Arboreous Vegetation of an Alluvial Riparian Forest and Their Soil Relations: Porto Rico Island, Paraná River, Brazil

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ABSTRACT

The dynamics of alluvial deposits in floodplains forms islands and sandbanks. Deposits frequently accumulate at the river margins and on islands with consequent side growths. One of these sandbanks which started to form in 1952 annexed an area of 12.4ha to the Porto Rico island (53^{0}15'W and 22^{0}45'S). At present a forest fragment of approximately 2.0 ha exists in this place. The structural analysis of arboreous vegetation of this fragment showed a floristic gradient related to the physical and chemical variations of the substratum. High density of pioneer species associated to the absence of recruitment of new individuals of these and other successional categories indicated that the forest was impaired in its succession process. This fact could be associated with constant disturbances caused by cattle in the area.

Key words: Alluvial forest, floodplain, forest structure, phytosociology, riparian vegetation, succession

INTRODUCTION

After the closing of the Porto Primavera Dam in 1999, the floodplain of the high Paraná river between the backwater of Lake Itaipu, near the town of Guaira PR Brazil, and the Porto Primavera Dam SP Brazil as the only free stretch in the Paraná river in Brazilian territory. According to criteria established by Welcomme (1979) for these environments, the floodplain of the high Paraná river has its natural characteristics relatively preserved and is only slightly modified. In this stretch the Paraná river has a wide braided channel, with low declivity, sometimes with an extensive floodplain, sometimes with large islands and restricted plains (Agostinho & Zalewski, 1996). The dynamics of alluvial deposits in this region has formed sandbanks. By the evolution and the development of the sedimentation process the sandbanks annex themselves to islands and even to the margin of rivers (welded or coalescence banks) and cause lateral growth. A colonization process of herbaceous vegetation starts on the emerging banks and may evolve into arboreous vegetation (Campos, 1999).

According to Neiff (1986), the spatial distribution, the structure and the dynamics of this vegetation are strongly influenced by the hydrological and sedimentological regime and by associated geomorphological and soil factors which determine a certain degree of instability and heterogeneity of ecological parameters. The structure, distribution pattern of arboreous

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vegetation and its relations with soils, characteristics of the substratum of a sandbank

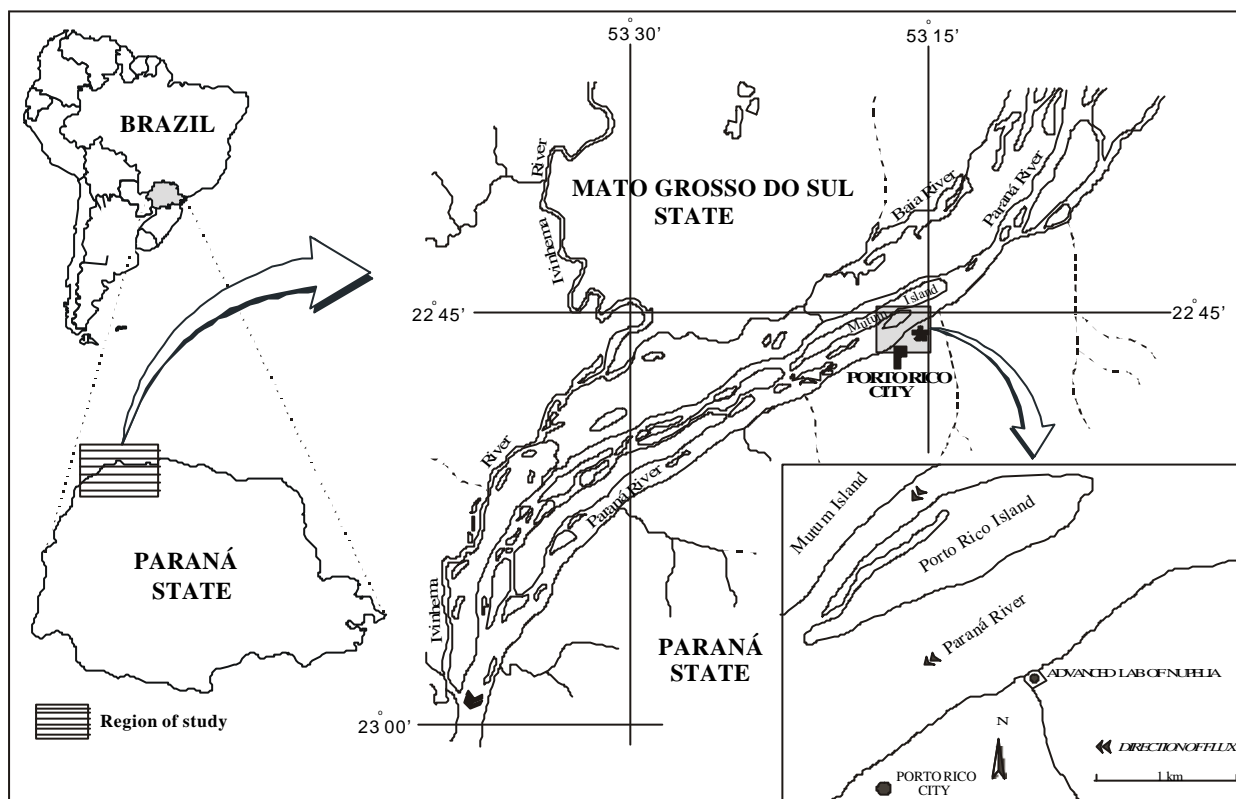which started to be annexed to Porto Rico island in 1952.

Figure 1 - Location of the study area in the high Paraná river floodplain, Brazil.

The area of the forest fragment is approximately 2.0 ha, bordered by the river in front, by a communicating channel (lake) at the back and grassland at the sides, which is extensively used for cattle raising. It lies on a previous welded sandbank or coalescence that annexed itself to the Porto Rico island. Abundant arboreous vegetation developed in the area with the annexation and the evolution of the sandbank. The beginning of this sandbank has been identified by a 1952 air photograph. Some 12.4ha have been annexed to the island (Campos, 1999) (Fig. 2).

Morphology of the terrain and soil analysis

Preliminarily two distinct environments have been identified: a topographically raised margin dyke and a low area. Soil samples were collected from these two areas at three different places (1 sample and 2 replicates), for chemical and granulometric analysis. Samples from margin dyke were collected from three depths (0 –20; 20 – 100; over

100 cm); in the low area samples were collected from two depths (0 –10 and 10 - 30 cm or over), due to no variation of soil was registered from depth 10cm.

Soil classification was undertaken in small trenches and from material collected by hand drills. Embrapa/Iapar (1984) classification was used. Declivity of terrain was obtained by level of water in hose with graduations.

Structure analysis, distribution pattern and floristic composition of arboreous vegetation

Structure of vegetation as defined by Richards (1940) *apud* Stutz de Ortega (1987), such as the architectural organization of the forest, was evaluated by floristic diversity and phytosociology. Phytosociological survey was undertaken by division method (Müeller-Dombois & Ellenberg, 1974), limited to an area of 4,500m^2, (100m perpendicular and 45m parallel to the river

bed) and divided into 30 samplings of 150m^2 each (15m x 10m). Total area was considered a transect

so that standard distribution of species could be determined.
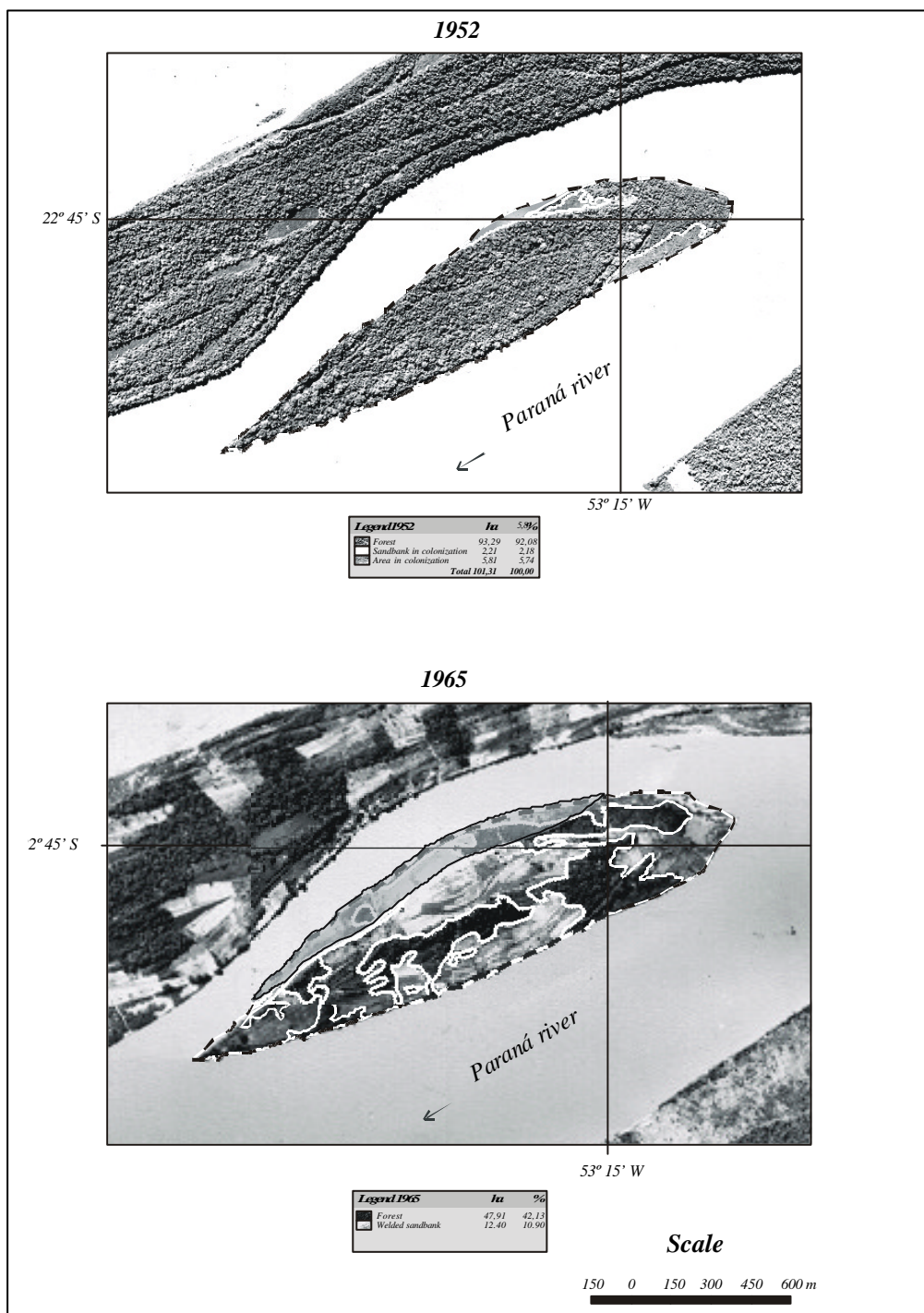

Figure 2 - Photo-maps of the Porto Rico island showing the start of formation of sandbank (1952) and the total area of welded sandbank in photo-map of 1965.

All individuals with CBH (circumference at breast height) equal or higher than 15 cm were sampled.

This included dead vegetation and standing and branched vegetation with at least one CBH branch.

FITOPAC program, version 1.4, was used for phytosociological parameters. Absolute and relative density, dominance and frequency were calculated. Importance values (IV), equitability and Shannon-Weaner diversity (H') were thus calculated (Müeller-Dombois & Ellenberg, 1974; Matteucci & Colma, 1982).

Succession stage of vegetation was evaluated by species classification in following categories: pioneer, secondary and climax, according to literature (Budowski, 1963, 1965, 1966; Denslow, 1980; Kageyama et al., 1992) and by personal field experience.

Two phytosociological subanalysis were undertaken to evaluate influence of soil and topography in the vegetation. One comprised the margin dyke (15 samplings) and the other the low area (14 samplings). One sampling was eliminated since it laid the transition area between the two environments.

Data analysis

Detrended Correspondence Analysis (DCA) was employed to evaluate the relation between arboreous species and environment (Hill & Gauch, 1980). Ten strips parallel to the river bed, between the margin and the channel, were delimited for analysis. Each comprised three sampling measuring 15cm x 10cm. Data of IV of each species per strip were employed. PC-ORD 2.0 was used.

RESULTS AND DISCUSSION

Morphology of the terrain and soil analysis

According to Santos et al. (1992), the most common terminology to differentiate island sandbanks is the criterion of considering the level of full river margins as an arbitrary limit. Islands are structures that go beyond the full margin level. The term sandbank is used for the deposits with height lower than the above-mentioned level. The studied area surpassed the sandbank stage and in its development process annexed itself to the island. The sandbank is now part of the island.

The cross section of the terrain showed a margin dyke with 2.93 m above the river level (measured on the 10-18-1996) with a declivity gradient towards the interior of the island, till it reached a higher point. Once more the declivity gradient proceeded towards the interior of the island as far as the channel which had the same level of the river.

Morphology of terrain and difference in soil characteristics could be attributed to the deposit process of particles by the river. The current thrust deposited first the coarser material (sand) which form the sandbank on the margin dyke (and forms the a alluvial soil) and then the finer material (silt and clay) in the areas where flux speed was slower. Besides, a shallow channel was formed between the annexed sandbank and the previous margin of the island communicating with the river. Channel water was rich in suspended material, which gradually deposited in the lowest part of the sandbank. The formation of a hydromorphic soil typical of marsh areas ensued.

According to Stevaux (1994), deposits of margin dyke are restricted to a narrow strip which accompanies the channel. With regard to the low area, it has been classified by the author as an area typical of "deposits of the flooding basin" which comprises places with sediments from marsh environments, channel paleolake and sections of the floodplain immersed in normal conditions of water level.

In granulometric terms, the differences between the margin dyke and the low area were very clear. Material that characterized soils of a cruder texture (coarse and fine sand) was predominant in the margin dyke, whereas in the low area silt and clay, characterizing fine texture, were predominant. With regard to fertility, as an average, the soil of the low area was more acid and levels of changeable aluminum (Al^{3+}) were higher than in the dyke area. On the other hand, it has higher values of calcium, magnesium, potassium and phosphorus, together with carbon percentage, indicating a higher quantity of organic matter (Table 1 and 2).

Results and field evaluations characterized in a distinct way the two environments: 1) the margin dyke with alluvial soil, sand texture, solid structure, loose non-plastic and non-sticky consistency, transition between diffused and gradual horizons and medially acid pH and 2) the low area with glazed hydromorphic soil, silt-clay texture, structure with small and firm sub-angular blocks, firm, plastic and sticky consistency, plain and gradual transition and medially acid pH.

Table 1 - Average values and standard deviation (n = 3) of granulometric analysis of soil in the margin dyke and in the low area of the Porto Rico island, floodplain of the high Paraná river.

Place	Depth (cm)	Granulometric analysis (%)			
		Course sand	Fine sand	Silt	Clay
	0-20	2 ± 1	68 ± 8	10 ± 5	19 ± 5
Dyke	20-100	3 ± 3	82 ± 6	03 ± 3	12 ±4
	100+	1 ± 0	50 ± 24	20 ± 15	28 ± 9
	0-10	4 ± 2	33 ± 18	33 ± 12	30 ± 7
Low area	10-30+	2 ± 1	22 ± 20	37 ± 12	39 ± 9

Table 2 - Average values and standard deviation of soil fertility analysis for margin dyke and low area in the Porto Rico island, floodplain of the high Paraná river.

Place	Depht (cm)	pH		Al^{3+}	$H^{+}+Al^{3+}$	meq/100ml of soil $Ca^{2+}+Mg^{2+}$	Ca^{2+}	K^{+}	ppm P	% C
		$CaCl_2$	H_2O							
	0-20	4,6 ± 0,1	5,3 ± 1,5	0,06 ± 0	3,9 ± 0,4	4,7 ± 0,5	3,7 ± 0,4	0,2 ± 0	6,3 ± 2,3	10,4 ± 3,0
Dyke	20-100	4,9 ± 0,2	5,7 ± 0,4	0,03 ± 0	2,5 ± 0,4	2,7 ± 1,0	2,2 ± 0,8	0,0	5,0 ± 0	7,1 ± 0,8
	100+	4,4 ± 0,2	5,4 ± 0,1	0,17 ±0,1	4,2 ± 1,4	3,9 ± 1,0	3,0 ± 1,1	0,0	4,0 ± 0	7,2 ± 0,7
Low	0-10	4,4 ± 0,2	5,2 ± 0,5	0,8 ± 0,7	5,6 ± 1,5	8,8 ± 3,9	6,8 ± 2.8	0,3 ± 0,2	9,6 ± 4,7	22,4 ± 6,7
area	10-30+	4,3 ± 0,2	5,1 ± 0,2	0,9 ± 0,6	6,0 ± 0,3	6,3 ± 1,5	5,0 ± 1,4	0,1 ± 0	4,3 ± 1,2	13,2 ± 2,7

According to Embrapa/Iapar (1984), alluvial soils are poorly developed soils, derived from non-consolidated alluvial sediments, without pedogenetic relation between layers and granulometry, with great variations in chemical and minerological composition. Hydromorphic Glazed soils are badly drained soils in which zone characteristics determined by climate and vegetation don't develop entirely owing to restrictions imposed by the great influence of water in the soil and periodic flooding, always conditioned by relief and material. The soils in the studied area are very different in texture and fertility with specific characteristics in each environment.

The great diversity in environments, characteristic of the floodplain, is associated with the physical and chemical variety of the deposited material and with the interaction of relief forms and the river's hydrological regime (Soares & Perez Filho, 1997). Differentiation of environments is the chief cause of floristic diversity (Montovani, 1989).

In studies on vegetation of the middle Paraná river undertaken by Neiff (1986) and in the high Paraná river by Campos et al. (2000), it has been suggested that vegetation is influenced by the water and sediment regime and by geomorphological and associated soil factors. However, in the above-mentioned studies, vegetation of unknown age were taken as references and samples. Inferences on level of interference and limitations which the above factors exercise on the colonization process and succession of the local vegetation were almost impossible. Since it is known that the process of natural colonization of vegetation began in 1952 and it was 44 years old on the date of the survey (September 1996), the influence of physical and chemical factors of the soil of different environments on the establishment and the dynamics of vegetation in the area may be inferred.

Analysis of vegetation
Phytosociological analysis of total area

Samples of 424 individuals were collected in the phytosociological survey. Besides the dead category, specimens were distributed in 15 families, 20 genera and 20 species. One specimens has been identified at the genus level (*Rapanea*) and another one at the family level (Flacourtiaceae) (Table 4 - Annex). Total density reached 942 individuals/ha in a basal area of 27.04 m^2/ha. Density was very low when compared to other surveys employing the same methodology in the same region (Souza et al., 1997; Romagnolo, 1997; Campos et al., 2000). On the other hand, the relation basal area/total density, indicating average basal area occupied by each individual (0.02869

m^2/ind), was high when compared to same studies (0.0122; 0.0161; 0.0168 and 0.0182 m^2/ind respectively). Values, low density and high relation basal area/total density could be related with the process of disturbance caused by cattle on the island. Hoof trampling and grassland might

cause the death and not the recruitment of new individuals.

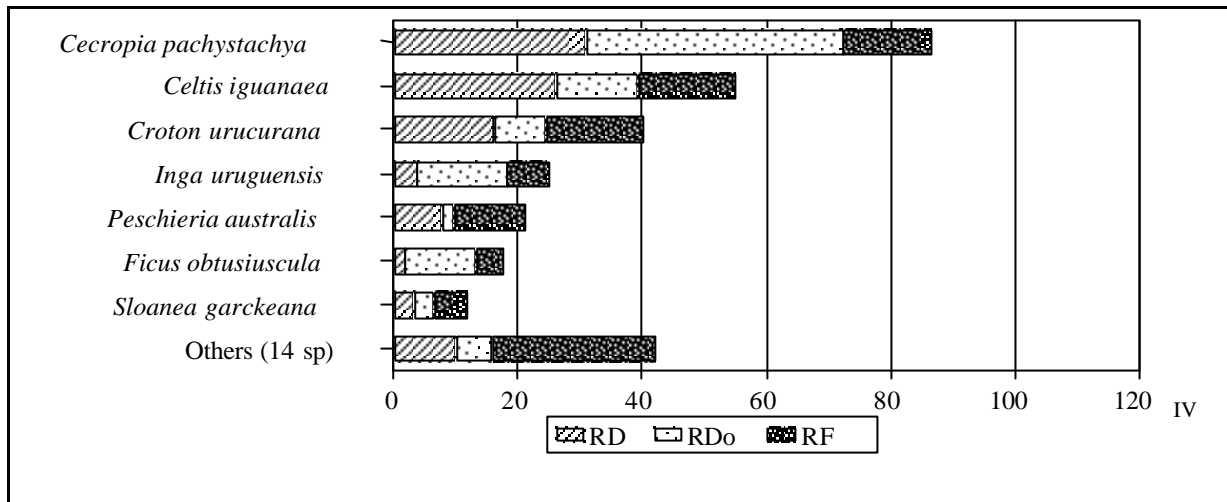With regard to Importance Value (IV), the contribution of the seven species of greatest value may be seen in Figure 3.

Figure 3 - Importance Value (IV) with values of Relative Density (RD), Relative Dominance (RDo) and Relative Frequency (RF) for the most important species.

Cecropia pachysyachya has been recorded in all phytosociological surveys in the region. It was the species with highest IV in studies by Souza et al. (1997), Romagnolo (1997) and Campos et al. (2000). It occupied the 43rd position in the phytosociological study by Assis (1991). All studies were undertaken in the high Paraná river.

Celtis iguanaea didn't have the same salient position. It was recorded 30th by Campos et al. (2000) and 38th by Romagnolo (1997). *Croton urucurana* occupied 42nd and 35th position in the same studies. However, these phytosociological surveys were undertaken in older and less disturbed forests than those under analysis.

Species of genus *Cecropia* were pioneers in secondary succession tropical forests (Budowski, 1965; Gomez-Pompa & Wiechers, 1976), whereas *Croton urucurana* was considered an "anthropic pioneer" in Kageyama (personal information) and as one of the most frequent species in areas of pioneer vegetation on recently formed sandbanks (Neiff, 1986). *Celtis iguanaea* had characteristics of a pioneer species too (Budowski, 1965, 1966; Gomez-Pompa & Wiechers, 1976; Denslow, 1980; Kageyama et al., 1992). In field surveys, it was

present in marginal dykes and, more frequently, in sandy soils.

In the survey, the most salient species with regard to physical occupation (RD) were *Inga uruguensis* and *Ficus obtusiuscula* with individuals with the largest diameters (108.50 and 107.90 cm respectively). *Peschiera australis* was smaller, with relatively low dominance.

Shannon-Weaner diversity index for species (H') reached 1.97. Value was low when compared to studies in the floodplain of the high Paraná river. In such studies, values varied from 1.30 to 3.20 (Campos et al., 2000), and between 2.0 and 3.0 nats (Souza et al., 1997).

With regard to successional categories, pioneer species predominated with 60.69% of total IV. They were followed by secondary (36.89% of total IV) and climax (1.02%) species. Dead species contributed 1.40% of total IV. Studies in the region, in older forests, showed a percentage relationship per differentiated category. Campos et al. (2000) showed an area with same physical characteristics as those in the present research work and registered higher values for secondary species (69.26% of total IV), followed by pioneer (18.27%) and climax (7.29%) species. In a

phytosociological survey of an area close to ours, were recorded a different sequence, with higher values for secondary species (55.00% of total IV), followed by climax (20.24% of total IV) and pioneer (16.97% of total IV) species (Souza et al., 1997).

Values for area under analysis were as expected, since such vegetation was close to the "pioneer standard" described by Budowski (1966), especially with regard to dominance of pioneer species of wide geographical distribution (*C. pachystachya, C. iguanaea* and *C. urucurana*).

Concerning ecological succession, Odum (1986) defined primary succession as that occurring in a previously unoccupied layer, while secondary succession started in an area previously occupied by a community. Gómez-Pompa & Wiechers 91976) defined secondary succession as an ecological process characterized by changes in an ecosystem after natural or human disturbance till a stable state was reached. According to these definitions, study area started as a process of primary succession when the sandbank was colonized in 1952. It developed towards a forest formation and is at present limited in its natural process of succession by cattle disturbance. This could explain the predominance of pioneer species. If the short age of pioneer species and the low number of individuals of secondary and climax species (109) are taken into account, together with the difficulty of recruitment and development of new individuals in the area, the forest may undergo a fast process of degradation and destruction if hoof trampling by cattle continues.

Comparative analysis of vegetation between the dyke and the low area

In qualitative and quantitative terms, groupings showed important differences (Tables 5 and 6). Even though with one sampling the less, the low area had higher values than those of margin dyke with regard to individual sampled (254 against 158), followed by higher values of total density (1209 x 702 ind/ha), total frequency (585 x 306 ind/ha) and basal area (31.70 x 17.77 m^2/ha). Lower values for margin dyke could be due to the great density of *Celtis iguanaea* (78 individuals). This species occupied extensive physical space because of decumbent stems.

Differences in value basal area/total density for dyke and for low area were not remarkable (0.0253 and 0.0262 m^2/ind respectively). This fact showed that distinct characteristics of the two environments such as fertility, texture and soil structure, morphology of terrain, competition between individuals and factors exerted less influence on values. Or rather, it was probable that activities caused by humans, similar in both environments (cattle raising, for instance), contributed to the leveling of values.

The number of species (19) in the low area was greater than that of the margin dyke (11). Same pattern was recorded for diversity (H' = 1.94 and 1.49 respectively). Highest values for low area, contrasting the low values in the dyke area, could be due to the diversification of environments in the low area. The latter has areas with frequent flooding and higher places (Fig. 5) with occupation by species with different requirements. Heterogeneity of environments is referred to by many authors as an important factor in floristic diversity (Odum, 1986; Mantovani, 1989; Soares & Perez Filho, 1997; Campos et al., 2000).

Besides the heterogeneity of the environment, dominance of *Cecropia pachystachya* (with its erect stem and open top) in the low area contrasting with the dominance of *Celtis iguanaea* of the margin dyke (with decumbent branches and dense top) might have interfered in these values. In their study on the tropical forest of Malaysia, Shariff et al. (1990) showed that low top density warrants more infiltration of light. The latter enhances germination and development of more species. Consequently, a greater floristic diversity is recorded.

With regard to species IV, the two areas have important differences in their structures (Fig. 4).

In the margin dyke only two species, *Celtis iguanaea* and *Croton urucurana* contributed more than half the total IV, with predominance of the former. In the low area, *Cecropia pachystachya* was predominant, with *Celtis iguanaea* occupying 4th place in IV. *Ficus obtusiuscula*, placed second in IV in the low area, was not sampled in the margin dyke. Out of 131 individuals of *Cecropia pachystachya* sampled in the total area, 116 (88.5%) were registered in the low area. Seventy eight individuals (70.3%) of *Celtis iguanaea* were in the margin dyke (Table 5 and 6 - Annex).

Higher density of individuals of *Cecropia pachystachya* was registered in the strip immediately near the channel (61 individuals).
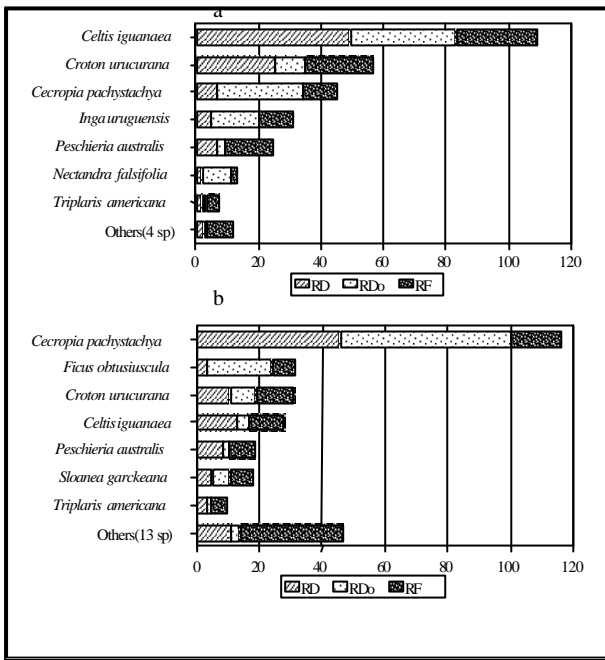
Figure 4 - IV with values of relative Density (RD), relative Dominance (RDo) and Relative Frequency (RF) for the principal species in the margin dyke (a) and in the low area (b).

Clayey and hydromorphic soil is the principal characteristic of the communicating channel. The same applies to the lowest area of the frequently flooded terrain. High concentration of this species in area with such characteristics was also registered by Campos et al. (2000). Since the area was frequently flooded, the authors stated that occupation niche was restricted to few species adapted to such conditions. Species was a case in question. According to these findings and taking into account that it was a general species within the region, its high density in the area close to the channel seems to be related to tolerance and resistance of the species to environments frequently subjected to flooding (Fig. 5). *Croton urucurana* had a more equitable distribution than *Cecropia pachystachya* in the area under analysis. Out of the 69 individuals sampled in the total area, 40 (58.00%) were in the dyke and the rest in the low area (42.00%). Besides the dead category, nine more species are exclusive of the low area and only one species (*Rapanea* sp) was sampled as exclusive of the margin dyke.
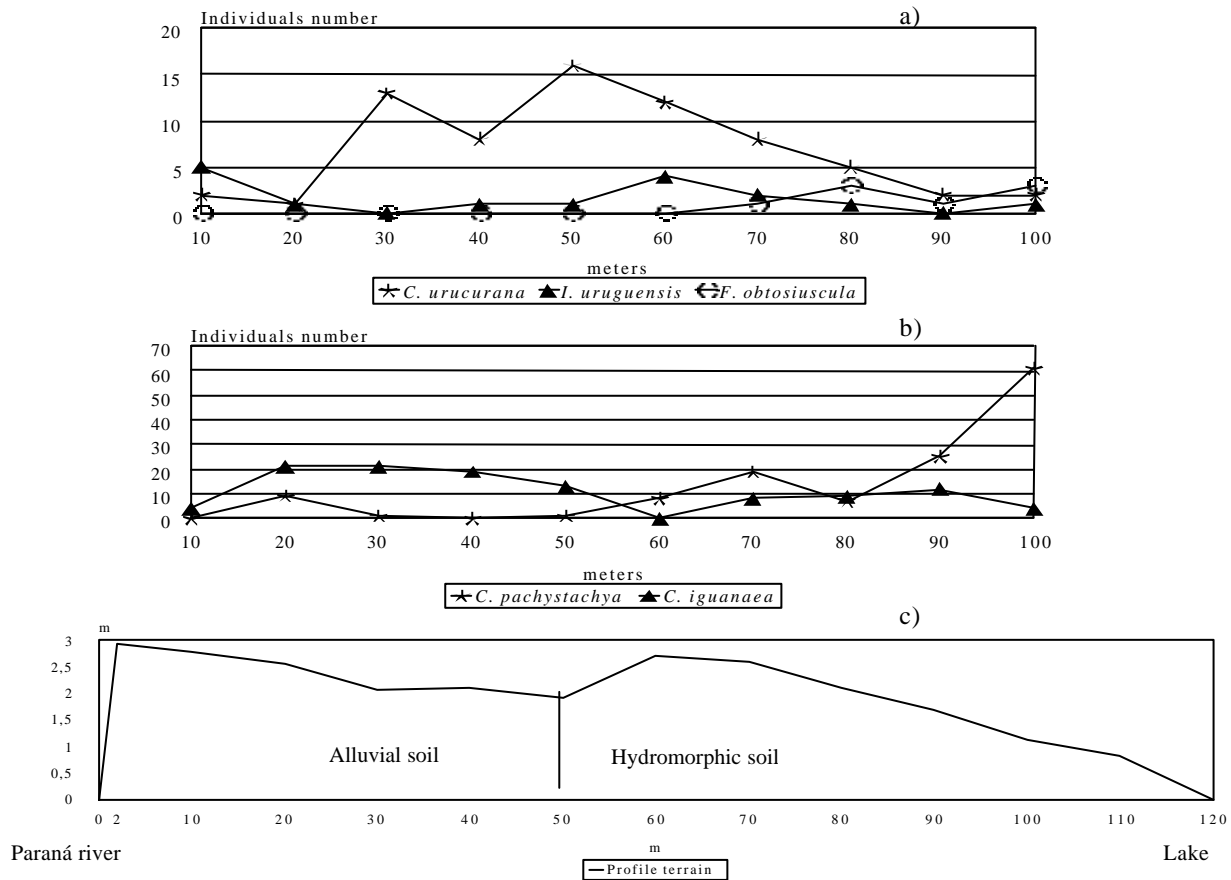

Figure 5 - Distribution of species (a and b) and cross section of terrain of area under analysis (c).

The highest concentration of individuals of *Inga uruguensis* was found in the margin dyke. Out of sixteen individuals, eight were in the dyke; out of these, five were in the sampling on the river margin. In the low area four individuals were sampled. The other four were in the sampling near

the transition zone between the dyke and the low area. Campos et al. (2000) detected in a transect on the right margin of the Paraná river (in an area close to that analyzed in this study) that the species didn't follow a clearly defined distribution pattern.
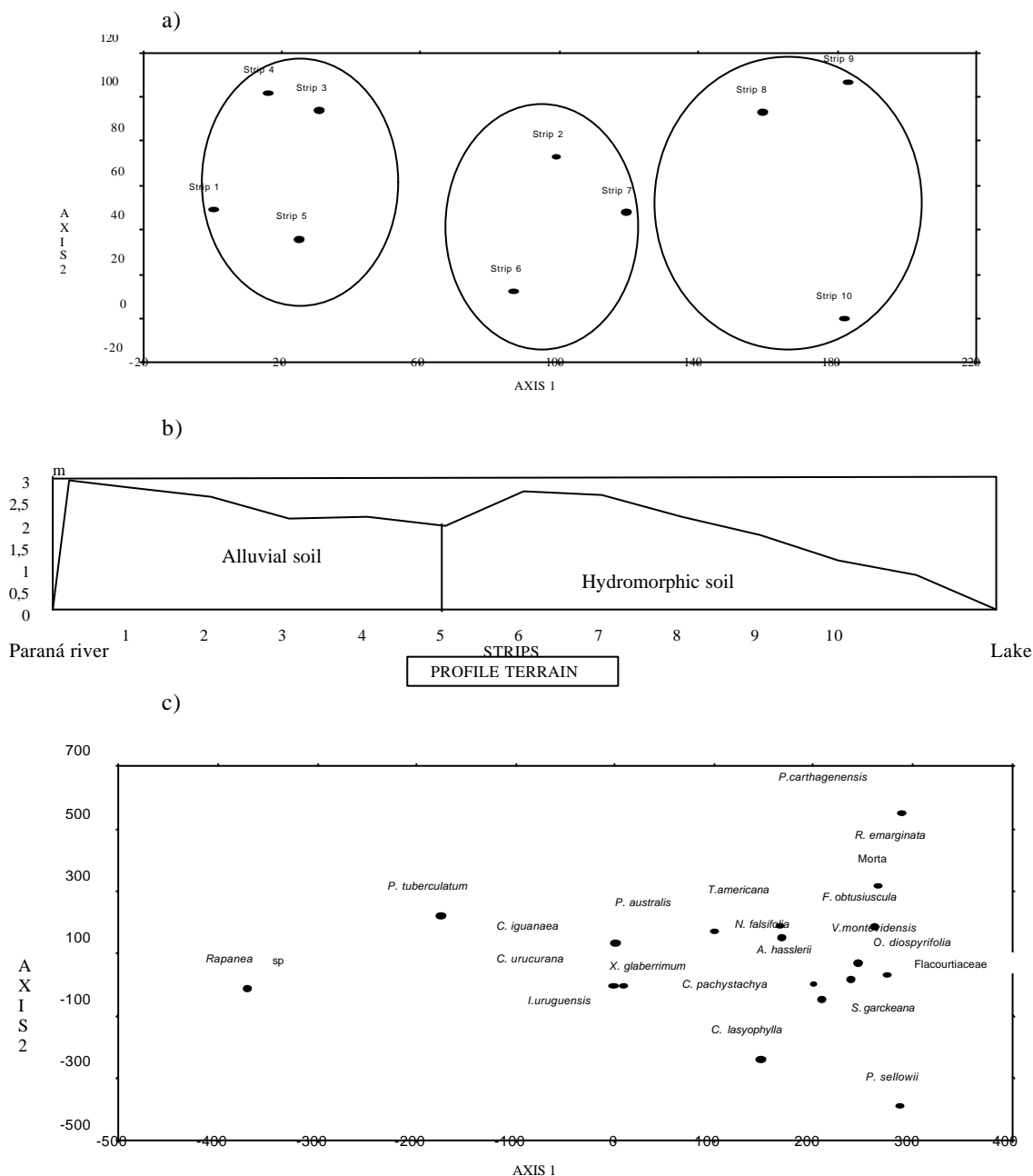

Figure 6 - DCA showing grouping of analysed strips (a), soil cross section and physical distribution of strips (b) and distribution of species corresponding to strips analysed by DCA (c).

Concerning successional categories, margin dyke had a higher value in IV totality of pioneer species. *Celtis iguanaea* occupied more than a

third of recorded value (108.91). Distribution of these values for successional categories in the low area were more equitable, with predominance of

pioneer species. In spite of dominance of *Celtis iguanaea* in the margin dyke, *Cecropia pachystachya* registered the greatest contribution in absolute and relative terms in the composition of value for pioneer species in total area (42% of IV).

Concerning the secondary category, the highest value in the low area (compared to that in the margin dyke) showed that successional process was more dynamic in the low area. It was probably due to higher diversity of environments and to dominance of species with open tops, which favor the development of more species.

DCA of IV of all species in sampled area clearly separated the sampled strips and the species characteristic of the distinct environments (Fig. 6). Strips of sampled area were separated into three distinct groups ($ë_1$ = autovalues for axis 1 = 0.41): strips 1, 3, 4 and 5 for the margin dyke environment; strips 2, 6 and 7 for the intermediate region; strips 8, 9 and 10 for the low area. Axes 1 and 2 ($ë_2$ = 0.1) in Fig. 6c separate the most characteristic species of certain strips, such as *Rapanea* sp, sampled only in strip 1 and *Picramnia sellowii*, sampled in strip 10. With the exception of strip 2, groupings by DCA was the real disposition of strips in the sampled area, where strips 1 to 5 lie in the dyke, strips 6 and 7 lied in the ecotone between the two environments and strips 8, 9 and 10 lied in the low area. This fact suggested the relationship between vegetation and the physical characteristics of the environments.

CONCLUSION

The dynamics of alluvial deposits in the high Paraná river favours the formation and the development of new areas (sandbanks) and gives rise to the colonization and the development of vegetation of great importance to ecological studies of primary and secondary succession. The river's hydrodynamic and hydrosedimentological regimes influenced the physical and chemical composition of soil and determined distinct categories of morphology, texture and fertility. The structure, dynamics and distribution of species were related to the environment's characteristics which determined the success in the establishment and exclusion of certain species.

In the alluvial forest studied in this research, the spatial heterogeneity of the substratum caused floristic differentiation and diversification, only detected through detailed investigation. Vegetation of the studied area started with a process of primary succession when the sandbank was colonized in 1952; it developed towards a forest formation and was limited at present in its natural process of succession by cattle disturbance. Cattle removal and the protection of areas with similar characteristics could lead to a better interpretation of factors caused by the development and limitation of the successional process in areas of primary succession.

ACKNOWLEDGEMENTS

RESUMO

A dinâmica de deposições aluviais em planícies de inundação proporciona a formação de ilhas e barras (bancos de areia), que muitas vezes agregam-se às margens dos rios ou ilhas propiciando o seu crescimento lateral. Uma dessas barras, com início de formação a partir de 1952, agregou a ilha Porto Rico (53^o15'W e 22^o45'S) uma área de 12,40ha, onde existe, atualmente, um fragmento florestal de aproximadamente 2,0ha. A análise estrutural da vegetação arbórea desse fragmento mostra a presença de um gradiente florístico relacionado às variações físicas e químicas do substrato. A elevada densidade de espécies pioneiras, associada a ausência de recrutamento de novos indivíduos, dessas e de outras categorias sucessionais, indicam que esta floresta está limitada em seu processo de sucessão, podendo, este fato, estar associado às constantes perturbações provocada pela presença de gado na área.

Table 4 - List of sampled species and dead in a remaining Alluvial Semideciduous Forest (4,500 m²) in the Porto Rico island, Brazil, with their respective phytosociological parameters: n = number of individuals; ns = number of samplings in which species occurred; RD = relative density; RDo = relative dominance; RF = relative frequency; IV = importance value and classification of ecological groups (EG): pioneer (P), secondary (S) and climax (C).

Specie	EG	n	ns	RD	RDo	RF	IV
Cecropia pachystachya Trec.	P	131	19	30,90	41,42	14,29	86,60
Celtis iguanaea (Jacq.) Sargent.	P	111	21	26,18	13,18	15,79	55,14
Croton urucurana Baill.	P	69	21	16,27	8,22	15,79	40,28
Inga uruguensis Hook & Arn.	S	16	9	3,77	14,54	6,77	25,08
Peschiera australis (Müll. Arg.) Miers.	S	33	15	7,78	2,01	11,28	21,07
Ficus obtusiuscula (Miq.) Miq.	S	8	6	1,89	11,41	4,51	17,81
Sloanea garckeana K.Schum.	S	14	7	3,30	3,22	5,26	11,79
Nectandra falcifolia (Nees.) Cast. ex Mez.	S	8	6	1,89	3,43	4,51	9,83
Triplaris americana L.	S	11	6	2,59	1,39	4,51	8,50
Dead	-	4	4	0,94	0,26	3,01	4,21
Casearia lasyophylla Eichler	S	4	4	0,94	0,20	3,01	4,15
Flacourtiaceae	S	3	3	0,71	0,18	2,26	3,14
Piper tuberculatum Jacq.	C	2	2	0,47	0,08	1,50	2,05
Xylosma glaberrimum Sleumer	S	2	2	0,47	0,07	1,50	2,05
Picramnia sellowii Planch.	S	2	2	0,47	0,06	1,50	2,04
Vitex montevidensis Cham.	S	1	1	0,24	0,15	0,75	1,14
Rollinia emarginata Schlent.	S	1	1	0,24	0,06	0,75	1,05
Psychotria carthagenensis Jacq.	C	1	1	0,24	0,03	0,75	1,02
Rapanea sp.	S	1	1	0,24	0,03	0,75	1,02
Ocotea diospyrifolia (Meissn.) Mez.	S	1	1	0,24	0,03	0,75	1,02
Albizzia hasslerii (Chodat) Burr.	S	1	1	0,24	0,02	0,75	1,01

Table 5 - List of sampled species and dead in phytosociological subanalysis of low area in the remaining Alluvial Semideciduous Forest (2,100m²) in the Porto Rico island, Brazil, with their respective phytosociological parameters: n = number of individuals; ns = number of samplings in which species occurred; RD = relative density; RDo = relative dominance; RF = relative frequency; IV = importance value.

Specie	n	ns	RD	RDo	RF	IV
Cecropia pachystachya Trec.	116	13	45,67	54,65	15,85	116,18
Ficus obtusiuscula (Miq.) Miq.	8	6	3,15	20,85	7,32	31,32
Croton urucurana Baill.	27	10	10,63	8,34	12,20	31,17
Celtis iguanaea (Jacq.) Sargent.	33	9	12,99	3,98	10,98	27,95
Peschiera australis (Müll. Arg.) Miers.	21	7	8,27	2,10	8,54	18,90
Sloanea garckeana K.Schum.	13	6	5,12	5,46	7,32	17,89
Triplaris americana L.	8	4	3,15	1,72	4,88	9,75
Nectandra falcifolia (Nees.) Cast. ex Mez.	5	5	1,97	0,71	6,10	8,78
Dead	4	4	1,57	0,48	4,88	6,93
Inga uruguensis Hook & Arn.	4	3	1,57	0,50	3,66	5,74
Flacourtiaceae	3	3	1,18	0,32	3,66	5,16
Casearia lasyophylla Eichler	3	3	1,18	0,13	3,66	4,97
Picramnia sellowii Planch.	2	2	0,79	0,12	2,44	3,34
Vitex montevidensis Cham.	1	1	0,39	0,28	1,22	1,89
Rollinia emarginata Schlent.	1	1	0,39	0,12	1,22	1,73
Psychotria carthagenensis Jacq.	1	1	0,39	0,06	1,22	1,67
Ocotea diospyrifolia (Meissn.) Mez.	1	1	0,39	0,05	1,22	1,67
Piper tuberculatum Jacq.	1	1	0,39	0,05	1,22	1,67
Albizzia hasslerii (Chodat) Burr.	1	1	0,39	0,04	1,22	1,65
Xylosma glaberrimum Sleumer	1	1	0,39	0,03	1,22	1,64

Table 6 - List of sampled species in phytosociological subanalysis of margin dyke in the remaining Alluvial Semideciduous Forest (2,250m^2) in the Porto Rico island, Brazil, with their respective phytosociological parameters: n = number of individuals; ns = number of samplings in which species occurred; RD = relative density; RDo = relative dominance; RF = relative frequency; IV = importance value.

Specie	n	ns	RD	RDo	RF	IV
Celtis iguanaea (Jacq.) Sargent.	78	12	49,37	33,78	26,09	108,91
Croton urucurana Baill.	40	10	25,32	9,78	21,74	56,84
Cecropia pachystachya Trec.	11	5	6,96	27,46	10,87	45,19
Inga uruguensis Hook & Arn.	8	5	5,06	15,63	10,87	31,56
Peschiera australis (Müll. Arg.) Miers.	11	7	6,96	2,33	15,22	24,51
Nectandra falcifolia (Nees.) Cast. ex Mez.	3	1	1,90	9,25	2,17	13,32
Triplaris americana L.	3	2	1,90	1,37	4,35	7,62
Casearia lasyophylla Eichler	1	1	0,63	0,38	2,17	3,19
Xylosma glaberrimum Sleumer	1	1	0,63	0,18	2,17	2,98
Piper tuberculatum Jacq.	1	1	0,63	0,15	2,17	2,96
Rapanea sp	1	1	0,63	0,10	2,17	2,91

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