Revista Brasileira de Ciências Agrárias
ISSN (on line) 1981-0997
v.13, n.2, e5533, 2018
Recife, PE, UFRPE. www.agraria.pro.br
DOI:10.5039/agraria.v13i2a5533
Protocolo 5533 - 26/11/2017 • Aprovado em 09/04/2018

Urban and agricultural impacts in the structure and diversity of tree vegetation in riparian forest

Paulo Henrique Jung[1*], Flávia Gizele König Brun[2], Eleandro José Brun[2], Solon Jonas Longhi[2], Aline Paula Pastorio[2]

[1] Universidade Federal de Santa Maria. Santa Maria, RS, Brazil. * *In memorian*
[2] Universidade Tecnológica Federal do Paraná. Campus Dois Vizinhos, PR, Brazil. E-mail: flaviag@utfpr.edu.br (ORCID: 0000-0002-4268-6763); eleandrobrun@utfpr.edu.br (ORCID: 0000-0003-3832-1320); longhi.solon@gmail.com (ORCID: 0000-0002-5701-2139); aline_paula8@hotmail.com (ORCID: 0000-0002-1282-6702)

ABSTRACT: The study was conducted on the Água Turva Stream bank, in the Hydrographic Microbasin of the Jirau Alto River, in Dois Vizinhos county, Paraná state, aiming to evaluate the environmental impacts of the urban occupations and agricultural activities on the floristic composition and the phytosociological structure of the arboreal stratum of the riparian forest, to obtain information on species diversity and biological invasion, which will enable the establishment of future forest restoration programs. The data collect was realized in ten sample points demarcated along the stream, where 20 sample plots of 10.0 x 10.0 m (100.0 m^2) were demarcated, 10 in each stream margin. The species were identified and evaluated regarding the following variables: the CAP (Circumference at Breast Height) and total height of all the trees with CAP ≥ 15.0 cm (DBH ≥ 4.8 cm). The vegetation structure was analyzed based on the phytosociological estimators and the indexes of diversity, equability and environmental impact index of exotic species. It was concluded that the riparian forest of the Água Turva creek is quite impacted, both in the rural and urban areas, with invasion of exotic species, mainly *Hovenia dulcis* (japanese grape) and *Musa* sp. (banana tree).

Key words: biological invasion; forest species; stream; urban forest

Impactos urbanos e agrícolas na estrutura e diversidade da vegetação arbórea em floresta ciliar

RESUMO: O estudo foi realizado nas margens do Córrego Água Turva, na Microbacia Hidrográfica do Rio Jirau Alto, Dois Vizinhos-Paraná, com o objetivo de avaliar os impactos ambientais de ocupações urbanas e de atividades agrícolas na composição florística e a estrutura fitossociológica do estrato arbóreo da floresta ciliar, procurando obter informações sobre a diversidade de espécies e a invasão biológica, que possibilitem o estabelecimento de futuros programas de restauração florestal. A coleta de dados foi realizada em dez pontos amostrais demarcados ao longo do córrego, onde foram demarcadas 20 parcelas amostrais de 10,0 x 10,0 m (100,0 m^2), 10 em cada margem do córrego. Foram identificadas e avaliadas a CAP (Circunferência à Altura do Peito) e alturas totais de todos os indivíduos com CAP ≥ 15,0 cm (DAP ≥ 4,8 cm). A estrutura da vegetação foi avaliada com base nos estimadores fitossociológicos e nos índices de diversidade, equabilidade e índice de impacto ambiental de exóticas. Concluiu-se que a floresta ciliar do córrego Água Turva se encontra bastante impactada, tanto no meio rural como no meio urbano e, com invasão de espécies exóticas, principalmente *Hovenia dulcis* (uva-do-japão) e *Musa* sp. (bananeira).

Palavras-chave: invasão biológica; espécies florestais; riacho; floresta urbana

Introduction

The riparian forests can be defined as a vegetal formation that occurs in the riparian zone, that is, along watercourses, lakes, humid areas or flood areas (Martins, 2005). They play important environmental functions, such as preservation of water resources, geological stability, control of erosive processes, reduction of flood risk and slide of soil/rocks in slopes, biodiversity maintenance besides ensuring the population´s life quality and welfare and providing stunning landscapes (Paraná, 2012).

In order to guarantee these important environmental functions, the Federal Law nº 12.651 from May 25th, 2012 (Brazilian Forest Code) considers the margins among the watercourses as permanent preservation areas (APP´s), and their dimension varies according to the streams width (Paraná, 2012).

In addition, the federal legislation, as well as the state and municipality ones, imposes on cities the duty of preserving the remaining vegetation of riparian forests. However, due to the inefficient structure of surveillance and to the occupation of the protected areas by irregular settlements, this reality ends up being totally different. For instance, using the example of Sao Paulo city, it is estimated that more than one million people live in areas that should be protected (Araújo, 2002).

Currently, most of the Brazilian population is concentrated in the cities (Guerra & Cunha, 2011), and in Parana state, the urban population reaches 85.3% of the total (Mammarella et al., 2011). This justifies the urgency of raising the discussion about the environmental issue in the urban centers and its diffusion in the society, trying to reverse the environmental degradation process (Guerra & Cunha, 2011).

The municipality of Dois Vizinhos is the third biggest urban center in the Southwest region of Parana, just behind the municipalities of Pato Branco and Francisco Beltrao. As reported by the 2010 Census, it has 77.0% of its population living in the urban area, which represents 28.095 people (IBGE, 2010).

By analyzing the urbanization process in Brazil, it can be noticed that the uncontrolled growth of the urban centers, beside the lack of planning and appropriate infrastructure, led to many environmental impacts, mainly in stream margins (Falcão et al., 2013). Currently, the consequences of this process are easily recognized, as the common occurrence of great floods with severe damages, pollution of soil and water resources, rivers siltation, inexistence of riparian forests, species extinction, susceptibility to erosion and soil degradation, among other environmentally catastrophic effects.

In this context, the urban centers produce a great pressure on the water resources and on the soil quality (Hogan et al., 2012). This issue is associated, mainly, with the fast demographic growth and the lack of planning in the urban centers, which have led the cities to environmental chaos, charging society with great costs (Guerra & Cunha, 2011).

Thus, the recuperation of riparian forests assumes great importance, once many streams had their area reduced, aside from the deforestation and sealing of their margins, which resulted in erosive processes, rivers siltation, floods and soil and water pollution (Ceconi, 2010).

One of the actions of major importance in the recuperation of riparian forests is their reforestation, due to the protective function that the native vegetation plays on the water quality and reduction of soil loss by erosive processes (Ceconi, 2010). For that, it is necessary to know the floristic composition and phytosociological structure of the riparian forests to be restored, as well as the main conflicts and environmental impacts in the area, and the suitable species for the area. It turns up to be of a great importance the conduction of researches focusing on the riparian urban forests, mainly.

Therefore, the present paper aims to evaluate the influence of the environmental impacts of urban occupations and agricultural activities on the floristic composition and phytosociological structure of the tree layer in the riparian forest located at the Agua Turva creek, in the municipality of Dois Vizinhos, Parana state, Brazil, seeking for information about the species diversity and biologic invasion, that can enable the establishment of future forest restoration programs.

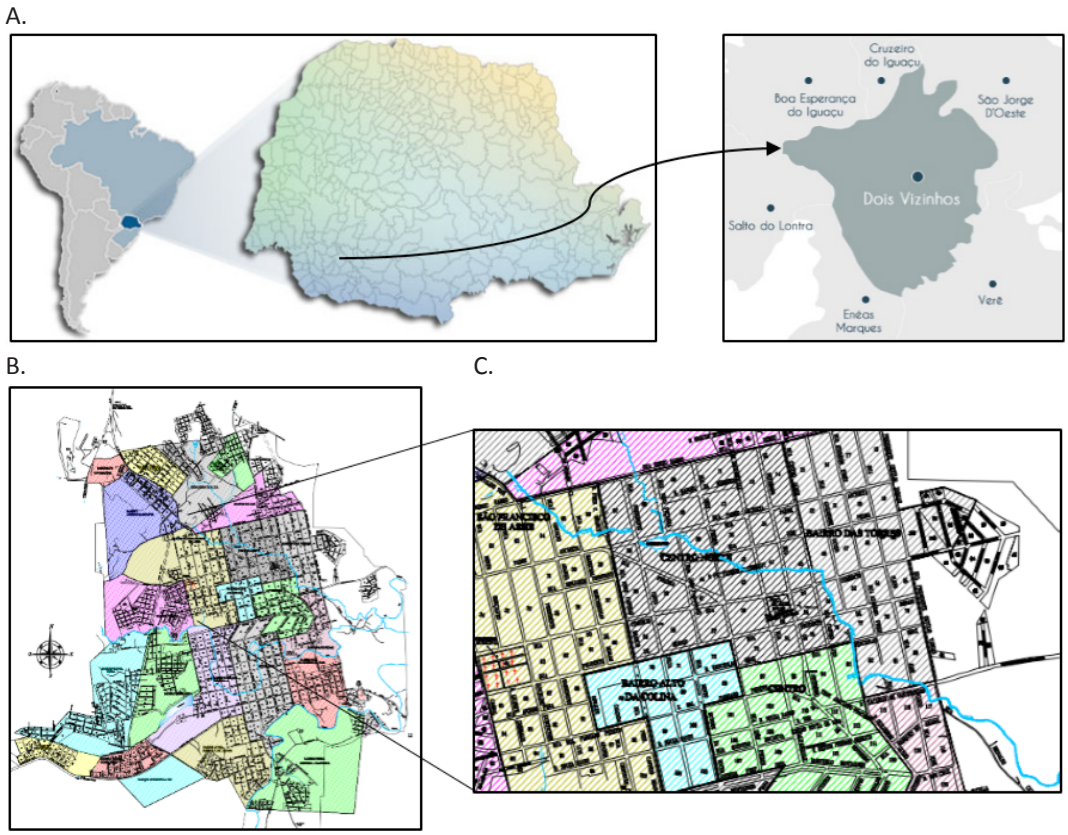
In this regard, the following hypothesis were analyzed: H1: the floristic composition and the phytosociological structure of the riparin forest, both in the urban and rural area, of the studied stream are preserved; H2: there are significant differences in the forest diversity between the urban and rural areas; H3: there is invasion of exotic species.

Material and Methods

This study was conducted on the margins of the Agua Turva creek, in the micro watershed of the Jirau Alto River, municipality of Dois Vizinhos, state of Parana, Brazil (Figure 1). The municipality is inserted in the third plateau of Parana, under the coordinates of 25° 44' 03'' and 25° 46' 05'' South and 53° 03' 01" and 53° 03' 10" West, with an average altitude of 500 m.a.s. and presence of relatively steep slopes, with declivity above 20.0% (Prefeitura Municipal de Dois Vizinhos, 2013). Its climate, according Köppen classification, is Cfa, and the current vegetation is composed of native forests fragments, characterized as a transition between Mixed Tropical Forest and Semideciduous Seasonal Forest (IGBE, 2012). The soils belong to the categories of Latosols, Argisols, Cambisol and Litholic (Pigosso et al., 2009).

The creek of Agua Turva has two main headwaters, one that is located in the Margarida Galvan neighborhood and another one that is located in the rural area of the municipality, with strong urban expansion. These two get together in the Luz neighborhood, where run across the North Centre, Torres neighborhood, agricultural area, and when it traverses this last area, the creek flows into the Dois Vizinhos River. Along the creek, it can be recognized the riparian forest suppressed by the housing and agricultural expansion, irregular settlements as well as erosive processes, deforestation, sewage discharge and garbage disposal.

The data collection was realized in ten (10) samples points along the Agua Turva creek, as the following: Point



Figures adapted from Biz et al. (2015) (A) and Prefecture of Dois Vizinhos (2015).

Figure 1. Localization of the municipality of Dois Vizinhos-Parana-Brazil (A); Urban area of Dois Vizinhos city (B) and the localization of the Agua Turva creek (C).

1 = main headwater of the Agua Turva creek in agricultural area; 2 = secondary headwater in agricultural area as well; 3 = pasture area with livestock access; 4 = agricultural area next to an irregular settlements occupation; 5 = agricultural area surrounded by native vegetation; 6 = urban area, on the surroundings of the Nossa Senhora de Lourdes cave; 7 = urban area with suppressed riparian forest; 8 = North Centre neighborhood of Dois Vizinhos city, with strong presence of banana trees; 9 = urban area, where the creek margins are almost totally occupied by households; 10 = end of urban perimeter with great declivity.

Regarding the floristic survey, ten plots of 10 x 10 meters (100 m²) were delimited in each margin of the stream. The plots delimitation in the field was realized with measuring tape, in places were the forest range reached up 10m. In the plots, the species were identified and evaluated regarding the CAP (Circumference at Breast Height) and total height of all the trees with CAP≥ 15.0 cm (DBH ≥ 4.8 cm). The circumferences and height measurements were carried out using a measurement tape and the hypsometer Vertex IV, respectively.

The species were identified *in loco* and, for the individuals that could not be identified in the field, botanic materials were collected in order to get identified in the Forest Herbarium of the UTFPR Campus Dois Vizinhos, counting on the help of specialists.

The vegetation structure was evaluated based on the parameters of absolute density (DA) and relative density (DR), absolute and relative frequency (FA and FR, respectively), absolute and relative dominance (DOA and DOR, respectively), importance value (VI), diversity index of Shannon-Wiener (H), maximum diversity (H´), equability index of Pielou (J´) and environmental impact index of exotic species (IIAE). For the last one, it was utilized the methodology described by Reaser & Meyerson (2007), Santana & Encinas (2008) and Andrade et al. (2009), which values vary from -1 to 1, and the closer to the negative extreme, the greater is the invasion level. It is calculated based on the following equation, where *P exotic* = VI of the exotic species; *P native* = VI of the native species; *P total* = VI of the total species (300)

Results

In the rural area, 46 species were observed belonging to 24 botanic families whereas in the urban area 24 species from 17 families were noticed (Table 1), demonstrating that the urban area has a lower species richness compared to the rural area. Among the species, there were seven exotic species, which corresponds to 15.22% of the individuals in the rural area, and nine species, which represents 37.5% of the individuals in the urban area.

In the rural zone, the Fabaceae Family revealed the greatest richness (6 species), followed by Meliaceae and

Table 1. Tree species sampled in the riparian forest localized in the urban and rural areas, in the Agua Turva creek, micro watershed of the Jirau Alto River, Dois Vizinhos – PR. 2015.

Families	Scientific names	Common names	ORI	AREA
Anacardiaceae	*Schinus molle* L.	Aroeira-piriquita	N	U
	Schinus terebinthifolius Raddi	Aroeira-vermelha	N	R
Annonaceae	*Annona cacans* Warm.	Araticum-cagão	N	R
Aquifoliaceae	*Ilex paraguariensis* A.St.-Hil.	Erva-mate	N	R, U
Araucariaceae	*Araucaria angustifolia* (Bertol.) Kuntze	Pinheiro	N	R
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	Coqueiro	N	R
Boraginaceae	*Cordia americana* (L.) Gottschling & J.S.Mill.	Guajuvira	N	R, U
Caricaceae	*Carica papaya* L.	Mamoeiro	E	U
Cyatheaceae	*Cyathea atrovirens* (Langsd. & Fisch.) Domin	Samambaiaçú	N	U
Euphorbiaceae	*Alchornea glandulosa* Poepp. & Endl.	Tanheiro	N	R
	Gymnanthes klotzschiana Müll.Arg.	Branquilho	N	R
	Sebastiania brasiliensis Spreng.	Branquilho-leiteiro	N	R
Fabaceae	*Bauhinia forficata* Link	Pata-de-vaca	N	R
	Bauhinia variegata L.	Pata-de-vaca	E	R
	Dahlstedtia muehlbergiana (Hassl.) M.J.Silva & A.M.G.	Farinha-seca	N	R
	Dalbergia frutescens (Vell.) Britton	Rabo-de-bugiu	N	R
	Leucaena leucocephala (Lam.) de Wit	Leucena	E	R, U
	Parapiptadenia rigida (Benth.) Brenan	Angico-vermelho	N	R, U
Lauraceae	*Nectandra lanceolata* Nees	Canela-amarela	N	R
	Nectandra megapotamica (Spreng.) Mez	Canela-preta	N	R, U
	Ocotea puberula (Nees et Martius) Ness	Canela-guaicá	N	R, U
	Ocotea pulchella (Nees & Mart.) Mez	Canela-lajeana	N	U
	Persea americana Mill.	Abacateiro	E	U
Loganiaceae	*Strychnos brasiliensis* (Spreng.) Mart.	Esporão-de-galo	N	R
Malvaceae	*Luehea divaricata* Mart. & Zucc.	Açoita-cavalo	N	R
Meliaceae	*Cabralea canjerana* (Vell.) Mart.	Canjerana	N	R
	Cedrella fissilis Vell.	Cedro	N	R
	Trichilia clausseni C.DC.	Catiguá	N	R
	Trichilia elegans A.Juss.	Pau-de-ervilha	N	R
Musaceae	*Musa* sp.	Bananeira	E	R, U
Myrtaceae	*Calyptranthes concinna* DC.	Guamirim	N	U
	Campomanesia guazumifolia (Cambess.) O.Berg	Sete-capotes	N	U
	Campomanesia xanthocarpa (Mart.) O.Berg	Guabiroba	N	R, U
	Eucalyptus spp.	Eucalipto	E	U
	Eugenia uniflora L.	Pitangueira	N	R
	Plinia peruviana (Poir.) Govaerts	Jaboticabeira	N	R
Oleaceae	*Ligustrum lucidum* W.T.Aiton	Ligustro	E	U
Phytolaccaceae	*Seguieria aculeata* Jacq.	Cipó-umbú	N	R
Primulaceae	*Myrsine coriacea* (Sw.) R.Br. ex Roem. & Schult.	Capororoquinha	N	R, U
	Myrsine guianensis (Aubl.) Kuntze	Capororoca	N	R
Rhamnaceae	*Hovenia dulcis* Thunb.	Uva-do-japão	E	R, U
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl.	Nespereira	E	U
Rubiaceae	*Psychotria* sp.	Psicotria	N	R
	Psychotria viridis Ruiz & Pav.	Chacrona	N	U
Rutaceae	*Citrus* x *aurantium* L.	Laranjeira	E	R
	Citrus x *limon* (L.) Osbeck	Limoeiro	E	R
	Citrus reticulata Blanco	Tangerina	E	R, U
	Zanthoxylum caribaeum Lam.	Mamica-de-cadela	N	R
Salicaceae	*Banara tomentosa* Clos	Guaçatunga-branca	N	R
	Casearia decandra Jacq.	Guaçatunga	N	R
	Casearia sylvestris Sw.	Chá-de-bugre	N	R
Sapindaceae	*Allophylus edulis* (A.St.-Hil. et al.) Hieron. ex Niederl.	Chal-chal	N	R, U
	Matayba elaeagnoides Radlk.	Camboatá-branco	N	R
Solanaceae	*Cestrum intermedium* Sendtn.	Mata-boi	N	R
Tiliaceae	*Luehea divaricata* Mart. & Zucc.	Açoita-cavalo	N	U
Urticaceae	*Cecropia pachystachya* Trécul	Embaúba	N	R
Verbenaceae	*Citharexylum solanaceum* Cham.	Tarumã-de-espinho	N	R
NI	Non identified		N	R
Tot. Rur.: 24 fam.	46 species			
Tot. Urb.: 17 fam.	24 species			

ORI = Origin (N=Native, E=Exotic); AREA = (R=Rural, U=Urban).

Rutaceae (4 species), Euphorbiaceae, Lauraceae, Myrtaceae and Salicaceae (3 species), Primulaceae and Sapindaceae (2 species). The other 16 families (66.67%) presented only one species. The Salicaceae Family had the highest number of individuals (19.67%), followed by Fabaceae (18.03%), Lauraceae (7.10%), Malvaceae (6.56%), Rhamnaceae (6.01%), Rutaceae (5.46%). Euphorbiaceae (4.92%), Myrtaceae (4.37%), Annonaceae (3.83%), Urticaceae (3.28%). These ten families gather 79.23% of the individuals. The other 15 families represent only 20.77% of the individuals (information extracted from Table 1).

In the urban area, the families that revealed the greatest richness were Lauraceae and Myrtaceae, with four species of three genders, followed by Fabaceae, with two species and two genders. The other 14 families (82.35%) had only one species. The Musaceae family came with the highest number of individuals (45.16%), followed by Rhamnaceae (13.71%), Myrtaceae (10.48%), Anacardiaceae and Lauraceae (5.65% each) and Oleaceae (4.84%). These six families totalize 80.65% of the individuals. The remaining 11 families express only 19.35% of the individuals (extracted from Table 1).

Between the rural and urban area, 12 families were found in both environments, which are the following: Anacardiaceae, Aquifoliaceae, Boraginaceae, Fabaceae, Lauraceae, Musaceae, Myrtaceae, Primulaceae, Rhamnaceae, Rubiaceae, Rutaceae and Sapindaceae. Regarding the occurrence of families in only one environment or another, 12 families were observed exclusively in the rural area (Annonaceae, Araucariaceae, Arecaceae, Euphorbiaceae, Loganiaceae, Malvaceae, Meliaceae, Phytolaccaceae, Salicaceae, Solanaceae, Urticaceae and Verbenaceae) and 4 families in the urban area (Caricaceae, Dicksoniaceae, Oleaceae and Tiliaceae).

About the species, 12 species were detected in both rural and urban regions, such as *Ilex paraguariensis*, *Cordia americana*, *Leucaena leucocephala*, *Parapiptadenia rigida*, *Ocotea puberula*, *Nectandra megapotamica*, *Musa* sp., *Campomanesia xanthocarpa*, *Myrsine coriacea*, *Hovenia dulcis*, *Citrus reticulata* and *Allophylus edulis*. Among these species, four are exotic, which are the leucena (*Leucaena leucocephala*), the banana tree (*Musa* sp.), the Japanese-grape (*Hovenia dulcis*) and the bergamoteira (*Citrus reticulata*).

In the rural area, 34 exclusive species were noticed, common in the regional riparian forests, and three of them are exotic, like the ornamental pata-de-vaca (*Bauhinia variegata*), the lemon tree (*Citrus* x *limon*) and the orange tree (*Citrus* x *auriculatum*). On the other hand, 12 species were found only in the urban area; most of them are introduced species and some of them are native species (*Schinus molle*, *Cyathea atrovirens*, *Ocotea pulchella*, *Calyptranthes concinna*, *Campomanesia guazumifolia*, *Psychotria viridis* and *Luehea divaricata*) and other five species are exotic (*Carica papaya*, *Persea americana*, *Eucalyptus* spp., *Ligustrum lucidum* and *Eriobotrya japonica*).

Regarding the rural zone, a total of 183 tree individuals were sampled (1830 ind ha^{-1}), which belong to 46 species, whereas a total of 124 tree individuals were observed in the urban region (1240 ind ha^{-1}), distributed in 24 species (Table 2). It is noticed that the species richness is lower in the urban area, as well as the tree density, as a consequence of the human degradation.

In the rural domain, the most notorious species in terms of structure in the riparian forest were *Casearia sylvestris*, *Luehea divaricata*, *Parapiptadenia rigida*, *Nectandra megapotamica*, *Hovenia dulcis*, *Dalbergia frutescens*, *Araucaria angustifolia*, *Myrsine coriaceae*, *Annona cacans*, *Gymnanthes klotzschiana*, *Bauhinia forficata*, *Strychnos brasiliensis*, *Cordia americana*, *Ocotea puberula* and *Cecropia pachystachya*, all of them with importance value (VI) higher than 2%. These 15 species were also highlighted by their density, dominance and frequency. They represent 70.70% of the importance value, 69.96% of the density (1,280 ind ha^{-1}), 56.85% of the frequency and 85.62% of the dominance (basal area of 40.8 $m^2.ha^{-1}$). Among these species, only the Japanese-grape is exotic (*Hovenia dulcis*), counting 6.01% of the individuals. The other 31 species (67.39%) represent only 29.3% of the VI, 30.04% of the individual's density, 43.15% of the frequency and only 14.38% of the dominance (basal area).

In the urban riparian forest, the highlighted species were *Musa* sp., *Hovenia dulcis*, *Eucalyptus* sp., *Ligustrum lucidum*, *Campomanesia xanthocarpa*, *Schinus molle*, *Parapiptadenia rigida*, *Cordia americana*, *Leucaena leucocephala*, *Citrus reticulata, Ilex paraguariensis, Ocotea pulchella* and *Allophylus edulis*, all of them with importance value (VI) higher than 1.93%. These 13 species are also highlighted by their density, dominance and frequency. They represent 84.76% of the importance value, 89.52% of the density (1110 ind ha^{-1}), 67.63% of the frequency and 97.14% of the dominance (basal area of 39.191 $m^2.ha^{-1}$). It is observed that 06 out of these 13 species are exotic, indicating the high stage of degradation and biological invasion of the fragment. Among them, the following species are distinguished: the banana tree (*Musa* sp.) with 45.16% of the individuals, followed by the Japanese grape (*Hovenia dulcis*) with 13.71%. The other 11 species (45.83%) are not very expressive in the forest, representing only 15.24% of the VI, 10.48% of the individual's density, 56.85% of the frequency and only 2.86% of the dominance (basal area).

The riparian forest of the rural environment presents greater diversity than the urban environment. The diversity index of Shanon-Wiener (H ') was 3.34, with a maximum diversity (Hmax) of 3.83 for the rural environment while the diversity index for the urban environment was 2.15, with a maximum diversity of 3.18.

On the other hand, the Pielou Equability Index, which measures the degree of homogeneity of the forest, was 0.87 for the rural area and 0.68 for the urban environment. The smaller value for the urban forest indicates that the forest is being dominated by a few species.

Regarding the invasion of exotic species, for both rural and urban environment, 54% of the species were introduced through the cultivation of fruit trees, 23% through the planting of ornamental species, and also, 23% by zoocoric dispersion, that is, by animals and insects.

Among the fruit trees, some species can be highlighted. Those are the banana tree (*Musa* sp.), orange tree (*Citrus* x *auriantum*), tangerine tree (*Citrus reticulata*), the lemon tree (*Citrus* x *limon*), avocado tree (*Persea americana*), papaya tree (*Carica papaya*) and the loquat tree (*Eriobothrya japonica*). Among the ones dispersed by animals and insects, it was found the species leucena (*Leucaena leucocephala*), japanese grape (*Hovenia dulcis*) and ligustro or albumin (*Ligustrum lucidum*) and among the introduced ones as ornamental or wood production are the eucalyptus (*Eucalyptus* spp.), the pata-de-vaca (*Bauhinia variegata*) and also the Japanese grape and Leucaena.

Table 2. Phytosociological estimators to the tree species in the riparian forest in the rural and urban areas along the Agua Turva creek, micro watershed of Jirau Alto River, Dois Vizinhos-PR. 2015.

Species	N	DR	FA	FR	DoA	DoR	VI	VI(%)
Rural domain								
Casearia sylvestris	29	15.85	70	7.96	3.418	7.18	30.98	10.33
Luehea divaricata	12	6.56	50	5.68	6.526	13.70	25.94	8.65
Parapiptadenia rigida	13	7.10	30	3.41	7.156	15.02	25.54	8.51
Nectandra megapotamica	8	4.37	40	4.55	5.968	12.53	21.45	7.15
Hovenia dulcis	11	6.01	40	4.55	1.958	4.11	14.67	4.89
Dalbergia frutescens	10	5.46	40	4.55	1.838	3.86	13.87	4.62
Araucaria angustifolia	3	1.64	10	1.14	5.182	10.88	13.66	4.55
Myrsine coriacea	4	2.19	40	4.55	3.229	6.78	13.51	4.50
Annona cacans	7	3.83	40	4.55	0.201	0.42	8.79	2.93
Gymnanthes klotzschiana	7	3.83	20	2.27	1.075	2.26	8.36	2.79
Bauhinia forficata	7	3.83	30	3.41	0.225	0.47	7.71	2.57
Strychnos brasiliensis	4	2.19	40	4.55	0.358	0.75	7.48	2.49
Cordia americana	5	2.73	20	2.27	0.972	2.04	7.05	2.35
Ocotea puberula	2	1.09	20	2.27	1.673	3.51	6.88	2.29
Cecropia pachystachya	6	3.28	10	1.14	1.003	2.11	6.52	2.17
Casearia decandra	5	2.73	10	1.14	0.597	1.25	5.12	1.71
Syagrus romanzoffiana	2	1.09	20	2.27	0.784	1.65	5.01	1.67
Campomanesia xanthocarpa	2	1.09	20	2.27	0.761	1.60	4.96	1.65
Eugenia uniflora	5	2.73	10	1.14	0.384	0.81	4.68	1.56
Nectandra lanceolata	3	1.64	20	2.27	0.340	0.71	4.63	1.54
Matayba elaeagnoides	3	1.64	20	2.27	0.298	0.63	4.54	1.51
Allophylus edulis	2	1.09	20	2.27	0.219	0.46	3.83	1.28
Citrus reticulata	2	1.09	20	2.27	0.194	0.41	3.77	1.26
Citrus x *auriantum*	4	2.19	10	1.14	0.177	0.37	3.70	1.23
Cabralea canjerana	2	1.09	20	2.17	0.125	0.26	3.63	1.21
Cedrella fissilis	1	0.55	10	1.14	0.752	1.58	3.26	1.09
NI	2	1.09	10	1.14	0.097	0.21	2.43	0.81
Ilex paraguariensis	1	0.55	10	1.14	0.312	0.66	2.34	0.78
Zanthoxylum caribaeum	2	1.09	10	1.14	0.054	0.11	2.34	0.78
Banara tomentosa	2	1.09	10	1.14	0.052	0.11	2.34	0.78
Citrus x *limon*	2	1.09	10	1.14	0.046	0.10	2.33	0.78
Seguieria aculeata	1	0.55	10	1.14	0.277	0.58	2.26	0.75
Psychotria sp.	1	0.55	10	1.14	0.244	0.51	2.20	0.73
Bauhinia variegata	1	0.55	10	1.14	0.186	0.39	2.07	0.69
Trichilia clausseni	1	0.55	10	1.14	0.168	0.35	2.04	0.68
Dahlstedtia muehlbergiana	1	0.55	10	1.14	0.145	0.31	1.99	0.66
Citharexylum solanaceum	1	0.55	10	1.14	0.140	0.30	1.98	0.66
Musa sp.	1	0.55	10	1.14	0.116	0.24	1.93	0.64
Schinus terebinthifolius	1	0.55	10	1.14	0.072	0.15	1.83	0.61
Leucaena leucocephala	1	0.55	10	1.14	0.067	0.14	1.82	0.61
Alchornea glandulosa	1	0.55	10	1.14	0.067	0.14	1.82	0.61
Myrsine guianensis	1	0.55	10	1.14	0.064	0.13	1.82	0.61
Sebastiania brasiliensis	1	0.55	10	1.14	0.037	0.08	1.76	0.59
Cestrum intermedium	1	0.55	10	1.14	0.027	0.06	1.74	0.58
Trichilia elegans	1	0.55	10	1.14	0.022	0.05	1.73	0.58
Plinia peruviana	1	0.55	10	1.14	0.020	0.04	1.73	0.58
Total	183	100	880	100	47.620	100	300	100

Continues on the next page

Continued from Table 2

Species	N	DR	FA	FR	DoA	DoR	VI	VI(%)
Urban domain								
Musa sp.	56	45.16	20	5.88	22.149	54.89	105.94	35.31
Hovenia dulcis	17	13.71	50	14.71	3.406	8.44	36.86	12.29
Eucalyptus sp.	3	2.42	10	2.94	4.733	11.73	17.09	5.70
Ligustrum lucidum	6	4.84	20	5.88	1.259	3.12	13.84	4.61
Campomanesia xanthocarpa	8	6.45	20	5.88	0.342	0.85	13.18	4.39
Schinus molle	7	5.65	20	5.88	0.575	1.43	12.95	4.32
Parapiptadenia rigida	1	0.81	10	2.94	2.440	6.05	9.79	3.26
Cordia americana	1	0.81	10	2.94	2.440	6.05	9.79	3.26
Leucaena leucocephala	2	1.61	20	5.88	0.355	0.88	8.38	2.79
Citrus reticulata	2	1.61	20	5.88	0.026	0.06	7.56	2.52
Ilex paraguariensis	2	1.61	10	2.94	1.077	2.67	7.22	2.41
Ocotea pulchella	3	242	10	2.94	0.218	0.54	5.90	1.97
Allophylus edulis	3	2.42	10	2.94	0.171	0.43	5.79	1.93
Myrsine coriacea	2	1.61	10	2.94	0.214	0.53	5.08	1.69
Nectandra megapotamica	2	1.61	10	2.94	0.081	0.20	4.76	1.59
Carica papaya	1	0.81	10	2.94	0.191	0.47	4.22	1.41
Persea americana	1	0.81	10	2.94	0.181	0.45	4.20	1.40
Luehea divaricata	1	0.81	10	2.94	0.158	0.39	4.14	1.38
Cyathea atrovirens	1	0.81	10	2.94	0.103	0.26	4.00	1.33
Eriobothrya japonica	1	0.81	10	2.94	0.079	0.20	3.94	1.31
Ocotea puberula	1	0.81	10	2.94	0.056	0.14	3.89	1.30
Calyptranthes concinna	1	0.81	10	2.94	0.047	0.12	3.86	1,29
Psychotria viridis	1	0.81	10	2.94	0.027	0.07	3.81	1.27
Campomanesia guazumifolia	1	0.81	10	2.94	0.021	0.05	3.80	1.27
Total	124	100	340	100	40.349	100	300	100

N = Number of individuals in 1.000 m²; DR = Relative Density; FA = Absolute Frequency; FR = Relative Frequency; DoA = Absolute Dominance (Basal Area); DoR = Relative Dominance; VI = Importance Value; VI% = Importance value in %.

Discussion

The riparian forest of Água Turva stream that cuts through the city of Dois Vizinhos-Paraná is quite anthropized, both in the rural and urban environments, a fact that is highly expected for ciliary formations in regions of intensive agriculture and in urban areas of municipalities.

A large number of exotic species (7 in the rural and 9 in the urban area) was observed, and among them, there are some species considered potential invaders, such as japanese grape and albumin (Lima, 2013; Rodolfo et al., 2008), leucena (Costa & Durigan, 2010). These species must be watched out, and their removal from the site is advisable, as well as the eucalyptus specimens. The other exotic ones are fruitful and some are ornamental, cultivated mainly in the urban environment, not presenting invasive character.

Although considerably altered, the riparian forest of the rural area still maintains the floristic composition specific of this typology, with predominance of species typical of the Araucaria forests and the seasonal forests belonging to the families Fabaceae, Meliaceae, Rutaceae, Euphorbiaceae, Lauraceae, Myrtaceae, Salicaceae, Primulaceae, Sapindaceae, among others, according to Dias et al. (1998) and Bianchini et al. (2003). The riparian forest of the urban environment is quite altered, due to urbanization and illegal housing construction, predominantly occupied by the families Lauraceae and Myrtaceae, but still minimally maintains the characteristics of the typology, since 12 common species with the forest of the rural area were found.

The urban forest presented less biological diversity than the rural environment, as it was more degraded by anthropic pressure, with the withdrawal of natural vegetation and the introduction of common exotic fruits in the residences. It also presented a greater homogeneity, with the predominance of few species, mainly banana trees.

The rural forest, although significantly altered, still retains a considerable diversity, which value of the Shannon-Wiener diversity index was 3.34, being very close to the calculated maximum diversity, 3.83. Its richness was 46 tree species of 24 botanical families, lower than the richness found by Dias et al. (1998) in the riparian forest of the Iapó River, in Tibaji, Parana, where 127 species of 43 botanical families occurred, and by Bianchini et al. (2003), which found 64 species of 26 families in flooded forest of the Mata dos Godoy State Park in Londrina.

The species *Casearia sylvestris* (chá-de-bugre), *Luehea divaricata* (açoita-cavalo), *Parapiptadenia rigida* (angico-vermelho), *Nectandra megapotamica* (canela-preta), *Hovenia dulcis* (uva-do-japão), *Dalbergia frutescens* (rabo-de-bugio), *Araucaria angustifolia* (Pinheiro) and *Myrsine coriacea* (capororoquinha) were the most characteristic and important of the riparian forest in the rural environment (Table 2). These species, with the exception of *Hovenia dulcis*, an exotic invader, are typical of the region's forests,

as stated by Dias et al. (1998) and Antonielli et al. (2012). Other important species, in terms of individuals' density, frequency and dominance, were *Annona cacans* (araticum), *Gymnanthes klozschiana* (branquilho), among others, and the last one is constantly found in riparian forests, being very important to preserve them.

Most of the species found were also essential because they presented expressive values of density, dominance and frequency in other studies of ciliary forests as well, such as Budke et al. (2004) and Ceconi (2010) in Santa Maria-RS, Toniato et al. (1998) in Campinas-SP, Dias et al. (2008) in Tibaji-PR and Bailly (2012) in riparian forest of Rio Iguatemi, MS.

It is important to emphasize the prominence of the exotic species *Hovenia dulcis*, with a large occurrence of individuals (6.56%) in the rural area, causing concern as it is an invasive species (Rodolfo et al., 2008, Lima, 2013) and allelopathic (Wandscheer et al., 2011; Reigosa et al., 2013), besides having fast growth and spontaneous dispersion, especially due to its intense fruiting, which is very appreciated by the fauna, that spreads out their seeds easily, being one of the forest degradation vectors.

There have been other exotic species such as *Citrus reticulata*, *Citrus* x *sinensis*, *Citrus* x *limon*, *Bauhinia variegata*, *Musa* sp. and *Leucaena leucocephala*, with a lower density of individuals though. Anyway, this last species is also allelopathic (Sxherer et al., 2005), already causing problems in other areas such as the Itaipu Hydroelectric dam margin (Dalmolin et al., 2011).

In the riparian forest of the urban area, *Musa* sp. (banana tree) presented a greater prominence (35.31% of the VI), being the most abundant and dominant. Since it is fruitful, it was introduced by the population that settled in the area that should be of permanent preservation. In addition to the banana, other exotic species such as *Hovenia dulcis*, *Eucalyptus* spp., *Ligustrum lucidum* and *Leucaena leucocephala* also appeared among the most abundant ones. This fact proves the great urban interference on the riparian forests, which have a reduced biological diversity and often do not perform their environmental functions.

In the urban environment, 124 individuals were sampled in 1000 m² of sampling area in the riparian forest, 32.24% smaller than the riparian forest of the rural area (183 ind. n 1000 m²). The banana tree (*Musa* sp.) obtained the highest relative density, corresponding to 45.16%, followed by *Hovenia dulcis* (13.70%), *Campomanesia xanthocarpa* (6.45%), *Schinus molle* (5.65%) and *Ligustrum lucidum* (4.84%). Therefore, it can be verified that these five species represented about 75.81% of the total density, with 63.71% being exotic. If it considers the other exotic species (five species more) found, this value increases to 70.97% of individuals in the riparian forest constituted by exotic species. There is, therefore, a great need for a recovery work of these riparian fragments in the urban environment, in order to maintain the integrity of the stream.

The banana tree, *Musa* sp., is an important species for the population, because its fruit is largely consumed due to the high nutritive content, mainly in potassium (Borges & Souza, 2004). Furthermore, according to the authors, another interesting aspect of their presence in riparian forests is their ability to absorb organic compounds from sewage and polluted waters, which could contribute to the improvement of water quality in streams.

In contrast, the species presents a superficial root system, that, on average, 30.0% of its roots are in the 0-10 cm layer, which would make the soil prone to erosive and overlapping processes, thus contributing to the sedimentation of the water body. In addition, banana is a species that does not develop in shady places (Borges & Souza, 2004). Due to this characteristic, their presence in forest fragments may indicate that the environment is disturbed and suffered anthropic modifications.

In relation to the frequency, it was observed that *Hovenia dulcis* was the species that obtained the highest frequency value, occurring in 50% of the sampled plots, indicating that it is well distributed in the area, proving its invasion potential, consequences of the great production of attractive fruits for animals, which spread the seeds.

There are numerous cases of biological invasion by *Hovenia dulcis*, especially in the southern region of the country, and Ferreira et al. (2013) diagnosed the presence of the species as moderately disseminated in four of the six Conservation Units studied in the state of Rio Grande do Sul. There are also reports of invasion by the species in the municipality of Dois Vizinhos, conducted by Bertolini et al. (2009), who observed, in fragment of natural secondary forest in medium stage, an infestation of 1022 ind ha^{-1}.

In the urban riparian forest, a basal area of 40.3 m^2 ha^{-1} was calculated and, of these, 22.1 m^2 ha^{-1} (54.9%) was of the banana tree, which, by its own characteristics, has rapid growth and standard diameters around 20 to 30 cm. The other species are not very expressive in terms of dominance. In the rural area, a basal area of 47.6 m^2 ha^{-1} was obtained, especially by *Parapiptadenia rigida*, *Luehea divaricata*, *Araucaria angustifolia*, *Myrsine coriaceae* and *Nectandra megapotamica*, which together represent 72.4% of the total basal area found.

Evaluating the floristic composition, the number of individuals of each species and the presence and quantity of exotic species allows inferring about the level of degradation or conservation of a riparian environment (Ceconi, 2010). Based on this, it can be affirmed that the riparian forests of Água Turva stream were disturbed by anthropic action in all the analyzed points, but with different intensities. The most deteriorated sites were those that showed the withdrawal of arboreal individuals for the development of agricultural activities and irregular settlement.

Disturbed or degraded areas are in ecological imbalance, which facilitates the establishment of invasive alien species, with consequent impoverishment of biota and natural cycles (Simberloff & Van Holle, 1999). This may explain the higher incidence of exotic individuals in the urban environment, where their index was negative (-0.35), while in rural areas it

was positive (0.80). According to Reaser & Meyerson (2007), this index ranges from -1 to 1, and the closer to the negative extreme the greater the biological invasion. In addition, when an environment presents an index below 0.8, it needs urgent intervention and management, as it is compromising the local biodiversity. Therefore, the great invasion of the urban riparian forests with exotic species and the need of interference for the conservation of the fauna and flora are noticed.

It should also be considered that it is common for forest fragments located within the urban perimeter to present large amounts of exotic species, by planting seedlings by the villagers themselves or by dispersing seeds by wind, birds or bats, coming from the green areas of cities, which have large numbers of exotic individuals (Melo et al., 2011).

From the exotic species found in the riparian forests, it is believed that most of them were introduced by the local population for fruit production, such as banana (*Musa* sp.), Lemon (*Citrus* x *limon*), tangerine (*Citrus reticulata*), orange (Citrus x *auriantum*), loquat tree (*Eriobothrya japonica*), avocado (*Persea americana*) and papaya (*Carica papaya*), followed by the animal and wind dispersion as the Japanese grape (*Hovenia dulcis*), alfeneiro (*Ligustrum lucidum*), leucena (*Leucaena leucocephala*) and introduction by the local population with an ornamental/wood production objective, such as eucalyptus (*Eucalyptus* spp.) and pata-de-vaca (*Bauhinia variegata*).

In front of all of this, the awareness of the local population about the impacts of exotic species is essential to avoid further invasions, since most of the individuals were introduced by the population. Another important strategy to adopt is the replacement of the exotic individuals of the urban arborization, especially the alfeneiro, that has great invading potential and disseminates its seeds to the ciliary forests, mainly urban, increasing the level of biological invasion of the species.

Conclusions

The riparian forest of Água Turva Stream is impacted by anthropic actions, especially in the urban environment, where it was verified low species richness, structure quite altered by the withdrawal of individuals and invasion of exotic species;

The species´ diversity in the urban riparian forest is pretty low, inferior to the rural forest, which is closer to the diversity of preserved ciliary forests;

Both forests (rural and urban) are being invaded by exotic species, mainly by *Musa* sp., *Hovenia dulcis*, *Leucaena leucocephala*, *Ligustrum lucidum* and *Eucalyptus* sp., which should be removed from the area through silvicultural programs to control invasive species. An enrichment program with native regional species of the natural forest typology should be conducted as well, to allow the riparian forests to perform their environmental functions in their totality.

Literature Cited

Andrade, L.A. de; Fabricante, J.R.; Oliveira, F.Z.de. Invasão biológica por *Prosopis juliflora* (Sw.) DC.: impactos sobre a diversidade e a estrutura do componente arbustivo-arbóreo da caatinga no estado do Rio Grande do Norte, Brasil. Acta Botânica Brasílica, v. 23, n. 4, p. 935-943, 2009. https://doi.org/10.1590/S0102-33062009000400004.

Araújo, S.M.V.G. As áreas de preservação permanente e a questão urbana. Brasília: Câmara dos Deputados, 2002. 12p. http://www2.camara.leg.br/documentos-e-pesquisa/publicacoes/estnottec/pdf/207730.pdf. 16 Nov. 2017.

Bailly, D.; Fernandes, C.A.; Silva, V.F.B.; Kashiwaqui, E.A.L.; Damásio, J.F.; Wolf, M.J.; Rodrigues, M.C. Diagnóstico ambiental e impactos sobre a vegetação ciliar da Microbacia do Córrego da Ponte, Área de Proteção Ambiental do Rio Iguatemi, MS. Revista em Agronegócios e Meio Ambiente, v.5, n.2, p. 409-427, 2012. http://periodicos.unicesumar.edu.br/index.php/rama/article/view/1680. 07 Nov. 2017.

Bertolini, I. C.; Silva, M. S. da; Hossel, C.; Novachaelley, A. J.; Medeiros, A.; Bechara, F.C.; Brun, E. J.; Freddo, A.R. Avaliação da invasão biológica por uva-do-japão (*Hovenia dulcis* Thunb.) em um fragmento de floresta estacional semidecidual no município de Dois Vizinhos/PR. Seminário: Sistemas de Produção Agropecuária – Ciências Agrárias, Animais e Florestais, 3., 2009, Dois Vizinhos. Anais. Dois Vizinhos: Universidade Tecnológica Federal do Paraná, 2009. http://revistas.utfpr.edu.br/dv/index.php/SSPA/article/view/111/58. 22 Out. 2017.

Bianchini, E.; Popolo, R.S.; Dias, M.C.; Pimenta, J.A. Diversidade e estrutura de espécies arbóreas em área alagável no município de Londrina, sul do Brasil. Acta Botânica Brasílica, v. 17, n. 3, p. 405-419, 2003. https://doi.org/10.1590/S0102-33062003000300008.

Biz, S.; Maria, T.R.B.deC.; Mota, C.J.; Favaro, J.F.; König Brun, F.G.; Brun, E.J. Levantamento florístico da mata ciliar urbana do córrego água turva em Dois Vizinhos-PR. **REVSBAU**, v. 10, n. 2, p. 14-26, 2015. http://www.revsbau.esalq.usp.br/artigos_cientificos/artigo405sn-publicacao.pdf. 05 Nov. 2017.

Borges, A.L.; Souza, L.S. O cultivo da bananeira. Cruz das Almas: Embrapa Mandioca e Fruticultura, 2004. 279 p.

Budke, J.C.; Giehl, E.L.H.; Athayde, E.A.; Eisinger, S.M.; Záchia, R.A. Florística e fitossociologia do componente arbóreo de uma floresta ribeirinha, arroio Passo das Tropas, Santa Maria, RS. Acta Botânica Brasílica, v. 18, n. 3, p. 581-589, 2004. https://doi.org/10.1590/S0102-33062004000300016.

Ceconi, D.E. Diagnóstico e recuperação da mata ciliar da sanga Lagoão do Ouro na Microbacia Hidrográfica do Vacacaí-Mirim, Santa Maria-RS. Santa Maria: Universidade Federal de Santa Maria. 2010. 132 p. Tese Doutorado. http://repositorio.ufsm.br/handle/1/3322. 12 Out. 2017.

Costa, J.N.M.N.da; Durigan, G. *Leucaena leucocephala* (Lam.) de Wit (Fabaceae): Invasora ou Ruderal?. Revista Árvore, v. 34, n. 5, p.8 25-833, 2010. http://dx.doi.org/10.1590/S0100-67622010000500008.

Dalmolin, M.F.daS.; Malavasi, U.C.; Malavasi, M.deM. Dispersão e germinação de sementes de *Leucaena leucocephala* (Lam.) de Wit na Região Oeste do Paraná. Semina: Ciências Agrárias, v. 32, n. 1, p. 355-362, 2011. https://doi.org/10.5433/1679-0359.2011v32n1p355.

Dias, M.C.; Vieira, A.O.S.; Nakajima, J.N.; Pimenta, J.A.; Lobo, P.C. Composição florística e fitossociologia do componente arbóreo das florestas ciliares do rio Iapó, na bacia do rio Tibagi, Tibagi, PR. Brasilian Journal of Botany, v. 21, n. 2, 16 p., 1998. https://doi.org/10.1590/S0100-84041998000200011.

Falcão, M.T.; Pinheiro, M. das N.M.; Rodrigues, R.F.; Souza, K.J.M.A. Implicações ambientais urbanas decorrentes das ocupações em fundo de vale: um estudo de caso na microbacia do Iguarapé Pricumã em Boa Vista/RR. Boa Vista: Universidade Estadual de Roraima, 2013. 15 p. http://www.geomorfologia.ufv.br/simposio/simposio/trabalhos/trabalhos_completos/eixo3/066.pdf. 10 Nov. 2017.

Ferreira, S.B.; Stumpf, P.P.; Colombo, P.; Mähler, J.K.F.; Focchi, S.S.; Castro, F.L. Diagnóstico preliminar de espécies exóticas invasoras nas Unidades de Conservação do Rio Grande do Sul inseridas no projeto Conservação da Mata Atlântica. Porto Alegre: Secretaria de Estado do Meio Ambiente; Departamento de Florestas e Áreas Protegidas, 2013. 15 p. http://www.mma.gov.br/estruturas/174/_arquivos/174_05122008113802.pdf. 10 Nov. 2017.

Guerra, A.J.T.; Cunha, S.B. Impactos ambientais urbanos no Brasil. Rio de Janeiro: Bertrand Brasil, 2011. 416 p.

Hogan, D.J.; Cunha, J.M.P.; Carmo, R.L.; Oliveira, A.A.B. Urbanização e vulnerabilidade sócio-ambiental: o caso de Campinas. Campinas: UNICAMP, 2012. 23p.

Instituto Brasileiro de Geografia e Estatística - IBGE. Censo 2010: população do Brasil é de 190.732.694 pessoas. Brasília: IBGE, 2010. 10 p.

Instituto Brasileiro de Geografia e Estatística - IBGE. Manual técnico da vegetação brasileira: sistema fitogeográfico, Inventário das formações florestais e campestres, técnicas e manejo de coleções botânicas, Procedimentos para mapeamentos. 2. ed. Rio de Janeiro: IBGE, 2012. 275 p.

Lima, R.E.M. de. Dispersão de sementes de *Hovenia dulcis* Thunb. (Rhamnaceae) – uma espécie invasora em área de Floresta Estacional Decidual. Florianópolis: Universidade Federal de Santa Catarina. 2014. 79 p. Dissertação Mestrado. https://repositorio.ufsc.br/handle/123456789/122602. 12 Out. 2017.

Mammarella, R.; Rodrigues, A.L.; Cintra, A.; Magalhães, M.V.; Moura, R.; Rodrigues, J.; Molina, A.; Rocha, L.Z. O estado do Paraná no censo de 2010. Curitiba: IPARDES. 2012. 31 p.

Martins, S.S. Recomposição de matas ciliares no Estado do Paraná. 2.ed. Maringá: Clichetec, 2005. 32 P.

Melo, A.G.C.; Carvalho, D.A.; Castro, G.C.; Machado, E.L.M. Fragmentos Florestais Urbanos. Revista Científica Eletrônica de Engenharia Florestal, v. 17, n. 1, p. 58-79, 2011. http://faef.revista.inf.br/imagens_arquivos/arquivos_destaque/Ozb1mN5plNQ3cZw_2013-4-29-11-34-29.pdf. 22 Out. 2017.

Paraná. Federação da Agricultura do Estado do Paraná - FAEP. Novo Código Florestal. Curitiba: FAEP. 2012. 83 p.

Pigosso, M.; Bonfante, E.; Farias, E.; Engel, I.; Rigatti, J.; Nunes, R.L. Diagnóstico ambiental da Bacia Hidrográfica do Rio Jirau Alto – Dois Vizinhos – PR. Geoambiente on line, n. 13, p. 174-193, 2009. https://doi.org/10.5216/rev.%20geoambie.v0i13.25995.

Prefeitura Municipal de Dois Vizinhos. Dados Gerais. Dois Vizinhos: Prefeitura Municipal, 2013. http://www.doisvizinhos.pr.gov.br/. 31 Jun. de 2017.

Reaser, J.K.; Meyerson, L.A.; Quentin, C.; Poorter, M.De; Eldrege, L.G.; Green, E.; Kairo, M.; Latasi, P.; Mack, R.N.; Mauremootoo, J.; O'Dowd, D.; Orapa, W.; Sastroutomo, S.; Saunders, A.; Shine, C.; Thrainsson, S.; Vaiutu, L. Ecological and socioeconomic impacts of invasive alien species in island ecosystems. Environmental Conservation, v. 34, n. 2, p. 98–111, 2007. https://doi.org/10.1017/S0376892907003815.

Reigosa, M.R.; Gomes, A.S.G.; Ferreira, A.G.; Borghetti, F. Allelopathic research in Brazil. Acta Botanica Brasilica, v. 27, n. 4, p. 629-646, 2013. https://doi.org/10.1590/S0102-33062013000400001.

Rodolfo, A.M.; Cândido Jr., J.F.; Temponi, L.G.; Gregorini, M.Z. *Citrus aurantium* L. (laranja-apepu) e *Hovenia dulcis* Thunb. (uva-do-japão): espécies exóticas invasoras da trilha do Poço Preto no Parque Nacional do Iguaçu, Paraná, Brasil. Revista Brasileira de Biociências, v. 6, n. s1, p. 16-18, 2008. http://www.ufrgs.br/seerbio/ojs/index.php/rbb/article/view/1076/794. 05 Nov. 2017.

Santana, O.A.; Encinas, J.I. Levantamento das espécies exóticas arbóreas e seu impacto nas espécies nativas em áreas adjacentes a depósitos de resíduos domiciliares. Biotemas, v. 21, n. 4, p. 29-38, 2008. https://doi.org/10.5007/2175-7925.2008v21n4p29.

Scherer, L.M.; Zucareli, V.; Zucareli, C.A.; Fortes, A.M.T. Efeito alelopático do extrato aquoso de folha e de fruto de leucena (*Leucaena leucocephala* Wit) sobre a germinação e crescimento de raiz da canafístula (*Peltophorum dubium* Spreng.). Semina: Ciências Agrárias, v. 26, n. 2, p. 161-166, 2005. https://doi.org/10.5433/1679-0359.2005v26n2p161.

Simberloff, D.; Von Holle, B. Positive interactions of nonindigenous species: invasional meltdown?. Biological Invasions, v. 1, n. 1, p. 21–32, 1999. https://doi.org/10.1023/A:101008632.

Toniato, M.T.Z.; Leitão, H. de F.; Rodrigues, R.R. Fitossociologia de um remanescente de florestal higrófica (mata de brejo) em Campinas, SP. Revista Brasileira de Botânica, v. 21, n. 2, p. 197-210, 1998. https://doi.org/10.1590/S0100-84041998000200012.

Wandscheer, A.C.D.; Borella, J.; Bonatti, L.C.; Pastorini, L.H. Atividade alelopática de folhas e pseudofrutos de *Hovenia dulcis* Thunb. (Rhamnaceae) sobre a germinação de *Lactuca sativa* L. (Asteraceae). Acta Botanica Brasilica, v. 25, n. 1, p. 25-30, 2011. https://doi.org/10.1590/S0102-33062011000100005.