of different floristic contingencies and geological formations, allied to the formation's ancientness.

Previous works focusing on grassland formations present at granitic hills are scarce or outdated. Rambo (1954) presents a vast, albeit outdated, floristic list for Porto Alegre city's flora. Aguiar *et al.* (1986) performed a "preliminary floristic survey" on 10 granitic hills, presenting lists of herbaceous and woody taxa and brief descriptions of each studied hill. Boldrini *et al.* (1998), Overbeck *et al.* (2005) and Ferreira *et al*. (2010), surveying ecological aspects of the grassland vegetation on three different hills, also presented floristic lists, respectively with 189, 165, and 282 species. Setubal & Boldrini (2010), surveying *Morro Sao Pedro*, the largest granitic hill at the region, found 497 grassland species.

Rare, extinction-threatened and endemic taxa, as well as species richness, are usually considered as key in conservation strategies (e.g. Lira *et al*. 2002; Hobohm 2003; Davila-Aranda *et al.* 2004), and areas with high levels of endemism, considering endemism as a type of rarity (Simon & Hay 2003; Knapp 2002), tend to contain significantly more species than expected by chance (Lamoreux *et al.* 2006). The current management and conservation of endangered species does not keep place with the raising extinction rates (Schemske *et al.* 1994), and in areas with high habitat fragmentation, such as the grassland formations at the granitic hills of Porto Alegre city, extinction risk raises exponentially (Burkey & Reed 2006), and rare species tend to be the most threatened due to their distributional pattern. As it is, knowledge concerning rare and endangered species is essential for the implementation of Conservation Units. However, no specific study concerning populations of rare and endangered species was carried out at the granitic hill chain of Porto Alegre city.

In spite of the high species diversity found in grassland formations present at this region, only 0.45 % (56 ha) of their covering area is presently inserted in Conservation Units (Setubal & Boldrini 2010). Since the granitic hills cradle the last remnants of these natural formations, they should be included in future Conservation Units. Moreover, legal protection for these formations is imperative due to the ongoing and mostly illegal urban expansion, which removes vegetation cover from lower slopes at alarming speed, even reaching hilltops at some less steep hills. Presently, only three of the 11 largest hills are covered (and only partially) by Conservation Units (Setubal & Boldrini 2010).

The objective of this work is to describe the conservation status of the remnant grassland formations at the granitic hills of Porto Alegre city, based on the presence of rare, extinction-threatened and endemic species. Also, we provide descriptions of these species, based on literature, field observations and herbaria revision, as well as comments on their conservation status, distribution, inclusion in extinction-threatened species lists and threat category based on IUCN criteria (IUCN 2001). With that, we aim to provide a basic framework for future conservation initiatives concerning the implementation of Conservation Units at the granitic hills.

Material and Methods

Nineteen rare grassland species were selected, based on floristic lists with species distribution comments (Rambo 1954; Aguiar *et al.* 1986; Setubal & Boldrini 2010) and vegetation structure data provided by previous research at the study sites (Boldrini *et al.* 1998; Overbeck *et al.* 2006; Focht & Pillar 2003; Ferreira *et al*. 2010). Populations of these species were searched at the nine granitic hills included in our surveys (Figure 1). Some granitic hills inserted near our sampling area were not included in our surveys, mainly for two reasons: (1) they presented no considerable original vegetation cover, due to anthropogenic disturbance, and (2) for security reasons, since many hills are within slum areas, where the researchers' lives would be jeopardized.

Climate at the study sites is subtropical humid, with no drought season (Köppen's Cfa). The average annual temperature is 19,5°C and the mean annual precipitation is 1.348 mm (Nimer 1990). Natural vegetation at the site comprises a mosaic of grasslands and forests (Atlantic Rainforest), the first occurring mostly on hilltops and north or northwest slopes and the latter mostly along river courses and south or southeast slopes (Rambo 1954, 1956; Müller *et al.* 2007).

Monthly expeditions to each granitic hill were carried out during 2008 and 2009, encompassing all seasons. Grassland patches at each hill were thoroughly covered, and all rare species populations were geo-referenced via GPS device, and plotted using GPS Trackmaster PRO and ArcGIS 3.2a software, datum UTM SAD 69. The area covered by each hill was estimated with the same software when no previous data could be found. Population size was visually estimated whenever possible.

Species descriptions were based on specific taxonomic literature, and were sometimes adapted according to field and herbaria observations. Since only original Latin descriptions were available for many of the selected species, we provide updated descriptions in English in order to facilitate future research involving these rare and threatened taxa. Comments on each species distributional range were based on our data and on herbaria and literature revision. Collections at ICN, HAS, PACA, and MPUC herbaria were reviewed. Collections deposited at international herbaria available on-line were also checked. Changes in threat category we suggested, as well as exclusion and inclusion of species in extinction-threatened lists, were based on IUCN criteria (IUCN 2001). Category changes were based on updates concerning each species known distributional range and, for some of them, estimated frequency along this distribution. Comments concerning conservation status of each granitic hill were based on the presence and conservation status of rare, endemic and threatened species populations. Field observations of each local flora and vegetation structure were also taken into account.

Results

The nine granitic hills surveyed cover 4.445 ha (Table 1), corresponding to ca. 10% of Porto Alegre total area. In Figure 1, each hill location is shown, as well as the surrounding human occupancy (implied by the concentration of roads). Among the nineteen sampled species (Table 2), only one was found at the nine surveyed hills (*Parodia ottonis*), another one at eight hills (*Mandevilla coccinea*) and four species were found at seven hills (*Eugenia dimorpha, Moritzia ciliata, Schlechtendalia luzulifolia* and *Waltheria douradinha*) (Table 2). *Alstroemeria albescens* and *Bipinnula canisii* were found at only one location each. Nine species are currently categorized as Vulnerable (VU), five as Endangered (EN), one as Data Deficient (DD), according to SEMA (2003) (Table 2). Three species were not included in any extinction-threatened lists, and one was included in a federal list, but had no IUCN threat category assigned. Among the sampled hills, *Morro São Pedro* presented the higher threatened species number (14), followed by *Morro do Osso* and *Morro Tapera* (12) and *Morro Agudo* (9) (Table 2).

Below we present the descriptions, known distribution, conservation status and threat level of the nineteen sampled species, as well as descriptions and conservation status of the nine granitic hills. The main taxonomic source used for each species, containing original descriptions, illustrations and sometimes identification keys, is provided below the descriptions. In addition, we comment on some species that we considered relevant but that were not included in our sampling, as well as on four non-sampled hills.

Species descriptions, distribution and conservation status

Alstroemeria albescens M. C. Assis (Alstroemeriaceae) (Figure 2-B,C)

Perennial herb ca. 0.7 m tall; rhizome with storage roots; stems cylindric, glabrous; Leaves of the vegetative stem evenly distributed along the stem, not resupinate, blade linear, 1.5–11.5 x 0.4–0.5 cm, coriaceous, apex acuminate, base cuneate, both faces glabrous; leaves of the reproductive stem distributed along the stem, not resupinate, blade linear or linear-lanceolate, 1.5–6 x 0.4–0.6 cm, coriaceous, apex acuminate, base truncate, both faces glabrous; inflorescence an umbel-like, composite cyme, 3 to 10 flowers; pedicel glabrous, 2–2.5 cm; bracts leaflike, chartaceous, 0.8–0.9 cm; bracteoles membranous, 0.3–0.5 cm; flowers patent, campanulate, white-lilac, 2.2–3 cm; tepals 6 in 2 whorls; the outertepals unpatterned, all 3 very similar, spatulate; the upper one ca. 2 x 0.8 cm; the lower two ca. 1.9 x 0.7 cm; the inner tepals ruby spotted, all 3 very similar; the upper two ca. 1.9 x 0.5 cm; the lower one ca. 1.9 x 0.5 cm; stamens 6, included, filaments glabrous, ca. 1–2 cm; stigma included, style glabrous, ca. 1.5–1.6 cm; capsules 1.3–1.5 x 0.7–1 cm.

Source: Assis (2009).

Distribution – According to Assis (2009), *Alstroemeria albescens* is endemic to *Morro São Pedro*, and can be found on rocky outcrops at 130-169 m a.s.l.. During our surveys, the species was only found at *Morro São Pedro*, and only at two sites (Table 2; figure 14-B).

Threat Category – Assis (2009) suggested that, according to the IUCN Red List criteria (IUCN, 2001), the species should be treated as Data Deficient (DD), needing further investigation. We suggest the inclusion of the species in the Critically Endangered (CR) category, as it is known to exist in only one location, its natural habitat is declining (both in area and quality) due to urban expansion and its extent of occurrence is estimated to be less than 100 km^2 (considering the total area of *Morro São Pedro* as the area of possible occurrence).

Conservation status – Only two populations of *Alstroemeria albescens* were found in our surveys, at the same place where the species type was collected. It is possible, due to spatial proximity, that the species is present in other granitic hills, although we did not find it, which could be related to its short flowering period and flower duration.

Bipinnula canisii Dutra (Orchidaceae) (Figure 5-A-C)

Terrestrial, erect, ca. 20 cm tall; roots numerous (10-15), clavate, fasciculate, 4-6 cm long, 5-6 mm wide at apex; leaves herbaceous, basilar, rosulate, erect-patent, narrowly oblong, acute, embracing stems at the base, 5-9 x 1.2-1.5 cm; scapes erect, glabrous, 12-15 x 0.3-0.4 cm; sheaths ca. 5, membranaceous, oblong, acute, glabrous, 4 x 0.8-1 cm, completely covering the scape; larger bracts resembling sheaths, narrowly-ovate, acuminate, 4 x 1.6 cm; ovary with long pedicel, 4 cm long, clavate, 6-carenate; flowers solitary, patent, 3 cm wide; dorsal sepal erect, oblong, acute, somewhat concave, green, 7-nerved, reticulated, nerves purple, 2.7 x 1 cm; lateral sepals oblique-ligulated, somewhat swelled towards the base, membranaceous, light-green, 7-nerved, appendices arranged in pinniform fashion at the apical third of margins, linear, acute, 4-5 mm of ornate portion; petals erect, narrowly ovate-oblong, somewhat falcate, 7-nerved, reticulated, 2.2 x 0.65 cm, margin whole; labellum fleshy, 3 x 2 mm (without ungula), abruptly expanded in sub-squared, somewhat 3-lobate, blade; disc with callum growing in 4 excurrent sub-equilong blades; lateral lobe margins crenate, crenas gradually thickened, turning into small, coarse, digitiform appendices; median lobe with papillose-digitiform appendices, growing in bundles; labellum 15 mm total length, 12 mm wide between lateral lobes, 9 mm towards apex; column thickened, semicylindric, 6 mm long, briefly extended at base; anther 4 mm long.

Source: Dutra (1959).

Distribution – The last known collection records date from 1933, at *Morro da Polícia* and *Morro da Glória*, and the species was not re-collected until now. In our survey, we found it only at *Morro Tapera*, and the species is probably endemic to dry grassland formations inserted in the granitic chain.

Threat category – Not included in national or regional threatened flora lists. We suggest the species inclusion in the Rio Grande do Sul Threatened Flora List, under the Critically Endangered (CR) category.

Conservation status – The only modernly known population of *Bipinnula canisii* is found at a granitic hill within Porto Alegre city limits. Due to the extremely narrow distributional range and to habitat fragmentation, we suggest the species inclusion in the Rio Grande do Sul Threatened Flora List, under the Critically Endangered category (CR), according to IUCN criteria (IUCN 2001).

Butia capitata var. *odorata* (Barb. Rodr.) Becc. (Arecaceae) (Figure 4-I)

Stems solitary, 1-8 m tall and 25-50 cm diameter, cinereous, rough, with scars from old petioles; leaves 7-32, bluish-green, arching, 30-67 cm long; rachis 76-106 cm long; petiole with coarse spines along the margins; leaflets 41-60 x 1.2-2.2 cm, 35-60, apex acuminate, light-green, lower face glaucous, more or less regularly arranged and stiffly spreading, forming a "V" shape; peduncular bract almost smooth or with shallow grooves on outer surface, glaucous; inflorescence bracts 55-167 cm long, rostrum ca. 2.1 cm long; flowering branches 50-99; staminate flowers beige, ca. 7.5 x 6 mm, sepals 3.1 x 0.6 mm, petals 3.9 x 1.8 mm, anthers 2.9 mm long, filete 2.7 mm long, pistilodium 4.3 mm; pistillate flowers yellow, 4.8-5.6 x 3.6-3.9 mm, sepals 5.3 x 3.6 mm, petals 3.9 x 3.2 mm; staminoids ring ca. 1 mm long; fruits ovoid, 2.0-2.6 x 1.1-1.5 cm, yellowish or orange-brown, perianth persistent, ca. 5 mm, staminoids 4-6, in a ring.

Sources: Henderson *et al.* (1995); Lorenzi *et al.* (2004); Marcato (2004).

Distribution – Marcato (2004) cites the species as restricted to Santa Catarina and Rio Grande do Sul, mainly for the seashore plain but also occurring westwards, as far as the *Depressão Central* physiographic region. There are also records for Uruguay (Montevideo), suggesting a broader distribution and collection gaps within Rio Grande do Sul territory. In our surveys, we found the species only at three granitic hills (Table 2). The largest populations within Rio Grande do Sul state are distributed south from Porto Alegre city, partly surrounding the local lagoon system and shaping unique formations locally known as *butiazais*.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Endangered (EN) category (SEMA 2003).

Conservation status – Within our study area, populations of *B. capitata* var. *odorata* comprised 1-3 individuals at almost every site were it was found. Only at three granitic hills the species was recorded, and this is probably related to removal for gardening, since the species is considered as ornamental. *Morro São Pedro* is the site where the species is better represented (Figure 14), with seven populations.

Marcato (2004) elevates *B. capitata* var. *odorata* to the species level (as *B. odorata*), mentioning a geographic disjunction between this species (recorded for Rio Grande do Sul and Santa Catarina) and *B. capitata* (Cerrado Biome). Henderson *et al.* (1995) also suggested that *B. capitata* populations found outside the Cerrado Biome (i.e., Paraná, Santa Catarina and Rio Grande do Sul and Uruguay) should perhaps be recognized as a separate species (*Butia odorata*). Lorenzi *et al.* (2004) treat *B. capitata* and *B. odorata* as separate species, using Marcato (2004) as source. Since *Butia odorata* is only mentioned at its new taxonomic status in a thesis, it is not valid, and we decided to use the name *B. capitata* var. *odorata* for the species we have found within our study area.

Dyckia choristaminea Mez (Bromeliaceae) (Figure 3-A-C)

Plant flowering 15-25 cm tall; leaves 7-12 cm long; sheaths suborbicular, 2 cm long, pale, glabrous, blades linear, 5 mm wide, deeply channeled, laxly serrate with slender curved spines 2.5 mm long, cinereous-lepidote on both sides; scape slender, glabrous; scape-bracts densely imbricate, broadly ovate, abruptly acute, subinflated, minutely lepidote; inflorescence simple, few-flowered, subterete, 3-5 cm long, 3 cm in diameter; rhachis densely white-villous; floral bracts like the scape-bracts, 15 mm long, equaling the sepals in lenght, entire, carinate toward apex; flowers 18-24 mm long, on short stout pedicels; sepals very broadly ovate, acute, 10-11 mm long; petals very short-connate, spreading to recurved at anthesis, dark-yellow, darkened along the median line; stamens included, filaments free above the common tube with the petals; ovary 8 mm long, style 8 mm long, very stout.

Source: Smith & Downs (1974).

Distribution – Smith & Downs (1974) point out Rio Grande do Sul as the distribution of this species, always associated to open rocky grounds. Haussen (1992) cites the species as endemic to Rio Grande do Sul. However, most records known for the taxa are within Porto Alegre granitic chain region, with one record at the granitic hills at Itapuã (ca. 25 km south of *Morro São Pedro*), which are floristically similar to our study sites, and one at the northern seashore plain.

Threat Category – The species is in the Rio Grande do Sul Threatened Flora List, under the Endangered (EN) category (SEMA 2003). Since distributional area for the species is extremely limited, we suggest the inclusion of the species on the Brazilian Federal List of Extinction-Threatened Flora.

Conservation status – Distribution of *D. choristaminea* is linked to the granitic hills present at Porto Alegre region. Populations recorded for the hills at Itapuã are relatively secure, since the collection sites are within a Conservation Unit. Populations found in our surveys, however, are under great threats, since they comprise very few individuals and present in only four hills (Table 2), thus being vulnerable to local extinction.

Dyckia leptostachya Baker (Bromeliaceae) (Figure 3-D)

Plant flowering 50-150 cm tall, very variable but with a gradual transitions between the extremes; leaves 4-10 cm long; sheaths persistent, shaping a thick bud, broadly ovate to suborbicular, 4 cm wide; blades arching, narrowly triangular, long-attenuate, 1-3 cm wide, densely white-lepidote on both faces or soon glabrous above, laxly repand-serrate with slender curved spines 3-4.5 mm long; scape very slender, minutely lepidote or glabrous; scape-bracts small, many times shorter than the internodes, very broadly ovate, apiculate, entire; inflorescence simple or few-branched, 12-16 cm long; axis sparsely lepidote or glabrous; primary bracts inconspicuous; floral bracts spreading, very broadly ovate, abruptly contracted to an acuminate point, 3-8(-12) mm long, much exceeded by the sepals; flowers sub-erect to spreading, 13-23 mm long, on very short stout pedicels; sepals broadly ovate, obtuse, 6-12 mm long, more or less carinate, even, soon glabrous; petals erect, red-orange, the blade broad, obtuse or emarginated, minutely crenulate; stamens usually exserted, filaments free above the common tube with the petals; anthers acute, mucronate, recurved; style distinct and sometimes long or partially divided.

Source: Smith & Downs (1974).

Distribution – According to Smith & Downs (1974), species distribution encompass southern Brazil, southeastern Bolivia, Paraguay, and northeastern Argentina. In our surveys, the species was found in five granitic hills (Table 2), always in small populations (2-5 individuals).

Threat category – Not included in national or regional threatened flora lists. We suggest the inclusion of this species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category, due to its restricted distribution and extremely fragmented habitat within the State (see below).

Conservation status – Although widely distributed in southern South America, records for the species in Rio Grande do Sul are scarce, with only two occurrences outside our study area (northern seashore plain and *Depressão Central* physiographic region; data from herbaria revision). Due to small population size, scattered distributional pattern, presence locally limited to the granitic hills and subsequent great habitat fragmentation, we considered this species as locally threatened, suggesting its inclusion on the local threatened flora list.

Eugenia dimorpha O. Berg (Myrtaceae) (Figure 4-J)

Subshrub 0.5-1.0 m tall; plants glabrous, trichomes only in the ovary; cortex rugous, grayish; leaves elliptic or obovate, rarely round, 30-60 x 12-35 mm, discolour (in nature and in dry plants), apex obtuse, base obtuse or cuneate, rarely chordate, central nerve plain in the adaxial face (reddish and distinct from the rest o the leaf in dry material) and prominent in the abaxial face, secondary nerves 8-10 pairs, generally evident in both faces and prominent at least in the abaxial face, marginal nerve 0.8-1.0 mm from the margin, margin usually revolute, with yellowish or brownish thickening of 0.5 mm; petiole 1-3 x 1.2-1.5 mm; inflorescences fasciculate or reduced racemes, 1-5 x 1 mm, ramiflorous, rarely axial, 2-6-florous; pedicels 3-12 x 0.2-0.3 mm; bracteoles elliptic, 0.9-1 x 0.5-0.6 mm, persistent on the anthesis, usually covering the ovary, this one sparsely or densely covered by rufescent trichomes of 0.1-0.3 mm; floral buds globose, 3-4 x 3 mm; calyx lobes glabrous, subequal, ovate-rounded, 1.2-2 x 1.4-2 mm; fruits elliptic, 8-10 x 5-6 mm, red to black when mature.

Source: Sobral (2003).

Distribution – According to Sobral (2003), the species occurs in grasslands with rock outcrops in Rio Grande do Sul state along the *Depressão Central* and *Serra do Sudeste* formations. In addition, the author emphasizes that the species is the only known Myrtaceae to have its distribution limited to Rio Grande do Sul state. In our surveys, the species was found at seven granitic hills (Table 2). Revising previously collected specimens, we found out that all the available herbarium accesses that could be geo-referenced are located on hills at least 100 m a.s.l.. We considered the species as endemic to the granite-based and surrounding grassland formations present at Rio Grande do Sul.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003). We suggest the inclusion of the species in the Brazilian Federal List of Extinction-Threatened Flora.

Conservation status – Albeit relatively well distributed among our study sites, *Eugenia dimorpha* shows a clumped distribution, with populations composed of few isolated individuals. The species distributional pattern, allied to the levels of threat acting over the local granitic hills, enhances the concern over this species conservation, since alterations in a single location in one of these formations may cause local extinction.

Frailea gracillima (Lem.) Britton & Rose (Cactaceae) (Figure 4-E,F)

Stems cylindric, simple, 10 x 2.5 cm, grayish green; ribs ca. 13, indistinct or somewhat spiral, tuberculate; areoles small, a purple blotch beneath each one; radial spines ca. 16, 2 mm long, setaceous, white, somewhat appressed; central spines 2-4, unequal, 4-8 mm; flowers yellow, 3 cm long; scales on the ovary and flower tube woolly and bristly in the axils; fruit 6 mm wide; seeds 1.5 mm long. According to Britton & Rose (1922), the species differs from its congenerics for being the only species with cylindric stems.

Distribution – According to Britton & Rose (1922), the species distribution is limited to Paraguay. We found no records of the species at Brazil, Uruguay or Argentina, although it has been seen at the granitic region of Rio Grande do Sul known as Serra do Sudeste (M.C. Machado, personal communication). In our surveys it was found only at two hills (Table 2), always associated to rock outcrops.

Source: Britton & Rose (1922).

Threat Category – Not included in any extinction-threatened flora list. We suggest the species inclusion in the Rio Grande do Sul Threatened Flora List, under the Critically

Endangered (CR) category. In addition, we suggest the inclusion of the species in the Brazilian Federal List of Extinction-Threatened Flora.

Conservation status – The only populations of *F. gracillima* with presently known location are the ones we present here, since the type locality is not cited on the species protologue. As the species is theoretically recorded for Paraguay, there is a major collection gap between these sites. It is likely that distribution of this species could be similar to *Parodia ottonis*, since both were collected in similar conditions within our study area (always at rock outcrops), besides the great morphological (and probably physiological) convergence. In that case, collection gaps at *F. gracillima* distribution would reflect lack of collection effort, a common phenomena among the cacti family. Notwithstanding, the species remains extremely rare, with known populations in isolation and natural habitat fragmented in alarmingly high levels. Therefore we suggest the species inclusion in the Rio Grande do Sul Threatened Flora List, under the Critically Endangered (CR) category, according to IUCN (IUCN 2002) criteria. Inclusion in the federal list of extinction-threatened species is also suggested.

Gochnatia cordata Less. (Asteraceae) (Figure 2-A)

Shrub 40-120 cm tall, stems erect, densely tomentose, leafy as far as the inflorescence; internodes 10-30 cm; leaves alternate, sessile, coriaceous, ovate or oblong-elliptic, round or obtuse, apex minutely mucronulate, base cordiform, margin whole, adaxial face glabrous and shiny, abaxial face densely velvety-tomentose, erect malpighiaceous trichomes; capitula numerous, briefly pedicellate or sessile, arranged in groups of usually 3 along the stem terminal portion; involucre campanulate, 10-12 x 10-12 mm; bracts numerous, ovate-lanceolate, densely velvety-tomentose in the adaxial face; florets numerous, yellow, hermaphrodite, corolla tubulose, 5-sect, tube 6-7 mm, curved segments 5-6 mm; anthers with connective lanceolate, apiculate, thecae apex plumose; style apex briefly 2-lobed; achenes turbinate, sericeous, 4 mm long; pappus tawny, 7-9 mm long.

Source: Cabrera (1971).

Distribution – According to Cabrera (1971), the species distribution comprises Southern Brazil (Paraná, Santa Catarina and Rio Grande do Sul states), Uruguay and Northeastern Argentina, as far as Entre Ríos province. In addition, the author comments that the species "seems to prefer sandy soils". In our survey, we found it in seven granitic hills (Table 2), but distributed in only one population at each site. Revising previously collected material we found three records for the species in Rio Grande do Sul state outside Porto Alegre city: one at the *Campanha* region (SW of the state), one at sandy soil grasslands (W of the state) and other at the center of the state. There are also records for São Paulo state. Records outside Brazilian territory (all close to Rio Grande do Sul borderline) were also found: two in Paraguay and three in Argentina. This data suggest the possibility of a continuous distribution of *Gochnatia cordata* from Southern Brazil to Uruguay and Northeastern Argentina, as pointed out by Cabrera (1971). However, caution is needed in order to determine this species distributional range, since there is a major gap in occurrence records between Eastern Rio Grande do Sul (Porto Alegre city region) and Argentina/Uruguay. In addition, there is no record for the species in Santa Catarina state. As it is, populations found at the granitic hills in Porto Alegre are in complete isolation, from northern, southern and western sides, if the available distribution record is taken into account.

Threat Category – Categorized as Vulnerable (VU) in Rio Grande do Sul threatened flora list (SEMA 2003). The distribution data shown here suggest conservation problems, since there are major gaps in the species assumed distributional range. However, further investigation is needed, especially in Southern Rio Grande do Sul and in Santa Catarina, in order to assess whether the species should be included in the Federal List of Extinction-Threatened Flora or not.

Conservation status – The rarity of *Gochnatia cordata* (only one population per hill in seven hills), allied to low values of individuals per population, enhances the levels of threat acting over the species within our study area. The population found at *Morro do Osso*, for instance, comprised only four individuals, and any local disturbance could cause local extinction. The populations found at the granitic hills at Porto Alegre city are completely isolated from the other known sites where the species occur, and the gaps between these sites could be due to a lack of collection effort, to natural habitat change/removal or to the species natural distribution pattern. Notwithstanding, the threat over the populations at the granitic hills is indeed concerning, due to their isolation and human-driven disturbances.

Gochnatia orbiculata (Malme) Cabrera (Asteraceae) (Figure 4-G, H)

Shrub 70-150 cm, with storage roots; stems erect, ribbed, white-tomentose, leafy as long as the apex; internodes 10-20 mm; leaves alternate, 35-70 x 30-45 mm, coriaceous, petiolate, petiole white-tomentose, 2-8 mm long; leaf blade ovate, widely ovate or circular (the three forms may occur in the same plant), acute or obtuse, apex mucronate, base deltoid or round, margin whole or minutely dentate on the upper half; nerves conspicuous, shaping a tenuous reticule; adaxial face glabrous, viscous (small sessile glandules), abaxial face densely pubescent, trichomes sericeous, mapighiaceous; capitula numerous, briefly pedicellate or sessile, arranged in terminal widened panicle; involucre campanulate, 6 x 4 mm; bracts in 4-5 series, abaxial face pubescent, ovate, acute or obtuse in the exterior and lanceolate and acute in the interior; florets 8-10, yellowish, feminine in some plants, hermaphrodite in others or the marginal ones feminine and the central ones hermaphrodite; corolla deeply 5-sect, 6-7 mm, anthers sagittate, connective lanceolate, apiculate; style lobes short, obtuse; achenes cylindric, pubescent; pappus strawy.

As pointed out by Cabrera (1971), some specimens with elliptic-ovate leaves could be misidentified as young specimens of *G. polymorpha*, but this last species, besides being a tree, presents larger leaves.

Source: Cabrera (1971).

Distribution – Cabrera (1971) defines the species distributional range as Southern Brazil, from São Paulo state to Rio Grande do Sul state, commenting that it can be found in dry grassland formations. Mondin & Baptista (1996) mention the species as restricted to Porto Alegre city within Rio Grande do Sul limits. In our surveys, we found the species in three granitic hills (Table 2), distributed in 3 populations at two hills and one in another hill (Figures 10 and 14). Although rare in our study sites, the species has a wider distribution, as pointed out by Cabrera (1971) and confirmed by revision of previously collected specimens. As there is a larger number of specimens collected in the northernmost portion of its distributional range (São Paulo and Paraná states), it is likely that *Gochnatia orbiculata* distribution is shaped in a gradient pattern, with decreasing frequency values southwards. The populations marked at *Morro São Pedro* configure the southernmost records for the species.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Endangered (EN) category (SEMA 2003). It is included in the Brazilian Federal List of Extinction-Threatened Flora (MMA 2008).

Conservation status – Populations of *Gochnatia orbiculata* show a clumped distribution pattern on the field, with few individuals. Populations found at *Morro do Osso*, although with few individuals, are the least threatened, considering that they are inserted into a Conservation Unit. The rarity of this species at the study sites seems to be related rather to a natural distributional gradient then to human-driven disturbances.

Gomphrena graminea Moq. (Amaranthaceae) (Figure 2-D, E)

Perennial herb, up to 80 cm tall, with xylopodium; stems simple or slightly ramose, sulcate, with adpressed and erect trichomes; leaves sessile, 6-10 x 0.4-1 cm, oblong-linear, apex acuminate, base half embracing the stem, trichomes erect, nervers parallel; inflorescence spiciform, terminal and axilar, up to 15 cm long; rachis pilose, peduncle 1-15 cm long; bracts rigid, ca. 7 mm long, ovate-lanceolate, acuminate, base and abaxial face slightly pilose; bracteoles slightly larger than bracts, laterally compressed, serrulate arista at apex; flowers up to 1.5 mm long; tepals strawy-yellow, narrow-lanceolate, acute, compressed trichomes at the base; staminal tube exceeding the perigonium; free portion of the filaments with 3-lobulate apex, central lobe nearly null and laterals short, not surpassing half the anthers; anthers oblong-linear, ca. 4 mm long, apex reflex; ovary shorter than staminal tube, ca. 4-5 mm long; style short, stigma deeply bifid, linear, erect; utriculus included in the persistent perigonium and the trichomes at the base of the tepals, detaching when mature; flowering and fruiting from October to November.

Source: Vasconcellos (1982).

Distribution – According to Vasconcellos (1982), the species is distributed from Minas Gerais to Rio Grande do Sul States in Brazil and in northeastern Argentina. In our surveys, it was found in four granitic hills (Table 2).

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003).

Conservation status – Due to its wide distribution within Brazilian territory, *G. graminea* should stay out of the National list of extinction-threatened flora. In Rio Grande do Sul, the species is also well distributed: trough herbaria and literature revision we found records for all regions of the State. However, both literature revision and our personal field observations suggest that the species is extremely rare, with reduced population size and clumped distribution. In our surveys, most populations comprised only one individual, which enhances chances of local extinction.

Mandevilla coccinea (Hook. & Arn.) Woodson (Apocynaceae) (Figure 2-J, K)

Subshrub ca. 30 cm tall, erect, with storage roots; leaves opposite, lanceolate or oblong-elliptic, acute or obtuse, 3-8 x 1-3.5 cm, membranaceous, subsessile; inflorescence terminal, loose, bracts lanceolate, 0.5 cm long; pedicels ca. 1 cm long; flowers 5-20; sepals 0.5-1.5 cm long, with glandules on the inside; corolla purple, fauces orange, tube 2-2.5 cm long, slightly distinguished in two parts, fauces 0.5 cm long, lobes obovate, acute, outstretched, 1.5-3 cm long; stamens in the middle of the tube; discs 2-scaled, similar to the ovary; fruits straight, cylindrical, 20-25 x 0.5 cm, glabrous; seeds 8 mm long, elliptic, apical crown 2 cm long; flowering from November to February, peeking in December.

Source: Markgraf (1968).

Distribution – Markgraf (1968) points out a large distributional range for this species, encompassing S and SE Brazil, Paraguay and Uruguay. We also found records for NE Argentina. In our surveys, the species was found in seven hills, being absent only at *Morro Pelado* (Figure 2), but always in extremely reduced and isolated populations.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003).

Conservation status – Although well distributed along Porto Alegre granitic chain, populations of *Mandevilla coccinea* are remarkably small, usually with 1-2 individuals. Albeit being natural and also acknowledged in literature, this discontinuous distributional pattern enhances local extinction danger in fragmented habitats such as the grasslands at the granitic hills within our study area.

Mikania pinnatiloba DC. (Asteraceae) (Figure 5-H, I)

Perennial herb, 40-80 cm tall; stems erect, sensitive, markedly ribbed, glabrous, leafy as far as the inflorescence; leaves opposite, 40-100 x 20-40 mm, rhombic-lanceolate, deeply lobed or pinnatissect, glabrous or abaxial face slightly pubescent; capitula with four flowers arranged in terminal corymbose cimes; peduncles 1-3 mm long; involucre cylindric, 8-9 mm long; bracts oblanceolate, obtuse, abaxial face pubescent; bracteole linear, very short; flowers white; corolla 7-8 mm long, tube 4 mm long, limbus 4 mm long, divided in lanceolate lobes ca. 3 mm long; achenes briefly hirsute.

Distribution – According to Burkart (1979), the species is distributed in S Brazil, Uruguay and NE Argentina. In Rio Grande do Sul, however, there is a great gap in records between Porto Alegre region and Uruguay/Argentina, so that the southernmost occurrence is recorded at the granitic hills of Itapuã. Rambo (1952) considers the species as endemic to Rio Grande do Sul and surrounding regions. Within our study area, the species was found in three granitic hills, always in reduced populations (less than 5 individuals each), a pattern not mentioned in literature we had access to.

Sources: Burkart (1979); Ritter & Miotto (2005).

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003).

Conservation status – Besides the wide distribution pointed out by Burkart (1979), records of this species within Brazilian territory are few and scattered. The small number of records at S, SW and W Rio Grande do Sul could be resulting from lack of collection effort, as well as from the apparently natural rarity of the taxa.

Mimosa rocae Lor. & Niederl. (Fabaceae) (Figure 2-F, G)

Subshrub up to 0.6 m tall, crawling, unarmed, extremely ramous; stems spread out, forming a dense carpet over stony soils; leaves 1-paired, folioles 2, 0.6-1.6 cm long; stipules 1.5 mm, linear, deciduous; petiole 1-3 mm; inter-foliole appendix 2.5 mm, subulate; rachis with terminal subulate appendix; foliolules 8-12 pairs, opposite, oblong, 3-4.5 x 0.6-1 mm, base asymmetric, apex widely acute, sometimes mucronate, pubescent in both faces, denser in the abaxial face, nerve sub-eccentric, visible in the adaxial face, apical pair smaller and sometimes sub-falcate; inflorescence globose, 6-7 mm (stamens included); peduncles axillary, 1-2.5 cm long; bracts oblong, apex triangular, incurved, obtuse, 0.5-1 mm long, 1-nerved, persistent, pubescent; calyx campanulate, glabrous, scarcely ciliate, 0.4-0.5 mm long; corolla campanulate, 4-lobulate, fleshy, yellowish, 2.3-2.8 mm long, lobules 1.3-1.5 mm long; stamens 4, free, 3-4 mm long, filaments yellow; ovary subglobose, papillose, 0.5 x 0.4 mm; legumes 1-10 per inflorescence, oblong outline, nearly erect, subcompressed, apex acute, indument mixed (setules with long or short axis), 1-3-articulate, 1-1.8 x 0.35-0.5 cm, replum persistent; articulus dehiscent, quadrangular, 5 x 5 mm; seeds 1-4, subglobose, dark, shiny, 4 x 3 mm, pleurogram dark, opened; flowering from April to September; fructification from October to December.

Source: Izaguirre & Beyhaut (2003).

Distribution – According to Izaguirre & Beyhaut (2003), the species has Rio Grande do Sul as its origin site, and spreads through Uruguay and Argentina on the ‘pampean sierras’. The authors link the species to rocky grasslands and hillsides, always flattened on rock outcrops or in rock cracks. Very few collection records exist for the species: ca. four in Argentina, two in Brazil and two in Uruguay. We consider this species as endemic to the Pampa Biome in a broad sense (i.e. including NE Argentina and Uruguay), with its northern/eastern limit at the granitic chain of Porto Alegre city. In our survey, the species was found in two hills (Table 2) and only three populations (Figures 9 and 11).

Threat category – Not included in national or regional threatened flora lists. We suggest the species inclusion in Rio Grande do Sul Threatened Flora List, under the Critically Endangered category (CR), and in the Brazilian Federal List of Extinction-Threatened Flora.

Conservation status – The only recently collected populations of *Mimosa rocae* in Rio Grande do Sul are within our study area, in extreme isolation from other known sites of occurrence at Argentina and Uruguay. The population found at *Morro Pelado* (Figure 11) is inserted in an area that is likely to be turned into a quarry site, which would cause local extinction and leave only one recently known population in Rio Grande do Sul. Due to its very limited distributional range, great population reduction and isolation and habitat fragmentation, we suggest the inclusion of *Mimosa rocae* in Rio Grande do Sul Threatened Flora List, under the Critically Endangered category (CR), according to IUCN criteria (IUCN 2001). In addition, we suggest the inclusion of the species in the Brazilian Federal List of Extinction-Threatened Flora.

Moritzia ciliata (Cham.) DC. (Boraginaceae) (Figure 3-H, J)

Herb 30-40 cm tall; stems numerous, erect, simple, with short trichomes covered by larger trichomes, white and patent; leaves acute, mildly strigose, abaxial face sparsely hispid in the nerves, margins strongly ciliate, distinctively bicolor, trichomes with no disciform base; basal leaves oblanceolate, 15-30 x 25-35 cm; stem leaves reduced, lanceolate to linear;

inflorescences paniculate; cimes 1-3 cm long; calyx broadly sessile, cylindric in anthesis, short-pubescent, trichomes scarce, angles thick; corolla blue, limbus patent, 4-5 mm wide, tube 4-5 mm long, apex with hirsute ligules, up to or longer than stamens; fruit nutlet, subovoid, 2.5-3 mm long, robust-stipitate; flowering from October to November.

Source: Smith (1970).

Distribution – Smith (1970) indicates the distribution as restricted to Rio Grande do Sul, emphasizing that it has not been found at Santa Catarina. In our surveys, it was found at seven hills (Table 2), in populations of extremely variable sizes, but small clumped populations of less than 15 individuals are more frequent. By analyzing available herbaria and literature, we also found collection records at Uruguay. We consider this species as endemic to the Pampa Biome in a broad sense (i.e. including NE Argentina and Uruguay), with its northern/eastern limit at the granitic chain of Porto Alegre city. It is likely that the species also occur in N Uruguay, due to a floristic continuum along the region.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003).

Conservation status – Although extremely fragmented due to urbanization, the species is well represented in Porto Alegre region, with large populations in many hills, remarkably at *Morro das Abertas* (Figure 7). As an endemic species with a clumped and small population distributional pattern, the species deserves conservational attention, as should be added to the Brazilian Federal List of Extinction-Threatened Flora.

Parodia ottonis (Lehm.) N. P. Taylor (Cactaceae) (Figure 4-A-D)

Gemmiferous roots; stems globose-flattened, cespitous, 4-7 x 5-7 cm, light to dark green, apex slightly immerse; ribs 7-12, wide, apex obtuse, seldom tuberculate, tubercles ca 1 x 0.12 cm; areoles 3-6, 3-4 mm wide, 10-15 mm apart; radial thorns 10-18, ca. 1-1.3 cm long, setose, straight or slightly sinuous, brownish-yellow to reddish; central thorns 0-4, 8-15 mm long, slightly more rigid than radials, brownish-red, apex lighter; flowers widely campanulate, ca. 3.6-6 cm long/wide, yellow, emerging from the center but from the superior areoles; perianth segments 2-seriate, oblong, apex apiculate, edges dentate, greenish-yellow, the exterior ones dorsally reddish, the interior ones 20-25 x 4-6 mm, greenish-yellow, velvety, shiny; style ca. 2 cm long, light-yellow; stigma 10-14-lobulate, lobules red; stamens included, yellow, base violaceous; fruits ovate, ca. 0.8 cm wide, green, scaly, covered by trichomes and bristles, dehiscent in longitudinal cleavage; seeds widened, 1.2 x 0.7 mm, shiny-black.

Source: Scheinvar (1985); Kiesling (2005).

Distribution – According to Kiesling (2005), the species distribution is the following: southern Brazil (Rio Grande do Sul), E Paraguay, Uruguay and Argentina (Misiones, Corrientes and Entre Ríos provinces), always associated to 'rocky hills' and herbaceous vegetation. In our surveys, the species was found at the nine sampled hills (Table 2), in variable population sizes and always at rock outcrops. Revision of available herbaria and literature revealed several records of the species for Rio Grande do Sul, exceptionally at Porto Alegre granitic hills and at the W and SW regions of the state. There are record gaps between Porto Alegre region and Uruguay/Argentina borderlines, but it is likely that these gaps along the species distribution are due to lack of collection effort, a common phenomenon among the Cactaceae. We consider this species as endemic to rocky grasslands inserted in the Pampa Biome in a broad sense (i.e. including NE Argentina and Uruguay), with its northern/eastern limit at the granitic chain of Porto Alegre city.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Vulnerable (VU) category (SEMA 2003).

Conservation status – Although heavily fragmented, populations of *Parodia ottonis* at our study sites are in good conservation status, given the high number of populations and the presence in almost every natural grassland patch we have found. Nonetheless, the species should remain in the State extinction-threatened list, since its occurrence is restricted to rock outcrops throughout its distribution and its populations are extremely fragmented, besides being a target to non-scientific cacti collectors.

Sellocharis paradoxa Taub. (Fabaceae) (Figure 5-G)

Subshrub up to 1 m tall; stems erect, branching, young branches densely sericeous, older branches glabrescent; leaves composite, spiraled sessile, 5-7 foliolate; leaflets lanceolate, apex acute, mucronulate, base attenuated, subcoriaceous, 3-nerved, 15-25 x 3-4 mm, briefly petiolulate, petiolules short, embracing branches as a sheath, shaping pseudo-whorls at each node; flowers solitary, yellow, peduncles 1-1.5 mm long; calyx 5 mm (floriferous) or 6 mm (fructiferous), subcampanulate, bilabiate, superior teeth 2, triangular, acute, inferior teeth 3, longer, nearly connate at apex, sericeous externally; vexillum orbicular, 5 x 5 mm, apex deeply emarginated, base unguiculate, 2-3 mm long, sparse long trichomes above ungula, externally sericeous; wings subequal to vexillum, sub-oblong, apex round, base narrow, unguiculate, 2 mm, sides unequal; keel with obtuse petals, 3 x 2 mm, ungula 3 mm long, filiform, insinuated tooth at the upper margin, near vexillum and above the ungula; stamens 10, shaping an adnate sheath opposed to the vexillum; ovary sub-sessile, linear, compressed, sericeous, multi-seeded; fructiferous peduncles 3 mm long; legume sub-sessile, or shortly stipitate, circled by calyx and stamens, strongly compressed, 30-35 x 4.5-5 mm, dense yellowish-brown pilosity, upper commissure marked, straight and prolonged in a persistent portion of the style, lower commissure somewhat thickened, 2-valvate; seeds 18-20, ovate, dark-brown, smooth, opaque, 2.5 x 2 mm.

Source: Taubert (1889).

Distribution – Until recently, the only known record of the species was its type specimen, which did not mention a specific collection site, but only southern Brazil. Recently, a large population was found at the granitic hills of Itapuã, suggesting possible occurrence of the species along the other granitic formations at the region.

Threat category – Included in the Brazilian Federal List of Extinction-Threatened Flora (MMA 2008). We suggest the species inclusion in the Rio Grande do Sul Threatened Flora List, under the Critically Endangered (CR) category.

Conservation status – The only known population of *Sellocharis paradoxa* is restricted to a granitic hill ca. 8 km away from Porto Alegre city southern limits. Although inserted in a local Conservation Unit (Parque Estadual de Itapuã), the extreme reduction of distributional range threatens the species, and further surveys at the surrounding area should be carried out in order to search for more populations. Due to the extremely narrow distributional range and to habitat fragmentation, we suggest the inclusion of *Sellocharis paradoxa* in Rio Grande do Sul Threatened Flora List, under the Critically (CR) Endangered category, according to IUCN criteria (IUCN 2001).

According to Lewis *et al.* (2005), leaf arrangement in this species is unmatched in Fabaceae. Until recently, it was known only from the type collection, until re-collected in a granitic hill ca. 8 km away from our southernmost study site. As it is, it is possible that the species occur in our study area, albeit we did not found it. We considered the species as endemic to the granitic chain present at northeastern Rio Grande do Sul.

Schlechtendalia luzulifolia Less. (Asteraceae) (Figure 5-D-F)

Perennial herb 30-100 cm tall, erect, fasciculated roots, stems simple, sericeous, densely leafy near the base and nearly aphyllous at upper portions; leaves opposite, graminaceous, glabrous in both faces or pubescent in the adaxial face, 200-600 x 4-10 mm, upper leaves gradually smaller, subulate; capitula large, few, arranged in a very loose terminal cime, peduncles opposite, tomentose, hirsute, 40-120 mm long; involucre hemispheric, 20-30 x 20-35 mm, bracts linear-lanceolate, scarious, rigid, widely acuminate in a subulate apex, silky-pubescent in the abaxial face, the external ones recurved; florets numerous, yellow, corolla ca. 12 mm long, exterior villose; achene turbinate, covered by tawny trichomes, 3-4 mm long; pappus formed by two rows of linear-lanceolate strawy appendices, 6-11 mm long.

Source: Burkart (1979).

Distribution – According to Burkart (1979) and Mondin & Baptista (1996), species distribution comprises Rio Grande do Sul, Uruguay and NE Argentina. Within Rio Grande do Sul area, records of the species are abundant at Porto Alegre region, but otherwise restricted to the extreme western and southern sections of the State. There are several records for Uruguay and NE Argentina, therefore the record gaps between Porto Alegre region and Uruguay/Argentina borderlines are probably due to lack of collection effort. In our survey, the species was found in seven hills (Table 2). We consider this species as endemic to the Pampa Biome in a broad sense (i.e. including NE Argentina and Uruguay), with its northern/eastern limit at the granitic chain of Porto Alegre city.

Threat Category – The species in the Rio Grande do Sul Threatened Flora List, under the Endangered (EN) category (SEMA 2003), also being present in the Brazilian Federal List of Extinction-Threatened Flora (MMA 2008).

Conservation status – Populations of *Schlechtendalia luzulifolia* are well distributed among Porto Alegre granitic hills, which configure the species northernmost distributional limit. However, records for other regions of Rio Grande do Sul are scarce and, whether this is a natural gap or due to lack of collection effort, the species should be maintained on extinction-threatened lists due to the extreme habitat fragmentation and population isolation at the site it presents most records of occurrence.

Stenachaenium macrocephalum Benth. (Asteraceae) (Figure 2-H, I)

Herb 29-35.5 cm tall; stems erect, simple, densely pilose, winged, wings 1-4 mm wide; lower leaves simple, 4-11, 3.5-14 x 1-4.5 cm, rosulate, sessile, oblanceolate, base attenuated, apex obtuse or acuminate, margin dentate, glandules and short trichomes in both faces, dorsal face densely pilose; stem leaves simple, 2-9, spiraled, distant from each other, densely pilose, sessile, decurrent, scattered glandules in both faces; mid leaves 4-7.5 x 0.9-1.7 cm, oblanceolate, base obtuse or acuminate, apex dentate; upper leaves 0.5-3 x 0.1-0.7 cm, linear, apex acute, margin whole; peduncle 2-9.5 cm long, densely pilose, ramose; capitula 1-7; involucre 1-2.6 x 1.1-4 cm; bracts 4-18 mm long, linear or lanceolate, apex acute, pilose in both faces or only in the dorsal face; corolla brown, tube 8-13 mm long; achene 4-7 mm long, light-brown, dorsiventrally compressed, lanceolate, glabrous; pappus 9-13 mm long, yellowish.

The species is similar to *S. riedelii*, differing by the following diagnostic characters: short and dense trichomes in leaves, stem leaves reduced in quantity and size and absence of fetid odor.

Source: Marodin & Ritter (1997).

Distribution – According to Marodin & Ritter (1997), species distribution comprises Rio Grande do Sul and Santa Catarina. However, the authors emphasize that it was the less collected species in their revision. Herbaria and literature revision showed that records of the species in Rio Grande do Sul are abundant at Porto Alegre region, but otherwise scarce: two records at the NE region, one at the extreme W and one at the granitic hills of Itapuã. This last record is relatively close to our study area (ca. 8 km), but the other two are ca. 500 km away from each other and ca. 400 and 150 km away from our study area. In our surveys, the species was found at three hills (Table 2), in only four reduced populations.

Threat Category – Categorized as Vulnerable (VU) in Rio Grande do Sul threatened flora list (SEMA 2003). We suggest updating the species threat category to Endangered (EN) (see below).

Conservation status – Given the very few known records for the species, the small population sizes observed and the great isolation between record points, conservation of this species is indeed a concerning matter. Although gaps between record points may be resulting from the species natural rarity, isolation allied to disturbance may still cause local extinction events. At *Morro Pelado*, for instance, two populations were found on an area that is likely to be turned into a quarry site (Figure 11), which would cause local extinction and leave only two remaining populations at Porto Alegre region. It is due to these threats, to extensive habitat fragmentation and to reduced geographic range that we suggest updating the species threat category to Endangered (EN), according to IUCN criteria (IUCN 2001). In addition, we suggest the inclusion of the species on the Brazilian Federal List of Extinction-Threatened Flora.

Thrasyopsis jurgensii (Hack.) Soderstr. ex A.G.Burm. (Poaceae) (Figure 4-K, L)

Caespitose perennial herb, 80-140 cm tall; rhizomes short, strong; culms erect, moderately robust, simple, glabrous with sparse trichomes, becoming pilose below the inflorescence; nodes glabrous, constricted; leaf-sheaths striate, sparsely to moderate pappilose-pilose, glabrous with age; ligule extremely short, membranaceous, erose, with collar of white trichomes; leaf-blades 15-50 x 0.8-1.2 cm, spreading, the uppermost reduced, erect, flat or partially folded, linear, acuminate, sparsely to densely hirsute; racemes terminal, solitary, curved, 10-15 cm long; rachis broadly winged, up to 7 mm wide, foliaceous, dorsally puberulent along midnerve, otherwise glabrous, covering spikelets for up to 2/3 their lengths; spikelets closely paired, standing away from the rachis, 4-4.7 x 1.8-2.1 mm, obtusely elliptical-obovate; pedicels short, upper not exceeding 1 mm long, apex expanded in membranaceous disc ca. 0.8 mm diameter; first glume membanaceous, ca. 0.4 mm long, nerveless, or short, 1-nerved, or well-developed, 3-5-nerved, occasionally null, broad as much as ½ the length of the spikelet; second glume obovate-truncate, glabrous, shorter than the anthoecium, 13-15-nerved, 5 to 7 of the nerves dorsally excurrent below the apex, shaping an obtuse membranaceous apical margin internally; lower floret male, staminal filaments long but anthers often not developed; sterile lemma deeply hooded, coriaceous, oblong and truncate-apiculate when seen from outside, acute when seen from inside, dorsally concave, 7-9-nerved, keel nerves excurrent; sterile palea developed, lanceolate-elliptical, thin in the centre, stout at the 2 submarginal nerves, margins thinly membranaceous, shaping broad flaps near the apex; upper floret hermaphrodite; fertile lemma elliptical-acute, firm, striolate, pale, areole thin, depressed, open U-shaped; fertile palea elliptical-acute, punctulate between nerves, smooth towards margins, these becoming membranaceous and forming broad flaps near apex, inner surface covered with tuberculate processes, particularly upwards; lodicules of both florets broadly cuneate, apex truncate, adaxial side becoming fleshy at a diagonal angle towards the base and forming a finger-like protuberance at posterior distal margin; stamens 3, anthers violet; styles 2, stigma plumose.

Source: Burman (1983).

Distribution – There are records of *Thrasyopsis jurgensii* for Paraná, Santa Catarina and Rio Grande do Sul states. In the latter, the species is traditionally associated to the high altitudes found at the northern region, and has only two records for Porto Alegre region (Setubal 2006). In our surveys, we found only three populations of the species at the granitic hills (Table 2), two at *Morro São Pedro* (the same populations cited by Setubal 2006) and one at *Morro Tapera*. These two records comprise the southern distributional limit of the species, and are the only ones inside the Pampa Biome.

Threat Category – Categorized as Vulnerable (VU) in Rio Grande do Sul threatened flora list (SEMA 2003). The species is present in the Brazilian Federal List of Extinction-Threatened Flora (MMA 2008).

Conservation status – Populations at Porto Alegre region are isolated from each other by ca. 8 km, and from the next northern record by ca. 170 km, and both gaps are largely urbanized. The isolation of the populations we found in our surveys may lead to local extinction, since the granitic hills are undergoing many human-driven disturbances.

Waltheria douradinha A.St.-Hil. (Malvaceae) (Figure 3-G, I)

Subshrub 20-50 cm tall; stems simple or slightly ramose, 2-4 mm wide, decumbent, erect or prostrated; flowering apex with short trichomes, wide and entangled; vegetative apex hirsute, trichomes longer; stipules linear, persistent, 5-12 mm long, setulose; petiole 5-12 mm long, semi-terete, indument variable as in the stems; leaf-blade ovate, obovate or orbicular, rare oval-lanceolate, obtuse, rare subacute, base round, sometimes subcordate, serrate, 1-3.5 x 1-2.5 cm, discolour, adaxial face cinereous, trichomes short and star-shaped or long and entangled, abaxial face hirsute, trichomes simple or 2-branched; cymes composite, dense, somewhat globose, terminal or axilar, flowers yellow, in pairs, bracteoles linear or subulate, bract simple, bifid or trifid; calyx ca. 6 mm long, teeth ca. 3 x 1 mm, exterior densely pubescent, mid nerve and marginal nerves conspicuous; petals spatulate, 6-8 mm long; long-styled flowers: staminal tube ca. 5 mm long, filaments fused almost up to the apex, ovary obovoid, ca. 1 mm wide, style up to 1 cm long, stigma laciniate; short-styled flowers: stamens 5-7 mm long, filaments fused up to the half, pistil ca. 4 mm long; capsule 3 x 2.5 mm, obovoid, upper portion flat, pubescent; seed 2-3 x 1.5 mm, smooth, dark brown.

Source: Cristóbal (2005).

Distribution – According to Cristóbal (2005), the species distribution includes Southern Brazil, Paraguay, Argentina (North and Entre Ríos province) and Uruguay. Herbaria and literature revision showed that the species is widely distributed in Rio Grande do Sul State, with continuous records southwards (as far as N Uruguay) and westwards (as far as NE Argentina). In our surveys, the species was found in seven granitic hills (Table 2), always in very large populations comprised of clumped and scattered individuals. We consider this species as endemic to the Pampa Biome in a broad sense (i.e. including NE Argentina and Uruguay), with its northern/eastern limit at the granitic chain of Porto Alegre city.

Threat Category – Categorized as Vulnerable (VU) in Rio Grande do Sul threatened flora list (SEMA 2003). We suggest the removal of the species from this extinction-threatened list (see below).

Conservation status – Populations of *Waltheria douradinha* are in good conservation status within our study area, since they always comprise several individuals and cover large extensions of dry grasslands. Since its distribution is also well recorded along its known distributional area, we suggest the removal of the species from Rio Grande do Sul threatened flora list, because it does not match the criteria suggested by the IUCN for taxa inclusion in red lists.

Other species

Some grassland species present at the study area are pointed out as 'endemic' (or 'restricted'), in different geographic scales, by some authors. These species were not included in our survey due to the high frequency values they presented in structural surveys of the state's grassland vegetation and/or their well recorded distribution, configuring low threat level and demanding no inclusion in extinction threatened species lists. *Eryngium ciliatum* and *Criscia stricta* are cited as endemic to Rio Grande do Sul and northern Uruguay (Rambo 1957; Matzenbacher 2003). *Eryngium megapotamicum, Baccharis riograndensis* and *Desmodium arechavaletae* are mentioned as endemic to Rio Grande do Sul (Irgang 1974; Oliveira 1983; Marchioretto & Siqueira 1998). *Heterothalamus psiadioides* and *Baccharis ochracea* were mentioned as restricted to Rio Grande do Sul and Santa Catarina, the latter with records for Uruguay too (Barroso & Bueno 2002). *Stipa filifolia* is cited as restricted to Rio Grande do Sul (collections only at the granite-based formations), Uruguay and Argentina (Zanin *et al.* 1992), with Porto Alegre granitic chain as its northern distributional limit.

Setubal & Boldrini (2010) recorded the presence of *Regnellidium diphyllum* (Marsileaceae) at *Morro São Pedro*. The species is categorized as Vulnerable (VU) in the state's extinction-threatened flora list.

At many of our surveyed hills, we found several large populations of a bromeliad we identified as *Dyckia maritima* (Figure 3-E, F). This species has many records of occurrence at Rio Grande do Sul Seashore Plain, extending as far as the southern portions of Santa Catarina, but always associated to rock outcrops, just like the populations we have found. However, there are sensible differences between collections from the granitic hills at Porto Alegre from those belonging to the Seashore Plain, suggesting a taxonomic problem that should be tackled in order to allow future biogeographic and/or phylogeographic approaches on the group.

There are historical records of two rare grassland orchids at our study area. *Geoblasta penicillata* was collected at *Morro da Polícia* in 1944 and at *Morro Teresópolis* in 2002 (C.A. Mondin, pers. comm.), and *Codonorchis canisioi* at *Morro Sapucaia* in 1935, a sandstone hill not included in our surveys, located at ca. 25 km north from our study area. The species were not re-collected since, and neither of them was found during our surveys. We think that *G. penicillata* may still be found at *Morro da Polícia* or at the surrounding hills, since it is the species supposed original distribution, it was recollected in 2006 (R.B. Singer, pers. Comm..) and we might have overlooked it due to the short flowering period and the inconspicuous vegetative structures. We suggest the inclusion of the species in the Rio Grande do Sul threatened flora list, under the Critically Endangered (CR) category, according to IUCN criteria (IUCN 2001). The case of *C. canisioi* is different, since the only known record for the species is from a hill that had its original vegetation cover almost completely removed, and the gap between this hill and the hills at Porto Alegre region are covered by urban landscape, diminishing the likeliness of dispersal events. Therefore, we suggest the inclusion of the species in the Rio Grande do Sul threatened flora list, under the Extinct (EX) category. The species was already mentioned as ‘presumable extinct’ in a book regarding Brazilian rare plant species (Giulietti *et al.* 2009). In addition, a species of *Cyrtopodium* (Orchidaceae) was collected at *Morro Tapera*, but could not be fully identified due to the lack of reproductive structures. According to comments presented in Rambo (1956), the species is probably *Cyrtopodium polyphyllum* (Vell.) Pabst ex F. Barros. It was found in only two populations, and at no other hill, and is currently under cultivation for future identification.

Some rare species of Asteraceae, also historically recorded at Porto Alegre’s granitic hills, were not accounted for in our survey. *Calea kristiniae* Pruski was collected at *Morro*

Teresópolis, and *Gochnatia mollissima* (Malme) Cabrera at *Morro Agudo*. Both species present restricted distributional ranges, being extremely rare along their known distribution.

Granitic hills description

Morro das Abertas (Figure 7)

With ca. 240 ha and 173 m a.s.l. maximum altitude, this hill is located at ca. 900 m SW of *Morro Tapera* (Figure 1). The local landscape is shaped by two hilltops: one N oriented, where the hill's maximum altitude is, and one S oriented, lower, with maximum altitude ca. 85 m a.s.l.. The southern section of this hill was only partially explored in our surveys, since some of the area belongs to the military, and we had no access to it. The northern section of the hill is chiefly dominated by grassland formations, with large continuous areas of rocky grasslands at the hilltop. Forest formations cover a small patch in the NW slope, and larger areas in S and E slopes. The NE section of the hill, at the lower slopes, is dominated by human settlements.

At *Morro das Abertas* we found the largest populations of *Moritzia ciliata*, which covered vast areas of the SW high slopes of the northern section, near the hilltop. The populations marked in Figure 7 comprised at least 50 individuals each, a distributional pattern not seen in any other sampled hill, also going against the few published ecological observations concerning the species (Smith 1970). Several small populations (less than five individuals) of *Frailea gracillima* were also found, which is remarkable due to the assumed rarity of this species, and its absence in most of the surveyed hills. *Parodia ottonis* was found in large populations, and those last two species were the only ones found at the hill's lower slopes. *Mandevilla coccinea*, *Mikania pinnatiloba* and *Butia capitata* var. *odorata* were represented by only one individual at the hill. The latter, only found in two other hills (Table 2), is at the brink of local extinction, given the undergoing urban expansion, the species' slow growth rate and the reduced population size. One small population of *Dyckia leptostachya* was found in a large rock outcrop, near the forest borderline.

Although surrounded by streets and constructions, grassland formations present at *Morro das Abertas* are in relatively good conservation status, probably due to the steepness of its slopes (Table 1) and to the presence of a military garrison in the area, probably discouraging illegal settlements. The conservational importance of the hill is emphasized by the presence of certain floristic singularities, such as: the extremely large populations of *Moritzia ciliata*, the high number of populations of *Frailea gracillima*, the presence of *Butia capitata* var. *odorata* and the lack of species that were accounted for in most of the other surveyed hills, such as *Schlechtendalia luzulifolia*, *Waltheria douradinha* and *Eugenia dimorpha*. Given the relative proximity between this hill and *Morro Tapera* (Figure 1), future conservation measures should encompass both formations. The military garrison stationed at *Morro das Abertas* should facilitate the implementation of future Conservation Units in the area.

Morro Agudo (Figures 6-A; 8)

The hill is located immediately north of *Morro Tapera* (Figure 1) and covers ca. 140 ha, with 210 m a.s.l. maximum altitude (Table 1). The lower portions of this hill are widely altered, either by cultivated tree species or by human settlements. Higher areas are relatively intact, and large well-preserved rocky grasslands can be found at the hilltop and at southern and southwestern slopes.

Schlechtendalia luzulifolia, *Waltheria douradinha* and *Moritzia ciliata* were found in large and dense populations. *Parodia ottonis* was found in four clumped populations, one of which presented ca. 30 individuals in a single rock outcrop. Very few individuals of *Dyckia leptostachya*, *Mandevilla coccinea*, *Gochnatia cordata* and *Eugenia dimorpha* were found, and only in one population for each species. Two populations of *Mikania pinnatiloba* were found, one with only one individual and other with five individuals. All populations were found in the upper portions of the hill, as seen in Figure 8.

The importance of *Morro Agudo* for the conservation of the natural vegetation of Porto Alegre city is emphasized by two main factors: (1) proximity to *Morro Tapera*, one of the better preserved and threatened-species rich among studied hills and (2) the presence of *Mikania pinnatiloba*, species found in only one other hill. Besides that, the topology of the hill, with steep slopes ascending towards two small hilltop areas, is completely inappropriate for human constructions.

Morro da Companhia (Figure 9)

Covering 301 ha and with 224 m a.s.l. maximum altitude, the hill is located W from *Morro Santana* and E from *Morro Pelado* (Figure 1). Topology at the hill is shaped by two hilltops, one E and other W oriented (Figure 9), and the latter, lower than the first, is dominated by forest formations and human settlements. Grassland formations dominate the eastern hilltop and the N, NE and E oriented slopes. At the hilltop, there is a lake (ca. 1 ha), surrounded by forest formations. A large native forest patch, reaching ca. 1.5 km southwards, dominates the southern slopes. Near the eastern hilltop, northern lower slopes have a few constructions. Plant populations found in this hill were concentrated at northern and northeastern slopes, with one species occurring at the hilltop.

Large populations of *Waltheria douradinha* (at least 20 individuals each) and *Parodia ottonis* (at least 8 individuals each) were found along the northeastern slope. The largest population of *P. ottonis* was found in this hill: ca. 40 individuals clumped in a flat rock outcrop. *Mandevilla coccinea* and *Eugenia dimorpha* were represented by two individuals each. The population of *Frailea gracillima* comprised only three individuals. At the hilltop, two populations of *Mimosa rocae* were found, those being the only modern records of this species at Porto Alegre region besides the populations we found at the extremely threatened *Morro Pelado*.

Although natural grasslands cover a large portion of this hill (Table 1), and they seem to be in a good conservation status, their future conservation demands attention, since they dominate mainly the hilltop and the northern slopes, the latter being under urbanization pressure. Many constructions built at the northern hillside are illegal and, since declivity at this section is not steep, new constructions at higher slopes will eventually occur, if no governmental control measures are taken. Among the hills that comprise Porto Alegre's central granitic formations (TE, GL, PO, PE and CO in Figure 1), *Morro da Companhia* seems to be the one that retains most of its original vegetation cover, in both grassland and forest formations. Therefore, among these hills, it would be the one indicated for implementation of a Conservation Unit, which should include areas of the nearby *Morro Santana*.

Morro do Osso (Figures 6-L; 10)

With an area of ca. 170 ha and 143 m a.s.l. maximum altitude, *Morro do Osso* is the westernmost hill of the granitic chain (Figure 1). Within the hill's total area there is a Conservation Unit since 1994, covering 127 ha of natural grassland and forest formations

(Brack *et al.* 1998). According to Ferreira et al. (2010), grassland formations cover ca. 40% of the area, and fire (either natural or human-driven) is a common disturbance (Figure 5-L). Grassland-covered areas are found at two hilltops (NW and SE oriented, ca. 130 and 115 m a.s.l., respectively; Figure 9), and at a lower area (NE oriented, ca. 90 m a.s.l.). In table 1, data for *Morro do Osso* were omitted, since the survey carried out by Güntzel *et al.* (1994) treated *Morro do Osso* and another nearby hill (that no longer presents natural vegetation cover) as a unit.

At both hilltops there are several populations of *Schlechtendalia luzulifolia* and *Moritzia ciliata*, as well as a large population of *Parodia ottonis* in each hilltop (Figure 9). The populations of *Waltheria douradinha* pointed out in Figure 9, located at lower areas, present an extremely large number of individuals, covering a vast although discontinuous area. The populations of *Dyckia leptostachya* and *D. choristaminea*, also located at the hilltops, presented very few and scattered individuals, a pattern shared with *Gochnatia orbiculata* and *G. cordata*. We found only one individual of *Gomphrena graminea*, *Eugenia dimorpha* and *Stenachaenium macrocephalum* at the hill.

Even though the grassland areas present at *Morro do Osso* are almost completely inserted in a Conservation Unit, the conservation status of several threatened species in the area are concerning, since population size of these species is alarmingly low. The lack of these species in the lower NE oriented grassland area is possibly related to recent fire events (Ferreira *et al*. 2010). It is important to mention that, at the extreme west section of the hill, an indigenous Kaingang community is settled, since their members use some local plants (mostly woody species) in handicrafts.

Morro Pelado (Figures 6-D, E; 11)

Located between *Morro da Polícia* and *Morro da Companhia* (Figure 1), this hill covers 408 ha, with 298 m a.s.l. maximum altitude. *Morro Pelado* is one of the most threatened hills surveyed, since its northern section is inserted in an extremely urbanized area, while in its E and SE sections there are two large quarrying sites (Figure 11). Although the urban area of the hill is not considered large (Table 1), the anthropogenic disturbance is present, since there are many trails and even some makeshift roads at the area. Probably due to these factors, populations of threatened species were found only at the usually less disturbed hilltop areas.

Morro Pelado cradles the largest population of *Eugenia dimorpha* among the surveyed hills. Some of these populations had more than five individuals, a pattern not found in any other hill for the species. Two small populations of *Stenachaenium macrocephallum*, an extremely rare Asteraceae found in only two other hills, were also found. In this area we obtained the first record of *Mimosa rocae* for the study area, in a population with three individuals growing in different rock outcrops. The species was only found at *Morro da Companhia* afterwards (Figure 9). *Gomphrena graminea* was represented by only one individual, and *Parodia ottonis* by ca. 5 individuals in a single rock outcrop. The population of *Schlechtendalia luzulifolia* was larger, with ca. 15 individuals, but with a clumped distribution, susceptible to local extinction.

Conservation status of this hill is probably the most concerning among our study area. Besides the already established quarry sites, the implementation of another quarry, which will include the threatened species distribution we here presented, is being analyzed by local environment authorities. If this new quarry is authorized, the populations we mapped should be transplanted to another site, or they will face local extinction. If that happens, only two more populations of *Mimosa rocae* will remain in Porto Alegre region. Moreover, the largest populations of *Eugenia dimorpha* present in the region will be severely diminished or even locally extinct. This threat is enhanced by the settlements located at the hill's northern section, since they are mostly illegal and thus tend to advance up the northern slopes. The remaining area covered by native vegetation, both grasslands and forests, should be protected from the mentioned threats by local environmental authorities, either with the creation of a Conservation Unit or by stopping quarry activities and reallocating and preventing illegal human settlements.

Morro da Polícia ((Figures 6-J, K; 12)

Also locally known as *Morro da Embratel*, the hill covers 434 ha, with 286 m a.s.l. maximum altitude. Inserted in an extremely urbanized area (Figure 1), this hill only retains original vegetation cover due its topology: predominance of very steep slopes (Table 1), rising towards a long and narrow hilltop (Figure 12), where a group of tall broadcasting antennas is placed. The area near the lower slopes is completely altered by streets and constructions (some of them illegal), and forest formations are restricted to fragments at W and E oriented slopes. Dry grassland formations dominate the thin hilltop, and some rocky grasslands can be found at E oriented slopes. Rare and threatened species were found only at a SW oriented high slope and at the northern section of the hilltop (Figure 12).

At the SW oriented high slope several populations of *Parodia ottonis* were found, ranging from 5-10 individuals each and always among rock outcrops. Small populations of *Dyckia leptostachya* (3 individuals) and *Moritizia ciliata* (ca. 10 individuals) were found near the forest borderline. The population of *Waltheria douradinha* found nearby was comprised by ca. 25 scattered individuals. *Schlechtendalia luzulifolia* covered a large area at a S oriented slope, with ca. 20 individuals. At the hilltop, small populations (less than 8 individuals) of *S. luzulifolia* and *W. douradinha* were also found, as well as one individual of *Gomphrena* *graminea* and two of *Mandevilla coccinea*. The two populations of *Dyckia chorystaminea* comprised ca. 5 individuals. There is a historical collection record of *Codonorchis canisioi* at this hill, collected in 1935 and never re-collected afterwards. We did not find the species during our surveys.

The remaining original vegetation cover at *Morro da Polícia* is under great anthropogenic pressure and, differently from other granitic hills, even the hilltops are greatly altered. The broadcasting system installed at the northern hilltop demands periodic maintenance, which leads to constant vehicle traffic and the subsequent maintenance of opened roads. People transit is also common, given the large number of settlements in the vicinity. A possible alternative, in order to hamper the alteration of natural vegetation cover at the area, is to control urban expansion at the northern slopes, preventing further construction and reallocating illegal residents. Since the area is being explored by broadcasting companies, a joint effort, joining these private sector and local authorities, could be made in order to turn the area into a mixed (private/governmental) conservation unit.

Morro Santana (Figure 6-F, G; 13)

With an area of 1031 ha and 311 m a.s.l. maximum altitude, this is the northernmost hill we surveyed. Besides the low percentage of urban area shown in Table 1, urban expansion is presently the most intense disturbance at this hill, with constant new constructions up the northern and eastern slopes, where concentration of roads, and consequently human dwellings, is higher (Figure 1). Grassland formations cover hilltops and part of northern and western slopes, although northern grassland patches are mostly altered by human activities, with lower slopes completely altered by constructions.

Most populations of threatened species were found at the western hilltop and high slopes and at the northeastern hilltop (Figure 13). Two isolated populations of *Schlechtendalia luzulifolia* were found in a southern hilltop (ca. 10 individuals) and in an eastern slope, both in extremely altered grassland patches. At the eastern section, comprised by a mosaic of natural grassland vegetation, shrubs and small forest remnants, we found large populations of *Waltheria douradinha* (more than 25 individuals), *Moritzia ciliata* (ca. 10 individuals) and *S. luzulifolia* (more than 20 individuals). *Mandevilla coccinea* and *Eugenia dimorpha* were represented by two and three individuals, respectively. At the western section, patches of rocky grassland are scattered along the slope, where several populations of *Parodia ottonis* (2-10 individuals each) were found. Populations of *M. ciliata* are smaller here than in the eastern section (2-5 individuals each), and *Butia capitata* var. *odorata* was represented by one individual at each point plotted on figure 13. Populations of *Eugenia dimorpha* ranged from two to five individuals, and were found in dry grassland patches.

The presence of several individuals of *Butia capitata* var. *odorata* at *Morro Santana* implies a relatively good conservation status for local grassland formations, since the species was found only at two other granitic hills (Table 2), both inserted in the southern section of Porto Alegre, where urbanization processes are less intense (Figure 1). The major threat at this hill is urban expansion at its northern and northwestern sections, since the hill is surrounded by human dwellings, most of them comprising slums, so that new constructions are not legally regulated and tend to expand towards the upper slopes. Moreover, this problem is enhanced by the light declivity of slopes, which facilitates new constructions.

Morro São Pedro (Figure 6-H, I; 14)

Covering 1.259 ha and with 289 m a.s.l. maximum altitude (Table 1), this is the southernmost and largest granitic hill our survey encompassed (Figure 1). Also, it is the hill in which most threatened species were found (Table 2). Albeit the low urban occupation at the site (Table 1), Setubal & Boldrini (2010) point out that the hill has been a historical target of human disturbances such as logging, quarry and cattle breeding. Grassland formations at the hill are distributed in patches at hilltops, interweaved with forest patches, and at N oriented slopes. Threatened species were found at hilltops and high slopes in four separate clusters, one at the northern section and one at the southern one (Figure 14).

At the northern section (Figure 14-A), five individuals of *Butia capitata* var. *odorata* were found: three at the northernmost hilltop and two in a population on a rocky grassland, surrounded by rock outcrops. In this same formation, several large (at least 10 individuals each) populations of *Parodia ottonis* and a large population of *Waltheria douradinha* (more than 50 individuals) were found, as well as two individuals of *Dyckia choristaminea*. Two populations of *Schlechtendalia luzulifolia* were found, one at the central hilltop (ca. 10 individuals) and one at the high southern slope (more than 30 individuals).

The southern section (Figure 14-B) presented a higher diversity of threatened taxa. The three aggregation of species found in this section correspond to the largest grassland patches, which are isolated from each other by forest formations. At the NE oriented patch, inserted in a S oriented high slope, there were populations of *Schlechtendalia luzulifolia* (ca. 15 individuals each), *Parodia ottonis* (ca. 5 individuals each) and *Waltheria douradinha* (more than 30 individuals). At the same site, *Mikania pinnatiloba* was represented by one individual. Closer to the hilltop, we found two individuals of *Gomphrena graminea* and four of *Gochnatia orbiculata*. The NW oriented patch also comprised a southern slope, although species were found at lower altitudes. Populations of *P. ottonis* (5-10 individuals each) were found all along the hillside, always associated to rock outcrops. Two populations of *G.*

orbiculata were found, one near the hilltop (ca. 5 individuals) and other at lower slopes (one individual). Populations of *Butia capitata* var. *odorata, Eugenia dimorpha*, *Dyckia leptostachya* and *D. choristaminea* comprised only one individual each. The southern grassland patch configures a hilltop and a NW oriented slope. At this site, the only known populations of *Alstroemeria albescens* were found (this is also the collection site of the type specimen; Assis 2009). Also, the first record of *Thrasyopsis jurgensii* for the Pampa Biome was found in this area (Setubal & Boldrini 2010). Populations of *P. ottonis* (northern slopes; 5-10 individuals each) and *S. luzulifolia* (hilltop and eastern slope; more than 20 individuals each) were also found. Populations of *B. capitata* var. *odorata* and *D. leptostachya* comprised only one individual.

Morro São Pedro is the largest hill we surveyed, and probably the one in better conservation status, chiefly due to its distance from the urban center located at the north (Figure 1) and to its large area, mostly comprising natural vegetation in different successional stages (Setubal & Boldrini 2010). The high number of rare threatened species found in the area (14 out of 19 species in al hills; Table 2) emphasizes the importance of this hill for the conservation of the natural landscape at the region. A floristic survey of the grassland vegetation at *Morro São* Pedro can be found in Setubal & Boldrini (2010). These authors have considered the conservation status of these formations as 'relatively good', mainly due to high species richness values and presence of rare and threatened species. Being the largest continuous fragment of original vegetation within the state's capital, it is imperative that local authorities take immediate action in order to preserve this formation. A Conservation Unit at the site, if implemented in the short term, would encompass a significant portion of the local original vegetation cover, in both forest and grassland formations, besides most of the threatened species found in local grassland formations. A private conservation initiative

(Econsciência Espaço de Conservação) is already implemented in this hill, which could help in the implementation of future public conservation efforts.

Morro Tapera (Figures 6-B, C; 15)

Covering 462 ha, with 252 m a.s.l. maximum altitude (Table 1), this hill consists in one of the largest and better-conserved natural grassland remnants is the area. The topology of this hill is unmatched by other surrounding hills: it consists on a linear series of N-S oriented narrow hilltops, with steep E and W oriented slopes, shaping a wedge-like elevation (Figure 14). Grassland formations dominate the hilltops, but are also well distributed in the slopes. Rocky grasslands, with a great amount of rock outcrops (Figure 5-B, C), are the dominant grassland physiognomy, although dry and humid grasslands are also present in the area. Forest formations cover large areas of the slopes, usually following streams. The lower portions of the hill are dominated by constructions, and the slopes remain untouched due to their steepness.

The northernmost slope of the hill (Figures 6-B;15-A) presents a large number of endangered species populations, which goes against the hilltop predominance found in other hills and in other areas of this same hill. *Waltheria douradinha* and *Moritzia ciliata* were found in large populations, with scattered individuals all along the lower slope. Three small populations of *Parodia ottonis*, *Gomphrena graminea* and *Mandevilla coccinea*, and one of *Dyckia choristaminea* were also found, all of which with only 1-3 individuals. Populations of *Schlechtendalia luzulifolia* in this slope presented few individuals (usually less than 10). Four individuals of *Frailea gracillima* were found in a rock outcrop at higher slopes, and two larger populations were found in a hilltop at the middle of the hill.

Species found at the southern section of the hill (Figure 15-B) were distributed mostly at the southernmost hilltop, differing from the pattern found at the northern section. Only a small population of *Moritzia ciliata* was found at a lower E oriented slope. Large populations of the same species, each with at least 15 individuals, were found at the southern hilltop and at the E oriented high slopes nearby. Only one small population of *Schlechtendalia luzulifolia* was found in this area. Also, only one individual of *Dyckia choristaminea* was recorded. The Cactaceae *Parodia ottonis* and *Frailea gracillima* were found in relatively large populations (more than 5 individuals), always linked to the presence of rock outcrops. Two small populations (one and three individuals) of *Gochnatia cordata* were found at the hilltop. The population of *Thrasyopsis jurgensii*, located close to the forest borderline and between rock outcrops and large boulders, covered ca. 16 m^2.

The floristic disparities between *Morro Tapera* and *Morro Agudo* are intriguing, do to the proximity between both hills. The absence of many species at *Morro Agudo* could be explained by the high levels of human impact at the hill, which may have caused local extinctions. However, we found no theories explaining the absence of *Mikania pinnatiloba* and *Dyckia leptostachya* at *Morro Tapera*, both present at *Morro Agudo*.

The presence of many rare and extinction-threatened species at the lower slopes of *Morro Tapera*, allied to the presence of extremely rare species such as *Frailea gracillima* and *Thrasyopsis jurgensii*, emphasizes the conservational importance of this hill. The northernmost slopes, albeit close to a secondary road and some minor constructions, cradles an extremely well preserved grassland ecosystem, in a mosaic of rocky and dry grasslands. Since the hill presents no appropriate landscape for human constructions, due to its steep slopes, the implementation of a future Conservation Unit in the area, also encompassing *Morro Agudo*, should be taken into account by local authorities.

Other granitic hills

Some granitic hills present near our sampling area were not included in our sampling effort (see Material and Methods), and among these hills, three were pointed out in Figure 1: *Morro Santa Tereza*, *Morro Teresópolis* and *Morro da Glória*. The last two encompass an area with other minor hills, which actually configure different hilltops but that have local names we do not mention. The area within these three hills is almost completely altered by urbanization. At *Morro Teresópolis*, there are some grassland and forest patches at the hilltops, but surveys there were not carried out for security reasons.

Outside Porto Alegre city limits, ca. 25 km south of *Morro São Pedro*, there is a group of granitic hills within a state Conservation Unit (Parque Estadual de Itapuã), which we did not include in our surveys. At these hills, there are records of eight threatened grassland species (Table 2), as is the southernmost known record of *Sellocharis paradoxa*, an extremely rare species, seemingly endemic to this granitic formation. We included this species in this work due to the probability of its occurrence at Porto Alegre granitic hills.

Discussion

The grassland formations present at the granitic hills of Porto Alegre city comprehend islands (or patches) of remnant natural vegetation cover, as was postulated by Rambo (1954), amidst an urban landscape. Differences between floristic lists among the hills (Ferreira *et al.* 2010) corroborate this hypothesis, as well as the non-uniform rare and endemic taxa distribution we presented in this paper. Although suffering from the increasing pressure caused by human-driven disturbances, several of these patches still thrive as relatively undisturbed grassland landscapes, maintaining their floristic and structural patterns. This conservation status can be acknowledged by the floristic list Setubal & Boldrini (2010) present for *Morro São Pedro*, encompassing 497 native grassland species. Considering that the state's grassland flora comprises ca. 2.200 species (Boldrini 2009), the grassland flora at *Morro São Pedro* is outstandingly rich, cradling within 1.259 ha ca. 23% of all species known for the grassland formations of Rio Grande do Sul. High species richness values were found at other granitic hills too (Boldrini *et al.* 1998; Overbeck *et al.* 2006; Ferreira *et al.* 2010), but none as high as the one found at *Morro São Pedro*. This difference is probably explained by three factors: (1) sampling effort, since the floristic survey carried out at *Morro São Pedro* lasted 48 months (Setubal & Boldrini 2010); (2) distance from the highly urbanized core at the north (Figure 1) and (3) the large area covered by the hill (Table 1), providing relative protection form edge effects and a higher degree of habitat heterogeneity. This last factor is extremely important at the study area, due to the high fragmentation of habitats and the consequent effects on diversity and structure (Ochoa-Gaona *et al.* 2004) and the potential influence over the survival of certain species (Wilcoxand & Murphy 1985; McGarigal & Marks 1994). Traditionally linked to forest formations, this threat also affects grassland formations (Parker & Mac Nally 2002; Curtin *et al*. 2002; Stoll *et al.* 2006; Jardim & Batalha 2009), may affect the local fauna (e.g. Öckinger *et al.* 2009) and should be taken into account when conservation initiatives take place. There is growing evidence that legal protection should target the largest areas available, in order to prevent further fragmentation (Tabarelli & Gascon 2005). Therefore, as the largest continuous natural vegetation remnant (comprising both grassland and forest formations) at Porto Alegre city, *Morro São Pedro* should be placed into a Conservation Unit as fast as possible, in order to prevent further disturbance and fragmentation.

The distribution of rare and endemic species we presented also corroborates the concept of a good conservation status for these formations. Even at extremely altered hills, such as *Morro da Polícia*, populations of rare, endemic and extinction-threatened taxa were found, suggesting a good conservation status, at least near the hilltops, were most populations included in our survey were found. Considering that the presence of endemic and rare taxa can be positively related to species richness (Lamoreux *et al.* 2006; Rodriguez-Cabal *et al*. 2008), and that rare, endemic and extinction-threatened species are key factors for conservation strategies (Lira *et al*. 2002; Hobohm 2003), the distribution of these taxa at Porto Alegre granitic hills configures a great asset for the implementation of future Conservation Units. Since they are useful indicators for diversity and conservation status, the distribution of these species could guide the zoning of future management plans.

Among our sampled species, several have showed distributional patterns restricted to Rio Grande do Sul or with records further south and westwards, but with the granitic chain of Porto Alegre city as their northern limit. Moreover, some species with a broader distribution in Brazil had this formation as their southern distributional limit. These patterns corroborate and strengthen the idea of Porto Alegre region (near the 30^{o}S parallel) as a floristic transitional point (Cabrera & Willink 1980; Waechter 2002), influenced by floristic groups from diverse origins (Rambo 1954) and consequently rich in species diversity and endemic taxa (Aguiar *et al.* 1986; Boldrini *et al.* 1998; Brack *et al*. 1998).

Many of our sampled species (and some that were not sampled but were previously commented) were considered ‘endemics’ at some geographic level in previous papers. As a rule, these species show records of occurrence for Rio Grande do Sul (at least its southern half), Uruguay (usually northern half and seashore plain) and Argentina (usually northeastern portions, at Entre-Ríos province and its surroundings). This pattern, repeated in many grassland taxa we do not comment in here, implies a floristic continuum throughout grassland formations found at southern South America, encompassing the Pampa Biome, which covers the southern half of Rio Grande do Sul, and the similar formations present at both neighboring countries (Bilenca & Minarro 2004). Since the extant grassland formations present at Southern Brazil are interpreted as relict formations, once dominant during the dryer Pleistocene (Behling 2002; Bredenkamp *et al.* 2002), its is likely that these formations covered larger areas both south and westwards, suffering the same pressures throughout geological time and thus evolving as a unit. The granitic chain present at Porto Alegre region is the northeastern limit of this floristic unit, and the beginning of a transitional gradient from subtropical to tropical grasslands.

According to the Brazilian Federal Law no. 4771, 15/09/1965, hilltops, slopes with declivity steeper than 45^o (> 25%) and water springs configure areas of permanent preservation. As it is, these areas are theoretically immune to human disturbances. Given the declivity values presented in Table 1 (and not taking hilltops into account), it would be reasonable to conclude that a large portion of most granitic hills should be untouched and, therefore, retain its original vegetal cover. As we mentioned before, this is not the local reality, as can be inferred from the roads plotted all around (and sometimes inside) each hill in Figure 1. According to Hasenack (2008), only 24.1% of the original vegetation cover at Porto Alegre city remains unaltered, 10.2% comprising grassland remnants. The author emphasizes that the remaining vegetal cover is cradled at the local granitic hills, and that these formations are threatened by urban expansion, especially at lower slopes near popular settlements. Most constructions placed at slopes are irregular according to the aforementioned law, and this problem tends to increase due to ongoing urban expansion, that finds little room is the already crowded plain relief and is likely to go up the hills if the local government takes no action. As Schemske *et al.* (1994) wisely stated, “plant conservation cannot succeed unless political, economic, and biological factors are incorporated in management strategies”.

We emphasize once more the importance of all granitic hills included in our study as the last remnants of native vegetation cover within a large and continuous urbanized area.

Even though these remnants are severely fragmented and inserted in an urban matrix, they retain, as stated before, part of their original composition. Therefore, conservation initiatives aiming to preserve these formations are imperative. We suggest the implementation of three Conservation Units, according to the presence of rare, endemic and extinction-threatened species and to floristic and structural data provided in previous papers. One should encompass *Morro São Pedro*, the largest and, as far as it is known, the hill with highest species richness and most threatened species. Another should include *Morro Tapera, Morro Agudo* and *Morro das Abertas*, since they are geographically close, showing floristic complementarities, good conservation status and inaptitude to constructions due to steepness of the slopes. The last Conservation Unit should be placed at *Morro Santana*, a hill with one of the largest total area in the region, relatively small urban area and proximity to a University, which would encourage future researche and facilitate logistics and management. After the establishment and consolidation of the Units, the unexplored potential for tourism latent at the hills could be developed, since the aggregated value of their scenic beauty and biodiversity could generate, if adequately managed, jobs for the population and, ultimately, income for the city. However, caution is advised in these endeavors, and no such exploration should start before the Conservation Units are fully established and functional, guiding exploration to minimize possible disturbances.

As pointed out by Schemske *et al.* (1994), the study of rare taxa must include population dynamics evaluation, as well as distribution of genetic variation among populations. However, taxonomic issues, such as species delimitation or distribution, often restrain ecologists and geneticists. Thus, we think that the distributional data we presented, as well as the revised descriptions, would shed some light on these problems. The present patchy configuration of the grasslands present at our study area, allied to the presence of many species at different hills, presents a unique scenario for phylogeographic studies. If species with distributional range reaching Uruguay and Argentina are selected, broader patterns concerning subtropical grasslands as a unit could be unraveled.

The Pampa Biome should be acknowledged in a broad sense, also encompassing grassland formations present at Uruguay and Argentina. By doing so, researchers will be evaluating aspects of a floristic unit, rather than isolated patches, and this is the only way to unravel the true species richness, levels of endemism and ecological dynamics of subtropical grasslands.

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Table 1 – Granitic hills present within Porto Alegre city. * Data from Güntzel *et al.* (1994); + Not included in the survey.

Granitic hill	Area (ha)	Altitude (m)	Area with declivity > 30% (%)*	Native grassland area (%)*	Urban area (%)*
Morro São Pedro	1259	289	20	35	2
Morro Santana	1031	311	20	30	5
Morro Tapera	462	252	30	30	20
Morro da Polícia	434	286	70	36	30
Morro Pelado	408	298	30	38	10
Morro da Companhia	301	224	30	35	20
Morro Teresópolis+	259	139	15	10	85
Morro das Abertas	240	173	50	35	15
Morro da Glória+	200	268	30	35	40
Morro do Osso	170	143	-	-	-
Morro Agudo	140	210	15	30	0
Morro Santa Tereza+	89	148	5	5	70

Table 2 – Rare and threatened grassland species present in granitic hills at Porto Alegre city, ordered by family, with current threat category. DD = data deficient; EN = Endangered; VU = vulnerable; SP = Morro São Pedro; SN = Morro Santana; PO = Morro da Policia; OS = Morro do Osso; TA = Morro Tapera; AG = Morro Agudo; PE = Morro Pelado; AB = Morro das Abertas; CO = Morro da Companhia; IT = Itapuã granitic hills; TE = Morro Teresópolis; * Not included in the survey, data from herbaria and literature revision.

			Granitic hills										
Species	Family	Threat	SP	SN	PO	OS	TA	AG	PE	AB	CO	IT*	TE*
Alstroemeria albescens M.C. Assis	ALST	DD	x										
Gomphrena graminea Moq.	AMAR	VU	x		x	x	x		x				
Mandevilla coccinea (Hook. & Arn.) Woodson	APOC	VU	x	x	x	x	x	x		x	x	x	x
Butia capitata var. *odorata* (Barb. Rodr.) Becc.	AREC	EN	x	x						x			x
Gochnatia cordata Less.	ASTE	VU				x	x	x				x	
Gochnatia orbiculata (Malme) Cabrera	ASTE	EN	x			x							
Mikania pinnatiloba DC.	ASTE	VU	x					x		x		x	
Schlechtendalia luzulifolia Less.	ASTE	EN	x	x	x	x	x	x	x			x	x
Stenachaenium macrocephalum Benth.	ASTE	VU	x			x			x			x	x
Moritzia ciliata (Cham.) DC. ex Meisn.	BORA	VU		x	x	x	x	x		x			x
Dyckia choristaminea Mez	BROM	EN	x		x	x	x					x	
Dyckia leptostachya Baker	BROM	-	x		x	x		x		x			
Frailea gracillima (Lem.) Britton & Rose	CACT	EN					x			x	x		
Parodia ottonis (Lehm.) N.P.Taylor	CACT	VU	x	x	x	x	x	x	x	x	x		
Mimosa rocae Lor. & Niederl.	FABA	-							x		x		
Waltheria douradinha A.St.-Hil.	MALV	VU	x	x	x	x	x	x			x	x	x
Eugenia dimorpha O. Berg	MYRT	VU	x	x		x	x	x	x		x	x	
Bipinnula canisii Dutra	ORCH	-					x						
Thrasyopsis jurgensii (Hack.) Soderstr. & A.G. Burm.	POAC	-	x				x						
Total species per hill			14	7	8	12	12	9	6	7	6	8	6

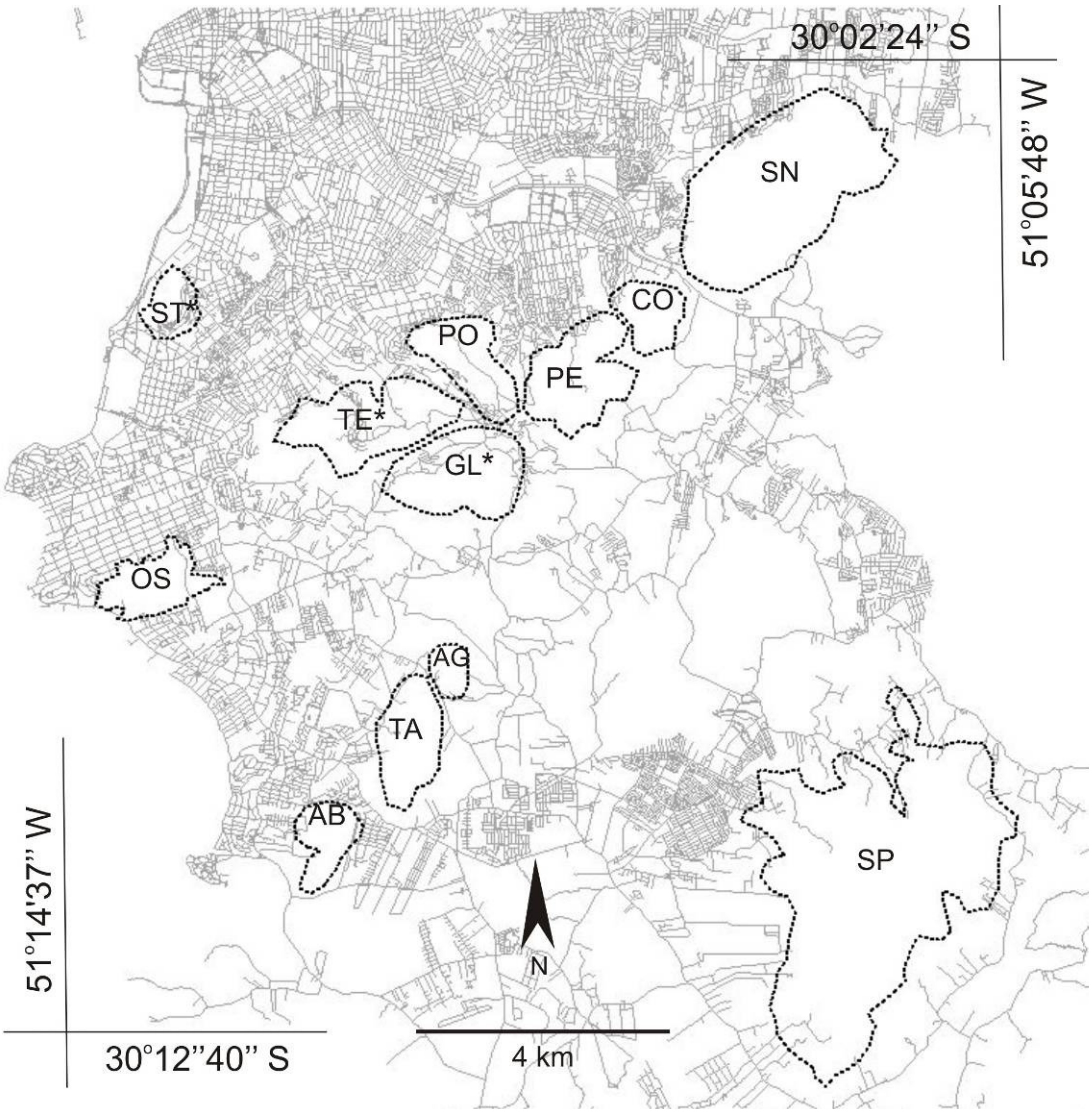

Figure 1 – Porto Alegre city limits, with roads (gray lines) and granitic hills (dotted lines). SP = Morro São Pedro; SN = Morro Santana; PO = Morro da Policia; OS = Morro do Osso; TA = Morro Tapera; AG = Morro Agudo; PE = Morro Pelado; AB = Morro das Abertas; CO = Morro da Companhia; ST = Morro Santa Tereza; TE = Morro Teresópolis; GL = Morro da Glória; * Not surveyed.

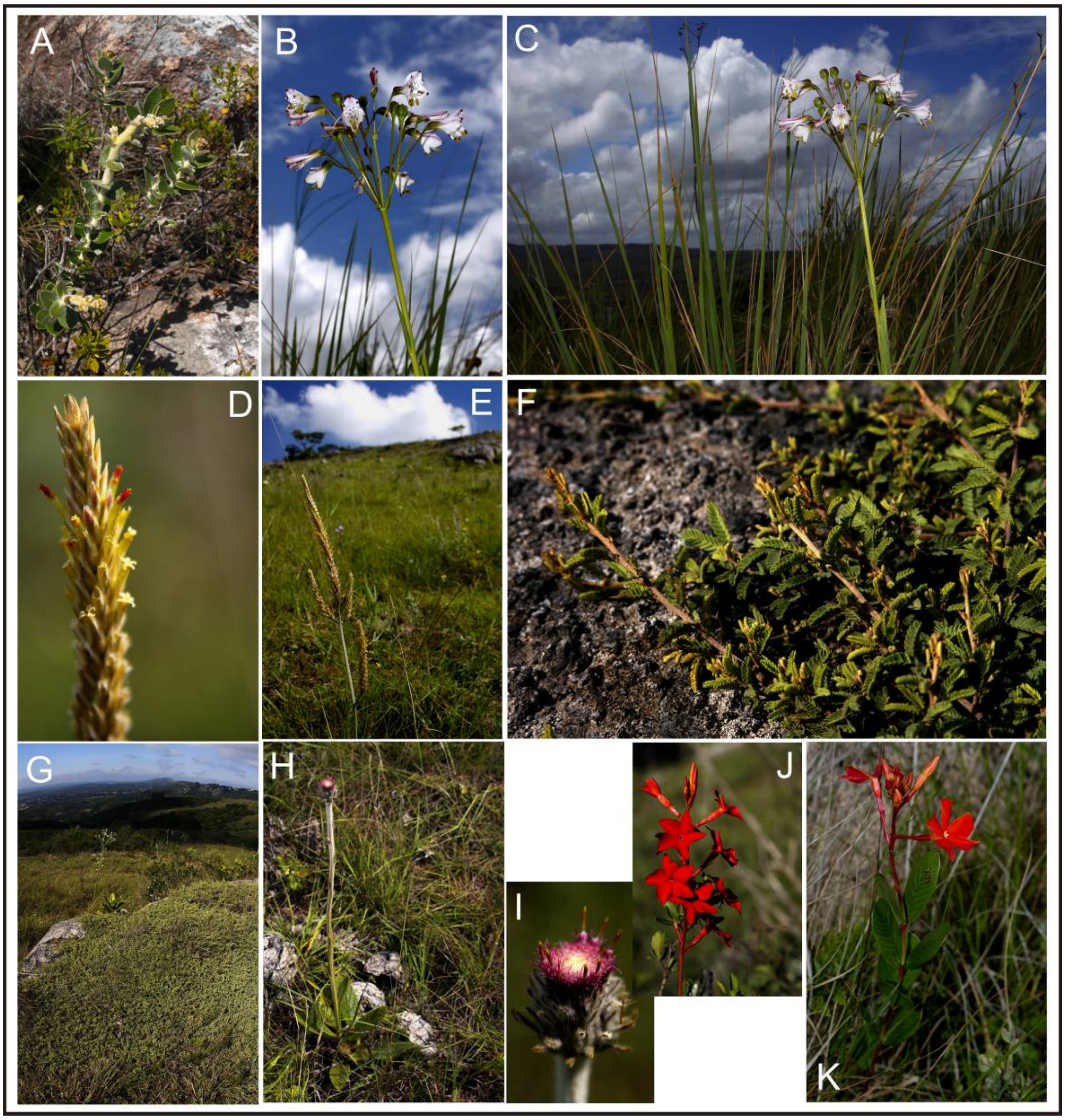

Figure 2 – A. *Gochnatia cordata*; B, C. *Alstroemeria albescens*; D, E. *Gomphrena graminea*; F, G. *Mimosa rocae*; H, I. *Stenachaenium macrocephallum*; J, K. *Mandevilla coccinea*. Photos: A. Becker

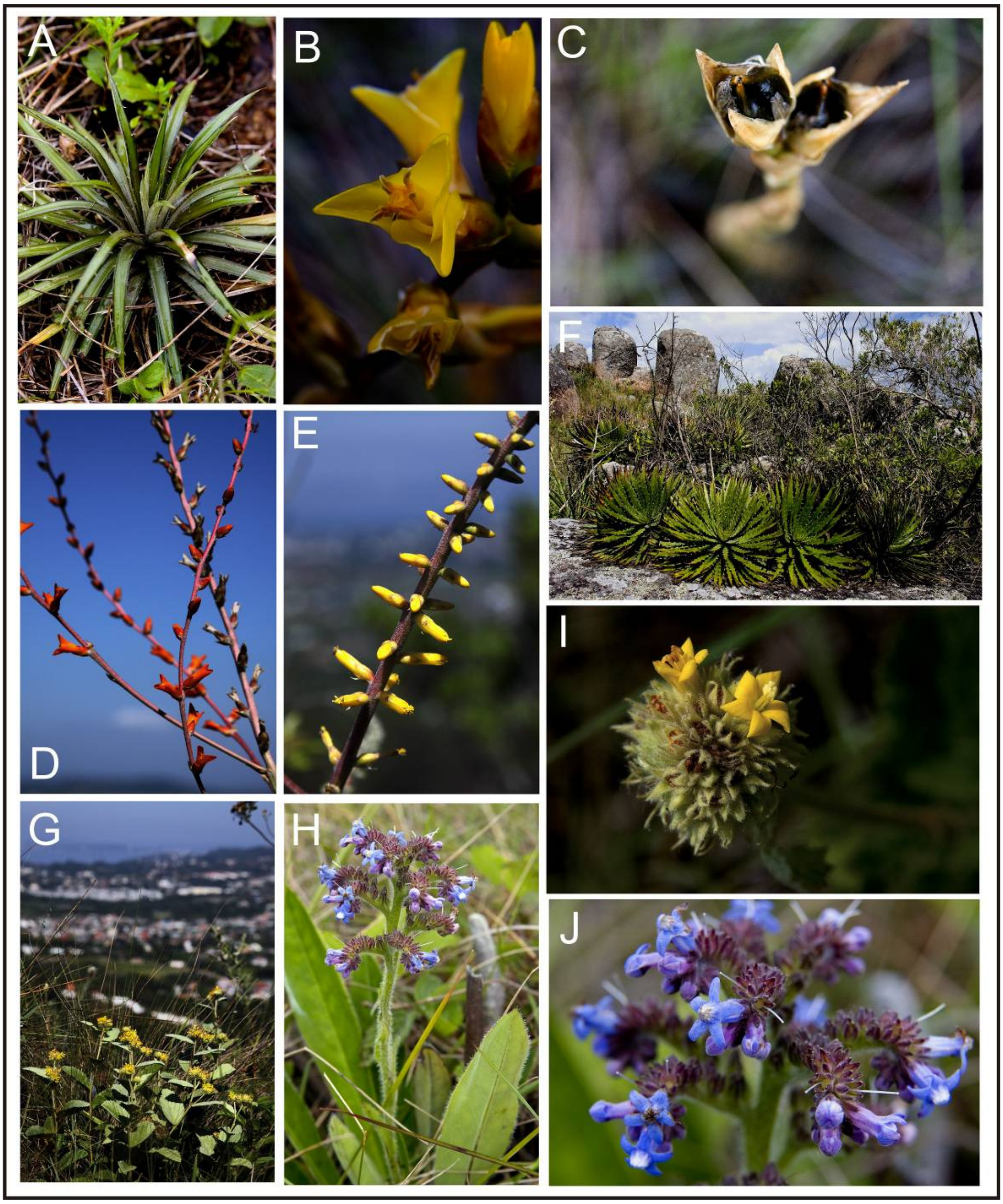

Figure 3 – A-C. *Dyckia choristaminea*; D. *Dyckia leptostachya*; E, F. *Dyckia maritima*; G, I. *Waltheria douradinha*; H, J. *Moritzia ciliata*. Photos: A. Becker

Figure 4 – A-D. *Parodia ottonis*; E, F. *Frailea gracillima*; G, H. *Gochnatia orbiculata*; I. *Butia capitata* var. *odorata*; J. *Eugenia dimorpha*; K, L. *Thrasyopsis jurgensii*. Photos: A. Becker

Figure 5 – A-C. *Bipinnula canisii*; D-F. *Schlechtendalia luzulifolia*; G. *Sellocharis paradoxa*; H-I. *Mikania pinnatiloba*. Photos: A. Becker

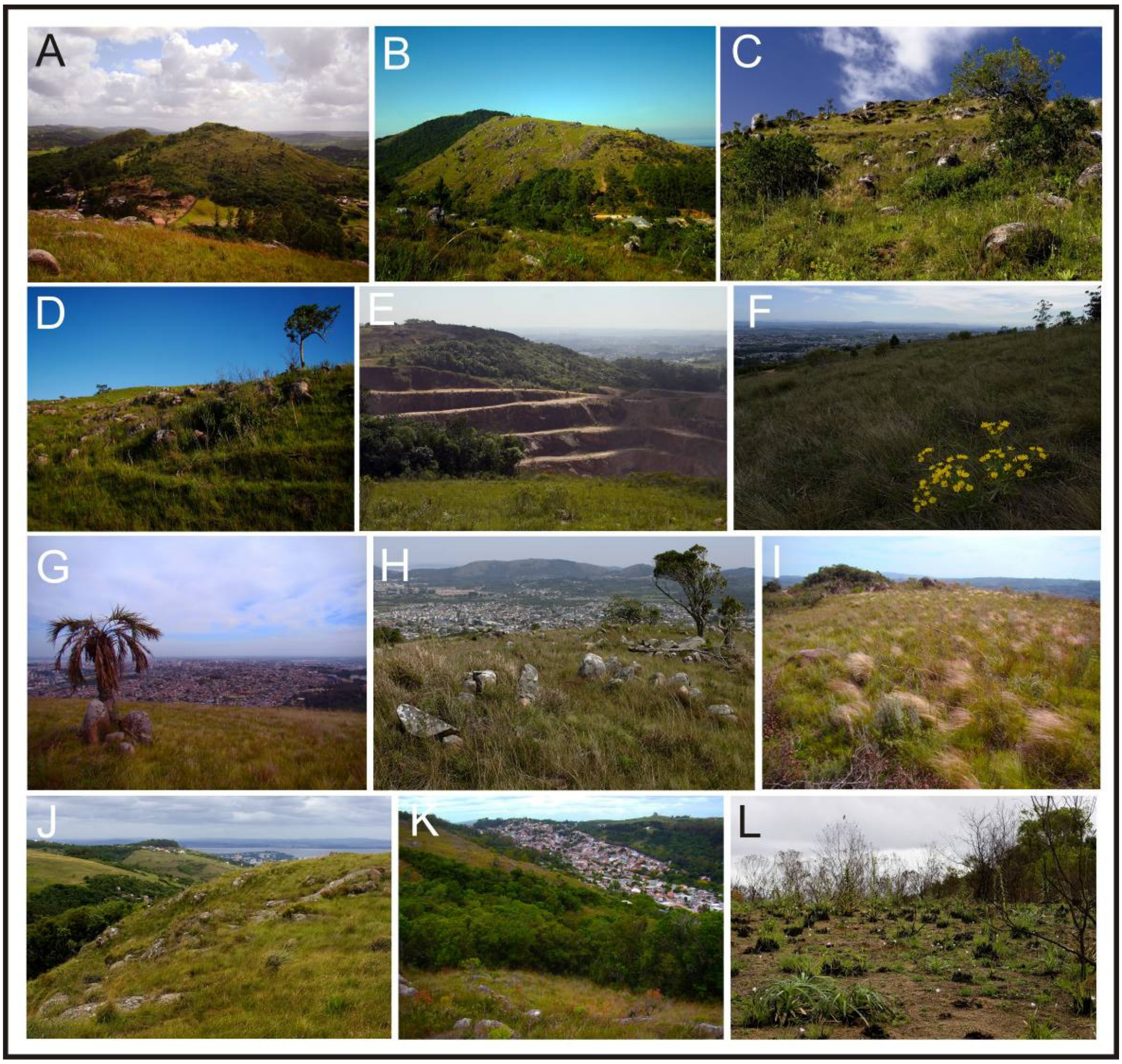

Figure 6 – A. Morro Agudo; B-C. Morro Tapera; D-E. Morro Pelado; F-G. Morro Santana; H-I. Morro São Pedro; J-K. Morro da Policia; L. Morro do Osso, recently burned grassland.

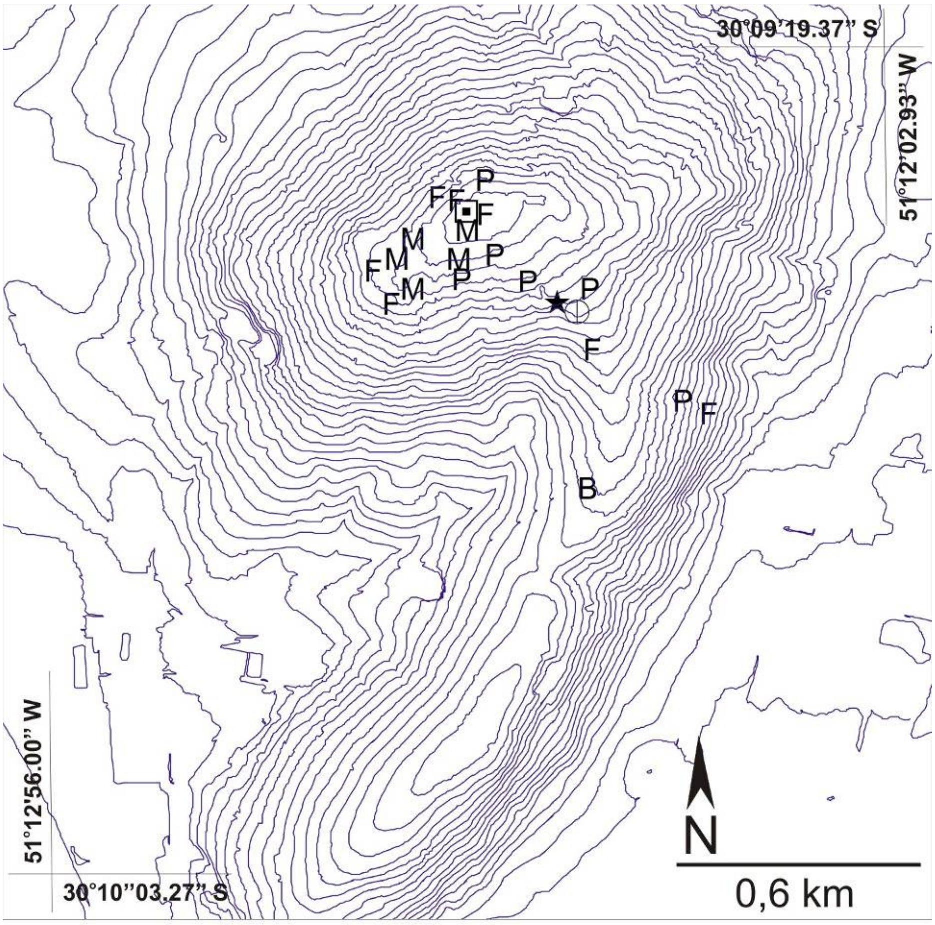

Figure 7 – Morro das Abertas. B = *Butia capitata* var. *odorata*; ⏀ = *Dyckia leptostachya*; F = *Frailea gracillima* ; ⊡ = *Mandevilla coccinea*; ★= *Mikania pinnatiloba*; M = *Moritzia ciliata*; P = *Parodia ottonis*.

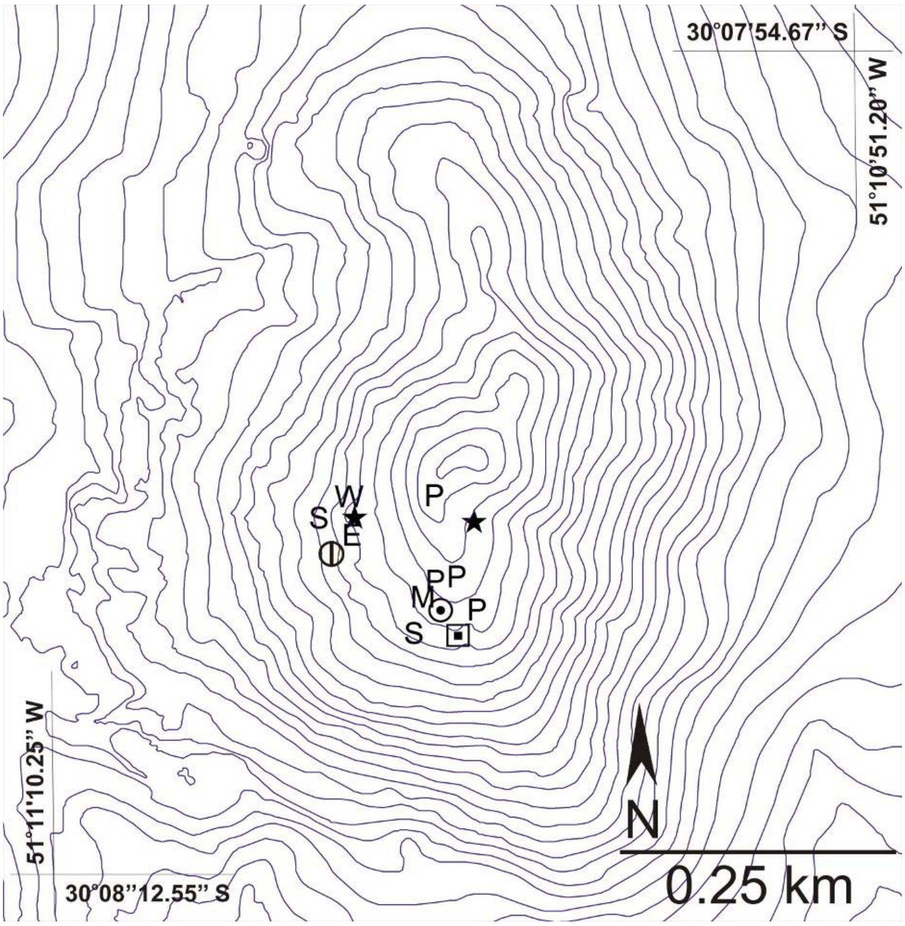

Figure 8 – Morro Agudo. ⦶ = *Dyckia leptostachya*; E = *Eugenia dimorpha*; ⊙ = *Gochnatia cordata*; ⊡ = *Mandevilla coccinea*; ★= *Mikania pinnatiloba*; M = *Moritzia ciliata*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; W = *Waltheria douradinha*.

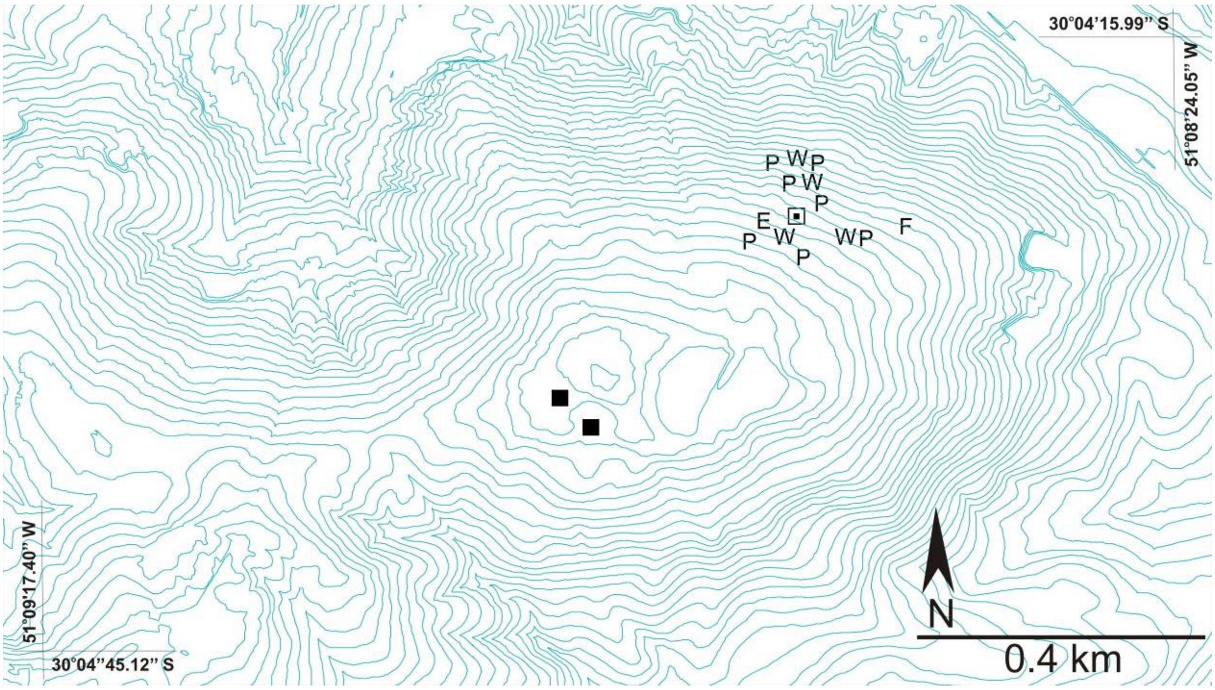

Figure 9 – Morro da Companhia. E = *Eugenia dimorpha*; F = *Frailea gracillima*; ⊡ = *Mandevilla coccinea*; ■ = *Mimosa rocae*; P = *Parodia ottonis*; W = *Waltheria douradinha*.

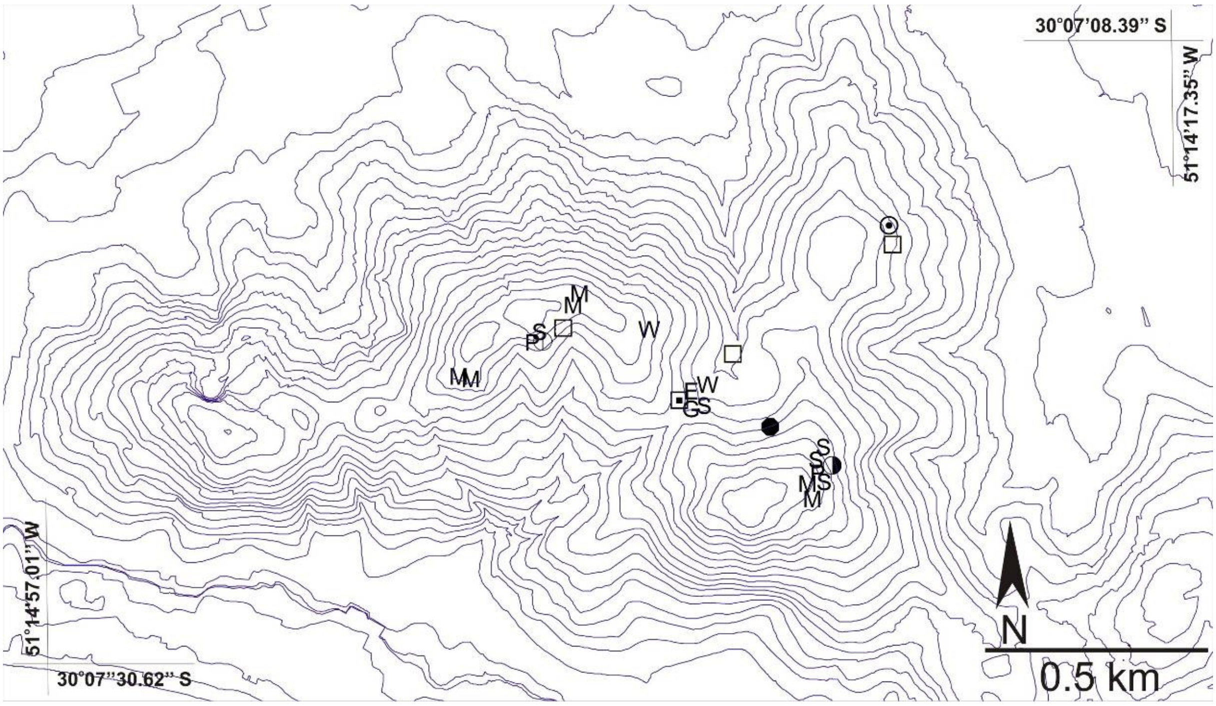

Figure 10 – Morro do Osso. ◑ = *Dyckia choristaminea*; ⦶ = *Dyckia leptostachya*; E = *Eugenia dimorpha*; ⊙ = *Gochnatia cordata*; □ = *Gochnatia orbiculata*; G = *Gomphrena graminea*; ▣ = *Mandevilla coccinea* M = *Moritzia ciliata*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; ● = *Stenachaenium macrocephallum* W = *Waltheria douradinha*.

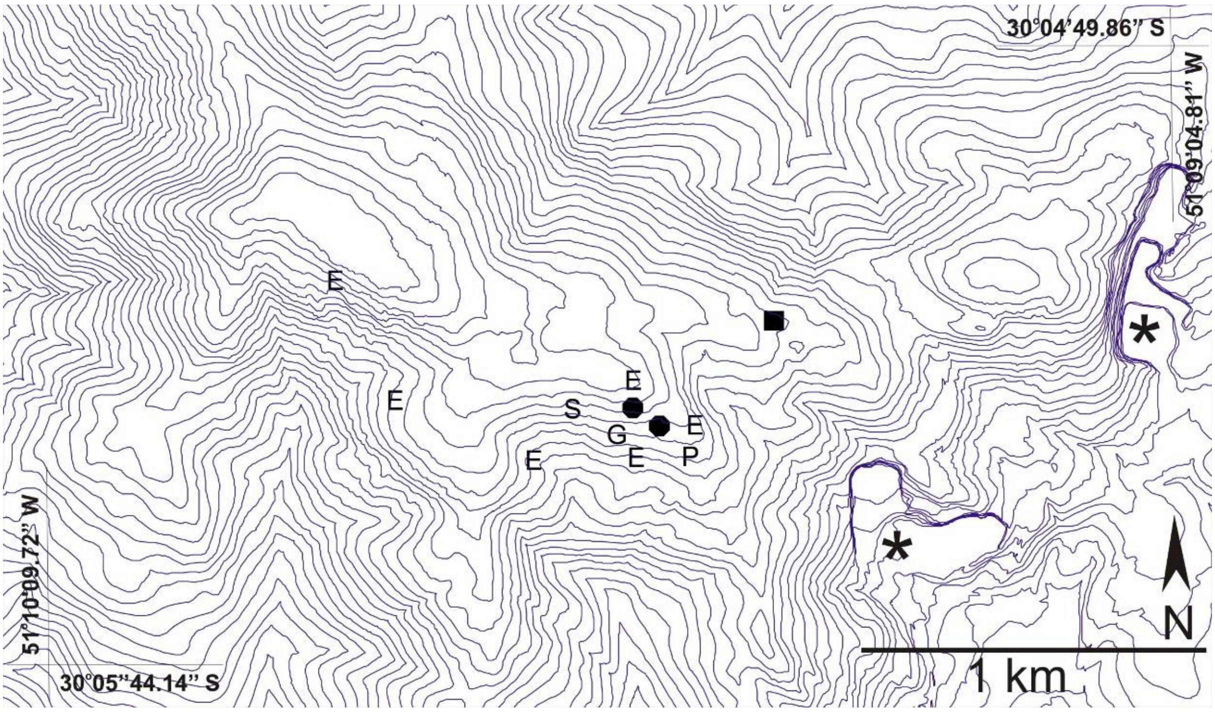

Figure 11 – Morro Pelado. E = *Eugenia dimorpha*; G = *Gomphrena graminea*; ■ = *Mimosa rocae*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; ● = *Stenachaenium macrocephallum*; * = Quarry sites.

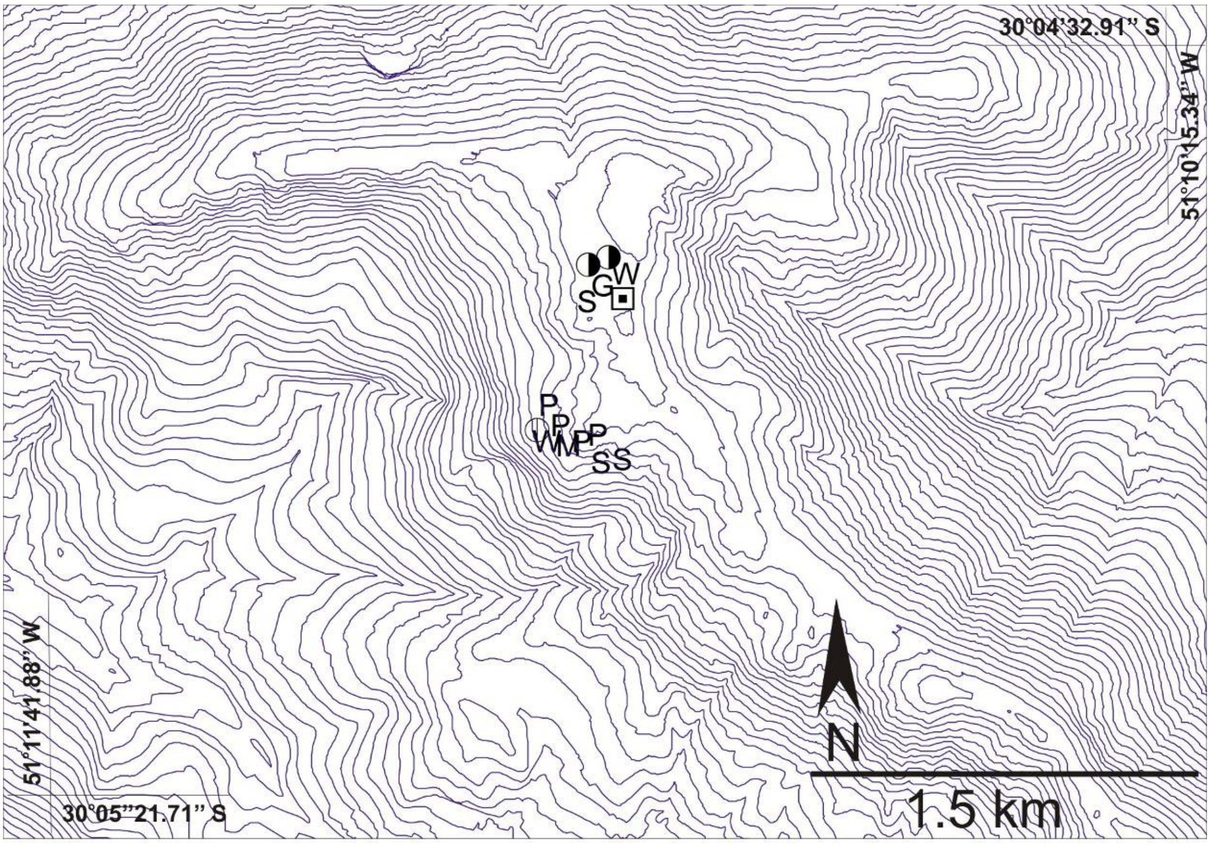

Figure 12 – Morro da Policia. ◑ = *Dyckia choristaminea*; ⦶ = *Dyckia leptostachya*; G = *Gomphrena graminea*; ⊡ = *Mandevilla coccinea*; M = *Moritzia ciliata*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; W = *Waltheria douradinha*.

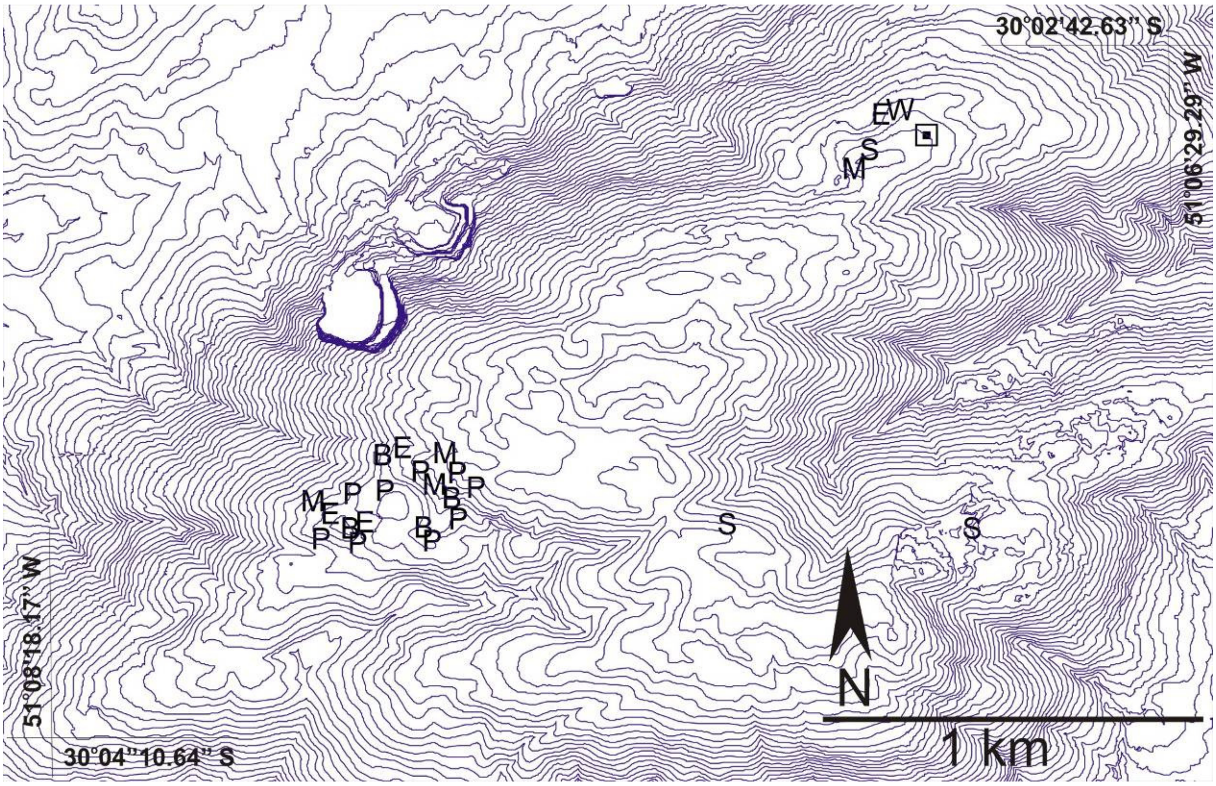

Figure 13 – Morro Santana. B = *Butia capitata* var. *odorata*; E = *Eugenia dimorpha*; ▣ = *Mandevilla coccinea*; M = *Moritzia ciliata*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; W = *Waltheria douradinha*.

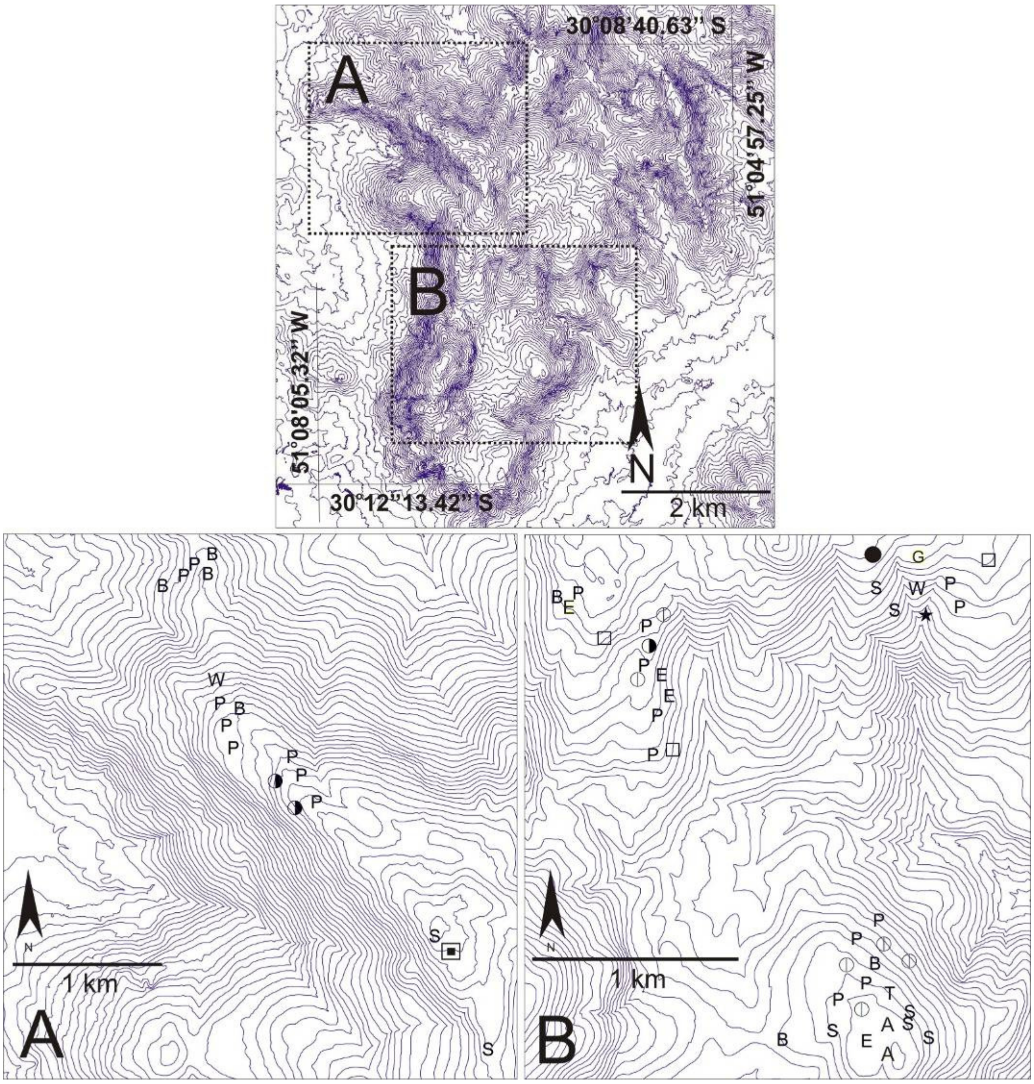

Figure 14 – Morro São Pedro. A = *Alstroemeria albescens*; B = *Butia capitata* var. *odorata*; ◑ = *Dyckia choristaminea*; ⦶ = *Dyckia leptostachya*; E = *Eugenia dimorpha*; □ = *Gochnatia orbiculata*; G = *Gomphrena graminea*; ⊡ = *Mandevilla coccinea*;★= *Mikania pinnatiloba*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; ● = *Stenachaenium macrocephallum*; T = *Thrasyopsis jurgensii*; W = *Waltheria douradinha*.

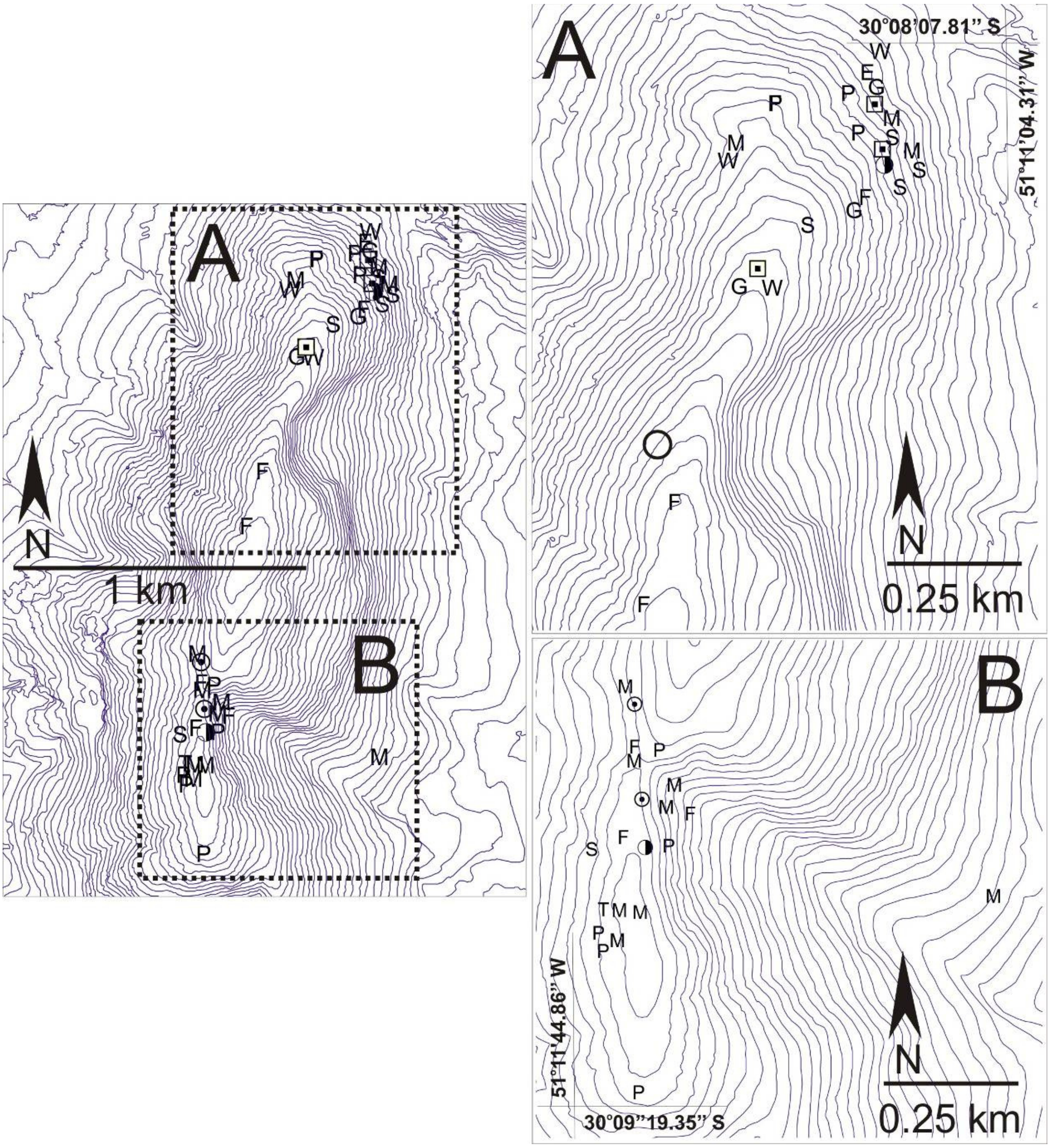

Figure 15 – Morro Tapera. ○ = *Bipinnula canisii*; ◑ = *Dyckia choristaminea*; E = *Eugenia dimorpha*; F = *Frailea gracillima*; ⊙ = *Gochnatia cordata*; G = *Gomphrena graminea*; ▣ = *Mandevilla coccinea*; M = *Moritzia ciliata*; P = *Parodia ottonis*; S = *Schlechtendalia luzulifolia*; T = *Thrasyopsis jurgensii*; W = *Waltheria douradinha*.

CAPÍTULO 2

SUGGESTION OF PLANT ENDEMISM CATEGORIES AS STANDARDIZED CONSERVATION TOOLS REFLECTING DISCRETE FLORISTIC UNITS

PEDRO M.A. FERREIRA & ILSI I. BOLDRINI

ARTIGO A SER SUBMETIDO À REVISTA CONSERVATION BIOLOGY

Title: Suggestion of plant endemism categories as standardized conservation tools reflecting discrete floristic units

Running Title: Plant endemism categories

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Keywords: endemic species, rare species, range-restriction, Pampa biome, subtropical grasslands, campos

Word count: 6,526

Abstract

Endemism is a relative concept, essentially dependent on scale. Endemism level is an important conservation tool, and there is growing evidence that it may be a good predictor of sites with high species richness. However, assessing endemism levels in groups like plants might be complicated due to its high species richness when compared to groups such as vertebrates, widely used as tools to identify endemic-rich sites worldwide. Notwithstanding, the worst problem in defining plant species as endemics seems to be the lack of standardization, mostly concerning scale: species are defined as endemic to countries, continents, cities or states, areas limited by artificial boundaries that in most cases do not reflect biological range restrictions. In this paper, we present a conceptual history of endemism concerning plant taxa, suggesting that researchers fit their potentially endemic species into standardized categories, so that future lists of endemic species become easier to analyze and to be used as tools in conservation efforts. We provide examples from the South American grasslands for each category, as well as a summarized diagram to guide the inclusion of taxa in the discussed categories. We also comment on endemism levels at the South Brazilian grassland ecosystems, discussing their distinctiveness as a floristic and structural unit.

Introduction

Conservation biologists and governments usually define priority areas for conservation based on three aspects of biological diversity: species richness, endemism or threat (Myers et al. 2000; Orme et al. 2005). Endemic species have long been important targets of global conservation efforts (Stattersfield et al. 1998; Myers et al.

2000), and there is growing evidence that confirms endemism as a powerful tool in such endeavors: hotspots based on endemism levels encompass more species richness than richness-based hotspots, as well as more threatened species than threat-based hotspots (Orme et al. 2005). Moreover, there seems to be a worldwide pattern of positive relation between endemism and species richness (Lamoreux et al. 2006).

However, the concept of endemism itself is relative (Simon & Hay 2003), being essentially dependent on scale (Hobohm 2003; Lu et al. 2007), and often overlaps with the concept of rarity. Recently, species that are restricted to very small ranges, once known as local or narrow endemics (Kruckenberg & Rabinowitz 1985), configure an endemism type named as range-restricted rarity (Cowling 2001; Knapp 2002). Species showing this distribution pattern are usually under greater extinction threat than widespread species (Gaston 1998; McKinney & Lockwood 1999; Lamoreux et al. 2006), thus configuring potential flagship species for conservational initiatives. But the definition of narrow endemics is often problematic, especially at regions presenting high species diversity. Common problems are lack of taxonomic and distribution data (Knapp 2002), varying sampling efforts, both among regions and taxa (Gaston & May 1992), analysis within political boundaries rather than natural units (Gaston & Williams 1996) and geographical scale (Hobohm 2003).

Although most of the latest research linking endemism and conservation biology focus on animals, and mostly on vertebrates (e.g. Stattersfield et al. 1998; Orme et al. 2005), because it is a relatively small and well-documented group, plant species databases are also used (e.g. Knapp 2002; Hobohm 2003), and the concept of endemism is applied to plant taxa since De Candolle (1855) and Engler (1882). Plant taxa are usually more species-rich than any vertebrate taxa of the same taxonomic level and, due to that difference, general endemism patterns inferred through distributional data of the latter may not hold true for the first (Orme et al. 2005). The inclusion of plant taxa distribution databases in analyses of endemism patterns would shed light on this issue, but such inclusion is hampered by problems such as lack of distribution data and use of artificial political boundaries in the definition of endemic taxa.

Defining the distribution range of a plant species is up to the taxonomist specialized in that given group, and sometimes this information is lost in unpublished taxonomic revisions or is crippled by the use of artificial distribution areas. We are aware that most taxonomic revisions are geographically limited to political boundaries, and this approach is even encouraged by environmental authorities through funding granted for state floras, for instance. However, the taxonomist does not need to restrict his work to these boundaries, as herbaria and literature revision may provide records of occurrence outside them. If this information is omitted, or remains unpublished, it is likely to be a gap on the floristic knowledge until the taxa is taxonomically revised again, which could mean decades.

Defining a species as endemic should also be up to the taxonomist, since he is likely to be the one with better knowledge concerning the species distribution. However, due to concept overlapping and lack of standardization, as well as collection gaps and lacking distribution data, endemism is often arbitrarily defined within large and artificial boundaries. In large and megadiverse countries such as Brazil, to define a species as endemic to the country is often to overestimate the species distribution. Although not impossible, it is highly unlikely that a species would thrive on all ecological, topological, climatic and edaphic variation a country like Brazil encompasses, and this is the idea that a species 'endemic to Brazil' would imply. Wheeler (1996) addresses *Carex purpureovaginata* Boeck., a herb belonging to the sedge family, as 'endemic to Brazil'. Through herbaria and literature revision, G.

Silveira and H.M. Longhi-Wagner (unpublished data) state that the species distribution encompasses the Brazilian states of Minas Gerais, Rio de Janeiro, Santa Catarina and Rio Grande do Sul. This distribution excludes most of the N and NE regions of Brazil, thus excluding all the Amazonian Rainforest. As it is, we strongly discourage labeling a species showing this distribution pattern as 'endemic to Brazil', since it would not reflect its actual distribution and could mislead conservation efforts.

In this paper we aim to provide plant taxonomists and ecologists with a suggestion of endemism types, compiled from previous papers, to which they can match the range-restricted species within their taxonomic group. We also comment on scale problems concerning endemism and general distribution records concerning grassland formations present in South America, providing endemism examples extracted from subtropical grasslands. Also, we discuss the distinctiveness of South Brazilian grassland ecosystems as a floristic and structural unit.

Brief conceptual history

During the nineteenth century, when European explorers endeavored to discover lands beyond the known world, many taxa exclusive to these unknown places were brought into light (Kruckenberg & Rabinowitz 1985). In this context, the concept of 'endemic' applied to taxa distribution is ascribed to De Candolle (1855), implying geographical restriction according to the Greek etymological root, éndēmos, meaning 'indigenous to a region', or simply 'native'. Since than, the concept was used freely by botanists and zoologists, in different scales but always meaning distribution range restriction of a given taxa.

The acknowledgement of different endemism types appeared in the literature soon after this first use of the concept. Engler (1882) distinguishes ‘old endemics’ and ‘new endemics’, and this dichotomy is used to the present day, only under a different terminology. Wherry (1944) recognizes ‘primary’ and ‘secondary’ endemics, and the latter would correspond to repressed (environmentally or genetically) or senescent taxa. Cain (1944) postulates that endemism encompasses two ‘types’ of plants confined to a given region (not mentioning region size): ‘relatively young species’, namely endemics, and ‘old, relict species’, namely epibiotics.

From the late 1930’s to the 1960’s, several researchers suggested the use of cytological data to determine relative age and direction of origin of rare taxa, thus suggesting many different endemism types. Examples of early cytological approaches are found in Wulf (1932, 1937, 1943), Anderson (1937) and Senn (1938). Favarger and Contrandriopoulos (1961), revising and summarizing the cytological literature up to that point, propose four categories of endemics, recasting most of them from previous papers with new names: paleoendemics (ancient, systematically isolated taxa, often ecological specialists on the brink of extinction), schizoendemics (resulting from ‘gradual speciation’ or simultaneous divergence from a parental entity), patroendemics (ancient diploid endemics that originated widespread polyploids) and apoendemics (polyploid endemics originated from widespread diploids). Roughly speaking, these categories would fit the ‘new’ and ‘old’ endemics Engler (1882) recognized before.

Stebbins and Major (1965), extensively reviewed the available literature on rare and endemic species, and recast the endemism categories suggested by Favarger and Contrandriopoulos (1961) in their analysis of the Californian flora. In their work, paleoendemics remain acknowledged as ancient taxa, presenting an extant relict distribution resulting from ‘reduction of specialized habitats’, this last assumption being the most arguable point. The opposing category, neoendemics, are recognized as recently originated taxa, with possible future expansion, 'both on distribution and gene pool'. However, Stebbins and Major (1965) emphasize many problems involved on defining taxa as 'old' or 'new', namely paleoendemics or neoendemics, but also state that these two categories remained the only agreement concerning endemism types since Engler (1882).

In 1980, the journal of the New England Botanical Club (Rhodora), published a special issue regarding a symposium entitled 'Rare and Endangered Plant Species in New England', where many authors left great contributions concerning plant rarity and endemism. Distinctions regarding scale were arising, and species with extremely reduced distributions were addressed as 'narrow endemics' (Drury 1980; Stebbins 1980). Species that were restricted to larger areas were treated differently, as the 'Appalachian endemics' and 'regional endemics' mentioned in Bratton and White (1980). Among these 'not so restricted' endemics, many were assigned as endemic to a given state, county or any other political (and thus usually unnatural) boundary. Field and Coddington (1980), listing the rare plants of the state of Massachusetts, divided their species in four groups, according to their distributional pattern: (1) rare along their distribution; (2) concentrated at the northern or southern distribution limits; (3) with highly disjunct distribution and (3) with restricted total distribution, being endemic to the state of Massachusetts, to New England (which encompasses six states) or to a small geographic area. This last subcategory would fit the 'narrow endemism' concept according to the author's description, and their classification encompasses nearly all the possible distributional patterns the populations of a given species can display, except the gradient patterns, where the species frequency values (i.e., its rarity/commonness) varies along the distribution. Field and Coddington (1980) distinguished two groups of endemics: 'newly-evolved' and 'relict species', once again recasting Engler's new and old endemics.

Researchers started to question whether plant rarities and endemism were intrinsic features of each taxa, reflecting their biological aspects. Kruckenberg and Rabinowitz (1985), reviewing biological aspects of plant endemism, bring to light a new endemism category: the edaphic endemism, using heavy-metal-resistant herbs as examples. These cases would reflect biological aspects inherent to the species, usually physiological adaptations that allow colonization, establishment and growing under toxic or low-resource conditions, where other species would not thrive. Moreover, the degree of physiological specialization in some species is such that they are restricted to these uncommon conditions, as seen in serpentine soils (Brady et al. 2005) and gypsophile (Meyer 1986; Drohan & Merkler 2009). Kruckenberg and Rabinowitz (1985) also emphasize the scale problem involved in determining endemism, using the 'narrow endemic' (also mentioned as local endemic) concept. When plants are restricted to larger areas, the authors mention 'regional' and 'continental' endemism.

Gottlieb (1979), in a classic work comparing the reproductive biology of two Asteraceae species (one endemic and other widespread), found reproductive restrictions in the endemic species, such as higher achene weight and lower seed number. Many similar works were carried out after this one, seeking for common biological aspects among endemics, and Cowling (2001) summarizes three evolutionary trends in endemic species: self-incompatibility, low dispersion ability and low overall investment in reproduction. Richards (2003), comparing three pairs of endemic and widespread species, found no environmental or physiological common feature between the endemics, suggesting that competition could be the determining factor of these particular endemism cases. Simon and Hay (2003), comparing pairs of endemic and widespread species of *Mimosa* at the Brazilian Cerrado Biome, found no difference between their reproductive potential, contrasting with most of the previous findings in similar treatments. However, trough germination and establishment tests, one of the restricted species was defined as an 'edaphic specialist', fitting the 'edaphic endemic' concept of Kruckenberg and Rabinowitz (1985). Lavergne et al. (2004) compared 20 pairs of congeneric endemic and widespread species, in the largest sampling so far. They found some general trends common to most of the endemic species: they dwell in steeper slopes and rock outcrops, produce less flower and seeds and show lower fecundity than their widespread congeners. They present three main conclusions concerning narrow endemics: they may be poor competitors, showing no tolerance for this kind of stress; they may find shelter in habitats that remain unaltered due to topographic display; persistence (in opposition to colonization) seems to be a key feature for their survival.

More recently, endemism has been considered as a type of rarity, namely 'range-restricted rarity' (Cowling 2001), 'range-size rarity' (Knapp 2002) or 'endemic rarity' (Richards 2003). These definitions, albeit under different names, still fit the concept of 'narrow endemism' proposed by Kruckenberg and Rabinowitz (1985), but caution is advised in order to avoid problems involving the concept of rarity used in community ecology. Rarity is a concept based on frequency, a measurable parameter usually estimated in vegetation structure surveys (e.g. Overbeck et al. 2005; Müller et al. 2007). Species presenting extremely low frequency values are considered rare within the sampled area (or within a larger area, depending on the extrapolation allowed by data and analyses). Although similar approaches to determine degrees of endemism exist (e.g. Kier & Barthlott 2001; Lu et al 2007), the definition of a species as endemic is often based on map plotting of collection records, which is useful to infer a taxon's distribution but by no means shows its frequency along this distribution.

Since its first use by De Candolle (1855), the concept of endemism permeated the botanical literature, being a constant target of scientific argument and, therefore, changing with time. Although many endemism categories were suggested, based on different criteria, some found more acceptance than others. Concerning the scale problem, the concept of 'narrow endemics' (Drury 1980; Stebbins 1980) seems to be well-accepted (although sometimes under new terminologies, as in 'range-size rarity') to define the most restricted species, or 'true endemics' (Cremene et al. 2005), reflecting the common notion of rarity (Kruckenberg & Rabinowitz 1985). The distinction between old and new endemics suggested by Engler (1882) remains to the present day, under the new names of paleoendemism and neoendemism. The 'edaphic endemism' described by Kruckenberg and Rabinowitz (1985), recast by many authors who searched for biological causes of endemism, seems like a consistent and self-explanatory category to place endemic species when their distribution is restricted to peculiar abiotic conditions. Although historical events are pointed out as the main cause of endemism in many papers (e.g. Simon & Hay 2003), some authors suggested that competition could be a determining factor in range restriction (Richards 2003; Lavergne et al. 2004), usually when abiotic and physiological variables could not explain the endemism. This 'ecological endemism' also seems like a promising category, as it provides likely explanations for endemism when other variables fail, although its determination would demand experimental ecological approaches.

Narrow endemism

All definitions of narrow endemism (including analogous concepts such as 'local endemics' and 'range-restricted rarity') emphasize that narrow endemics show very restricted distributions, but none provide ways to determine how restricted a species must be in order to be considered as one. Species that are restricted to particular soil types, such as the serpentine grasslands of California (Kruckeberg 2002) or the sandy soils of southern Brazil (E. M. Freitas & I. I. Boldrini unpublished data), configure the obvious type of narrow endemism due to their extremely restricted range, and can also be defined as edaphic endemics (see below). However, we think that some species presenting wider distribution may also be considered as narrow endemics. The globose cactus *Parodia ottonis* (Lehm.) N. P. Taylor, is recorded at Uruguay, Argentina and Rio Grande do Sul (RS), the southernmost Brazilian state (P.M.A.F & I.I.B. unpublished data), and this distribution overlaps with the granite-based formation present in the area, as well as with the Pampa biome and its surrounding floristically similar areas (Overbeck et al. 2007). However, the species is found only on rock outcrops at dry grasslands, in very disjunct populations, suggesting high habitat specificity. We consider this species as a narrow endemic, due to its restriction to rock outcrops in granite-based formations within a known floristic unit.

We think that species that show no apparent habitat restriction, but are restricted to known floristic units, such as biomes, should also be recognized as narrow endemics, since these formations usually present discrete floristic and structural composition (e.g. Overbeck et al. 2007, for the south Brazilian Pampa biome). An example of such taxon is *Moritzia ciliata* (Cham.) DC., a small grassland herb recorded, similarly to the previously mentioned *P. ottonis*, at Uruguay and RS (Smith 1970; P.M.A.F & I.I.B. unpublished data). This species, however, is not restricted to rock outcrops as *P. ottonis*, being well-recorded in dry grasslands all along its known distribution, which comprises the Pampa biome and its floristic continuum at Uruguay (Figure 1). Information concerning endemism levels of biomes is extremely important for global conservation initiatives, but is unfortunately lacking or dubious for many regions, and should therefore be supplied by taxonomists working with local taxa.

However, defining *M. ciliata* and *P. ottonis* at the same endemism level seems wrong, given the differences we stated before. We suggest the inclusion of a brief habitat/area description when similar endemism is proposed, such as follows: *P. ottonis* is endemic to granitic outcrops at the Pampa biome; *M. ciliata* is endemic to the Pampa biome. We emphasize once again that, in both examples, we consider the Pampa biome in a wider sense, encompassing grassland formations present in Uruguay and Argentina, as shown in figure 1 (Overbeck et al. 2007; P.M.A.F & I.I.B. unpublished data).

In cases that involve taxa with range restriction similar to our examples, we strongly discourage the use of political boundaries to describe endemism. To define *M. ciliata* as 'endemic to the state of RS', for instance, would imply that the species distribution covers all the state's area, which is not true, because it is recorded only at its southern half. Defining the species as 'endemic to Brazil' would lead to the same, if not worst, problem. However useful and practical political boundaries might be, when many species are wrongly assigned as endemics in that way, conservation efforts, that often take levels of endemism into account (e.g. Brooks et al. 2002; Hobohm 2003; Orme et al. 2005), will undoubtedly be mislead, and this problem is exponentially aggravated in megadiverse countries such as Brazil.

Narrow endemism is a *scale*-related concept. In the following sections we present examples of paleoendemism and neoendemism (*time*-related concepts) and edaphic endemism (*physiology*-related concept). The possible existence of an ecological endemism is also discussed. Please note that we considered all species mentioned below as narrow endemics, so that the other endemism categories we suggest are tools to better explain the observed range restriction, trying to link it to biological or historical causes and ultimately explain endemism as a natural biological phenomenon.

Paleoendemics and neoendemics

Defining restricted taxa according to their age, that is, as paleoendemics or neoendemics, may be an easier task today, due to modern molecular-based phylogenies, which could be used as tools just like the plate tectonics theory was used before to explain apparently unexplainable distribution patterns. After reviewing the known distribution of a given taxon, and finding out that it is restricted to a small geographic range, the researcher can browse published phylogenies of the group. If the taxon is found out to be early-diverged within its group, it is likely to be a paleoendemic. In the opposite case of a late-diverged taxon, neoendemism is likely to be the case. Geological data can be coupled with phylogenetic information, strengthening the choice between these endemism types: restricted distribution ranges overlapping with new geological formations, such as the south Brazilian seashore plain (Menegat et al. 1998), when belonging to an extremely divergent taxon within its phylogeny, is likely to configure an example of neoendemism. The opposite also holds true: early-diverged restricted taxa with distribution overlapping with ancient geological formations are likely to be cases of paleoendemism.

The orchid *Prescottia ostenii* Pabst, an extremely rare and inconspicuous (up to 8.4 cm tall) herb, presents a very narrow distribution range, with records only for Uruguay (the type collection) and RS (two records) (Singer et al. 2009). Records at both regions are inserted in the seashore plain, the most recent geological formation present at the region, originated after the last ocean transgressions (Menegat et al. 1998). Singer et al. (2009) stress that this species is the only one on the genus to be extremely water-tolerant, and was collected, both historically and in the present, in full-sun, with roots underwater or in very moist conditions. The collection gap between both records is likely to be due to lack of collection effort, plant inconspicuousness and uncommon habitat among the genus, since the local seashore formation presents similar habitats and floristic composition all along its extension. The species also seems to be a late divergent apomorphic taxon within the group phylogeny (Azevedo et al. in prep.), suggesting recent speciation. Based on known and inferred distribution, phylogeny and geology, we infer that *P. ostenii* is a neoendemic species, restricted to the seashore plain formation that encompasses eastern RS and Uruguay (Figure 1).

The Asteraceae *Schlechtendalia luzulifolia* Less., is a potentially ornamental and extinction-threatened grassland herb present in Southern Brazil, categorized as endangered (EN) according to the International Union for Conservation of Nature (IUCN) criteria. The species distribution comprises, according to Burkart (1979), RS, Uruguay and NE Argentina. Trough herbaria and literature revision, we found out that, within RS, the species was recorded only at its southern half, i.e., the Pampa Biome (Figure 1). Still within RS, collection records presented a high concentration at the NE section of the state, but were also present in the central, S, SW and W regions. There are two records at Argentina, close to the common border between Uruguay, Argentina and Brazil, and one at Uruguay, at the country’s southernmost point. The existing collection gap in a large area between the S distribution limit at Uruguay and the records in southern RS represents lack of collection effort, since the northern portions of Uruguay, as well as the southern portions of RS, are poorly collected grassland-dominated formations. Therefore, the distribution of *S. luzulifolia* overlaps with the Pampa Biome, mostly over granite-based soils, extending southwards through Uruguay's similar formations. This granitic formation, known as the South Brazilian Crystalline Shield, is the oldest geological formation present at the region (Menegat et al. 1998), and reaches southwards through a large extension of Uruguayan territory. All collection records of *S. luzulifolia* that provide habitat information relate the species to shallow, rocky soils. Phylogenetic works place the species as an early-divergent, plesiomorphic taxon within the sunflower family (Gruenstaeudl et al. 2009). Based on these data, we suggest that *S. luzulifolia* is a paleoendemic species, restricted to the granite and sandstone-based grassland formations present at the Pampa Biome and its floristically similar surrounding formations at Argentina and Uruguay.

Edaphic endemics

Tolerance to stressful abiotic conditions has long been used as an explanation for range restriction in plant species. Kruckenberg and Rabinowitz (1985) mention edaphic endemism on their extensive revision, and the concept has been used since mainly to describe plant endemism in extreme conditions such as serpentine and toxic soils. Kruckeberg (2002) estimates that 9% of the Californian plant species are restricted to serpentine soils, demonstrating the importance of this phenomenon in plant distribution. Concerning the Brazilian flora, few species have been appointed as edaphic endemics. Simon and Hay (2003), after germination and establishment experiments, mentioned a species endemic to the Cerrado biome as an 'edaphic specialist'. E. M. Freitas and I. I. Boldrini (unpublished data), working in sandy-soil grasslands at southwestern RS, were sandy patch process is common, recorded several endemic species, at different levels of range restriction. Some of these species are recorded only at their study sites, presenting high levels of morphological (and probably physiological) adaptation to water shortage, such as *Butia lallemantii* Deble & Marchiori*, Baccharis albolanosa* An. S. de Oliveira & Deble and *Baccharis multifolia* A.S.Oliveira , Deble & Marchiori. Other species, such as *Senecio cisplatinus* Cabrera and *Pappophorum macrospermum* Roseng., B.R. Arrill. & Izag., presented a wider distribution, encompassing Uruguay and NE Argentina, but were always associated to sandy patch process as well, suggesting high edaphic specificity. Albeit the work of E. M. Freitas and I. I. Boldrini (unpublished data) involved no experimental approach, we think that distributional and morphological evidences allow these species to be addressed as edaphic endemics. Future germination and establishment tests involving such taxa would shed more light into how abiotic variables influence plant distribution.

Other possible explanation for endemism: competition

When there is no evident historical reason (i.e. geological and climatic processes) explaining an endemic distribution pattern, no environment variable suggesting habitat limitation, and no physiological feature suggesting plant adaptation (or restriction), some authors suggest that competition could be the driving factor of range restriction. Richards (2003) compared environmental and physiological variables between pairs of endemic and widespread congeners, and found no unifying features among the endemics. He suggested that, consequently, competition would play a key role in processes that lead to restriction. Lavergne et al. (2004), in a similar pairwise comparison, found out no difference between endemics and widespread congeners in attributes such as soil pH, net estimated photosynthesis and herbivory rates. The authors suggested that some endemic species may present their extant restricted distribution due to poor competing ability, as well as low tolerance to competitive stress. Endemic species fitting this scenario could be addressed as 'suppressed endemics', since it is likely that their distribution would increase in the absence of one or more dominant competitors. However, researchers should be extremely cautious before putting a species under this category, since it is relatively new and demand extensive experimental testing to be reliable. Many factors affect species distribution, and it is highly unlikely that competition alone could explain it.

Placing species into an endemism category

As mentioned before, we suggest that only plant species confined to known (or presumable) floristic units such as biomes should be treated as endemics. In figure 2 we present a summarized diagram designed for taxonomists, ecologists and other researchers to fit their restricted taxa in the endemism concepts we discussed above.

When the taxon is recorded at more than one floristic unit, we recommend that it is considered as 'widespread'. However, widespread taxa may also show levels of range restriction, even when they are common (i.e., frequent, easily found) within this range. Sometimes, due to their broader distribution in comparison to endemics, their collection records may coincide almost completely with large political units, such as counties, states, countries or larger units. We recommend that these taxa are addressed as 'restricted' to a given political unit, avoiding the use of the endemism concepts when artificial boundaries and species showing no apparent specificity are involved.

The best scenario to assign a taxon as paleoendemic or neoendemic is configured when both phylogenetic and geological data are available. However, we consider geological data as a complement that may or may not corroborate phylogenetic information. When no phylogenetic information is available, taxonomists revising large groups may couple geological and distribution data to sets of presumably plesiomorphic or apomorphic characters that a restricted taxon presents, in order to infer its early or late divergence within the group.

Before assigning edaphic endemics, we suggest a revision of published papers concerning adaptations present in the species (or in closely related taxonomic groups), which would corroborate and strengthen the habitat specificity. We also recommend germination and establishment experiments, since they are relatively cheap and easy to carry out.

We chose not to include the 'suppressed endemics' category on the diagram presented in figure 2, due to the lack of a specific protocol to determine competition as a driving factor of range restriction. Although competition probably influences plant species distribution, as seen in competitive exclusion (e.g. Grime 1973; Kessler 2001), it is always complicated to use absence of evidence to infer biological relationships of causality. When tools such as edaphic and historical variables fail to explain restricted distributional patterns, ecologists must step in to test whether or not relationships among taxa might explain them.

We emphasize that the endemism categories we suggest are based on grassland species, and on our knowledge concerning their general distribution patterns. Therefore, there might be drawbacks when it comes to arboreal taxa, mainly concerning edaphic endemism. Also, we strongly recommend a thorough revision of available distribution data of the studied species before defining it as endemic, minimizing the chances of over/underestimation of its range.

Although we discourage the use of political boundaries when defining endemism, we are aware that these artificial boundaries sometimes overlap with the natural ones, and countries at isolated islands are the most obvious cases. Perhaps in these cases defining taxa as ‘endemic to Madagascar’, for example, might be more informative, but in essence this endemism fits our delimitation of narrow endemism, since these islands often configure discrete (and unique) floristic units.

Endemism in South Brazilian *campos* grasslands

The Pampa biome is a grassland-covered area that dominates the landscape at the southern half of the Brazilian state of Rio Grande do Sul (RS; Figure 1-A). Within Brazilian territory, many species are recorded only at this formation, which would imply high levels of endemism. However, most of these species (including some we mentioned before) can also be found in the surrounding grassland areas of Uruguay and Argentina, suggesting a floristic continuum. The occurrence of many common grassland species between Uruguay, Argentina and Brazil dramatically decreases the endemism levels at the Pampa biome, which is legally restricted to RS. This political boundary does not truly express the biome’s floristic and structural boundaries, and it is imperative that the Pampa biome is acknowledged in a broader sense, including its neighboring formations. Previous works have already seen this area as a floristic unit (Burkart 1975; Soriano et al. 1992; Bilenca & Minarro 2004).

Endemism level within a biome is a powerful conservation tool, highlighting its global importance and ultimately attracting financing agencies (both public and private), and they are key assets to biodiversity conservation. Biomes that reflect discrete floristic and structural units, however variable they might be, usually present high endemism levels. The Cerrado biome, inserted in central Brazil and cradling large areas of grassland formations, is a good example: it cradles ca. 10.000 species, 44% of which are considered endemic to the formation (Simon & Hay 2003). Overbeck et al. (2007) raised a warning concerning the south Brazilian Pampa biome (addressed as *campos* grasslands in their paper), emphasizing that it has been historically neglected by Brazilian government and scientific community. The only way to unravel the true levels of species richness and endemism of this formation is to recognize it as a transnational floristic unit, as suggested before and shown in figure 1-B. By doing so, future surveys seeking to estimate endemism levels at this formation will find values similar to the ones found at other South American biomes, if not higher due to the uniqueness of their grassland-dominated landscapes. Studying this formation as a discrete unit will also enable comparisons with similar formations from other places in the continent and around the world, ultimately helping to undisclosed general floristic and structural patterns applicable to subtropical grasslands as a whole, providing information that will shape a framework for future conservation.

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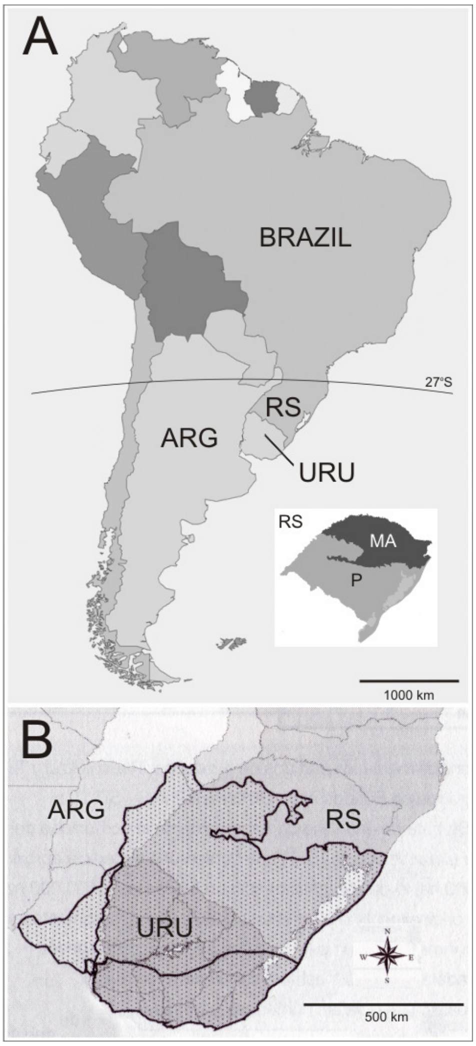
Figure Legends

Figure 1 – A. South America, indicating Brazil, Argentina (ARG), Uruguay (URU) and the Brazilian state of Rio Grande do Sul (RS). On the detail, distribution of biomes within RS, according to IBGE (2004); P = Pampa biome; MA = Mata Atlântica biome. B. Extended Pampa biome, including similar grassland formations present at Uruguay and Argentina. Adapted from Bilenca and Minarro (2004).

Figure 2 – Summarized diagram for placement of taxa into different endemism categories. See text for discussion and examples.



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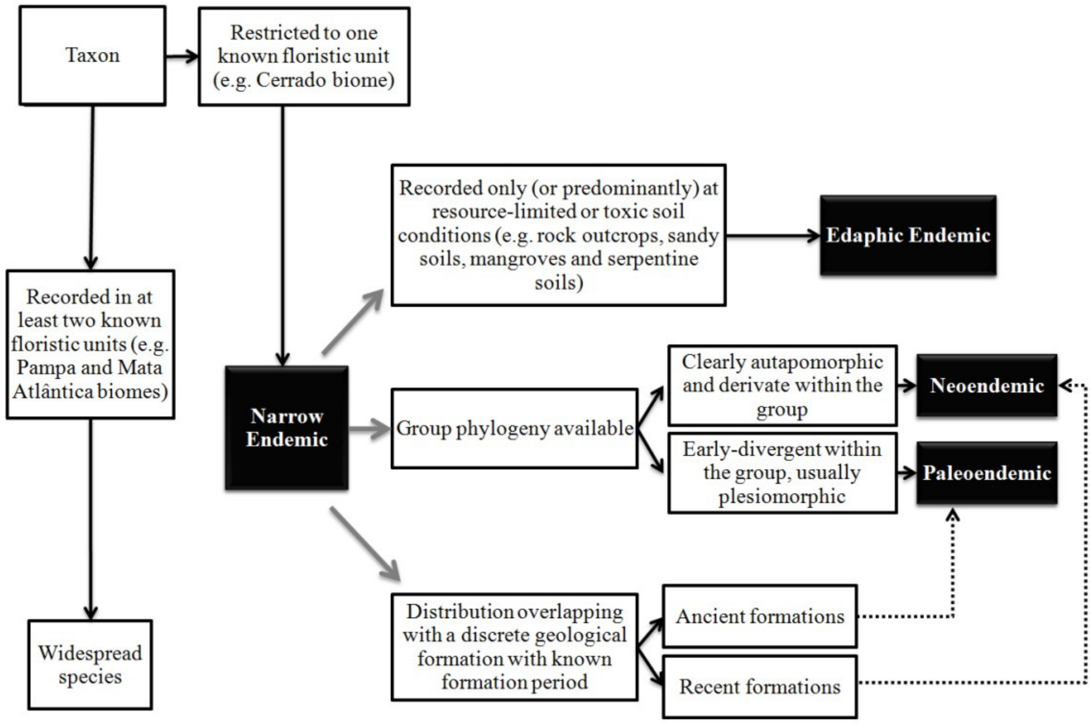

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CONSIDERAÇOES FINAIS

Os dados apresentados no artigo do Capítulo 1 denotam um estado de conservação razoável das formações campestres presentes nos morros graníticos de Porto Alegre, com a presença de diversos táxons raros, ameaçados e endêmicos. Todavia, a pressão exercida pela urbanização demanda, em caráter de extrema urgência, atitudes governamentais e da sociedade civil visando à preservação dessas formações. Manter vivas essas últimas ilhas de biodiversidade na capital do Estado trará benefícios sociais e econômicos a médio e longo prazo, tendo em vista o potencial turístico completamente inexplorado da cidade.

As categorias de endemismo propostas no Capítulo 2 têm como objetivo uniformizar um conceito que, apesar de extremamente utilizado na literatura, tem sido aplicado de maneira dúbia, ao menos em táxons vegetais. É importante que conceitos biológicos sejam universais, para que estudos comparativos confiáveis sejam realizados. Como os níveis de endemismo são amplamente utilizados na determinação de áreas prioritárias para a conservação, é fundamental que eles sejam medidos em unidades ecológicas discretas, como o exemplo dos biomas citado no capítulo. Só assim iniciativas de conservação serão alocadas nos lugares corretos, ou seja, onde ocorra a conservação da maior parcela possível de biodiversidade.

É em relação a este aspecto que discuto nos dois capítulos a unidade florística denominada bioma Pampa. Em sua circunscrição atual, esta formação não reflete uma unidade florística discreta, tendo em vista que formações contíguas, análogas estrutural e floristicamente, ocorrem nos territórios do Uruguai e Argentina. Por este motivo, a biodiversidade e a importância ecológica desse bioma é subestimada. Assim sendo, penso que seja fundamental para a futura compreensão dos reais níveis de endemismo, riqueza específica e complexidade estrutural dessas formações que elas sejam tratadas como uma unidade. Tratar o bioma Pampa como uma formação transnacional trará, além dos já citados benefícios diretos para o conhecimento, novas oportunidades de financiamento para pesquisadores, incentivando futuros cientistas a realizar pesquisas nessas formações campestres. Além de abrigarem biodiversidade e processos ecológicos ainda pouco conhecidos, o campo faz parte da cultura do povo do Rio Grande do Sul, Uruguai e Argentina, definindo o gaúcho como identidade que sem ele não existe.