Check List the journal of biodiversity data

LIST OF SPECIES

Check List 14 (1): 203–211
https://doi.org/10.15560/14.1.203

PENSOFT

Exotic woody plants in Pelotas, Rio Grande do Sul, southernmost Brazil

Tiago Schuch Lemos Venzke,[1] Vilmar Luciano Mattei,[2] Maria Antonieta Décio da Costa[3]

1 Federal University of Pelotas, Department of Soil, Program in Management and Conservation of Soil and Water, Campus Universitário s/n, Caixa Postal 354, CEP 96010-900, Capão do Leão, RS, Brazil. **2** Federal University of Pelotas, Faculty of Agronomy Eliseu Maciel. **3** Catholic University of Pelotas, Félix da Cunha, 412, CEP 96010-000, Pelotas, RS, Brazil.
Corresponding author: Tiago Schuch Lemos Venzke, venzke.tiago@gmail.com

Abstract
Exotic species are spreading in various parts of the planet and sometimes becoming biological invaders. A floristic survey was carried out to find exotic trees, shrubs, and climbers in different communities in Pelotas, Rio Grande do Sul, southern Brazil. The traversal method was used at 26 sites. The richness totaled 26 species in 22 genera and 17 families. There are 19 trees, 5 arborescents, 1 shrub, and 1 climber. Most of the exotic species are already naturalized in the study area. Between 1 and 10 individuals sporadically occur at each site. For species of characteristically invasive exotic plants were observed, including 3 trees (*Pinus elliottii* Engel, *Pinus taeda* L. Engelm., and *Pittosporum undulatum* Vent.) and 1 shrub (*Ulex europaeus* L.). A continuous monitoring of exotic flora is needed to eliminate or control invasive plant species and to avoid economic and ecological damage to ecosystems.

Key words
Floristic; taxonomy; alien species; biodiversity; invasive species; non-native plants; Seasonal Semideciduous Forest.

Academic editor: Francisco Santos-Filho | Received 23 November 2016 | Accepted 20 August 2017 | Published 2 February 2018

Citation: Venzke TSL, Mattei VL, Costa MAD (2018) Exotic woody plants in Pelotas, Rio Grande do Sul, southernmost Brazil. Check List 14 (1): 203–211. https://doi.org/10.15560/14.1.203

Introduction

Most species have their geographical extent limited by climatic and/or environmental barriers (Ricklefs 2009). Mountain chains and oceans form natural barriers to the dispersal of species and ecosystems remain relatively isolated (Lowe et al. 2000). However, natural biogeographical barriers have lost their effectiveness due to the increase in economic globalization (Borokini 2010). The flow of species associated with the disturbance of habitat and destruction and fragmentation of ecosystems accelerates the accidental or intentional introduction of many species of plants into ecosystems where they are not native (Cronk and Fuller 1995, Richardson et al. 2000, Delnatte and Meyer 2011).

Biological invasion is a process of introduction and consequent adaptation of species that are not naturally part of an ecosystem (Ziller 2001). The capacity for reproduction of invasive exotic species permits these invasives to colonize areas far from the parent plant and with the potential to spread in a considerable area of the environment (Richardson et al. 2000). Biological invasion has been causing economic damage and undermining the provision of services and the functioning of ecosystems (Gisp 2005). In addition, invasive exotic species are considered the second greatest threat and cause of global biodiversity loss (Wilson 1997, Lowe et al. 2000, Ziller 2001).

In the state of Rio Grande do Sul, in southernmost

Brazil, floristic and phytosociological surveys were conducted that included exotic plants (Silveira 1992, Carneiro and Irgang 2005, Mondin 2006, Medeiros and Focht 2007, Schneider 2007, Venzke et al. 2008, Guadagnin et al. 2009, Soligo et al. 2009, Cordazzo and Rosa 2010, Karam and Cardoso 2010, Burgueño et al. 2013, Rio Grande do Sul 2013, Rio Grande do Sul 2014, Rolim et al. 2015, Cordero et al. 2016). In these studies, exotic species in the process of biological invasion were found sporadically. Guadagnin et al. (2009) collected data from alien species in the Biome of Pampa, the grassland physiognomy in Uruguay, Argentina, and Brazil in Southernmost, where 365 species were found with spontaneous populations. The floristic of alien species of Silveira (1992) researches more than 1500 exotic plants. Schneider (2007) listed 270 vegetables exotics herbaceous and subspontaneous. In forests of state of Rio Grande do Sul, Mondin (2006) found 59 exotic species. Carneiro and Irgang (2005) studied the geographical origin of the vascular flora of the municipality of General Câmara, and found that 32% were non-native species from around the world, and several pantropical and pansubtropicals. Medeiros and Focht (2007) wrote about the invasive *Eragrostis plana* Nees, an aggressive Poaceae invasive in grassland of Rio Grande do Sul.

In Brazil of Southernmost, in the urban areas of maritime dunes of Cassino's Beach, Cordazzo and Rosa (2010) found half (35 spp.) of the plant species exotic, originating as ornamentals. Cordero et al (2016) studied the phytossociology of the shrub *Ulex europaeus* in a forest–grassland mosaic and found that this shrub it cover 10.1% of the total area studied. In a literature survey of alien herbaceous plants and shrubs, Rolim et al. (2015) found that most species have geographical origin in Central Europe and predominantly reproduce by small seeds or fruits. The authors also observed a lack of data on natural ecosystems in several regions of the state.

The ecological problem of the biological invasion is governed by Brazilian law through the National Biodiversity Policy (Brasil 2002) and in Rio Grande do Sul, by state law (Rio Grande do Sul 2013). The federal decree points out the need for inventory and mapping of invasive exotic species to guide studies evaluate of the generated environmental impacts and control actions (Brasil 2002). State law prohibits the cultivation of and establishes control rules for 99 species of plants, algae, fish, invertebrates, and terrestrial vertebrates. Thus, we contribute to the knowledge of non-native species by surveying of trees, arborescents and woody shrubs into forest and grassland physiognomies in the municipality of Pelotas, southernmost Brazil.

Methods

Study area. The study area was vegetation in the municipality of Pelotas, in southernmost Brazil. (Fig. 1). The native vegetation is classified into 2 phytogeographical regions: (1) areas of Pioneer Formations with fluvial influence and distributed in the Coastal Plain geological unit (This region of the landscape matrix is formed by grassland vegetation, wetland vegetation, lagoon and clumps of tree); and (2) Semideciduous Seasonal Forest, on the eastern slope of the Shield of Rio Grande do Sul geological unit (IBGE 1986).

Data collection. This survey of the exotic species with tree, arborescents and woody shrub was part of a larger study including native vegetation in Pelotas. At moment, the richness of native plants in Pelotas is 148 species tree, arborescents and woody shrub (Venzke 2012). The list of species was estimated by the method of walking in different transects and others phytossociological data at 26 sites with forest and grassland vegetation. (Fig. 1, Table 1). The transversal method is performed by walking through the same physiognomy of vegetation, noting species (Filgueiras et al 1994).

The survey of the exotic species in fragmented habitats consisted of 28 transects in the phytogeographic unit of the Semideciduous Seasonal Forest unit and 9 transects in Areas of Pioneer Formations. Sampling time was 596 h. In the Semideciduous Seasonal Forest, sites were in riparian forest and slope forests, as well as abandoned mines and plantations of Pinus and Eucalyptus. In areas of Pioneer Formations, sites were in sandy and swamp forest, in mosaic of grassland–forest, alongside roads, and in urban areas.

These fragmented habitats were at different successional stages or were anthropic areas around abandoned houses, in orchards, in abandoned plantation forests, along roads, and in abandoned rock and sand quarries. We included in the sample species of trees, arborescents, shrubs, and climbers. We classified trees as having a minimum height of 6 m and diameter at breast height (DBH) of at least 5 cm, and arborescents having heights between 3 m and 6 m.

The plants were identified using popular knowledge and by consultating the herbarium of the Federal University of Pelotas (PEL). We classified exotic species in the field following Richardson et al. (2000) and Zenni and Ziller (2011), and reserch in database about the theme (Gisp 2005, Mondin 2006, Zenni and Ziller 2011, Rio Grande do Sul 2013, Australian Invasive Species Program 2015, Hear 2014, Instituto Horus 2015, Issg 2015). Two categories were used. Naturalized exotic plants are those with scattered individuals, usually near adult plants. However, invasive exotic plants are those having many seedlings, often at a considerable distance from the parent plant, reproducing and spreading in the environment and advanced over natural and/or anthropic habitats (Richardson et al. 2000). We classified exotic species by their anthropic use. Ornamental, wood, food and hedges. Ornamental: planted for shade or to beautify parks, gardens, streets and avenues. Wood: planted for use as firewood or lumber. Food: planted for consumption of edible fruits and seeds. Hedges: planted to divide areas, such as farms, as living fences.

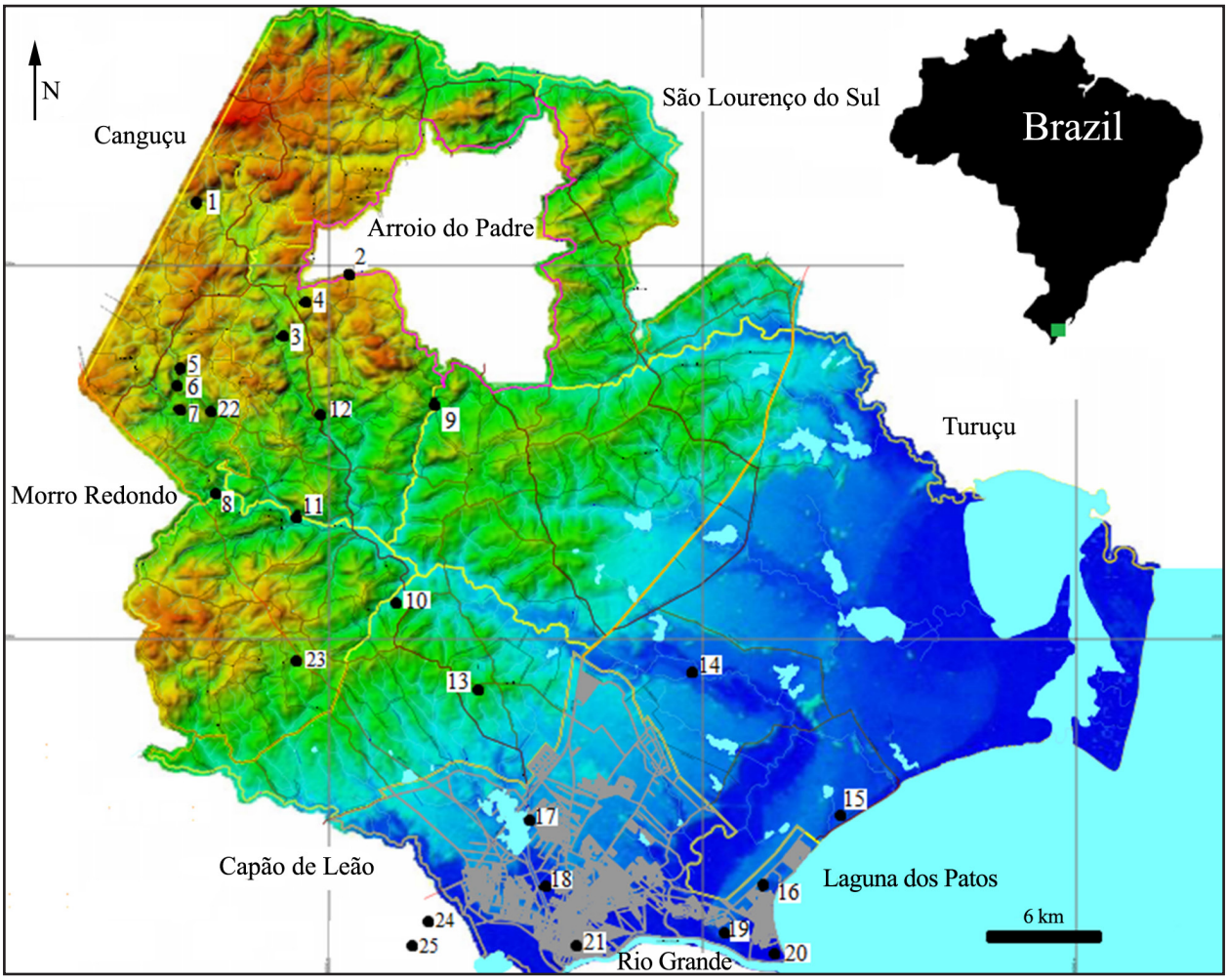

Figure 1. Location map fragments in the Municipality of Pelotas, Rio Grande do Sul State, Brazil. ● = collection points. Adapted from relief map of the Prefeitura Municipal de Pelotas (2006). Numbers refer to collection sites in Table 1.

Results

The survey resulted in 26 exotic species, 22 genera and 17 families (Table 2). There are 19 trees, 5 arborescents, 1 shrub, and 1 climber. The richest family was the Fabaceae, with 4 species, followed by Rutaceae with 3 species, and Rosaceae and Pinaceae with 2 each. We found 2 native species from other phytogeographic regions of Rio Grande do Sul state, *Ceiba speciosa* (A.St.-Hil., A.Juss. & Cambess) Ravenna and *Araucaria angustifolia* (Bertol.) Kuntze, from the Deciduous Seasonal Forest and Mixed Ombrophilous Forest, respectively. Anthropic usages are listed in the Table 1 (see also Fig. 2). The ornamental usage was the most common. For 84% of the species shown there was no focal point of biological invasion, and we consider these to be naturalized exotic species.

We observed that *Psidium guajava* L., *Ligustrum japonicum* W.T. Aiton, *Morus nigra* L., *Hovenia dulcis* Thunb., *Eriobotrya japonica* (Thunb.) Lindl., *Acacia mearnsii* De Wild., *Melia azedarach* L., *Lonicera japonica* Thumb., *Prunus persica* (L) Batsch, and *Citrus* genus spp. were naturalized, usually in anthropic environment. Only the genus *Citrus*, including *C. limonia* Osbeck and *C. reticulata* Blanco, was observed in regenerating native forests in places far away from peridomestic and/or anthropized areas.

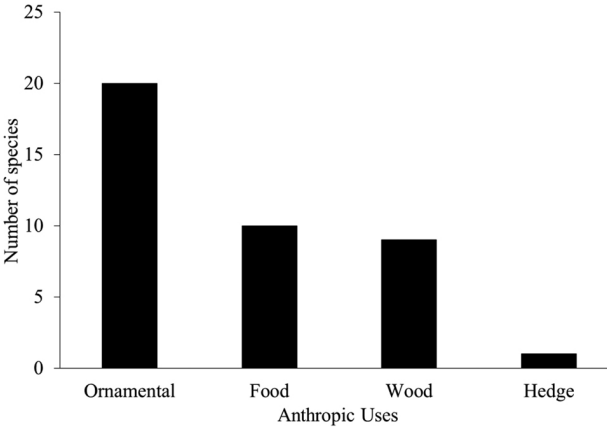

Figure 2. Anthropic uses for exotic species observed in fragments of native vegetation in the municipality city of Pelotas, Rio Grande do Sul state, Brazil.

However, currently, invasive exotic species at an advanced stage of infestation has been observed for species *Pinus elliottii* Engelm., *Pinus taeda* L., *Pittosporum undulatum* Vent. and *Ulex europaeus* L. *Pinus* species have a preference for grasslands (Fig. 3a, 3c). The largest foci area of infestation was observed in open grasslands of

Table 1. Characteristics of collection points of study the exotic species in the municipality of Pelotas, Rio Grande do Sul, Brazil. Estimated area = estimated area of the fragment; s = Semideciduous Seasonal Forest; r = areas of pioneer formations (Restinga Forest).

No. on map	Name location	Estimated area (ha)	Vegetation type	Characteristics of floral physiognomy	Hours of walking
1	Arroio Pelotas - Stream Arroio Bonito	1.8	s	Mature riparian vegetation in the upper reaches of the Arroio Pelotas	4.5
2	City of Arroio do Padre	0.2	s	Riparian forest in early succession (10 years abandoned)	24
2	City of Arroio do Padre	0.5	s	Riparian vegetation in secondary succession (50 years abandoned)	32
2	City of Arroio do Padre	0.5	s	Primary forest with cut wood trees for farm.	36
3	Stream Quilombo in Marini	3.1	s	Secondary riparian forest with cattle in the middle course of the Arroio Pelotas.	5
4	*Eucalyptus* Colônia Arroio do Padre	2.3	s	Eucalyptus plantations with low density and natural regeneration of native species	2
5	Colonia Maciel train tunnel	2.6	s	Secondary riparian forest with cattle in the middle course of the "stream Pelotas"	7
6	Eucalyptus train tunnel	2.8	s	Eucalyptus plantations with low density and natural regeneration of native species	2
7	Templo das Águas in Colonia Maciel	2.1	s	Riparian Forest secondary in the middle course of Arroio Pelotas	9
8	Collection point 13 ciliary	6.9	s	Ciliary forest in mature stage	10
8	Collection point 13 slope	9.6	s	Secondary forest on mountain slope	6
9	Stream Andrade	4.5	s	Riparian forest early secondary	6
10	Small farm Panamar - ciliary	4.4	s	Riparian Forest secondary in the middle course of Arroio Pelotas	7.5
10	Small farm Panamar - Slope	4.2	s	Pasture abandoned and forest of slope	4
11	Bridge Cordeiro de Farias	0.1	s	Secondary forest in the high slope of the topography	24
11	Bridge Cordeiro de Farias	0.1	s	Secondary forest in the middle slope of the topography	24
11	Bridge Cordeiro de Farias	0.1	s	Secondary riparian forest middle course of Arroio Pelotas	24
11	Bridge Cordeiro de Farias	0.1	s	Secondary forest with cattle on the high slope of the topography	36
11	Bridge Cordeiro de Farias	0.1	s	Secondary forest with cattle on the middle slope of the topography	24
11	Bridge Cordeiro de Farias	0.1	s	Riparian forest degraded by cattle	18
11	Bridge Cordeiro de Farias	30	s	Different forest fragments of secondary riparian forest	23
12	Village of Bacchini - Cachoeira do Paraíso	5.4	s	Secondary forest on mountain slope	9
13	Stone-pit of Climbers in Monte Bonito	2.3	s	Natural regeneration forest in mine of rocks abandoned after 100 years	4
14	Stream Pelotas - low course	5.1	r	Riparian Forest secondary in low course of Arroio Pelotas	9
15	Mata do Totó forest	160	r	Restinga forest sandbank and swamp in advanced succession stage	70
16	Village Mariana of Laranjal Beach	2.8	r	Restinga secondary forests in urban areas	3
18	Cannal do Santa barbara	1	r	Forest regeneration in urban drainage	2.5
19	Dunes of Beach Laranjal	46.3	r	Grassland and restinga forest sandbank and swamp	4
20	Pontal da Barra of Laranjal Beach	6.1	r	Restinga forest swamp with cattle	3
21	Terrain fenced in urban area	0.8	r	Natural regeneration in fruit orchard abandoned in downtown of Pelotas	7
22	Municipal Park Farroupilha	7.4	s	Mature forest on mountain slope	1.5
23	*Pinus* in Cascata	1.4	s	Crops area abandoned with use the *Pinus* for wind-break	2
24	Stone-pit State of DEPREC	9.6	s	Regeneration forest and individuals isolated in mine of rocks abandoned after 10 years	7
25	Centro Experimental da Palma-UFPel	50	s	*Eucalyptus* plantation experiments with abandoned secondary forests.	40
25	Centro Experimental da Palma-UFPel	40	s	*Pinus* plantation experiments with abandoned secondary forests.	40
—	Roads and grassland	42km	r	Beside of roads with forest and grasslands.	6

the Coastal Plain, near forest plantations and windbreaks of pine (Fig. 3). *Pinus elliottii* and *P. taeda* occurred on cropland and/or pastures within the Semideciduous Seasonal Forest and in abandoned stone and sand quarries. *Ulex europaeus* occurred on roadsides, and in grasslands used as pastures (Fig. 4a).

We observed *Pittosporum undulatum* in open areas in the early stages of forest succession of Semideciduous Seasonal Forest fragments and in shaded understory (Figs 3d, 4c, 4d).

Discussion

Thus as ornamentals is the primary means worldwide by which exotic plants become invasive. This is pattern was seen in other studies (Mondin 2006, Cordazzo and Rosa

Table 2. List of exotic woody species in the municipality of Pelotas, Rio Grande do Sul state, Brazil. O = ornamental, W = wood, F = food, H = hedge. *observed as invasive species. **Herbarium PEL = Federal University of Pelotas.

Family/Species	Portuguese name	Voucher**	Use	Habit	Geographical origin
Araucariaceae					
Araucaria angustifolia (Bertol.) Kuntze	pinhão, araucária	3.176	O, W, F	Tree	Mixed Ombrophilous Forest (Brazil)[1]
Caprifoliaceae					
Lonicera japonica Thumb.	madre-silva	1.384	O	Climber	Asia (Japan)[3]
Euphorbiaceae					
Ricinus communis L.	mamona	25.942	O	Arborescent	Tropical Africa; NE Africa[3, 4, 6]
Fabaceae					
Acacia longifolia (Andr.) Willd.	acacia-trinervis	25.941	O	Tree	Tasmania; E Australia[5, 6]
Acacia mearnsii De Wild.	acacia-negra	25.940	O, W	Tree	SE Australia[5, 6]
Leucaena leucocephala (Lam.) de Wit	leucena	20.039	O, W	Tree	Central America and Mexico[4, 6]
Ulex europaeus L.*	tojo	768	O, H	Shrub	Western and central Europe[6]
Lauraceae					
Cinnamomum camphora (L.) J. Presl	canfora	—	O	Tree	Asia (China; Taiwan; Korea)[14]
Malvaceae					
Ceiba speciosa (A.St.-Hil., A.Juss.) Ravenna	paineira	22.763	O	Tree	Decidual Seasonal Forest (Brazil)[2]
Meliaceae					
Melia azedarach L.	cinamomo	4.571	O, W	Tree	Himalaya; India; China[6, 7]
Moraceae					
Morus nigra L.	amoreira	23.154	O, F	Tree	China[6, 13]
Myrtaceae					
Eucalyptus spp.	eucalipito	—	W	Tree	Oceania[8]
Psidium guajava L.	goiaba	22.726	F	Tree	Tropical America[8]
Syzygium cumini (L.) Skeels	jambolão	22.625	O, F	Tree	S Asia[4]
Oleaceae					
Ligustrum lucidum W.T.Aiton	ligustro	1.429	O	Tree	China[7]
Pinaceae					
Pinus elliottii L.*	pinus, pinheiro	26.499	O, W	Tree	SE United States[7, 9, 12]
Pinus taeda L.*	pinus, pinheiro	-	O, W	Tree	SE United States[9, 12]
Pittosporaceae					
Pittosporum undulatum Vent.*	cafezinho	25.941	O, W	Tree	Australia[2]
Platanaceae					
Platanus × *acerifolia* (Ait.) Willd..	plátanu	-	O	Tree	Europe[13]
Rhamnaceae					
Hovenia dulcis Thunb.	uva-do-japão	26.500	O, W, F	Tree	Asia (India; Japan)[6, 7]
Rosaceae					
Eriobotrya japonica (Thunb.) Lindl.	ameixa-amarela	23.155	O, F	Tree	Japan; China[6,7]
Prunus persica (L.) Batsch	pêssego	22.767	F	Arborescent	S Asia[10]
Rutaceae					
Citrus × *aurantium* L.	laranja	22.637	F	Arborescent	China[10]
Citrus limonia Osbeck	limão	22.672	F	Arborescent	SE Asia[4, 10]
Citrus reticulata Blanco	bergamota	23.157	F	Arborescent	NE India; S China[10, 11]
Salicaceae					
Salix babylonica L.	salso-chorão	26.498	O	Tree	Asia (China; Iran)[2]

[1]Rizzini 1997; [2]Marchiori 2000; [3]Schneider 2007; [4]Leão *et al.* 2011; [5]Marchiori 2007; [6]GISP 2005; [7]Backes and Irgang 2004; [8]Marchiori and Sobral 1997; [9]Marchiori 2005; [10]Webber 1967; [11]Donadio *et al.* 1998; [12]Mattos 198-; [13]Marchiori 1997; [14] Langeland et al. 2008.

2010). Guadagnin et al. (2009) noted that there are no records of exotic woody plants introduced accidentally to the Pampas biome. All woody plants were introduced intentionally for some anthropic use, and that half of the species introduced for ornamental purposes became invasive over time should be considered dangerous (Ziller 2001). Mondin (2006) comments that more research about the greater use of native flora for ornamental, fruits, and wood is necessary

Pittosporum undulatum and *Pinus* spp. are frequent in urban and rural afforestation in the region of our study, and this tradition of using exotic plants in the afforestation does not value native biodiversity, favoring the development of a culture distanced from the surrounding natural environment (Leão et al. 2011). Furthermore, forestation with exotic trees can work as a source of propagules for biological invasions (Dehnen-Schmutz et al. 2007, Blum et al. 2008). Reforestation with native species should be encouraged to improving the natural environment and to avoid possible future biological invasions. The state law of Rio Grande do Sul (2013) established procedures and standards to prevent and control biological invasions.

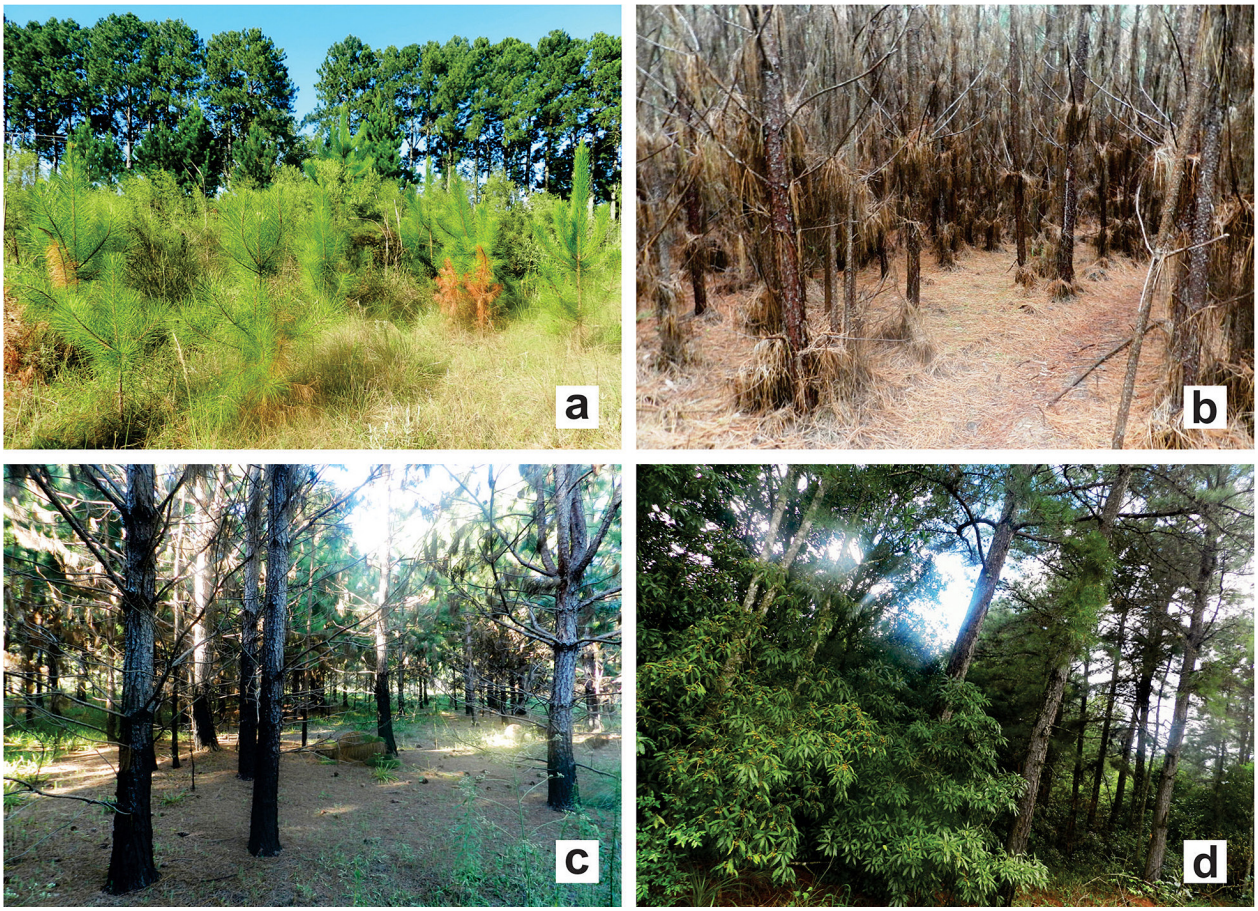

Figure 3. Exotic invasive species in the municipality of Pelotas, RS, Brazil. a. Seedlings in annual crops abandoned and trees in the background matrices of a windbreaker. b. Natural regeneration in heavily thickened area after harvest of pine trees. c. Understory in areas of fossil dunes on the Coastal Plain. d. Canopy of mature individuals of *Pinus* with *Pittosporum undulatum* on the edge of the fragment.

Under this law, cultivation of some species such as *Acacia longifola*, *Hovenia dulcis*, *Lonicera japonica*, *Pittosporum undulatum*, and *Ulex europaeus* are prohibited in farming. Another category of law is that alien species may be used under controlled conditions such as *Pinus* spp., *Acacia mearnsii*, *Leucaena leucocephala*, *Morus nigra* and *Syzygium cumini*.

Although some naturalized species do not show characteristics of invasive plants, which spreads throughout the environment, they are cited in other regions of Brazil and in the world, behaving as biological invasive (Australian Invasive Species Program 2015, Hear 2014, Instituto Horus 2015, Issg 2015, Rio Grande do Sul 2013, Zenni and Ziller 2011). Sometimes, the naturalized species present a long-term pattern of pre-infestation, before the explosive invasion (Odum 2001). This principle shows the necessity to accompany exotic species for preliminary detection of the biological invasion process. These species are not currently spreading in the studied sites, citing *Acacia longifolia*, *Leucaena leucocephala*, *Melia azedarach*, *Ligustrum japonicum* and *Eriobotrya japonica*. For this group of plants, monitoring is necessary, for the possibility of biological invasion in the future.

Biological invasion of *Pinus* in grassland environments is an expected pattern. Its regeneration is not being sampled in the understory of native forests and plantations of the species (Lombardi and Motta-Junior 1992, Oberhauser 1997, Soligo et al. 2009, Venzke et al. 2012). This reinforces such genus *Pinus* as an invader of grasslands (Ziller and Galvão 2002, Gisp 2005, Soligo et al. 2009, Falleiros et al. 2011, Leão et al. 2011, Zenni and Ziller 2011).

The infestation of *Pittosporum undulatum* in the understory of native forests was observed in Australia, Portugal and Brazil (Gleadow and Ashton 1981, Alves et al. 2003, Karam and Cardoso 2010, Zenni and Ziller 2011, Mielke et al. 2015). The specie in the Semideciduous Seasonal Forest in the municipality of Pelotas had the highest importance values in three forest fragments (Karam and Cardoso 2010). The invasion of *P. undulatum* in native ecosystems is conditioned by allelopathy, rapid dispersal, early seed production and rapid growth, forming high densities in the canopy that reduce the intensity of luminosity, suppressing the survival and growth of native species that are tolerant to shade (Goodland and Healey 1996).

In the studied region, the use of shallow cutting and burning for pasture renovation is very common for farmers. This practice benefits the gorse *Ulex europaeus*, since it accelerates the process of invasion. This is explained once the species sprouts with multiple stems, maximizing the occupation of the area and forming dense

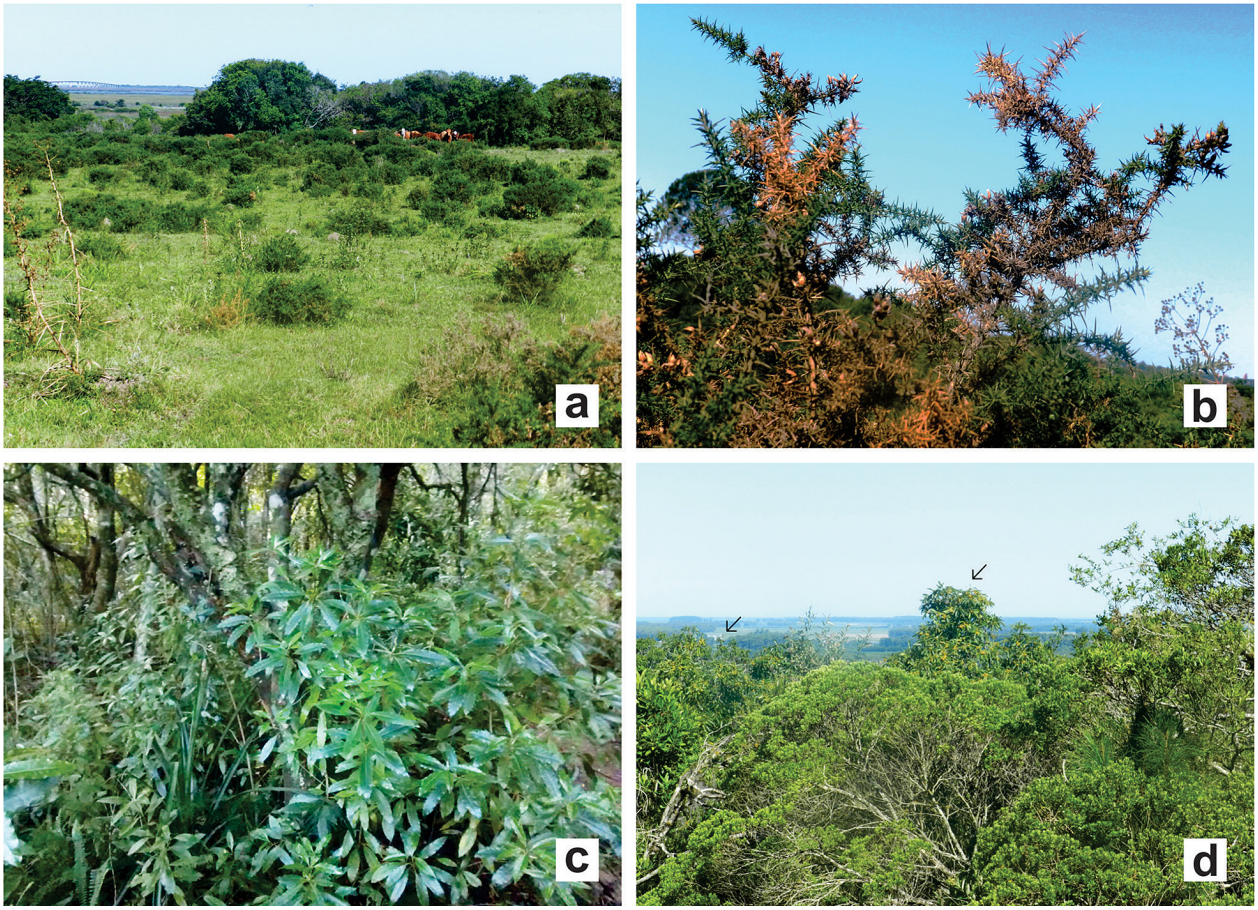

Figure 4. Exotic invasive species in the municipality of Pelotas, RS, Brazil. a. Grazing field invaded by *Ulex europaeus* in the Coastal Plain. b. *Ulex europaeus* branch full of thorns. c. Seedling *Pittosporum undulatum* inhabiting the understory of Semideciduous Seasonal Forest. d. Fragment infested of *Pittosporum undulatum* (arrows).

bushes (Zielke et al. 1992). As illustrated in Figure 4b, *U. europaeus* has numerous spines and forms dense clumps, which decreases natural pasture and become insurmountable by animals and humans (Rees and Hill 2001, Gisp 2005). Furthermore, seeds of the species germinate best if subjected to fire at high temperatures and for prolonged time (Zielke et al. 1992, Mcalpine and Timmins 2002). The seed bank of the soil may continue to germinate after 30 years, being extremely difficult to eradicate it from pastures (Lee et al. 1986). The fire, besides benefiting germination, provides open sites for establishment of *U. europaeus*. As Johnson (2001) highlights, the expansion of established gorse bushes scrub into the areas of natural grasslands after fire. Cordero et al (2016), in the study of the structure of mosaics community of forests and fields in the region, observed that *Ulex* did not invade native forests. However, the species invaded planted forests and highly grazed fields. The authors found out in the understory of *Ulex* few species and more homogeneous populations than outside the understory of *Ulex*. The woody species were more abundant in the *Ulex* canopy, but it was a group of pioneers and ruderal species. Resuming, the invasion of *U. europaeus* changes the successional vegetables, affecting the cover and diversity of native plants community.

The species nowadays have focus on invaders in the municipality of Pelotas, *Pinus* spp., *Ulex europaeus* and *Pittosporum undulatum*, already cited as invasive for the studied region (Mondin 2006, Zenni and Ziller 2011, Rio Grande do Sul 2013). The state law for *Pinus* (Rio Grande do Sul 2014) prohibits the use as windbreak, shading and thermal comfort, ornamentation of urban areas and roads, environmental recuperation and other purposes that are not specific to forest production. Still, for forest production, for *Pinus* plantations, environmental licensing and permanent control methods of dispersion into the environment are required. *Ulex europaeus* and *Pittosporum undulatum* cultivation is prohibited in any situation (Rio Grande do Sul 2013).

It must be emphasized that economic costs of controlling exotics invaders are growing with the passage of time. In this way, precaution is the most efficient strategy to face and prevent biological invasions (Hobbs and Humphries 1995, Ziller et al. 2007). The precaution generates lower economic costs and the chances of solving the problems are greater when compared to control strategies after biological invasion is already established (Leão et al. 2011).

Currently, it is necessary to seek strategies for management of invasive species on ecosystems to eradicate or even reduce the infestation and control the geographic expansion of these species. Moreover, the use of inva-

sive exotic species in urban and rural afforestation and degraded areas recovery projects is not recommended. Other studies are necessary to evaluate the exotic species of herbaceous stratum to identify possible biological invaders. Some invasive exotic herbaceous species around the world have been identified inhabiting the ecosystems in the region (*Asparagus setaceus* Kunth (Jessop), *Impatiens walleriana* Hook.f., *Cyperus esculentus* L. and *Cynodon dactylon* L. (Pers.).

Acknowledgements

We thanks the Scientific Initiation Program at the Catholic University of Pelotas (BIC-UCPEL) and the Research Support Foundation of the State of Rio Grande do Sul (CAPES/FAPERGS), for the Scholarship of the first author throughout the completion of this study. To the field assistants in the persons of Alisson Andreu, Aline Ritter Curti, Carla Franciele Spohr, Felipe Borges Teixeira, Francisco Junior, Gabriel Kaster Herter, João Duarte Schuch, Larissa Padilha, Miriam Cristina Schmidt Priebe, Rafael Paiva Duarte, João Vicente da Luz Silveira, Vinícius Leite and trainees of the laboratory of biology and ecology at the Catholic University of Pelotas.

References

Alves JMCD, Monjardino J, Moreira I (2003) Infestantes ambientais no Parque da Pena (Sintra). Anais do Instituto Superior de Agronomia: 271–284.

APG III (2009) An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG III. Botanical Journal Linnean Society 161 (2): 105–121. https://doi.org/10.1111/j.1095-8339.2009.00996.x

Australian Invasive Species Program (2015) http://www.environment.gov.au/biodiversity/invasive/weeds/index.html. Accessed on: 2015-8-25.

Backes P, Irgang B (2004) Árvores Cultivadas do Sul do Brasil: Guia de Identificação e Interesse Paisagístico das Principais Espécies Exóticas. Paisagem do Sul, Porto Alegre, 205 pp.

Blum CT, Borgo M, Sampaio ACF (2008) Espécies exóticas invasoras na arborização de vias públicas de Maringá, PR. Revista SBAU 2 (3): 78–97.

Borokini TI (2011) Invasive alien plant species in Nigeria and their effects on biodiversity conservation. Tropical Conservation Science 4 (1): 103–110. http://doi/abs/10.1177/194008291100400110

Brasil (2002) Decreto Federal 4.339, of Aug. 22, 2002 Institui princípios e diretrizes para a implementação da Política Nacional da Biodiversidade. http://www.planalto.gov.br/ccivil_03/decreto/2002/D4339.htm. Accessed on: 2015-8-25.

Burgueño LET, Quadro MS, Barcelos AA, Saldo PA (2013) Impactos ambientais de plantios de *Pinus* sp. em zonas úmidas: o caso do Parque Nacional da Lagoa do Peixe, RS, Brasil. Biodiversidade Brasileira 3 (2): 192–206.

Carneiro AM, Irgang BE (2005) Origem e distribuição geográfica das espécies ruderais da Vila de Santo Amaro, General Câmara, Rio Grande do Sul. Iheringia, Série Botânica. 60: 175–188.

Cordazzo CV, Rosa LS (2010) Plantas exóticas e invasoras nas dunas costeiras da Praia do Cassino (RS), Brasil. Fepam em Revista 4 (1): 4–11.

Cordero RL, Torchelsen FP, Overbeck GE, Anand M (2016) Invasive gorse (*Ulex europaeus*, Fabaceae) changes plant community structure in subtropical forest–grassland mosaics of southern Brazil. Biological Invasions. 18: 1629–1643. https://doi.org/doi:10.1007/s10530-016-1106-5

Cronk QCB, Fuller JL (1995) Plant Invaders: The Threat to Natural Ecosystems Worldwide. Chapman & Hall, London, 241 pp.

Dehnen-Schmutz K Perrings JTC, Williamson M (2007) The horticultural trade and ornamental plant invasions in Britain. Conservation Biology 21 (1): 224–231. https://doi.org/10.1111/j.1523-1739.2006.00538.x

Delnatte C, Meyer J (2011) Plant introduction, naturalization, and invasion in French Guiana (South America). Biological Invasions 14 (5): 915–927. https://doi.org/10.1007/s10530-011-0129-1

Donadio LC, Stuchi ES, Cyrillo FLL (1998) Tangerinas ou mandarinas. Boletim Citrícola 5: 1–40.

Falleiros RM, Zenni RD, Ziller SR (2011) Invasão e manejo de *Pinus taeda* em campos de altitude do Parque Estadual do Pico Paraná, Paraná, Brasil. Floresta 41 (1): 123–134. https://doi.org/10.5380/rf.v41i1.21193

Filgueiras TS, Brochado AL, Nogueira PE, Guala GF (1994) Caminhamento – um método expedito para levantamentos florísticos qualitativos. Instituto Brasileiro de Geografia e Estatística – IBGE Cadernos de Goeciências 12 (4): 39–43.

GISP (2005) América do Sul Invadida: A Crescente Ameaça das Espécies Exóticas Invasoras. Global Invasive Species Programme. GISP, Cape Town, 80 pp. http://www.institutohorus.org.br/download/gispSAmericapo.pdf. Accessed on: 2013-10-27.

Gleadow RM, Ashton. AD (1981) Invasion by *Pittosporum undulatum* of the forests of central Victoria: invasion patterns and plant morphology. Australian Journal of Botany 29 (6): 705–720. https://doi.org/10.1071/BT9810705

Goodland T, Healey JR (1996) The invasion of Jamaican montane rainforests by the Australian tree *Pittosporum undulatum*. University of Wales. http://pages.bangor.ac.uk/~afs101/iwpt/pittorep.pdf. Accessed on: 2014-3-8.

Guadagnin et al. (2009) Árvores e arbustos exóticos invasores no Pampa: questões ecológicas, culturais e sócio-econômicas de um desafio crescente. In: Pillar VP, Muller SC, Castilhos ZMS, Jacques AVA (Eds) Campos Sulinos-Conservação e Uso Sustentável da Biodiversidade. MMA Press, Brasília, 300–316.

HEAR (2014) Hawaiian Ecosystems at Risk Project. http://www.hear.org. Accessed on: 2014-10-24.

Hobbs RJ, Humphries SE (1995) An integrated approach to the ecology and management of plant invasions. Conservation Biology 9 (4): 761–477. https://doi.org/10.1046/j.1523-1739.1995.09040761.x

IBGE (Instituto Brasileiro de Geografia e Estatística) (1986) Vegetação: as regiões fitoecológicas, sua natureza e seus recursos econômicos: estudo fitogeográfico. In: Teixeira AB, Coura-Neto AB, Pastore U, Rangel-Filho ALR (Eds) Levantamento de Recursos Naturais. IBGE Press, Rio de Janeiro, 541–632.

Instituto Horus (2016) Base de Dados de Espécies Invasoras no Brasil. 2015. http://i3n.institutohorus.org.br. Accessed on: 2016-7-26.

ISSG (2015) Invasive Species Specialist Group. http://www.issg.org/database/welcome/. Accessed on: 2016-7-26.

Johnson PN (2001) Vegetation recovery after fire on a southern New Zealand peatland. New Zealand Journal Botany 39: 251–267. https://doi.org/10.1080/0028825X.2001.9512736

Karam LM, Cardoso JH (2010) Caracterização fitossociológica do impacto de *Pittosporum undutalum* Vent. em três fragmentos de Floresta Estacional Semidecidual (FESD) na encosta da Serra do Sudeste, Pelotas, RS. Boletim de Pesquisa e Desenvolvimento, Embrapa Clima Temperado 127: 1-19.

Langeland KA, Cherry HM, McCormick CM, Burks KA (2008) Identification and Biology of Nonnative Plants in Florida's Natural Areas, Second Edition. University of Florida https://plants.ifas.ufl.edu/wp-content/uploads/files/caip/SP257/Cinnamomum_camphora(SP257-089).pdf, Accessed on: 2016-7-26

Leão TCC, Almeida WR, Dechoum M, Ziller SR (2011) Espécies exóticas invasoras no Nordeste do Brasil: contextualização, manejo e políticas públicas. Centro de Pesquisas Ambientais do Nordeste

e Instituto Hórus de Desenvolvimento e Conservação Ambiental, Recife, 101 pp. http://cepan.org.br/uploads/file/arquivos/6b89ddc79ee714e00e787138edee8b79.pdf. Accessed on: 2014-4-28.

Lee WG, Allen RB, Johnson PN (1986) Succession and dynamics of gorse (*Ulex europaeus* L.) communities in the Dunedin Ecological District South Island, New Zealand. New Zealand Journal Botany 24: 279–292. https://doi.org/10.1080/0028825X.1986.10412678

Lombardi JA, Motta-Junior JC (1992) Levantamento do sub-bosque de um reflorestamento monoespecífico de *Pinus elliotti* em relação ás síndrome de dispersão. Turrialba 42 (4): 438–442.

Lowe S, Browne M, Boudjelas S, De Poorter M (2000) 100 of the Worst Invasive Alien Species: a Selection from Global Invasive Species Database. Invasive Species Society Group, IUCN. http://www.issg.org/database/species/reference_files/100English.pdf. Accessed: 2013-3-5.

Marchiori JNC (1997) Dendrologia das Angiospermas: das Magnoliáceas às Flacurtiáceas. Editora da Universidade Federal Santa Maria, Santa Maria, 271 pp.

Marchiori JNC (2000) Dendrologia das Angiospermas: das Bixáceas às Rosaceas. Editora da Universidade Federal Santa Maria, Santa Maria, 240 pp.

Marchiori JNC (2005) Dendrologia das gimnospermas. Editora da Universidade Federal Santa Maria, Santa Maria, 161 pp.

Marchiori JNC (2007) Dendrologia das angiospermas: leguminosas. Editora da Universidade Federal Santa Maria, Santa Maria, 199 pp.

Marchiori JNC, Sobral M (1997) Dendrologia das angiospermas: Myrtales. Editora da Universidade Federal Santa Maria, Santa Maria, 304 pp.

Mattos JR (198-) Espécies de *Pinus* Cultivados no Brasil. Grupo Editorial Chacarás e Quintais, São Paulo, 133 pp.

McAlpine K, Timmins S (2002) The effect of fire on bone-seed and gorse germination. Department of Conservation of New Zealand, Wallington, 1 pp. http://www.doc.govt.nz/Documents/science-and-technical/SciencePoster56.pdf. Accessed: 2016-7-25.

Medeiros RB, Focht T (2007) Invasão, prevenção, controle e utilização do capim-annoni-2 (*Eragrostis plana* Nees) no Rio Grande do Sul, Brasil. Pesquisa Agropecuária Gaúcha 13 (1–2): 95–104.

Mielke EC, Negrelle RRB, Cuquel FL, Lima WP (2015) Espécies exóticas invasoras arbóreas no Parque da Barreirinha em Curitiba: Registro e Implicações. Ciência Florestal 25 (2): 327–336. https://doi.org/10.5902/1980509818451

Mondin CA (2006) Espécies vegetais exóticas invasoras em florestas no Rio Grande do Sul. In: Os Avanços da Botânica no Início do Século XXI—57º Congresso Nacional de Botânica. Sociedade Botânica do Brasil, Gramado, 529–531.

Oberhauser U (1997) Secondary forest regeneration beneath pine (*Pinus kesiya*) plantations in the northern Thai Highlands: a chronosequence study. Forest Ecology Management 99 (1–2): 171–183. https://doi.org/10.1016/S0378-1127(97)00203-X

Odum EP (2001) Fundamentos de Ecologia. Fundação Calouste Gulbenkian, Lisboa, 927 pp.

Prefeitura Municipal de Pelotas (2006) Mapa Temático: Relevo. Secreataria de Urbanismo, Pelotas, 1:60,000.

Rees M, Hill RL (2001) Large-scale disturbances, biological control and the dynamics of gorse populations. Journal Applied Ecology 38 (2): 364–377. https://doi.org/10.1046/j.1365-2664.2001.00598.x

Richardson DM, Pysek P, Rejmánek M, Barbour MG, Panetta FD (2000) Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6: 93–107. https://doi.org/10.1046/j.1472-4642.2000.00083.x

Ricklefs RE (2009) A Economia da Natureza. Guanabara Koogan, Rio de Janeiro, 572 pp.

Rio Grande do Sul (2013) Portaria Sema nº 79, of Oct. 31, 2013. Reconhece a lista de espécies exóticas invasoras do estado do Rio Grande do Sul. http://www.sema.rs.gov.br/upload/arquivos/201612/23180118-portaria-sema-79-de-2013-especies-exoticas-invasoras-rs.pdf. Accessed on: 2018-1-15.

Rio Grande do Sul (2014) Instrução Normativa Sema nº 14, of Dec. 10, 2014. Estabelece procedimentos para o uso de *Pinus* spp. http://ww1.sema.rs.gov.br/conteudo.asp?cod_menu=427&cod_conteudo=9039. Accessed on: 2017-1-15.

Rizzini CT (1979) Árvores e Madeiras Úteis do Brasil: Manual de Dendrologia Brasileira. Universidade de São Paulo, São Paulo, 294 pp.

Rolim RG, Ferreira PMA, Schneider and AA, Overbeck GE (2015) How much do we know about distribution and ecology of naturalized and invasive alien plant species? A case study from subtropical southern Brazil. Biological Invasions 17: 1497–1518. https://doi.org/10.1007/s10530-014-0811-1

Schneider AA (2007) A flora naturalizada no estado do Rio Grande do Sul, Brasil: herbáceas subespontâneas. Revista Biociências 15 (2): 257–268.

Silveira N (1992) Levantamento preliminar das espécies exóticas de plantas no Estado do Rio Grande do Sul, Brasil. In: Congresso Florestal Estadual, Prefeitura Municipal de Nova Prata/Sec. Agric. Abast./Empresa Assistência Técnica do Rio Grande do Sul/CIENTEC/Universidade Federal de Santa Maria, 7° Congresso Florestal Estadual, Nova Prata, 441–485.

Soligo AJ, Vuaden E, Spuza EBA, Selle GL (2009) Dispersão natural de *Pinus* na Flora de São Francisco de Paula, RS. Caderno de Pesquisa, série Biologia 21: 20–30.

Venzke TS (2012) Florística de comunidades arbóreas no Município de Pelotas, Rio Grande do Sul, Brasil. Rodriguesia 63 (3): 571–578. https://doi.org/10.1590/S2175-78602012000300008

Venzke TS, Seibel GP, Cunha R, da Costa MAD (2008) Origem geográfica das espécies de uma comunidade de plantas encontradas em um terreno baldio no município de Pelotas, RS. In: XVII Congresso de Iniciação Científica, X Encontro de Pós-Graduação, UFPEL, 2008, Pelotas.

Venzke TS, Cunha JF, Martins SV, Neri AV (2012) Regeneração natural do estrato arbóreo sob talhão de *Pinus caribaea* var. *hondurensis*, Viçosa, MG, Brasil. Global Science and Technology 5 (3): 74–86.

Webber HJ (1967) History and development of the Citrus industry. In: Reuther W, Batchelor LD, Webber HJ (Eds) The Citrus Industry. University of California, Riverside, 1-39.

Wilson EO (1997) Biodiversidade. Nova Fronteira, Rio de Janeiro, 657 pp.

Zalba SM (2005) Introdução às invasões biológicas: conceitos e definições. In: Global Invasions Species Programme. América do Sul Invadida: a Crescente Ameaça das Espécies Exóticas Invasoras. Cape Town: Global Invasions Species Programme, Cape Town, 4–5.

Zenni RD, Ziller SR (2011) An overview of invasive plants in Brazil. Revista Brasileira de Botânica 34 (3): 431–446. https://doi.org/10.1590/S0100-84042011000300016

Zielke K, Boateng JO, Caldicott N, Williams H (1992) Broom and Gorse in British Columbia. British Columbia Ministry of Forests, Victoria, 27 pp. http://www.for.gov.bc.ca/hfp/publications/00042/broom-gorse.pdf. Accessed on: 2014-1-29.

Ziller SR (2001) Plantas Exóticas invasoras: a ameaça da contaminação biológica. Ciência Hoje 178 (12): 77–79.

Ziller SR, Galvão FF (2002) A degradação da estepe gramíneo-lenhosa no Paraná por contaminação biológica de *Pinus elliottii* e *Pinus taeda*. Floresta 32 (1): 42–47. https://doi.org/10.5380%2Frf.v32i1.2348

Ziller SR, Zalba ZM, Zenni RD (2007) Modelo para o Desenvolvimento de uma Estratégia Nacional para Espécies Exóticas Invasoras: Programa de Espécies Exóticas Invasoras para a América do Sul. The Nature Conservancy/Global Invasive Species Programme, Curitiba, 62 pp. http://www.institutohorus.org.br/download/Estrategia_nacional/Modelo_estrategia_nacional_port.pdf. Accessed on: 2016-5-25.