



Bosque

ISSN: 0304-8799

revistabosque@uach.cl

Universidad Austral de Chile

Chile

Käffer, Márcia Isabel; de Azevedo Martins, Suzana Maria
Evaluation of the environmental quality of a protected riparian forest in Southern Brazil
Bosque, vol. 35, núm. 3, 2014, pp. 325-336
Universidad Austral de Chile
Valdivia, Chile

Available in: <http://www.redalyc.org/articulo.oa?id=173133052007>

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Evaluation of the environmental quality of a protected riparian forest in Southern Brazil

Evaluación de la calidad ambiental de un área de bosque ribereño protegido del sur de Brasil

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SUMMARY

Environmental Protection Areas (EPA) are of extreme importance for species conservation and establishment. We investigated different areas of riparian forests in the Environmental Protection Area of Ibirapuitã, southern Brazil. We analyzed the environmental quality of these areas by studying the lichen community and using the index of atmospheric purity (IAP) with the environmental classification factor (ECF) as the correction factor. The lichen community was analyzed in 12 riparian forest stands located in the southern region of EPA. Lichens were registered on 60 tree barks, from 50 cm to 150 cm above the ground, on both north and south sides. A cluster analysis was used to test whether there were changes in lichen species similarity among communities from each forest vegetation stands. A total of 193 lichen species were registered. The stands were classified into poor-lichen, transition zone, and normal for lichen development. The cluster analysis showed distinct groups, demonstrating differences in species composition among the stands. Indicator lichen species were registered in 80 % of the studied stands. In the most conserved areas, higher species richness and a greater number of fruticose species were registered, besides the presence of key species such as the genus *Lobaria*. The conservation of forest areas in environmental protection areas is essential for biodiversity conservation. Our results confirm the usage of the index of atmospheric purity with ECF to evaluate environmental quality of forest areas.

Key words: EPA of Ibirapuitã, protected, conservation, corticolous lichens, IAP.

RESUMEN

Las áreas de protección ambiental (APA) son de importancia para la conservación de las especies y su establecimiento. Se investigaron diferentes áreas de bosques ribereños en el área de protección ambiental de Ibirapuitã, sur de Brasil. Se analizó la calidad ambiental de estas áreas de la comunidad líquénica, utilizando el índice de pureza atmosférica (IPA), con el factor de clasificación ambiental (FCA) como el factor de corrección. La comunidad líquénica fue analizada en 12 sitios del bosque ribereño ubicados en la región sur de la APA. Se registraron los líquenes en 60 árboles, de 50 cm a 150 cm sobre suelo, en las exposiciones norte y sur. Se utilizó el análisis de conglomerados para verificar cambios en la similitud de especies líquénicas entre los diferentes sitios del bosque. Se registró un total de 193 especies de líquenes. Los sitios fueron clasificados en zonas pobres, de transición y normal para el desarrollo de los líquenes. El análisis de conglomerados mostró grupos distintos, lo que demuestra diferencias en la composición de especies entre los sitios del bosque. En el 80 % de los sitios se registraron especies de líquenes indicadoras. En las zonas más conservadas se registró mayor riqueza de especies, mayor número de especies fruticulosas, además de la presencia de especies del género *Lobaria*. La preservación de las áreas de protección ambiental es esencial para la conservación de la biodiversidad. Los resultados obtenidos confirman que el uso del índice de pureza atmosférica con FCA permite evaluar la calidad ambiental de las áreas forestales.

Palabras clave: APA de la Ibirapuitã, protegido, conservación, líquenes cortícolas, IPA.

INTRODUCTION

Protected areas are of extreme contribution to the Earth's natural and cultural research context, since they aim at conserving representative samples of natural regions and the biological diversity associated with them (Backes 2012). Tropical forests and associated systems from the Neotropical region represent 7 % of the planet surface. The Brazilian territory, which is mainly tropical, concentrates in its many biomes the greatest biodiversity (Backes 2012).

The temperate grasslands from southern South America (Pampa Biome) were originally composed by an area of

more than one million square kilometers, but only a little percentage remains in its natural state and the few areas left are threatened by agricultural intensification (WBW 2012). This biome harbors a great biodiversity, comprising around two thousands of plant species (Boldrini 2009); however, knowledge about other biological groups is still scarce.

In this context, changes in forest landscapes and management practices highly influence biodiversity, for both species richness and population size. Lichens, especially species from old forests, are more affected among the groups of organisms, reacting even to small changes in their habitat structure (Richardson and Cameron 2004). They are

important epiphytic components in forest environments, dominating more than 8 % of the terrestrial area of our planet (Hale 1983, Valencia and Ceballos 2002). These organisms are used as indicators of forest succession stages, since they are more developed in older forests than in younger forests, which can demonstrate whether the forest system remained intact over time (McCune 1993, Esseen *et al.* 1996, Tuvi *et al.* 2011, Hauck *et al.* 2013, Nascimbene *et al.* 2013).

For the area of Pampa Biome there are no studies about lichens and since they are pioneer organisms for environmental colonization (Valencia and Ceballos 2002) and also sensitive to environmental changes (Dyer and Letourneau 2007, Giordani *et al.* 2012), it is possible to evaluate environmental conditions through this group of organisms, as a measure of forest quality. Most studies carried out on lichens aiming at evaluating the conservation stage in forest environments (Lidén *et al.* 2004, Cáceres *et al.* 2007, 2008, Käffer *et al.* 2009, Tuvi *et al.* 2011, Boudreault *et al.* 2013, Hauck *et al.* 2013, Nascimbene *et al.* 2013, Estrabou *et al.* 2014) are based on the evaluation of species richness and diversity and/or on key species from preserved environments. Thus, our hypothesis is that lichen community occurring in riparian forest areas in an environmental protection area (EPA of Ibirapuitã) may indicate the environmental quality of these regions, mapping better areas for lichen development by using the index of atmospheric purity (IAP) (Le Blanc and De Sloover 1970) with the environmental classification factor (ECF) as the correction factor, proposed by Käffer *et al.* (2011). Hence, this study had as main objectives: a) to evaluate different riparian forest areas which are inserted in an environmental protection area (APA) in Pampa Biome indicating the environmental quality of these regions and identify the best zones for lichen development and, b) to identify indicator species of more conserved forest environments.

METHODS

Study area. The environmental protection area of Ibirapuitã (EPA of Ibirapuitã) is classified as a conservation unit for sustainable use and its territory is distributed in four municipalities of Rio Grande do Sul state, Brazil: Alegrete (15 %), Quaraí (12 %), Rosário do Sul (16 %) and Santana do Livramento (57 %). The climate is classified as subtropical hot, Cfa type according to the updated Köppen classification, the average temperature is 18.6 °C and the average rainfall is 1,500 mm year⁻¹ (Backes 2012). The main vegetation type is grassland, but along the rivers there are also riparian forests and remnants of slope forest in other areas, as well as some forest patches (Backes 2012, Andrade 2013). This study was carried out in the southern region of the EPA, in Santana do Livramento (29°05' S and 55°29' W), during the period comprised between 2011 and 2013, in twelve stands of riparian forest: Lolita Farmland (LO1-LO6); São Maurício Farmland (MA1-MA3) and Rincão Bonito Farmland (RB1-RB3) (figure 1, table 1).

Table 1. Geographical characteristics of the stand at the EPA of Ibirapuitã.

Características geográficas de los sitios del APA de Ibirapuitã.

Riparian forest stand	Coordinates	Altitude (m)
LO1	30°46'48.1"S 55°36'32.6"W	244
LO2	30°46'77.0"S 55°36'44.6"W	247
LO3	30°45'99.6"S 55°36'16.6"W	770
LO4	30°45'92.4"S 55°36'38.2"W	792
LO5	30°46'77.2"S 55°36'05.6"W	787
LO6	30°46'78.9"S 55°35'69.7"W	883
MA1	30°37'77.9"S 55°33'92.9"W	871
MA2	30°37'82.1"S 55°34'09.3"W	972
MA3	30°37'52.1"S 55°33'82.6"W	862
RB1	30°34'29.5"S 55°31'63.8"W	674
RB2	30°33'80.7"S 55°31'46.4"W	524
RB3	30°33'88.7"S 55°31'01.6"W	540

Sampling and identification. At each stand of the riparian forest (LO, MA and RB) five host trees, with DBH (diameter at breast height) over 7.3 cm were randomly sampled comprising a total of 60 host trees. Each host tree was identified to species and the DBH was recorded (table 2). The analyzed riparian forest stands were characterized by the presence of medium and large trees, understory and closeness to a watercourse. These stands also had some agropastoral influence, mainly livestock (cattle and/or sheep).

Lichens were registered on the tree barks from 50 cm to 150 cm above the ground, in both north and south sides of the trunk. For lichen mapping, a total of five pieces of transparent plastic with 20 cm x 20 cm each (acetate method) were disposed along the host-tree trunk (both sides) (figure 2). All sampled species were identified *in situ* or collected for posterior confirmation at the laboratory.

Lichen identification was carried out through the observation of anatomical sections of the thallus and fructifications, by using stereoscopic and optical microscopes. Some external characteristics were also analyzed, such as color and thallus aspect, length and width of lobes, presence of picnids and aspect of rhizines, cilia and apothecia. Spot-tests reaction with potassium hydroxide 20 % (KOH), calcium hypochlorite (CaClO₂), paraphenylenediamine (P), lugol solution (I reaction) and fluorescence under UV-light (long wave) were used to determine the presence of acid substances in the cortex, medulla, hymenium, ascus and ascospores. Also for identification purposes, specialized literature for each taxonomic group was checked; besides materials from the Herbarium Prof. Dr. Alarich Schultz Herbarium (HAS) at the Zoobotanical Foundation of Rio

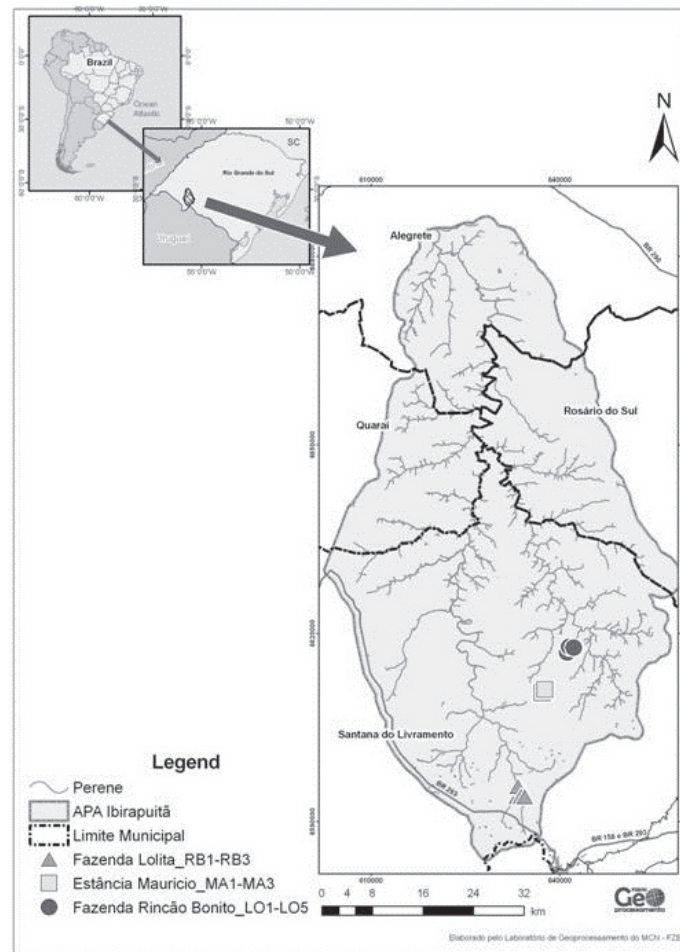


Figure 1. Map of the study stands at the environmental protection area of Ibirapuitã (EPA of Ibirapuitã), southern Brazil.
Mapa de los sitios de estudio en la área de protección ambiental (APA de Ibirapuitã), sur de Brasil.

Table 2. Host trees characteristics and frequency in the riparian forest stand at the EPA of Ibirapuitã.
Características y frecuencia de los árboles en los sitios del APA de Ibirapuitã.

Family	Species	Number of individuals	DBH (cm)	Riparian forest stand
Anacardiaceae	<i>Lithraea brasiliensis</i> Marchand	1	15.9	LO2
	<i>Lithraea molleoides</i> (Vell.) Engl.	2	10.2-12.7	MA2
	<i>Schinus lentiscifolius</i> Marchand	1	12.4	LO6
Euphorbiaceae	<i>Sebastiania brasiliensis</i> Spreng	4	7.6-13.1	LO1, MA3, RB2
	<i>Sebastiania commersoniana</i> (Baill.) L.B. Sm. et Downs	31	9.2-19.6	MA1, MA3, RB1, RB2, RB3
Lauraceae	<i>Ocotea acutifolia</i> (Nees) Mez	3	13.1-14.5	LO2, LO5
	<i>Ocotea pulchella</i> (Nees) Nez	1	31.2	RB1
Myrtaceae	<i>Blepharocalys salicifolius</i> (Kunth) O.Berg.	1	21.3	LO2
Myrsinaceae	<i>Myrsine coriacea</i> (Sw.) R.Br.	6	11.5-23.1	MA1, MA2, MA3
Sapotaceae	<i>Pouteria salicifolia</i> (Spreng.) Radlk.	7	9.6-13.2	LO4, LO5
Styracaceae	<i>Styrax leprosus</i> Hook. et Arn.	1	10.4	LO2
Verbenaceae	<i>Aloysia gratissima</i> (Gillies et Hook) Tronc	2	7.3	LO3



Figure 2. Acetate method used for the lichen mapping in stands of riparian forest.

Método del acetato utilizado para el mapa de los líquenes de los sitios del bosque ribereño.

Grande do Sul State, Brazil. The collected material was herborized and stored in this Herbarium catalogue.

Environmental quality and forest areas. Data analyses only considered species whose thalli represented at least 0.5 cm in each of the five host-trees analyzed in each area. The coverage estimate for each lichen species was carried out by summing the total coverage of all thalli present in each of the five transparent pieces from all host trees, in each stand of riparian forest.

Data analyses. The environmental quality of the riparian forest areas was analyzed through the index of atmospheric purity (IAP) (Le Blanc and De Sloover 1970) with the environmental classification factor (ECF) as the correction factor, as proposed by Käffer *et al.* (2011). For each riparian forest stand the IAP with ECF was used, considering frequency data, coverage and the environmental index of each species. The environmental classification factor (ECF) incorporates IAP parameters as a correction factor through a scale of coverage percentage of the morphological lichen groups.

Species richness was considered as the total number of lichen species occurring in the five host trees that were analyzed in each riparian forest stand. In order to investigate possible changes in species similarity among lichen com-

munities present in each stand, a cluster analyses method based on the relative Sørensen coefficient of dissimilarity as a classification method was used, and a flexible beta = 0.25 was used as the clustering algorithm (McCune *et al.* 2002).

The indicator species analysis was performed to detect species that can be classified as typical of a given stand in a riparian forest. For this analysis, a Monte-Carlo test was performed on the frequency and abundance data of the lichen species (McCune *et al.* 2002). All statistical analyses were carried out with the statistics software PC-ORD 6.0 (2010).

RESULTS

A total of 193 lichenized fungi from 55 genera were recorded (Appendix). Among them, only 6.7 % were colonized by cyanobacteria and 93.3 % by chlorophytes.

Environmental quality of the riparian forest areas. The index of atmospheric purity with the ECF in the riparian forest stands varied from 8.1 to 64.2. They were classified into three different zones for the development of the lichenized mycota: two lichen-poor areas (LO2 and LO6), five transition areas (LO1, LO3, LO4, LO5 and MA2) and five normal areas for lichen development (MA1, MA3, RB1, RB2 and RB3). The analyzed riparian forest stands were classified into five zones, considering a scale variation from 1.0 to above 75.5, established by Le Blanc and De Sloover (1970) for the IAP: Zone I – lichen-absence (1.0 to 5.5), Zone II – lichen-poor (5.6 to 15.5), Zone III – transition area (15.6 to 35.5), Zone IV – normal (35.6 to 75.5) and Zone V – excellent (higher than 75.6) (table 3).

Lichen richness was higher in the riparian forest stand RB2 (64 species) than in other areas. The riparian forest stands LO6 and LO4 showed the lowest species richness (both with 27) (table 3).

Lichen community patterns among riparian forest stands. The cluster analysis showed five distinct groups and demonstrated that there were differences in species composition among the riparian forest stands (figure 3). Stands LO1 and MA2 were characterized as lichen-poor and lichen transition areas, both with similar richness and same species composition, mainly composed by species from Graphidaceae. Stands LO6 and MA1 were classified as poor and normal for lichen development. However, these areas showed similar composition, especially with species from the genus *Leptogium* and *Lobaria*. Stands MA3 and RB1, as well as RB2 and RB3, were characterized as normal zones for lichen development. In these areas the lichen community was sampled on the same host tree species and they showed similar lichen species richness, composition and coverage, mainly constituted by representatives from Parmeliaceae and Physciaceae. And finally, stands LO4 and LO5 were classified as transition areas for lichen development, with the same lichen species richness and similar composition, with the predominance of species from Parmeliaceae.

Table 3. Values for the index of atmospheric purity (IAP) and richness at each riparian forest stand at the environmental protection area of Ibirapuitã.

Índice de la pureza atmosférica (IPA) y riqueza en las áreas del bosque ribereño del área de protección de Ibirapuitã.

Riparian forest stand	IAP	Classification	Richness
LO1	27.4	transition	31
LO2	8.1	lichen-poor	46
LO3	31.9	transition	31
LO4	18.8	transition	27
LO5	26.1	transition	34
LO6	8.5	lichen-poor	27
MA1	43.8	normal	50
MA2	26.6	transition	55
MA3	42.3	normal	40
RB1	50.5	normal	50
RB2	64.2	normal	64
RB3	55.0	normal	53

Lichen species as indicators of riparian forest. There were indicator species of riparian forests in around 80 % of the analyzed areas. Seven species were considered as indicator species of riparian forests according to the richness values of each species. The foliose species revealed the highest predominance (five), while the crustose and fruticose group registered only one species, representing 20 % of all specimens. The taxa with the highest indication values (IV), considering statistically significant values only, were: *Dirinaria picta* (Sw.) Clem. et Shear (IV=80.7, $P = 0.0270$), *Graphis* sp. 1 (IV = 72.6, $P = 0.0572$), *Hypo-*

trachyna livida (Taylor) Hale (IV = 74.7, $P = 0.0520$), *Lep-
togium isidiosellum* (Riddle) Sierk. (IV = 100, $P = 0.0060$), *Lobaria discolor* (Bory ex Delise) Hue (IV=75.0, $P = 0.0546$), *Parmelinopsis minarum* (Vainio) Elix et Hale (IV = 98.6, $P = 0.0056$) and *Usnea angulata* Ach. (IV = 75.0, $P = 0.0546$).

DISCUSSION

The application of the index of atmospheric purity with the ECF in riparian forest areas revealed the presence of some changed environments and others in better conservation status in the southern region of the EPA of Ibirapuitã, which corroborates our initial hypothesis.

The most changed areas (LO1, LO3, LO4, LO5 and LO6) registered in this study were characterized as regions with sparse woody vegetation, low lichen species richness, smaller number of taxa of the fruticose morphologic group and were then classified as transition and poor zones for lichen development. The presence of the fruticose morphologic group is associated with less modified areas (Büdel and Scheiddeger 2008). The most preserved areas (MA1, MA3, RB1, RB2 and RB3) were characterized by possessing denser vegetation and being closer to watercourses, which provides them a different microclimate when considering the other regions. These zones were classified as normal for lichen development, with higher richness values and the presence of species that are characteristic of preserved environments, such as *Lobaria erosa* (Eschw.) Trev., *Lobaria discolor* (Bory ex Delise) Hue and species from genus *Chapsa* and *Usnea*. In these areas, especially in the stands MA1 and RB2, we found some lichens that were new species for science, as well as new records for the southern hemisphere, Brazil and the state of Rio Grande do Sul (Kitaura et al. 2014, Aptroot et al. 2014, Kärfer et al. 2014).

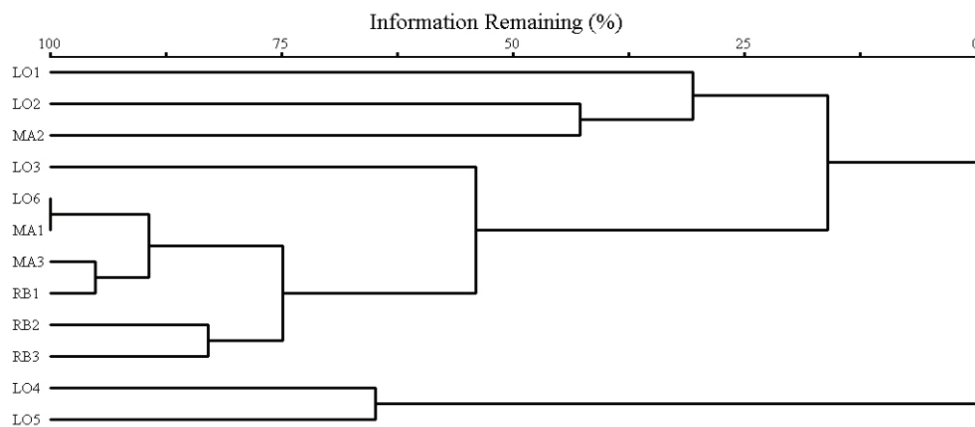


Figure 3. Cluster of similarity composition based on the relative Sørensen coefficient of dissimilarity. Riparian forest stand represent: LO1-LO6 = Lolita Farmland, MA1-MA3 = São Maurício Farmland and RB1-RB3 = Rincão Bonito Farmland.

Análisis de *cluster*, considerando la composición, con base en el coeficiente de la disimilitud relativa de Sørensen. Las áreas de bosque ribereño representan: LO1-LO6 = hacienda Lolita, MA1-MA3 = hacienda São Maurício y RB1-RB3 = hacienda Rincão Bonito.

Most studies carried out in conservation unities using lichens report the changes in forest areas, especially related to management practices (Käffer *et al.* 2009, Giordani *et al.* 2012, Boudreault *et al.* 2013, Király *et al.* 2013) and habitat fragmentation (Tuvi *et al.* 2011, Nascimbene *et al.* 2013). In our study, the changes observed in different forest areas are especially related to the management made in the area, due to the presence of cattle and sheep.

The EPA of Ibirapuitã is composed by private properties (Backes 2012) presenting distinct forms of economic development, influenced by the dimensions of each rural property. These properties are based on primary production (extensive livestock) and grain production (Chomenko 2008).

Habitat fragmentation, degradation or destruction and the consequent magnification of the human space and of its activities consist in negative actions in relation to the biodiversity (Backes 2012). The changes occurred in the forest areas can cause changes in lichen community structure and composition. These changes were verified in different forest areas, especially in species composition. The host tree characteristics could also have influenced the results found, mainly in relation to bark structure, DBH and the tree position in the forest areas. We observed that some host trees had higher light incidence than others. The community structure of epiphytic lichens can be determined by its host trees characteristics (Löhmus *et al.* 2007). Trees barks that suffer shredding can also inhibit lichen growth (Topham 1977). The host tree level has been an important variable explaining lichen species composition and richness (Juriado *et al.* 2009). The diameter of the tree is correlated to space availability for lichen species development and it is known as a key factor for community structure (Belinchon *et al.* 2007). According to Lie *et al.* (2009) it is possible that physical-chemical bark characteristics change with time and that an old substrate can provide a different substrate in a young tree.

In all the studied forest areas, representatives of families Parmeliaceae and Physciaceae were frequent, mainly in the regions with sparse vegetation. Species from these families are characteristic of forest edges, areas with higher luminosity and wind, and they are well represented in Brazilian landscapes (Marcelli 1998). In the areas closer to the watercourse, with denser vegetation, species from family Collemataceae were abundant, highlighting the genus *Leptogium*, with nine species. Representatives from this family are characteristic of humid and shaded environments (Wolseley 1991).

The presence of species from genus *Lobaria* was registered in more preserved areas of this study, with high coverage values. Species from this genus have been cited as indicators of preserved forest ecosystems and associated with forest areas of high ecological continuity (Campbell and Fredeen 2004, Liira and Sepp 2009). Their presence is also associated with a variety of other rare or endangered species, and hence they can be considered as umbrella species (Scheidtger and Werth 2009, Nascimbene *et al.* 2010).

CONCLUSIONS

The conservation of forest areas in Environmental Protection Areas is fundamental for biodiversity preservation. However, anthropic influences may cause loss of species that are characteristics from these environments. The results here presented confirm the use of the index of atmospheric purity with the environmental classification factor to evaluate the environmental quality in forest areas. The presence and the high coverage values of species from the genus *Lobaria* showed the good conservation status of some of the analyzed areas; the occurrence of this species also reinforces the importance of conserving riparian forests in this region.

ACKNOWLEDGMENTS

We thank the lichenologist Dr. Marcos Kitaura for the identification of some *Leptogium* species from the Botanic Institute of UNESP and also Felipe C. Maciel, Renata V. Dantas, Fabiane Lucheta and Natália M. Koch for their help with the fieldwork. Lastly, we thank the Museu de Ciências Naturais for offering its structures for laboratory activities and the Geoprocessing Laboratory for helping to compile maps, both from Fundação Zoobotânica do Rio Grande do Sul. We also thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq (process number 160115/2012-4) for the Post-Doctoral fellowship.

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Recibido: 28.03.14
Aceptado: 04.08.14

Appendix. Lichen species found in all riparian forest stand with abundance values for each one. LO1-LO6: Lolita Farmland, MA1-MA3: São Maurício Farmland and RB1-RB3: Rincão Bonito Farmland. Taxa prepended by an asterisk (*) indicated a new citation for the South America, Brazil and the state of Rio Grande do Sul.

Taxa	Riparian forest stands											
	LO1	LO2	LO3	LO4	LO5	LO6	MA1	MA2	MA3	RB1	RB2	RB3
<i>Anisomeridium</i> sp. 1*	0	0	0	0	0	0	2	0	0	0	0	0
<i>Anisomeridium</i> sp.2*	0	1	0	0	0	0	0	0	0	0	0	0
<i>Anthracotheicum prasinum</i> (Eschw.) R. C. Harris	0	0	0	0	0	0	0	0	2	0	0	0
<i>Astrothelium</i> sp.*	0	1	0	0	0	0	0	0	0	0	0	0
<i>Bacidia alutacea</i> (Krempplh.) Zahlbr.	0	0	0	0	0	0	0	0	0	0	1	5
<i>Bacidia fluminensis</i> (Malme) Cáceres et Lücking	0	0	0	0	0	3	3	15	1	0	9	0
<i>Bacidia russeola</i> (Kremp.) Zahlbr.	7	0	0	0	0	13	0	0	3	0	3	7
<i>Bacidia subtestacea</i> Malme	0	0	0	0	0	0	0	0	0	0	0	2
<i>Bacidia</i> sp.1*	0	0	0	0	0	0	1	0	0	0	6	0
<i>Bapalmuia</i> sp.*	0	0	0	0	0	0	0	0	0	0	0	2
<i>Brigantiaea leucoxantha</i> (Spreng.) R. Sant. et Hafellner	27	13	0	0	2	0	0	3	1	0	4	4
<i>Calopadia</i> sp.*	0	0	2	0	0	0	0	0	0	0	0	0
<i>Caloplaca erythranta</i> (Tuck.) Zahlbr.	0	0	0	0	0	0	0	1	1	0	0	0
<i>Caloplaca</i> sp.	0	0	0	0	0	0	1	0	0	0	0	0
<i>Canoparmelia caroliniana</i> (Nyl.) Elix et Hale	0	1	0	0	0	0	0	3	0	0	0	0
<i>Canoparmelia roseoreagens</i> Marcelli et Canêz	0	0	0	0	0	0	0	1	0	0	0	0
<i>Canoparmelia texana</i> (Tuck.) Elix et Hale	0	0	0	1	0	0	1	1	0	1	0	0
<i>Chapsa chionostoma</i> (Nyl.) Rivas-Plata et Mangold	0	0	0	0	0	0	3	2	0	0	0	0
<i>Chapsa</i> sp.	0	0	0	0	0	0	0	0	0	0	2	0
<i>Coccocarpia erythroxyli</i> (Sprengel) Sw. et Krog	0	0	0	0	0	0	0	10	0	0	0	0
<i>Coccocarpia pellita</i> (Ach.) Müll.Arg.	0	0	0	0	0	0	4	0	0	0	0	0
<i>Coccocarpia stellata</i> Tuck.	0	0	0	0	0	0	2	0	0	0	0	0
<i>Coenogonium interplexum</i> Nyl.	0	0	0	0	0	0	0	0	0	0	1	0
<i>Coenogonium subdilutum</i> (Malme) Lücking, Aptroot et Sipman	0	12	0	0	0	0	0	0	0	0	0	0
<i>Coenogonium</i> sp. 1	0	0	0	0	0	1	0	0	0	0	0	0
<i>Coenogonium</i> sp. 2*	0	0	0	0	8	0	0	0	0	0	0	0
<i>Coenogonium</i> sp. 3*	0	0	0	1	0	0	0	0	0	0	1	0
<i>Coenogonium</i> sp.4*	0	0	0	0	0	0	0	0	2	0	0	0
<i>Collema fasciculare</i> (L.) Wigg.	0	0	6	0	3	0	0	3	0	0	0	0
<i>Crespoa carneopruinata</i> (Zahlbr.) Lendemer et Hodkinson	0	41	5	5	9	23	31	53	19	35	5	19
<i>Crocodia aurata</i> (Ach.) Link	2	9	39	0	3	2	5	0	0	12	11	22
<i>Crocodia clathrata</i> (De Not.) Trevis.	0	1	5	0	3	11	1	0	2	1	0	1
<i>Diorygia</i> sp.*	2	1	0	7	44	7	0	0	0	0	0	2
<i>Dirinaria picta</i> (Sw.) Clements et Shear	0	1	0	0	0	0	7	2	9	5	1	3
<i>Glyphis cicatricosa</i> (Ach.) Vain.	2	0	0	0	0	0	0	2	0	0	0	0

Continue

Appendix continued

<i>Graphis calcea</i> (Fée) A. Massal.	3	18	0	0	0	2	0	0	0	5	23	4
<i>Graphis consanguinea</i> (Müll.Arg.) Lücking	0	0	0	0	0	0	0	2	0	0	0	0
<i>Graphis dolichographa</i> Nyl.	0	0	0	0	0	4	2	4	0	0	0	0
<i>Graphis paraserpens</i> Lizano et Lücking	0	8	0	0	0	0	0	0	0	0	0	0
<i>Graphis rimulosa</i> (Mont.) Trevis.	0	0	0	0	0	0	0	5	0	0	0	0
<i>Graphis</i> sp. 1*	0	0	0	0	0	2	0	0	0	5	23	4
<i>Graphis</i> sp. 2	0	1	0	0	0	0	0	0	0	0	0	0
<i>Graphis</i> sp. 3*	0	9	0	6	1	0	0	0	0	0	1	1
<i>Graphis</i> sp. 4*	0	0	0	0	0	0	2	0	0	0	0	0
<i>Graphis</i> sp.5*	0	1	0	0	0	1	0	4	0	0	0	0
<i>Graphis</i> sp. 6 *	0	0	0	0	0	0	0	1	0	0	0	0
Grupo <i>Lepraria</i> sp.	0	0	0	0	0	0	0	0	2	1	3	0
<i>Haematomma</i> sp.*	0	0	0	0	0	0	1	5	0	0	0	0
<i>Hemithecium chlorocarpum</i> (Fée) Trev.	0	3	0	0	0	0	0	27	0	0	0	0
<i>Herpothallon rubrocinctum</i> (Ehrenb.) Aptroot et Lücking	0	6	0	51	24	0	0	0	0	6	0	0
<i>Heterodermia albicans</i> (Pers.) Swinsc. et Krog	0	0	0	0	6	0	1	11	1	11	0	5
<i>Heterodermia casarettiana</i> (Massal.) Trevis	0	0	0	0	0	0	0	0	0	0	15	8
<i>Heterodermia diademata</i> (Taylor) Awasthi	0	7	0	0	1	0	0	7	2	0	2	0
<i>Heterodermia</i> cf. <i>diademata</i> (Taylor) Awasthi	0	2	0	0	0	0	0	2	0	0	0	0
<i>Heterodermia flabellata</i> (Fée) Awasthi	0	0	0	0	0	0	0	0	0	0	0	1
<i>Heterodermia leucomela</i> (L.) Poelt	12	0	0	0	0	0	3	0	1	5	3	0
<i>Heterodermia lutescens</i> (Kurok.) Follmann	0	0	0	0	0	0	5	0	0	3	2	13
<i>Heterodermia obscurata</i> (Nyl.) Trevis	57	33	88	19	63	129	179	97	150	113	88	117
<i>Heterodermia pseudospeciosa</i> (Kurok.) W.L. Culb.	0	0	0	0	0	0	0	0	0	1	0	0
<i>Heterodermia</i> cf. <i>pseudospeciosa</i> (Kurok.) W.L. Culb.	0	3	0	0	0	0	0	0	0	0	0	0
<i>Heterodermia speciosa</i> (Wulf.) Trevis	0	0	0	2	0	0	4	4	0	9	22	2
<i>Heterodermia</i> sp. 1*	3	0	0	0	0	0	0	0	0	0	0	0
<i>Heterodermia vulgaris</i> (Vain.) Follmann et Redón	16	5	11	0	3	5	9	3	0	7	19	7
<i>Hyperphyscia adglutinata</i> (Flörke) H. Mayrhofer et Poelt	0	0	0	0	3	0	0	0	0	0	0	0
<i>Hyperphyscia syncolla</i> (Tuck.) Kalb	0	0	0	0	0	0	2	0	0	0	0	0
<i>Hyperphyscia</i> sp.*	0	0	0	2	0	0	0	0	0	0	0	0
<i>Hypotrachyna livida</i> (Taylor) Hale	4	4	0	0	3	1	6	23	0	0	1	3
<i>Hypotrachyna polydactyla</i> (Krog et Swinsc.) Nash	0	0	0	0	0	0	0	10	0	0	0	0
<i>Hypotrachyna</i> cf. <i>polydactyla</i> (Krog et Swinsc.) Nash	0	1	0	0	0	0	0	0	0	0	0	0
<i>Lecanora</i> grupo <i>subfusca</i> (L.) Ach.	0	0	0	0	0	0	0	4	0	3	1	0
<i>Lecanora achroa</i> Nyl.	0	0	11	0	0	0	0	3	6	0	0	0
<i>Lecanora albella</i> (Pers.) Ach.	2	0	0	0	0	0	9	0	2	0	18	0
<i>Lecanora concilianda</i> Vain.	0	0	0	0	0	0	0	19	0	0	0	0
<i>Lecanora</i> sp.*	0	0	0	0	0	0	0	0	0	0	0	1

Continue

Appendix continued

<i>Leptogium austroamericanum</i> (Malme) Dodge	0	0	0	0	0	0	0	0	0	1	0	0
<i>Leptogium azureum</i> (Sw.) Mont.	0	0	20	0	4	21	19	4	2	0	9	11
<i>Leptogium cochleatum</i> (Dicks.) P.M. Jorg. et P. James	0	3	0	0	0	0	0	0	0	0	0	0
<i>Leptogium cyanescens</i> (Rabenh.) Körb.	0	0	3	0	7	7	0	0	0	0	4	0
<i>Leptogium denticulatum</i> Nyl.	0	7	0	0	0	0	0	0	0	0	0	0
<i>Leptogium isidiosellum</i> (Ridd.) Sierk	0	0	0	0	0	0	0	0	1	3	2	1
<i>Leptogium phyllocarpum</i> (Pers.) Mont.	0	0	18	0	0	0	2	0	18	0	7	20
<i>Leptogium</i> sp. 1 *	0	0	40	0	0	0	0	0	0	0	0	0
<i>Leptogium</i> sp. 2 *	0	0	0	0	0	4	0	0	0	6	0	0
<i>Lobaria discolor</i> (Bory ex Delise) Hue	0	0	0	0	0	0	0	0	0	2	10	56
<i>Lobaria erosa</i> (Eschw.) Nyl.	0	25	13	3	21	34	16	0	14	28	20	3
<i>Lobaria intermedia</i> (Nyl.) Vain.	0	0	0	1	0	0	0	0	0	0	0	0
<i>Lobaria patinifera</i> (Taylor) Hue	0	0	0	0	0	0	0	0	0	0	0	3
<i>Malmidea vinosa</i> (Eschw.) Kalb, Rivas Plata et Lumbsch	0	2	0	0	0	0	0	0	0	0	0	0
<i>Malmidea</i> sp. 1 *	0	22	0	0	0	0	0	0	0	1	0	1
<i>Malmidea</i> sp. 2 *	16	0	0	0	0	0	0	0	0	0	0	0
<i>Myelochroa lindmanii</i> (Lynge) Elix et Hale	0	3	0	0	0	0	0	0	0	0	4	0
<i>Normandina pulchella</i> (Borrer) Nyl.	0	0	1	0	0	0	0	6	0	0	0	4
<i>Ochrolechia pallescens</i> (L.) Massal.	0	0	0	0	0	0	1	0	0	0	0	0
<i>Opegrapha</i> sp. 1	0	1	0	0	0	0	1	0	0	0	0	0
<i>Parmelinopsis minarum</i> (Vain.) Elix et Hale	0	11	0	0	1	1	1	20	0	0	0	0
<i>Parmelinopsis</i> sp.	0	0	0	0	0	0	0	4	0	0	0	0
<i>Parmotrema catarinae</i> Hale	0	0	1	0	0	0	2	0	0	1	0	0
<i>Parmotrema cetratum</i> (Ach.) Hale	36	14	0	12	5	11	60	80	25	34	14	18
<i>Parmotrema clavuliferum</i> (Räsänen) Streimann	0	0	0	0	5	2	3	0	0	0	1	6
<i>Parmotrema consors</i> (Kremp.) Spielmann et Marcelli	0	0	0	0	0	0	1	6	31	8	1	0
<i>Parmotrema ecilatum</i> (Nyl.) Hale	0	0	1	9	0	0	0	0	0	0	18	1
<i>Parmotrema</i> cf. <i>eurysacum</i> (Hue) Hale	0	0	19	0	0	0	0	0	0	0	0	0
<i>Parmotrema haitiense</i> (Hale) Hale	0	9	0	0	0	0	0	0	0	0	0	0
<i>Parmotrema internexum</i> (Nyl.) Hale ex De Priest et B.W. Hale	0	0	1	0	0	0	0	0	0	0	0	0
<i>Parmotrema melanothrix</i> (Mont.) Hale	1	0	0	0	0	0	4	0	0	2	1	8
<i>Parmotrema mellissii</i> (Dodge) Hale	0	0	0	0	0	0	0	0	0	0	2	0
<i>Parmotrema muelleri</i> (Vain.) Blanco, Crespo, Divakar, Elix et Lumbsch	0	0	0	0	0	0	0	0	0	1	0	0
<i>Parmotrema pilosum</i> (Stizenb.) Krog et Swinscow	0	0	5	14	0	0	0	0	0	1	0	0
<i>Parmotrema praesorediosum</i> (Nyl.) Hale	1	0	6	0	0	0	0	0	0	0	0	0
<i>Parmotrema</i> cf. <i>rampoddense</i> (Nyl.) Hale	0	0	0	0	1	0	0	0	0	0	0	0
<i>Parmotrema recipiendum</i> (Nyl.) Hale	0	0	0	0	0	3	0	4	1	2	0	0
<i>Parmotrema reticulatum</i> (Taylor) M. Choisy	37	20	11	0	4	4	23	0	31	23	4	17
<i>Parmotrema rigidum</i> (Lynge) Hale	0	0	0	0	0	0	3	0	0	0	4	3

Continue

Appendix continued

<i>Parmotrema sancti-angeli</i> (Lyng.) Hale	0	0	0	0	0	0	0	0	2	0	0	0
<i>Parmotrema simulans</i> (Hale) Hale	0	0	0	0	0	0	0	0	1	0	0	0
<i>Parmotrema subcaperatum</i> (Kremp.) Hale	4	0	0	0	0	0	3	3	5	4	2	0
<i>Parmotrema subrugatum</i> (Kremp.) Hale	0	0	8	16	0	0	9	0	0	0	2	0
<i>Parmotrema tinctorum</i> (Nyl.) Hale	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pertusaria carneola</i> (Eschw.) Müll.Arg.	0	0	0	0	0	0	0	6	0	0	0	0
<i>Pertusaria flavens</i> Nyl.	0	0	0	0	0	0	0	0	0	0	1	0
<i>Pertusaria velata</i> (Turner) Nyl.	0	1	0	0	0	0	0	0	0	0	0	0
<i>Pertusaria</i> sp. 1	0	2	0	0	0	0	0	0	0	0	0	0
<i>Pertusaria</i> sp. 2	0	0	0	1	0	0	0	0	0	0	0	0
<i>Pertusaria</i> sp. 3	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pertusaria</i> sp. 4	0	0	0	0	0	0	0	7	0	0	0	0
<i>Phaeographis lecanographa</i> (Nyl.) Staiger	0	0	0	0	0	0	0	2	0	0	0	0
<i>Phlyctella brasiliensis</i> (Nyl.) Nyl.	0	0	4	0	0	0	0	0	0	1	0	0
<i>Phyllopsora breviuscula</i> (Nyl.) Müll. Arg.	0	0	0	27	3	0	0	0	0	5	0	0
<i>Phyllopsora buettneri</i> (Müll.Arg.) Zahlbr.	0	0	0	0	0	0	0	0	0	2	5	0
<i>Phyllopsora chlorophaea</i> (Müll.arg.) Zahlbr.	0	0	0	0	0	4	0	0	0	0	0	0
<i>Phyllopsora confusa</i> Swinsc. et Krog	0	0	0	0	2	0	0	0	0	0	0	0
<i>Phyllopsora furfuraceae</i> (Pers.) Zahlbr.	0	0	0	0	0	0	0	0	0	1	0	0
<i>Phyllopsora</i> sp. *	0	0	0	0	0	0	0	0	0	0	0	1
<i>Physcia aipolia</i> (Humb.) Fűrnr.	0	4	0	0	0	0	0	12	0	2	2	0
<i>Physcia alba</i> (Fée) Müll.rg.	0	0	0	0	0	0	0	5	0	0	0	0
<i>Physcia atrostriata</i> Moberg	0	40	8	22	9	27	15	5	4	23	28	2
<i>Physcia crispa</i> Nyl.	0	0	0	0	1	0	0	0	0	0	0	0
<i>Physcia krogiae</i> Moberg	0	0	0	0	0	0	0	1	0	0	0	0
<i>Physcia poncinsii</i> Hue	0	0	0	0	0	0	0	0	3	4	0	0
<i>Physcia sorediosa</i> (Vain.) Lyng	0	0	0	7	0	0	0	3	0	0	0	0
<i>Physcia tribacoides</i> Nyl.	0	0	0	0	0	0	0	20	0	0	0	0
<i>Physcia undulata</i> Moberg	0	0	0	0	0	4	0	0	0	0	0	5
<i>Physcia</i> sp. 1 *	0	0	0	0	0	3	0	0	0	0	0	0
<i>Physcia</i> sp. 2 *	0	0	0	0	0	0	0	3	0	0	0	0
<i>Platygramme caesiopruinosa</i> (Fée) Fée	0	0	0	0	0	0	1	2	0	0	1	0
<i>Porina africana</i> Müll. Arg.	0	0	0	0	0	0	0	0	0	10	0	0
<i>Pseudocyphellaria</i> aff. <i>clathrata</i> (De Not.) Malme	0	4	0	0	0	0	0	0	0	0	0	0
<i>Pseudocyphellaria</i> sp.	0	0	0	0	0	0	0	0	0	1	0	0
<i>Psoroglaena</i> sp. *	0	0	0	0	0	0	0	0	0	0	4	0
<i>Punctelia bolliana</i> (Müll.Arg.) Krog	0	0	0	6	0	0	0	0	0	0	0	0
<i>Punctelia constantimontium</i> Sérus.	1	0	23	0	0	0	6	0	0	1	0	0
<i>Punctelia fimbriata</i> Marcelli et Canêz	0	0	0	0	11	0	0	0	0	0	0	0
<i>Punctelia graminicola</i> (B. de Lesd.) Egan	0	0	0	0	0	0	0	0	0	0	1	0
<i>Punctelia hypoleucites</i> Nyl.	3	3	0	0	0	0	0	0	0	0	0	0
<i>Punctelia microsticta</i> (Müll.Arg.) Krog	0	0	0	0	0	0	0	0	1	0	10	0
<i>Punctelia osorioi</i> Canêz et Marcelli	0	0	0	0	0	0	14	0	0	0	0	0

Continue

Appendix continued

<i>Punctelia riograndensis</i> (Lynge) Krog	0	0	2	0	0	0	0	0	0	0	0	0
<i>Punctelia</i> sp. 1	0	0	0	0	15	0	0	5	9	14	14	9
<i>Punctelia</i> sp. 2	20	3	0	0	15	0	0	15	21	0	13	0
<i>Punctelia</i> sp. 3	0	0	0	17	0	0	9	0	0	0	0	0
<i>Punctelia</i> sp. 4 *	0	0	0	0	0	2	0	0	0	0	0	0
<i>Punctelia</i> sp. 5	0	16	1	51	38	0	2	43	6	21	44	34
<i>Punctelia</i> sp. 6	0	2	0	0	0	0	0	0	0	0	0	0
<i>Punctelia</i> sp. 7	0	0	0	9	0	0	0	0	1	32	6	0
<i>Punctelia</i> sp. 8	0	0	0	1	0	0	0	0	0	0	0	0
<i>Punctelia</i> sp. 9	0	0	0	0	1	0	0	0	0	0	0	0
<i>Punctelia</i> sp. 10	0	0	0	0	8	0	0	0	0	0	0	0
<i>Pyrenula</i> sp. *	5	0	0	0	0	0	0	0	0	0	0	0
<i>Pyrenula mucosa</i> (Vain.) R.C. Harris	0	0	0	0	0	0	0	0	0	0	1	0
<i>Pyrenula pyrenuloides</i> (Mont.) R.C.Harris	0	0	0	0	0	0	6	0	0	0	0	0
<i>Pyxine cocoës</i> (Sw.) Nyl.	0	0	0	0	0	0	0	1	0	0	0	4
<i>Pyxine daedalea</i> Krog et Santesson	0	0	0	0	0	0	0	0	0	0	0	11
<i>Pyxine subcinerea</i> Stirton	0	0	0	0	0	0	2	14	4	0	0	0
<i>Ramalina celastri</i> (Spreng.) Krog et Swinscow	5	0	21	16	0	0	0	0	0	2	11	0
<i>Ramalina peruviana</i> Ach.	4	0	5	0	9	0	0	0	60	23	77	10
<i>Ramalina sprengelli</i> Krog et Swinscow	0	0	1	0	0	0	0	0	0	2	6	0
<i>Ramalina usnea</i> (L.) Howe	0	0	3	0	0	0	0	0	0	0	0	0
<i>Teloschistes exilis</i> (Michx.) Vain.	5	0	0	0	0	0	4	5	10	4	7	3
<i>Tephromela americana</i> (Fée) Kalb	1	0	0	0	0	0	0	0	0	0	0	7
<i>Trichothelium</i> sp.*	0	1	0	2	0	0	0	0	0	0	0	2
<i>Trypethelium nitidiusculum</i> (Nyl.) R. C. Harris	1	5	0	0	0	0	0	0	0	0	0	1
<i>Trypethelium</i> sp. *	0	0	0	0	0	0	0	0	6	0	0	0
<i>Usnea angulata</i> Ach.	0	0	0	0	0	0	0	0	0	8	1	4
<i>Usnea</i> cf. <i>rubicunda</i> Stirton	0	0	0	0	0	0	0	0	0	10	0	5
<i>Usnea florida</i> (L.) Wigg.	0	0	0	0	0	0	0	0	0	0	1	0
<i>Usnea rubicunda</i> Stirton	0	0	0	0	0	0	0	0	0	0	1	2
<i>Usnea</i> sp. 1	4	0	1	2	0	0	2	0	3	0	0	0
<i>Usnea</i> sp. 2	20	0	0	0	0	0	0	0	0	0	0	0
<i>Usnea</i> sp. 3	3	0	0	0	0	0	1	0	0	0	0	0
<i>Usnea</i> sp. 6	0	0	0	0	0	0	0	0	0	0	1	0
<i>Usnea</i> sp. 7	0	0	0	0	0	0	0	0	0	0	13	7
<i>Usnea</i> sp. 8	0	0	0	0	0	0	0	0	0	0	2	0
<i>Usnea</i> sp. 9	0	0	0	0	0	0	0	5	9	0	0	0