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Regional distribution of native and exotic species in levees of the lower delta of the Paraná river

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ABSTRACT. The distribution and abundance of exotic and native species in levee neo-ecosystems were analyzed. No invasive species were found in unit A; their absence could be explained by the fluvial action of the Paraná river, extraordinary flood episodes and anthropic disturbances. Invasive species associated with the tidal regimen of the de la Plata river were present in units B and C, particularly Chinese privet (*L. sinense*), green ash (*F. pennsylvanica*), honey locust (*G. triacanthos*), Japanese honeysuckle (*L. Japonica*), blackberry (*Rubus* spp.), box elder (*A. Negundo*) and glossy privet (*L. Lucidum*). Native species showed low recovery values, both at a regional level and within each unit, with the exception of A. The neo-ecosystems with the greater degree of abandonment of units B and C exhibited dominance of exotic tree species and, to a lesser extent, recovery of native species of the original gallery forest (seibo, *Erythrina crista galli*; laurel, *Nectandra falcifolia*; canelón, *Rapanea* spp. and arrayán, *Blepharocalyx tweediei*).

Key words: wetlands, lower delta, neo-ecosystems, invasive species, “Monte Blanco” species.

RESUMO. A distribuição de espécies exóticas e nativas em diques marginais do baixo delta do rio Paraná, Argentina. Analisam-se a distribuição e a abundância das espécies exóticas e nativas nos neo-ecossistemas de diques marginais. A unidade A não apresentou espécies invasoras. A ação fluvial do rio Paraná, acontecimentos como inundações extraordinárias e distúrbios antrópicos poderiam explicar a sua ausência. B e C apresentaram espécies invasoras associadas ao regime de marés do rio de la Plata. Entre as espécies destacam-se: alfeneiro-da-china, ligustro-chinês (*L. sinense*), freixo vermelho (*F. pennsylvanica*), acácia meleira (*G. triacanthos*), madrissilva do Japão (*L. japonica*), amoreira-preta (*Rubus* spp.), bordo (*A. negundo*) e ligustro (*L. lucidum*). As espécies nativas apresentaram baixos valores de recuperação em nível regional e em cada unidade. A exceção foi a unidade A. Os neo-ecossistemas com maior abandono nas unidades B e C apresentaram dominância de espécies arbóreas exóticas e em menor escala a recuperação de espécies da selva em mata ciliar original (corticeira, *Erythrina crista gall;* louro, *Nectandra falcifolia;* capororoca, *Rapanea* spp. e guapuriti, *Blepharocalyx tweediei).*

Palavras-chave: zonas úmidas, baixo delta, neo-ecossistemas, espécies invasoras, espécies de Monte Blanco.

Introduction

Wetland ecosystems are susceptible to invasive processes. Variations in the hydrological regime can modify the composition and structure of communities, being one of the agents responsible for the incorporation of invasive species (Brinson *et al.,* 1981; Howe and Knopf, 1991; Brown and Pezeshki, 2000). Some authors established a relationship between the structural simplicity that characterizes some types of wetlands and the invasive success of certain species (Taylor and Dunlop, 1985; Cowie and Werner, 1993). Wetlands are subjected to an intense anthropic handling, which leads to high fragmentation of the landscape with juxtaposition of natural and anthropic environments, and alteration of the main conditioning variables. This would substantially increase the dispersion of invasive species in natural environments (Hobbs, 1989; Touzard *et al.*, 2004).

The islands of the Lower delta are formed by the accretion of silts transported and deposited by the Paraná river in the de la Plata river. They are bin-shaped surrounded by a perimetric levee (20% of the total area) that encloses a depressed center (80% of the area) (Bonfils, 1962; Latinoconsult, 1972). Nowadays levees sustain different vegetation from the original gallery forest, locally referred to as Monte Blanco, which has been almost entirely replaced by afforestations of Salicaceas (willow, *Salix* spp.; and poplar, *Populus* spp.) (Burkart, 1957; Kalesnik, 2001). Interestingly, unlike low marshland areas (Valli, 1990), the original vegetation does not recover quickly, even in lots with long-term abandonment of human activity (Kandus, 1997; Kalesnik, 2001; Vallés *et al.*, 2005). The high degree of dispersion and the success in the occupation of exotic plant species are the main factors that interfere with recovery. Burkart (1957) listed 29 naturalized or soon-to-be naturalized species in the islands of the Lower delta, some of which were already cause for concern for being bothersome invaders in affforestations, of difficult eradication, and for displacing native species in levees of Monte Blanco. Currently, this situation would remain, or even tend towards an increase in their occupation in the study region, as well as in de la Plata river riverside (Goya *et al.*, 1992; Montaldo, 1993; Dascanio *et al.*, 1994; Cagnoni *et al.*, 1996; Boffi Lissin *et al.*, 1999; Ruiz Selmo, 1998; De Urquiza, 1999; Kalesnik *et al*., 2005). In all aforementioned instances, exotic species invade different natural communities and can even become dominant, displacing the original native species and forming different types of neo-ecosystems (Morello *et al.*, 2000; Kalesnik, 2001; Vallés *et al.*, 2005).

The present work analyzed the status concerning exotic invasive species, given that, as was pointed out before, the success of their invasion and propagation could be associated with the native species of Monte Blanco's difficulty to regenerate. In this sense, distribution patterns and relative abundance of both native and exotic species were analyzed in each type of neo-ecosystem in levees for all environmental units constituting the study area. The degree of invasion of exotic species and the degree of regeneration of native species in the different environmental conditions of the Lower delta were also investigated.

Material and methods

Study site: the Bonaerense Lower delta

This study was conducted in the Lower delta of the Paraná river located in Buenos Aires Province (Figure 1), covering an area of 2,071.06 km^2 (Latinoconsult, 1972). The climate is temperate-subhumid, with mean annual temperatures around 17ºC and annual precipitations of 1073 mm (Servicio Meteorológico Nacional, 1980). The Lower delta islands are located on the terminal portion of the Paraná river delta, at the point of its bifurcation into two main branches, Paraná Guazú and Paraná de las Palmas. The Paraná river and the de la Plata river estuary are the main influence on the area's hydrological regime (Mujica, 1979). The former has a seasonal cycle with high flow starting in September that may cause occasional floods, such as the ones that took place in 1905, 1966 and 1982-3 (DNCP, 1983; Boneto, 1986). The latter presents both lunar and eolic tides with daily ranges of 1 meter and 2.5-3 meters, respectively (Iriondo and Scotta, 1978). The Uruguay river has minimal influence on the area.

The Bonaerense Lower delta islands are formed by the accretion of silts transported and deposited by the Paraná river in the de la Plata river. They are bin-shaped surrounded by a perimetric levee (20% of the total area) that encloses a depressed center (80% of the area) (Bonfils, 1962). Marshlands cover the inner portion, being the only natural ecosystem present (Kandus and Adámoli, 1993). In the levees, the original forest gallery was replaced almost entirely by afforestations of Salicaceas, with only small patches remaining today (Kalesnik, 2001; Vallés *et al*., 2005).

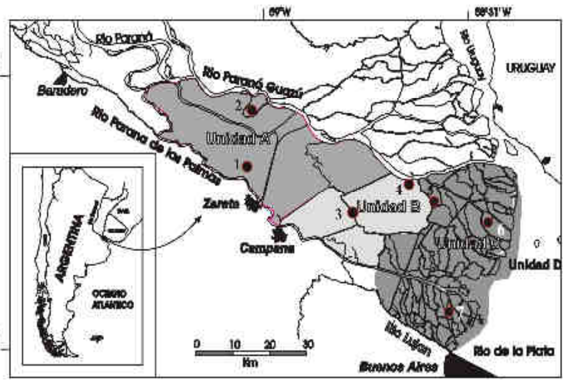

Figure 1. Study area: lower delta of the Paraná river. ● Modal areas (Sampling sites). 1 - Paraná de las Palmas. Ñacurutú Stream. 2 - Botija Island. 3 - Carabelas river. 4 - Paraná Guazú. 5 - Paraná Miní. 6 - Barca Grande river. 7 - Boraso Stream.

Amongst the hydromorphic soil types found in levees, humic, subhumic gley and alluvial soils were the most common (Bonfils, 1962). According to the US Soil Taxonomy (Soil Survey Staff, 2003) they correspond to Mollisols and Entisols (Endoaquolls, Hapludolls, Endoaquents) (Godagnone *et al*., 2002). Kandus (1997) proposes a regionalization of the Lower delta area, in which the spatial distribution of habitats and the hydrological dynamics are the main factors defining four distinct ecological units (Figure 1).

Unit A consists of a deltaic plain (Sumerfield, 1991) with strong fluvial influence due to the seasonal rise of the Paraná river. The annual flood frequency is rather low, but the area can remain flooded for over six months at the time of the highest seasonal flow. Extraordinary floods due to "El Niño" also have a strong impact on this unit. It is comprised of large islands, with most of their extension consisting of permanently inundated lowlands surrounded by perimetral levees.

Unit B, downstream from A and locally referred to as forest nucleus, has a transitional hydrology between the fluvial influence of the Paraná river and the tidal influence of the de la Plata river. The islands in this unit show a high degree of anthropic action.

Unit C forms the front of the delta and is subjected to direct influence of the tidal and eolic tides of the de la Plata river, which range from 1 to over 3 meters during strong southeastern winds. From the Paraná

Guazu and Paraná de las Pampas rivers, numerous streams fan out bordering small bin shaped islands with a perimetral levee and a depressed center dominated by Cortadera marshes (*Scirpusgiganteus*). Forestry in this area consists of open ditch Salicaceas afforestations that have completely replaced the original vegetation of the levees.

The delta's accretion portion, where it grows by the deposition of sediments carried on the main rivers on their way to their mouth in the de la Plata river forming new islands and banks, constitutes Unit D. These islands have small, scantly developed levees and are continued downstream by extensive sediment banks that are only exposed during the lowest flow periods of the de la Plata river. This unit was not evaluated in the present work, since the habitats of the levees are not developed enough.

In summary, the hydrological regime of the Lower delta is subjected to a main northeast-southeast fluvial-tidal gradient (Figure 1).

Sampling procedure and data collection

Modal areas were selected based on the analysis of satellite images (Landsat, bands 5 and 7, FCC) and stereoscopic pairs of aerial photos (scale 1:20.000, 1989). Sampling sites in Units A, B and C were then selected from these modal areas (Figure 1).

Ninety-seven plots were performed on levees of the modal areas, including different types of neo-ecosystems (21 in unit A, 41 in unit B, 35 in unit C). In order to guarantee internal homogeneity, censuses were randomly stratified and the plot size was 10 x 10 m.

Species cover was estimated using a modified Braun Blanquet scale (Mueller-Dombois and Ellemberg, 1974). Determination of species, their origin and life form were analyzed according to Cabrera (1963-1968), Burkart (1957), Cabrera and Dawson (1944) and Barkman (1988).

A typology of neo-ecosystems by degree of abandonment and handling type was used: Neo-ecosystem with recent anthropization (An): Afforestations of Salicaceas (*Salix* spp. or *Populus* spp.) with at least an annual removal of the understory. Short-term abandonment neo-ecosystem (Sh): 2-7 year-old afforestations. Removal of the understory only in the first year, from that time on vegetation starts to regenerate. Mid-term abandonment neo-ecosystem (M): 8-14 year-old afforestations. Removal of the understory only in the first year; regeneration of vegetation with presence of tree species saplings and seedlings. Long-term abandonment neo-ecosystems (Lo): Afforestations that have not been commercialized or subjected to removal of the understory for over 14 years. There can be found remains of the original forest cover or a new secondary replacement forest if deterioration of the original one took place. In all neo-ecosystems analyzed, afforestation practice had been carried out by an open ditch technique, which allows water to drain quickly from the surface after a flood. In long-term abandonment neo-ecosystems (Lo) the original hydrological conditions have re-emerged due to lack of maintenance.

Numerical analysis

Plant species distribution at a regional level was analyzed in terms of relative constancies of the whole study area (TC) and of each individual unit (AC, BC and CC). Total constancy was calculated as relative frequency over total number of plots; unit constancy was calculated as relative frequency over number of plots of each environmental unit of the Lower delta (Units A, B and C).

The degree of invasion of exotic species in each unit and in the whole region was analyzed taking into account the mean cover of exotic species and the mean invasion index (II) (Britgewater and Backshall, 1981), being II = number of exotic species in the plot / total number of species in the plot.

The degree of recovery of native species in each unit and in the whole region was analyzed considering the mean cover of native species and the mean recovery index (NI), being NI = number of native species in the plot / total number of species in the plot (complementary to II).

The invasive nature of the introduced exotic species and the recovery of native species in each unit were also analyzed, using relative constancy and mean cover for both types of species.

Results

Vegetation of levee neo-ecosystems

Richness of plant species and dominant life forms

A total of 123 plant species were found. Unit B showed the highest richness of the studied region with 78 species, followed by Unit A with 66, and Unit C with 61 species (Table 1). At a regional level, there were 19 tree species, 11 shrub species, 57 latifoliated herbaceous species (H), 17 graminoid herbaceous species (GH), 2 equisetoid herbaceous species (EH) and 17 vine-creeper species (C). The mean number of species per plot in the different types of neo-ecosystems within each unit was close to 10 species, with the exception of the neo-ecosystems with recent anthropization (An) of units A and C, which had a low mean number of species per plot (4 and 3.25 respectively). This type of neo-ecosystem is subjected to periodic disturbances (introduction of cattle, anthropic disturbances, to name a few).

Regional distribution pattern of species

Eight groups of species were determined in terms of their differential presence in the three units and their relative constancy (Table 1). The first two groups contained species present in all three units. Species forming group 1 had a constancy value of over ten per cent in each unit, and included three native tree species – anacahuita (*Blepharocalyx tweediei*), canelón (*Rapanea* spp.), seibo (*Erythrina crista galli*) – and an exotic sarmentose shrub, blackberry (*Rubus* spp.) with one of the highest regional relative constancy values (TC = 40,21) (Table 1).

Group 2 included species with a constancy value of less than 10 per cent for at least one of the units: three exotic tree species, box elder (*Acer negundo*), green ash (*F. pennsylvanica*) and mulberry (*Morus* sp.); and an exotic creeper, Japanese honeysuckle (*Lonicera japonica*), present in 60% of regional plots but only in a small number of plots in unit A (Table 1).

Groups 3, 4 and 5 consisted of species present in only two regional units. Species which were jointly found in units B and C were placed together in group 3, and were only exotic tree species – Chinese privet (*Ligustrum sinense*), glossy privet (*Ligustrum lucidum*), honey locust (*Gleditsia triacanthos*), and native herbaceous species. Only one species present

Table 1. Plant species distribution in the Lower delta of the Paraná river.

	SPECIES	O	LF	A	B	C	C.A	C.B	C.C	Cv.A	Cv.B	Cv.C	C.T	GROUP	M.B
1	*Blepharocalyx tweediei*	N	T	*	*	*	14,29	0,37	11,43	3,67	3,97	7,80	22,68	1	*
2	*Carex riparia*	N	GH	*	*	*	38,10	0,34	22,86	10,88	4,15	5,56	30,93	1	*
3	*Cestrum parqui*	N	Sh	*	*	*	42,86	0,32	28,57	13,00	1,12	6,23	32,99	1	*
4	*Eryngium pandalifolium*	N	GH	*	*	*	19,05	0,20	48,57	1,51	1,25	3,75	19,59	1	*
5	*Erythina crista-galli*	N	T	*	*	*	14,29	0,27	11,43	2,17	13,64	12,20	18,56	1	*
6	*Rapanea* spp.	N	T	*	*	*	14,29	0,22	37,14	2,17	21,78	28,21	25,77	1	
7	*Rubus* spp.	E	Sh	*	*	*	14,29	0,51	42,86	7,50	59,31	52,06	40,21	1	*
8	*Acer negundo*	E	T	*	*	*	4,76	4,88	31,43	0,50	64,50	35,09	14,43	2	
9	*Allophylus edulis*	N	T	*	*	*	4,76	0,02	8,57	0,01	62,50	6,13	5,15	2	*
10	*Aspilia silphioides*	N	H	*	*	*	38,10	0,17	2,86	25,50	5,22	7,51	16,49	2	
11	*Baccharis* sp.	N	Sh	*	*	*	23,81	0,20	14,29	1,30	0,26	11,92	18,56	2	
12	*Cayaponia* sp.	N	Cr	*	*	*	23,81	0,07	2,86	0,30	1,33	10,75	9,28	2	*
13	*Fraxinus* pennsylvanica	E	T	*	*	*	4,76	0,46	22,86	3,00	29,61	24,56	28,87	2	*
14	*Hidrocotile bonariensis*	N	H	*	*	*	23,81	0,29	5,71	7,00	2,92	10,01	19,59	2	*
15	*Ipomoea* spp.	N	Cr	*	*	*	23,81	0,05	8,57	0,80	0,01	8,01	10,31	2	
16	*Lonicera japonica*	E	Cr	*	*	*	4,76	0,63	85,71	87,50	37,87	52,74	58,76	2	
17	*Ludwigia* spp.	N	H	*	*	*	23,81	0,05	14,29	0,61	0,01	6,26	12,37	2	*
18	*Mikania micrantha*	N	Cr	*	*	*	52,38	0,05	8,57	21,64	0,01	9,25	16,49	2	
19	*Morus* sp.	E	T	*	*	*	4,76	0,20	28,57	7,50	4,94	15,64	19,59	2	
20	*Panicum grumosum*	N	GH	*	*	*	61,90	0,24	8,57	15,50	4,05	9,63	26,80	2	
21	*Passiflora coerulea*	N	Cr	*	*	*	9,52	0,12	2,86	0,26	0,21	19,51	8,25	2	
22	*Plantago* sp.	N	H	*	*	*	9,52	0,12	2,86	0,01	8,00	20,01	8,25	2	*
23	*Rynchospora* sp.	N	GH	*	*	*	4,76	0,10	8,57	0,01	0,88	15,38	8,25	2	*
24	*Smilax campestri*	N	Cr	*	*	*	23,81	0,15	11,43	0,30	0,26	9,71	15,46	2	*
25	*Solanum bonariense*	N	H	*	*	*	4,76	0,24	20,00	0,50	0,71	8,63	18,56	2	
26	*Stigmatophyllum littorale*	N	Cr	*	*	*	9,52	0,10	11,43	0,50	0,13	11,00	10,31	2	
27	*Tradescantia* sp.	N	H	*	*	*	28,57	0,12	14,29	0,09	0,30	8,84	16,49	2	*
28	*Vigna luteola*	N	H	*	*	*	4,76	0,07	5,71	3,00	0,01	13,38	7,22	2	
29	*Aeschinomene montevidense*	N	Sh		*	*		0,07	2,86		0,01	6,51	4,12	3	*
30	*Cuphea fructicosa*	N	H		*	*		0,05	2,86		0,26	12,25	3,09	3	*
31	*Diodia brasiliensis*	N	H		*	*		0,27	48,57		7,73	5,33	28,87	3	
32	*Eupatorium tremulum*	N	H		*	*			8,57			7,38	3,09	3	*
33	*Fragaria* sp.	*	H		*	*		0,05	2,86		31,94	31,25	4,12	3	*
34	*Gleditsia triacanthos*	E	T		*	*		0,24	8,57		36,55	48,63	13,40	3	
35	*Lantana camara*	N	Sh		*	*		0,02	8,57		0,01	8,26	4,12	3	*
36	*Ligustrum lucidum*	E	T		*	*		0,02	57,14		3,00	34,52	21,65	3	*
37	*Ligustrum sinense*	E	T		*	*		0,39	68,57		46,53	47,42	41,24	3	*
38	*Metastelma virgatum*	N	Cr		*	*		0,12	5,71		0,01	11,84	7,22	3	*
39	*Oxalis* spp.	N	H		*	*		0,12	11,43		4,20	8,10	9,28	3	*
40	*Rosa* sp.	E	Sh		*	*		0,02	2,86		0,50	8,75	2,06	3	*
41	*Sesbania punicea*	N	Sh		*	*			2,86			22,75	2,06	3	*
42	*Sida rombifolia*	N	H		*	*		0,05	2,86		0,01	23,51	3,09	3	
43	*Solanum spp.*	N	H		*	*		0,07	2,86		0,01	25,01	4,12	3	*
44	*Cyclosorus gongylodes*	N	H	*		*	19,05		2,86	1,88		12,75	5,15	4	*
45	*Amorpha fructicosa*	E	Sh	*	*		9,52	0,17		7,50	7,29		9,28	5	*
46	*Apium* sp.	N	H	*	*		9,52	0,10		0,01	0,50		6,19	5	
47	*Begonia cucullata*	N	H	*	*		14,29	0,05		0,17	0,01		5,15	5	*
48	*Boehmeria cilindrica*	N	H	*	*		9,52	0,02		0,01	0,01		3,09	5	*
49	*Carex* spp.	N	GH	*	*		4,76	0,02		0,50	0,01		2,06	5	*
50	*Cephalanthus glabratus*	N	Sh	*	*		33,33	0,07		15,07	3,67		10,31	5	
51	*Conyza* sp.	N	H	*	*		4,76	0,07		0,01	1,17		4,12	5	*
52	*Cortaderia selloana*	N	GH	*	*		19,05	0,07		0,88	3,00		7,22	5	*
53	*Echinodorus argentinensis* Rataj.	N	H	*	*		4,76	0,07		0,50	0,17		4,12	5	
54	*Eleocharis bonariensis*	N	EH	*	*		9,52	0,02		0,50	0,01		3,09	5	
55	*Iris pseudacorus*	E	GH	*	*		9,52	0,27		0,26	15,32		13,40	5	
56	*Mimosa pigra*	N	T	*	*		28,57	0,10		3,17	1,13		10,31	5	*
57	*Monteiroa glomerata*	N	H	*	*		4,76			0,01			6,19	5	*

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58	*Muehlembekia sagittifolia*	*N*	*Cr*	*	*		9,52	0,02		0,01	0,01		3,09	5	*
59	*Myrceugenia glaucescens*	*N*	*T*	*	*		19,05	0,05		1,00	3,00		6,19	5	*
60	*Nectandra falcifolia*	*N*	*T*	*	*		57,14	0,15		3,13	7,58		18,56	5	
61	*Poligonum acuminatum*	*N*	*H*	*	*		9,52			3,00			3,09	5	
62	*Poligonum* sp.	*N*	*H*	*	*		19,05	0,07		3,00	0,17		7,22	5	
63	*Poligonum steligerum*	*N*	*H*	*	*		28,57	0,07		0,17	0,17		9,28	5	
64	*Sapium haematospermun*	*N*	*T*	*	*		9,52	0,12		1,75	43,20		7,22	5	
65	*Solidago chilensis*	*N*	*H*	*	*		9,52	0,10		0,01	2,63		6,19	5	
66	*Thalia* sp.	*N*	*GH*	*	*		14,29	0,02		0,17	0,01		4,12	5	*
67	*Tillandsia sp.*	*N*	*H*	*	*		4,76	0,07		0,01	0,50		4,12	5	*
68	*Trifolium repens*	*E*	*GH*	*	*		9,52	0,05		0,01	0,01		4,12	5	
69	*Adesmia*+C103	*N*	*H*	*			4,76			0,01			1,03	6	*
70	*Alternanthera philoxeroides*	*N*	*H*	*			9,52			3,00			2,06	6	
71	*Gomphrena* sp.	*N*	*H*	*			4,76			0,01			1,03	6	*
72	*Hyptis fasciculata*	*N*	*H*	*			4,76			3,00			1,03	6	
73	*Marsilea concinna*	*N*	*H*	*			9,52			0,50			2,06	6	
74	*Mimosa bomplandii*	*N*	*T*	*			14,29			2,00			3,09	6	*
75	*Passiflora missera*	*N*	*Cr*	*			4,76			0,01			1,03	6	
76	*Pavonia* sp.	*N*	*H*	*			14,29			0,01			3,09	6	
77	*Psichotria cartaginensis*	*N*	*T*	*			4,76			0,50			1,03	6	
78	*Solanum amigdalifolium*	*N*	*Cr*	*			28,57			2,08			6,19	6	
79	*Athyrium auriculatum*	*N*	*H*		*			0,02			0,01		1,03	7	
80	*Cisssus palmata*	*N*	*Cr*		*			0,02			0,01		1,03	7	*
81	*Citrus aurantium*	*E*	*Sh*		*			0,02			0,01		3,09	7	*
82	*Cynodon dactylon*	*N*	*GH*		*			0,05			4,00		2,06	7	
83	*Cyperus* sp.	*N*	*GH*		*			0,02			0,01		1,03	7	
84	*Dioscorea sinuata*	*N*	*Cr*		*			0,02			0,01		1,03	7	
85	*Equisetum* sp.	*N*	*EH*		*			0,12			0,50		5,15	7	*
86	*Hidrocotile modesta*	*N*	*H*		*			0,07			4,50		3,09	7	
87	*Parietaria debilis*	*N*	*H*		*			0,02			0,01		1,03	7	*
88	*Pfaffia glomerata*	*N*	*H*		*			0,02			0,01		1,03	7	*
89	*Poa annua*	*E*	*GH*		*			0,07			44,17		3,09	7	
90	*Relbunium* sp.	*N*	*H*		*			0,10			0,88		4,12	7	
91	*Solanum glaucophylum*	*N*	*H*		*			0,02			0,01		1,03	7	
92	*Stipa* sp.	*N*	*GH*		*			0,02			0,01		1,03	7	*
93	*Teucrium vesicarium*	*N*	*H*		*			0,07			1,33		3,09	7	*
94	*Verbena* spp.	*N*	*H*		*			0,02			0,01		3,09	7	*
95	*Adiantum raddianum*	*N*	*H*			*			2,86			6,01	1,03	8	*
96	*Blechnum auriculatum*	*N*	*H*			*			2,86			8,51	1,03	8	*
97	*Canna glauca*	*N*	*GH*			*			5,71			6,50	2,06	8	*
98	*Clematis bonariensis*	*N*	*Cr*			*			2,86			11,75	1,03	8	*
99	*Ipomoea alba*	*N*	*Cr*			*			5,71			10,50	2,06	8	
100	*Populus* sp.	*E*	*T*			*			2,86			5,50	1,03	8	
101	*Pouteria salicifolia*	*N*	*T*			*			8,57			18,25	3,09	8	
102	*Rhamnus catharticus*	*E*	*T*			*			22,86			11,50	8,25	8	*
103	*Scirpus giganteus*	*N*	*GH*			*			5,71			18,17	2,06	8	
104	*Setaria onurus*	*N*	*GH*			*			11,43			9,31	4,12	8	
	19 especies sin determinar														
	Richness:			66	78	61									

in the extreme units of the region, A and C, formed group 4. Group 5 consisted of species present in units A and B, mainly native, such as tree species laurel (*Nectandra falcifolia*) and murta (*Myrceugenia glaucescens*), and the shrubs begonia (*Begonia cucullata)* and lambedor (*Poligonum steligerum*). Two shrubs typical of high flooding frequency environments, sarandí (*Cephalanthus glabratus*) and the exotic false indigo (*Amorpha fructicosa*) also form this group. Despite typically growing in lowland environments (Kandus, 1997; Valli, 1990), the exotic shrub species paleyellow iris (*Iris pseudacorus*) was found in 14% of plots.

The last three groups (6, 7 and 8) consisted of particular species in each unit, which could be indicators of the environmental status or the usage history of the units analyzed. The presence of alligator weed (*Alternanthera philoxeroides*), usually found in flooded environments (Cabrera, 1971), could be indicating a state of flooding in unit A (Group 6); the presence of invasive weeds like *Cynodon dactylon* and *Poa annua* could be related to high anthropic disturbances in unit B (Group 7), since it contains the oldest and currently active productive settlements (afforestation core area) (Bó and Quintana, 1999); the presence of the native tree species mata ojo (*Pouteria salicifolia*) in unit C (Group 8) could be associated with the influence of the hydrological regime of the Uruguay river, which acts as an entryway for species from the Paraná basin (Menalled and Adámoli, 1995) (Table 1).

Exotic vegetation of neo-ecosystems in levees of the Paraná river Lower delta

Degree of invasion in the Lower delta region

The main invasion index of exotic species per plot for the whole Lower delta region was 0.349 (Table 2); on average, 3 out of 10 species present per plot were of exotic origin. This index does not take into account the degree of development of the species. Exotic species regional cover was 76.56% of the total plant cover (Table 3).

The degree of invasion varied among the regional units. Unit A showed a very low degree of invasion, with an invasion index (II) of 0.052 and small development of exotic species cover (6.5%). The highest invasion was found in unit C, with a high invasion index (II = 0.517) and a large development of exotic species cover (88.28%); half the species present in each plot for this unit were of exotic origin. Similar to unit C, Unit B had high exotic species plant cover (79.03%) but only a medium index of invasion (II = 0.357).

Table 2. Invasion indexes of exotic species and recovery indexes of native species in neo-ecosystems of the Lower delta units.

		Units			
		A	B	C	
B	II	0.048 (5)	0.309 (10)	0.508 (6)	
	NI	0.95	0.69	0.49	
M	II	0.69 (7)	0.435 (16)	0.369 (8)	
	NI	0.93	0.57	0.63	
A	II	0.031 (6)	0.349 (7)	0.497 (17)	
	NI	0.97	0.65	0.50	
AN	II	0 (3)	0.268 (8)	0.917 (4)	
	NI	1.00	0.73	0.08	Region
Total	II	0.052 (21)	0.357 (41)	0.517 (35)	0.349 (97)
	NI	0.95	0.64	0.48	0.65

II: Mean invasion index. NI: Mean native species recovery index. ( ): number of plots. Neo-ecosystems: Sh: short-term abandonment, M: mid-term abandonment, Lo: long-term abandonment, An: recent anthropization. Units of the Lower delta: A, B and C.

Table 3. Native and exotic species mean cover per plot in the different neo-ecosystems of the Lower delta units.

		Units			
		A	B	C	
B	E	19	92.14	94.84	
	N	44.2	7.86	5.16	
M	E	3.79	82.16	91.49	
	N	36.88	17.84	8.51	
A	E	2.28	64.29	79.06	
	N	97.72	35.71	20.94	
AN	E	0	82.46	99.99	
	N	0.52	17.54	0.01	Region
Total	E	6.5	79.03	88.29	76.56
	N	55.6	20.97	11.71	23.44

E: Exotic species, N: Native species, Types of neo-ecosystems: Sh: short-term abandonment, M: mid-term abandonment, Lo: long-term abandonment, AN: recent anthropization. Units of the Lower delta: A, B and C.

Exotic species and their invasive nature

Exotic species represented 13 % of total species (16 species); 8 were tree species, 4 shrubs, 3 herbaceous and 1 creeper (Table 1). They showed different cover growth depending on the Lower delta unit and the type of neo-ecosystem analyzed. Their invasive nature was thus analyzed, considering whether they were able to spread and expand their population successfully in the new types of environments they encountered.

Unit A

Out of 66 total species for this unit, only eight were exotic, and none showed a considerable relative constancy value in the unit (AC) (Table 1). In addition, they had low cover values in the plots analyzed (Table 1). Even blackberry (*Rubus* spp.), which had a high total regional relative constancy (TC = 40.21), showed low constancy and cover values in this unit. Therefore, none of the exotic species found in this unit could be considered *invasive species* in any of the neo-ecosystems analyzed.

Unit B

Twelve exotic species out of a total of 78 were found in this unit; only 5 showed high relative constancy and cover values. Three tree species, *F. pennsylvanica*, of North American origin; *G. triacanthos*, honey locust of the east coast of North America; and *L. sinense*, an Asiatic privet; could be considered *invasive species* since they had successfully established themselves in the area, exhibiting saplings, juvenile individuals and adults as part of their population structure (Kalesnik, 2001). Particularly, the green ash (*F. pennsylvanica.*) displayed higher relative constancy and cover values in long-term abandonment neo-ecosystems (Lo). The honey locust (*G. triacanthos*) was present only in neo-ecosystems with recent anthropization (An) and in short-term abandonment neo-ecosystems (Sh), with medium relative constancy values but a wide cover in some of the plots. The Chinese privet (*L. sinense*) exhibited high cover values in all long-term abandonment neo-ecosystems (Lo) plots, and in the mid-term abandonment neo-ecosystems (M) where it was present (Tables 1 and 4). The other two exotic species present in this unit, the Asiatic creeper Japanese honeysuckle (*L. japonica*) and the European sarmentose shrub blackberry (*Rubus* spp.), could also be considered *invasive species* since they displayed high relative constancy and cover values in the plots analyzed. They possess great vegetative growth, which allows them to develop successfully in neo-ecosystems where they are introduced. Blackberry showed its maximum constancy value in neo-ecosystems with recent anthropization (An) and in short-term abandonment neo-ecosystems (Sh), though it was also present in mid-term abandonment neo-ecosystems; it was notoriously absent from long-term abandonment neo-ecosystems (Lo). On the contrary, the Japanese honeysuckle developed in all long-term abandonment neo-ecosystems (Lo), and also had medium constancy and cover values in the remaining types of neo-ecosystems (Tables 1 and 4).

Unit C

Sixty-one species were detected in this unit, eleven of them being exotic species. Most of them (7 species) ranked with high relative constancy and cover values. The five exotic tree species found include all three species present in unit B and two new species – *Acer negundo*, box elder indigenous to North America, and *Ligustrum lucidum*, Asiatic privet. Saplings, juvenile

Table 4. Main native e and exotic species mean cover in levee neo-ecosystems of the Lower delta of the Paraná river.

SPECIES		UNIT A				UNIT B				UNIT C			
EXOTIC	LF	Sh	M	L	AN	Sh	M	L	AN	Sh	M	L	AN
Acer negundo	T	*	0,07	*	*	*	*	18,43	*	3,42	*	23,03	2,00
Fraxinus sp.	T	*	0,43	*	*	11,95	8,66	42,43	0,94	*	*	12,00	3,75
Gleditsia triacanthos	T	*	*	*	*	19,60	*	*	21,19	*	*	11,26	*
Ligustrum lucidum	T	*	*	*	*	*	*	*	*	1,25	14,94	28,82	26,00
Ligustrum sinense	T	*	*	*	*	2,55	27,38	40,14	*	29,17	37,50	31,21	43,75
Morus sp.	T	*	1,07	*	*	*	2,22	0,07	0,44	1,50	7,38	5,71	*
Populus sp.	T	*	*	*	*	*	*	*	*	*	*	0,18	*
Rhamnus catharticus	T	*	*	*	*	*	*	*	*	*	0,38	5,38	*
Amorpha fructicosa	Sh	*	2,14	*	*	3,65	0,91	*	*	*	*	*	*
Rubus sp.	Sh	1,50	*	2,50	*	52,10	24,47	0,07	41,56	87,50	36,31	0,21	0,75
Lonicera japonica	Cr	17,50	*	*	*	39,15	13,34	35,07	16,75	66,08	58,81	42,38	10,38
Iris pseudacorus	GH	*	0,07	*	*	0,35	10,31	*	*	*	*	*	*
SPECIES		UNIT A				UNIT B				UNIT C			
NATIVE	LF	Sh	M	L	AN	Sh	M	L	AN	Sh	M	L	AN
Allophylus edulis	T	*	*	*	*	*	*	8,93	*	*	*	0,62	*
Blepharocalyx tweediei	T	1,50	0,07	0,50	*	1,10	0,56	5,22	0,38	*	*	1,24	*
Erythina crista-galli	T	*	0,07	1,00	*	0,05	3,22	13,93	0,06	0,00	3,69	0,21	*
Mimosa pigra	T	0,60	0,14	2,50	*	0,05	0,25	*	*	*	*	*	*
Myrceugenia glaucescens	T	0,10	0,07	0,50	*	*	*	0,86	*	*	*	*	*
Nectandra falcifolia	T	2,20	1,57	2,50	0,17	*	2,75	0,14	0,06	*	*	*	*
Pouteria salicifolia	T	*	*	*	*	0,30	1,13	24,93	0,06	*	*	1,88	*
Psichotria cartaginensis	T	0,10	*	*	*	*	*	*	*				
Rapanea sp.	T	0,70	0,43	*	*	*	*	*	*	0,08	1,75	19,91	*
Sapium haematospermun	T	*	0,07	0,50	*	0,00	5,19	19,00	*	*	*	*	*
Cephalanthus glabratus	Sh	*	14,64	0,50	*	0,80	0,19	*	*	*	*	*	*
Cestrum parqui	Sh	22,30	0,50	0,17	0,33	0,65	0,22	0,22	0,38	0,08	*	2,71	*
Mimosa bomplandii	Sh	*	*	1,00	*	*	*	*	*	*	*	*	*
Mikania micrantha	Cr	3,00	5,64	30,59	*	*	*	*	*	*	0,06	0,03	*
Aspilia silphioides	H	0,60	5,64	26,92	*	0,10	2,22	*	*	*	*	*	*
Diodia brasiliensis	H	*	*	*	*	0,01	0,21	11,57	0,00	1,83	0,25	3,35	*
Carex riparia	GH	0,10	1,07	13,17	*	4,50	0,03	0,14	1,44	4,17	0,19	0,21	*
Panicum grumosum	GH	3,00	6,64	23,33	*	*	*	*	*	*	*	*	*

LF: Life form, T: tree, Sh: Shrub, H: Latifoliated Herbaceous, GH: Graminoid Herbaceous, EH: Equisetoid herbaceous, Cr: Creeper/Vine. Types of neo-ecosystems: Sh: short-term abandonment (2-6 years), M: mid-term abandonment (6-14 years), Lo: long-term abandonment (over 14 years), An: recent anthropization.*: absence of the species.

individuals and adults were present in the population structure for all exotic tree species (Kalesnik, per. com.), implying a successful settlement of the species as *invasive species*. Two other exotic species introduced were *Rhamnus catharticus*, European buckthorn, and *Morus* sp., Asiatic mulberry, with considerable relative constancies in this unit, but without significant cover or evidence of regeneration, and were therefore not considered invasive species. Similar to what was found in unit B, the green ash (*F. pennsylvanica*) showed higher relative constancy and cover values in long-term abandonment afforestations (Lo) and low relative constancy and cover values in neo-ecosystems with recent anthropization (An). The honey locust (G. *triacanthos*) was also present in long-term abandonment neo-ecosystems (Lo), where only adult individuals of more than 30 years of age were found. The Chinese privet (*L. sinense*) exhibited high or medium cover values in almost every long-term abandonment neo-ecosystem analyzed, but also developed in other types of neo-ecosystem. The two invasive species exclusive to this unit (*A. negundo*, box elder, and *L. lucidum*, glossy privet) were present in nearly all neo-ecosystem types, but showed their highest cover values in long-term abandonment neo-ecosystems (Lo) (Tables 1 and 4).

The Japanese honeysuckle (*L. japonica*) and the blackberry (*Rubus* spp.) showed a similar developmental pattern to that of the previous unit, but exhibited higher cover values; hence they were also considered *invasive species* for this unit (Tables 1 and 4).

Two other exotic species that develop in other types of neo-ecosystem of levees not considered for this study should be mentioned. Chinese wisteria (*Wisteria sinensis*), a woody creeper species that can grow as high as 10 m, was seen bordering streams and rivers of units B and C. New Zealand flax (*Phormium tenax*) was seen adjoining old abandoned flax afforestations. Burkart (1957) makes no mention of the former species, so its introduction must have taken place at a later date. The latter is mentioned as a crop in unit C, but not as a naturalized species.

Native vegetation of neo-ecosystems in levees of the Paraná river Lower delta

Degree of recovery of the native species of the Lower delta

Native species (88 species) account for 71.5% of total species in the region. They include 11 tree species, 6 shrub species, 14 creepers-vines species, 42 latifoliated herbaceous species, 13 graminoid herbaceous species and 2 equisetoid herbaceous species. Most of the native species (56 species) belong to the original Monte Blanco and Seibals communities, cited by Burkart (1957) and Kalesnik (2001) for levee environments (Table 1). The remaining species were mentioned as plant members of the Paraná river delta and the riverside of the de la Plata river by several authors (Hauman, 1923; Cabrera and Dawson, 1944; Cabrera, 1971, to name a few). The mean recovery index of native species per plot for the whole Lower delta region had a value of NI = 0.651 (Table 2). On average, 7 out of 10 species per plot were native species, members of the original plant communities, though most of them were herbaceous species. Despite this high number of native species, their mean regional cover per plot was low (23.44%). Unit A exhibited the greatest degree of recovery, with most of the species present in this unit being native (NI = 0.95) and covering 55.6% of the surface. Units B and C also showed high recovery indexes (NI = 0.78 and 0.75, respectively) but with low cover of native species (20.97% and 11.71%, respectively) (Table 3).

Native species and their recovery in neo-ecosystems

As previously mentioned, a group of native species was present throughout the region (Table 1, Groups 1 and 2). However their growth, as well as that of the rest of native species, differs among units and types of neo-ecosystem (Tables 1 and 2).

Unit A

This unit included 10 native tree species, nearly all of the tree species found in the region, belonging to the original Monte Blanco: arrayán (*B. tweediei*), canelón (*Rapanea* spp.), seibo (*E. crista galli*), laurel (*Nectandra falcifolia*), curupí (*Sapium haematospermun*), huevo de gallo (*Psichotria cartaginensis*), chal - chal (*Allophylus edulis*), rama negra (*Mimosa bomplandii*), carpinchera (*Mimosa pigra*) and murta (*Myrceugenia glaucescens*). Laurel *(N. Falcifolia*) was the only native tree species with high constancy in this unit, present in all neo-ecosystems including those with recent anthropization (An) where it was the only native tree species present, but had low cover values. The shrub duraznillo negro (*Cestrum parqui*) was also present in all neo-ecosystems with low cover values (Table 2). Among the graminoid herbaceous species, the carrizo (*Panicum grumosum*) showed the highest degree of development, being present in nearly all types of neo-ecosystems analyzed, especially in long-term abandonment neo-ecosystems where it reached its maximum cover value; however, it was not present in neo-ecosystems with recent anthropization (An) (Table 2). The creeper guaco (Mikania micrantha) also reached its maximum development in long-term abandonment neo-ecosystems (An) (Table 2).

Unit B

Eight of the tree species present in the previous unit were also found in neo-ecosystems of this unit, including arrayán (*B. tweediei*), canelón (*Rapanea* spp.) and seibo (*E. crista galli*), which were present in all types of neo-ecosystems even though they showed low cover values. This three species' maximum constancy and cover values were detected in long-term abandonment neo-ecosystems (Lo). The remaining tree species had low constancy and cover values in this unit as a whole, as well as in all types of neo-ecosystems considered (Table 2).

As in the previous unit, the duraznillo negro (*Cestrum parqui*) was prominent among native shrub species, present in all neo-ecosystems with low cover values. The same was true of the oreganillo (*Diodia brasiliensis*), native latifoliated herbaceous species, and of *Carex riparia*, native graminoid herbaceous species (Table 2).

Unit C

Only five native tree species were detected in this unit. The most prominent one was the canelón (*Rapanea* spp.), present in almost 40% of plots, with high cover values in some long-term abandonment neo-ecosystems.

The latifoliated herbaceous species oreganillo (*Diodia brasiliensis*) and the graminoid herbaceous species caragüatá (*Eryngium pandanifolium*) were present in nearly half the plots in this unit, but showed low cover values. The remaining native species had both low constancy and cover values in the unit as a whole, and in each type of neo-ecosystem. In the neo-ecosystems with recent anthropization of this unit, no significant recovery of native species was detected (Tables 1 and 2).

Discussion

Exotic species and their degree of invasion in the Paraná river Lower delta

Out of a total of 632 species cited for the Lower delta (Kalesnik and Malvárez, 1996), 16.14% were of exotic origin (102 species). This finding is in accordance with reported worldwide invasion patterns for temperate systems and tropical natural reserves, in which 10% of species were of exotic nature (Macdonald and Frame, 1988; Usher, 1991; Cowie and Werner, 1993). Over half the introduced species in the Lower delta were indigenous to Europe (63.70%), with the remaining originating in Asia (17.64%), North America (8.82%), Africa (5.88%) and Oceania (3.92%). These species represented 33 different plant families: Asteraceae (21 species), Fabaceae (10 species), Poaceae (9 species), Brassicaceae (6 species), Polygonaceae (5 species), and several others with less than 4 species each. The three most prominent families found in this work were also reported to be dominant in the flora of the delta region (Kalesnik and Malvárez, 1996) and the

Buenos Aires Metropolitan area (Matteucci *et al.*, 1999). The first four families mentioned also agree with the pattern referred by Pysek (1998), in which those same four families had the highest number of exotic species in the analysis of 26 representative floras of different habitats around the globe.

Burkart (1957) mentions 28 naturalized or soon-to-be naturalized species in the delta region islands. A more recent work by Kandus (1997) cites only four exotic species (paleyellow iris, *Iris pseudacorus*; Japanese honeysuckle, *Lonicera japonica*; Chinese privet, *Ligustrum sinense*; and blackberry, *Rubus* spp.) in natural environments of islands of the Lower delta. It should be mentioned that most of the sampling for that work was performed on lowlands and only to a lesser degree on mid-hill and relative highlands (levees). These species were not considered exotic invasive species, since they had very low constancy and mean cover values; the author mentions that paleyellow iris and Japanese honeysuckle only reached high cover values in a few plots located in seibo forests of low inland levees or in mid-hill environments. Kalesnik (2001) and Vallés *et al.* (2005) described the flora composition of relict patches of natural forests in the Lower delta, and mentioned 11 exotic species with small regional development; only forests of unit C (seibal and Monte Blanco) exhibited high cover values of exotic species, including Chinese privet (*L. sinense*), glossy privet (*L. lucidum*), Japanese honeysuckle (*L. japonica*), white mulberry *(Morus alba*) and box elder (*A. negundo*).

Valli (1990) analyzed the main types of anthropically modified environments or neo-ecosystems in lowlands (*Salix* spp. afforestations) and established the succession trend in terms of the degree of abandonment for unit C of the Lower delta. The author found that terrestrial species were replaced by species adapted to temporal or permanent floods, and that the original marshland recovered in time. Throughout the succession five exotic species reached low cover values: paleyellow iris (*I. pseudacorus*) in short-term abandonment neo-ecosystems, false indigo (*Amorpha fructicosa*) in long-term abandonment neo-ecosystems, Japanese honeysuckle (*L. japonica*) and Chinese privet (*L. sinense*) in all types of neo-ecosystem. In the present work, 16 introduced species with low mean regional invasion index were found in levee neo-ecosystems. However, they showed high average cover percentage when compared to that of the seven exotic species considered invasive in the region (Chinese privet, *L. sinense*; green ash, *F. pennsylvanica;* honey locust, *G. triacanthos*; Japanese honeysuckle, *L. japonica*; blackberry, *Rubus* spp.; box elder, *A. negundo* and glossy privet, *L. lucidum*). The regional degree of invasion for levee neo-ecosystems varied among units. Unit A had a very low invasion index, low cover of exotic species and no invasive species. The joint action of the fluvial influence of the Paraná river, extraordinary flooding events and anthropic disturbances related to fire due to hunting could explain the absence of invasive species in this unit; under these conditions, exotic species would only be able to settle but would not become invasive. The lack of invasive exotic species in the fluvial sectors of the Middle and upper delta and upstream of the Paraná Medio would support this conclusion (Lewis and Franceschi, 1987; Franceschi e Lewis, 1991; Malvárez, 1997). McIntyre *et al.* (1988) suggested that high levels of endogenous disturbance would grant resistance to species invasion.

Medium invasion indexes and a great cover growth were found for exotic invasive species in the other two units (B and C). Species present in these units were associated with the diminished fluvial influence of the Paraná river and the greater influence of the tidal regime of the de la Plata river. The extraordinary and seasonal rises of the Paraná river are weaker and the anthropic disturbances (fire and stockbreeding) are of a lesser magnitude when compared with unit A. In addition, the tidal regime of the de la Plata river causes a bidirectional hydrological flow, which incorporates an additional hydric input and compensates for the seasonal drought characteristic of the Paraná river.

Invasive exotic species present in these units would possess the needed adaptations to develop under the aforementioned environmental conditions. Numerous studies carried out over the entire length of the de la Plata river riverside (Dascanio *et al.*, 1994; Cagnoni *et al.*, 1996; Matteucci *et al*., 1999; Kalesnik and Malvárez, 2003; Kalesnik and Kandel, 2004; Kalesnik *et al.*, 2005) mentioned the same tendency, with the same seven exotic species which invaded levee neo-ecosystems of the Lower delta of the Paraná river invading different types of environments.

In conclusion, upon analysis of the introduction and invasion of exotic species in the Lower delta and its islands, 8.82% of exotic species, out of a total of 102, became invasive species in the islands, in accordance with the 10% reported for temperate ecosystems. By contrast, for tropical ecosystems the percentage increases to almost 100% (Williamson and Brown, 1986; Usher, 1991). However, this value varies considerably between the different types of ecosystem present in the islands of the Lower delta. In the levee neo-ecosystems analyzed in the present work, the ratio was close to 50%, since half of the 16 introduced exotic species behaved as invasive.

Native species in levee neo-ecosystems of the Paraná river Lower delta

The different types of neo-ecosystem in the units analyzed showed similar richness (123 species) to that of the original natural forests in levees (Burkart, 1957; Kalesnik, 2001).

Native species exhibited low mean cover and recovery index values, both regional and in each Lower delta unit, with the exception of unit A, where medium cover values and a high recovery index were found for native species. In the neo-ecosystems with the greatest degree of abandonment of units B and C, exotic tree species dominated and native tree species of the original Monte Blanco forest were scantly developed. Taking the region as a whole into consideration, a significant number of native species belonging to the original forests communities recovered in levee neo-ecosystems, but they did not reach extensive cover development. Among native species in these environments, herbaceous species were found in greater numbers (56 species) than tree species (11 species). Four tree species in particular had relevant constancy values in some of the units of the Paraná river Lower delta, though they showed low cover values: seibo (*Erythrina crista galli*), laurel (*Nectandra falcifolia*), canelón (*Rapanea* spp.) and arrayán (*Blepharocalyx tweediei*). Laurel (*N. falcifolia*) was the only native tree species to achieve high constancy in unit A, although with low cover values, and was the only native tree species to recover in all four types of neo-ecosystem analyzed, displaying a capacity to tolerate different disturbances and luminosities. This hydrophilic species grows rapidly, producing great number of flowers and fruits, and has a fertility period of over six months; it is also capable of vegetative reproduction forming propagative roots, thus being able to endure conditions of limited water supply (Neiff *et al*., 1985). These traits would explain its recovery in environments subjected to the mentioned conditioning variables of unit A, and in all types of levee neo-ecosystem analyzed.

Seibo (*Erythrina crista galli*) and arrayán (*Blepharocalyx tweediei*) grew particularly well in unit B, with their highest relative abundance occurring in long-term abandonment environments. The canelón (*Rapanea* spp.) reached its greatest growth in long-term abandonment neo-ecosystems of both units B and C. Most individuals of this genus were determined as *R. laetevirens*, but numerous saplings could not be determined further than genus and could have belonged to the species *R. lorentziana*.

The legume *Mimosa pigra*, a short 1.5 – 4 m tree, grew exclusively in unit A, and could therefore be an indicator species for the characteristic conditions of this unit. It grows on riverbanks and floodable areas, reaching its greatest development in the Paraná Medio (Burkart, 1957). Cowie and Werner (1993) refer to it as a dangerous invasive species that expanded to riparian and wetland environments in the Kakadu National Park in Australia. Future studies should focus on why this native tree species did not invade neo-ecosystems or natural environments of the Lower delta.

Among shrubs, *Cestrum parqui*, a short 1 – 3 m shrub, showed high constancy values in all three units and was present in all types of neo-ecosystem. Hence this species would be adapted to environments subjected to different kinds of hydrological regimes and disturbances. Unlike the former species, *Diodia brasiliensis*, a short sufrutice of 0,50 – 1 m, would be sensitive to the varying conditions of unit A, given that it was present in all types of neo-ecosystem in units B and C, but not in unit A. The sarandí (*C. glabratus*), 3 – 5 m shrub, grew almost exclusively in unit A; it had a very low constancy and mean cover in unit B, and was entirely absent in unit C. In natural environments, this species grows in floodable marshlands of the Middle and Lower delta islands (Burkart, 1957) and could also be used as an indicator species of the hydrological regime of unit A.

Three native herbaceous species exhibited high constancy and relative abundance in some of the units. The tall (1 – 1.5 m) graminoid herbaceous species carrizo (*Panicum grumosum*), tolerant to the opposing flood and drought conditions typical of fluvial environments (Neiff, 1979; 1986) and to different kinds of anthropic disturbances (fire, cattle), grew considerably and almost exclusively in all types of levee neo-ecosystems of unit A. *A. silphioides*, a latifoliated herbaceous species typical of marshland communities of the upper Paraná river (Morello, 1949; Burkart 1957) and the Lower delta (Burkart, 1957; Kandus, 1997) that can grow up to 1 or 2 meters, was found in long-term neo-ecosystems of unit A exclusively and can therefore be used as a local hydrological regime indicator. The third species, *Carex riparia*, a tall (1 – 1.5 m) graminoid herbaceous species, exhibited relevant constancy levels in all three units and in all types of neo-ecosystems, but with low cover values. It also forms natural homogenous marshlands (Kandus, 1997) and grows readily in salicaceas afforestations of varying degrees of abandonment in lowlands (Valli, 1990), suggesting its association with anthropically modified environments (neo-ecosystems), both in lowlands and in levees.

Lastly, among creepers, *M. micrantha* could be considered an indicator species for the existing conditions of unit A; it was present in all types of levee environments of this unit. This species can be found in aquatic and floodable environments, such as hyacinth beds (*Eichornia crassipes*), duraznillo blanco (*Solanum glaucophyllum*) varillares, marshlands of the Middle and Lower delta (Burkart, 1957; Kandus, 1997) and the Victoria islands of the upper Paraná river (Entre Ríos).

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