Dispersal of forest birds and trees along the Uruguay River in southern South America
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ABSTRACT
The Uruguay River starts in Serra do Mar in Brazil, runs through the Paranense forest, and flows southward through grassland and savannas. It has a continuous gallery forest of 750 km from the southern border of the Paranense forest to the river mouth. The gallery forest extends for 100 km more along the Río de la Plata. 125 (68.7%) of the 182 species of forest birds recorded in the southern Paranense forest penetrate into the gallery forest of the Uruguay River and only 13 (7.1%) reach the end of the gallery forest (Punta Lara). The number of bird species is inversely correlated ($r^2 = 0.942$) with distance and the slope of the regression is 58.10. This means a decline in diversity with 32% of species lost per unit distance. A hundred and eighty forest tree species were recorded in the southern Paranense forest, of which 113 (62.8%) penetrate into the gallery forest of the Uruguay River, and 28 (15.6%) reach Punta Lara. The number of tree species is inversely correlated ($r^2 = 0.976$) with distance and the slope of the regression is $-45.62$. This means a decline in diversity with 25% of species lost per unit distance. The Uruguay River enables the dispersal of many species of forest birds and trees from the rain forest, but species richness tends to decrease with increased distance from the source area. A clear association pattern was found for birds between size, diet, habitat use and distance reached into the gallery forest. Species of smaller body size, granivores, insectivores and those that use both the interior and exterior parts of the gallery forest advanced noticeably further along the river than larger species, carnivores, nectarivores or frugivores, and those that frequent only a part of the forest. Similarly, a clear association between dispersal mechanism, water dependence and distance reached into the gallery forest was found for trees. Species with vegetative reproduction, zoochorous species and riparian species advanced markedly longer distances along the river than, anemochorous species and non-riparian species.

Key words
Birds, trees, distribution, gallery forest, Paranense Region, species/distance, South America.

INTRODUCTION
Rivers, with their associated vegetation, are crucial sources of food, refuge, and other resources for animals (Carothers et al., 1974). Within rain forest, riparian forest is barely evident, but in open areas it forms conspicuous galleries (Hueck, 1972). Although gallery forests are finger-like extensions of rain forest, ecologically they are somewhat different. They occur in regions where natural conditions are not favourable for forest and allow vast extensions in the range of forest dwelling species.

Despite the numerous studies of riparian wildlife (Bell, 1974; Hupp, 1982, 1983; Knopf, 1985; Nilsson, 1986, 1992; Tabacchi et al., 1990; Gregory et al., 1991; Kalliola et al., 1992; Naiman et al., 1993; Mares & Ernest, 1995; Stromberg et al., 1996; Nilsson et al., 1997, 1999; Kellman et al., 1998; Johnson et al., 1999), few authors have examined patterns of species richness along the entire course of a river (Short & Horne, 1981; Nilsson, 1986; Nilsson et al., 1989; Silva, 1996).

Around the Tropic of Capricorn, in eastern South America, two major vegetation types cover virtually all the area: the rain forest (Paranense–Atlantic forest), extending through eastern and south-eastern Brazil, eastern Paraguay, and north-eastern Argentina, and non-forest vegetation (grassland and savannas) in central and southern Brazil, south-eastern Paraguay, eastern
Figure 1 Map of the study area showing the location of forest and non-forest vegetation and location of the distribution points. Numbers indicate bird points: (1) Paranense forest border (2) Colonia Santa María (3) Garruchos (4) Colonia Garabí (5) Santo Tomé (6) Torrent (7) Alvear (8) Yapeyú (9) Colon (10) lower Paraná Delta, and (11) Punta Lara. Letters indicate tree points: (a) Paranense forest border (b) northern Corrientes (c) southern Corrientes (d) northern Entre Ríos (e) southern Entre Ríos (f) lower Paraná Delta, and (g) Punta Lara.
Argentina, and Uruguay (Fig. 1). In predominantly non-forest regions (Cerrado, Chaco and Pampas), narrow and well-defined gallery forests occur along rivers and streams (Hueck, 1972). Gallery forests enable many forest species to disperse from the rain forest (Darrieu, 1986; Redford & da Fonseca, 1986; Nores, 1992; Mares & Ernest, 1995; Darrieu & Camperi, 1996; Silva, 1996). However, species richness tends to decrease with increased distance from source areas (Silva & Oniki, 1988; Nores, 1992; Silva, 1996).

To the south of the Tropic of Capricorn, gallery forests generally occur where annual precipitation is at least 900 mm and they have a close relation to the microclimate of rivers. According to Martínez Crovetto (1963), morning fogs protect the vegetation from winter frost and allow tropical and subtropical species to survive in temperate regions.

A major river of subtropical South America is the Uruguay River, with a total course of 1600 km starting in the southern part of the Atlantic forest, running through the Paranense forest and flowing southward through grassland and savannas (Fig. 1). It is 1.3 km wide at the beginning of the gallery forest and 13 km wide near its mouth. It joins the Paraná River and together they form the Rio de la Plata. The Uruguay River has a conspicuous gallery forest of 750 km that extends for 100 km more along the first part of the Rio de la Plata. The Paraná River, however, does not have a continuous gallery forest in this area. The gallery forest follows a decreasing temperature and rainfall gradient ranging from 20 °C and 1600 mm (annual average) at its beginning in southern Misiones and north-western Rio Grande do Sul to 16 °C and 900 mm at the end of the gallery forest in the Rio de la Plata. During the rainy season the Uruguay River raises several meters and floods gallery forest along most of its course.

In this paper we describe the distance that Paranense birds and trees have advanced along the gallery forest of the Uruguay River (and its extension along the first part of the Rio de la Plata) and evaluate the relationship between these distances and some ecological characteristics of the species. We also compare our bird data with Atlantic–Paranense bird data from gallery forests in the Cerrado region (Silva, 1996).

**METHODS**

The study was conducted from February 1999 to June 2001. These data were supplemented by data we had obtained previously at various sites of the Paranense–Atlantic forest of Brazil, Paraguay and Argentina, and along gallery forests of several rivers and streams originating in these forests. We covered most of the roads that give access to the Uruguay River (and to the first part of the Rio de la Plata) to verify the presence or absence of gallery forest and determined the extent and continuity of the gallery forest using satellite images.

We selected all those species of forest birds and trees recorded in the gallery forest of the Uruguay River (and the first part of the Rio de la Plata) and assumed that these species have expanded their range from the Paranense–Atlantic forest by following the gallery forest of these rivers. We evaluated the distance that forest birds and trees have advanced along the Uruguay River (and the Rio de la Plata) by considering the distance for each species from the source area to its southernmost record. For this reason, we generated the figures treating the species as all continuously distributed.

Forest bird distribution along the Uruguay River (and the Río de la Plata) was determined from three sources: (i) the huge collection made by William Partridge in the 1960s, which was communicated mainly by Darrieu and colleagues (Darrieu & Martínez, 1984; Darrieu, 1986, 1987, 1990; Darrieu & Camperi, 1988, 1991, 1992, 1993a, 1993b, 1994, 1996, 1998); (ii) literature from Brazil (mainly from the works of Belton, 1984, 1985, 1994), Argentina, and Uruguay; and (iii) surveys conducted at various sites where Partridge did not collect, especially Santa María, Yapeyú, Colón and Punta Lara. Some occasional records, particularly from Buenos Aires Province (Narosky & Di Giacomo, 1993), were evidently from escapees or vagrants. Most of these species are cage birds, recorded in unsuitable habitats, geographically far from their normal range. They were therefore excluded from further analysis. We surveyed bird species by visual and audio identification, and occasional mist netting.

To represent forest bird distribution along the river, 11 points were established that correspond to Partridge’s collection sites and our ornithological surveys. Point 1 was on the southern border of the Paranense forest in southern Misiones and north-eastern Rio Grande do Sul. Points 2–10 were located along the gallery forest of the Uruguay River, and point 11 at the end of the gallery forest on the Río de la Plata (Fig. 1).

Forest tree distribution along the Uruguay River (and the Río de la Plata) was determined from botanical literature from Brazil, Argentina and Uruguay, mainly the work of Dimitri et al. (1998). Additional sources used were taxonomic and geographical reviews, such as Hauman (1925); Cabrera & Dawson (1944); Martínez-Crovetto (1963); Reitz (1965–89); Burkart (1969–79); Dimitri (1974); Jozami & Muñoz (1983); Troncoso & Bacigalupo (1987); Hunziker (1994–2000); Daviña et al. (1999).

To represent forest tree distribution along the rivers we established seven points, in locations similar to those of the bird points as above (Fig. 1).

To analyse the relationship between the distance reached by Paranense birds into the gallery forest and some of their ecological characteristics, we classified each taxon in categories of size, diet, habitat use and migratory status. Size categories are the following: very small up to 12 cm, small 13–20, medium 21–30 and large more than 30 cm. Diet categories include insectivores (species whose diet includes mostly insects and other arthropods), frugivores (species whose diet is mainly based on fruits, and rarely on insects), carnivores (species that feed mainly on terrestrial vertebrates or fishes), granivores (species whose diet is based primarily on grains and seeds, generally including some insects and other arthropods), nectarivores (species that feed mainly on nectar, generally including some arthropods), and omnivores (species whose diet includes fruits/seeds and insects/small vertebrates in similar proportions). Habitat use: interior (species that concentrate their activities mainly in the understory and subcanopy of the gallery forest), exterior (species that concentrate their activities mainly in the canopy and/or borders) and both (species that use both interior and exterior of the gallery forest) (Silva, 1996). Migratory status: migratory species and residents.
| Species                          | Dest | Size | Habitats | Migratory Status | Rainforest Border | Santa María | Garruchos | Colón | Tropical | Alvear | Yapeyú | Paranal Delta | Punta Lapa |
|---------------------------------|------|------|----------|------------------|-------------------|-------------|-----------|-------|----------|--------|--------|--------------|------------|
| Crypturellus obsoletus          | O    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Crypturellus parvirostris       | O    | S    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Tigrioma fasciatum              | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Mesembrinibis cayennensis       | I    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Mergus octoacteas              | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Leptodon cayanensis            | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Chondroheras uncinatus          | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Harpagus dodon                 | C    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Accipiter bicolor              | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Accipiter poliogaster          | C    | L    | E        | M                |                   |             |           |       |          |        |        |              |            |
| Morphys quinlanensis           | C    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Spizaetus ornatus              | C    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Spizaetus tyrannus              | C    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Micrastur ruficollis            | C    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Micrastur semitorquatus         | C    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Penelope superciliaris          | F    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Penelope obscura                | F    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Aburria jacutinga               | F    | L    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Odontophorus capuaire            | F    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Aramides saracura               | O    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Ortygonax nigricans            | F    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Columba cayennensis             | F    | M    | E        | M                |                   |             |           |       |          |        |        |              |            |
| Leptotila rufaxilla             | F    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Geotrygon violacea              | F    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Ara chloroptera                 | F    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Ara maricana                    | F    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Aratinga leucophthalma          | F    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Pyrrhura frontalis              | F    | S    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Forpus crasirostris             | F    | V    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Pionipitta pileata              | F    | S    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Pionus maximilian               | F    | M    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Amazona pretrei                 | F    | M    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Amazona vinacea                 | F    | M    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Piaya cayana                    | I    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Dromococcyx pavoninus           | I    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Dromococcyx phasianellus        | I    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Otus atricapillus               | I    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Pseudotis koenwaldiana          | C    | L    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Aegolius harrisi                | C    | S    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Larocalis semitorquatus         | I    | S    | B        | M                |                   |             |           |       |          |        |        |              |            |
| Nyctidromus albicollis          | I    | M    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Caprimulgus sericocaudatus      | I    | M    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Acornis senex                   | I    | S    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Chaetura cinereivertis           | I    | V    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Phaethornis auriverno            | N    | V    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Anthracothorax nigricollis      | N    | V    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Stephanoxis lalandi             | N    | V    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Thalurania furcata               | N    | V    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Thalurania glaucops              | N    | V    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Amazilia versicolor              | N    | V    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Calliphlox amethystina           | N    | V    | E        | M                |                   |             |           |       |          |        |        |              |            |
| Trogon rufus                     | O    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Trogon surraccra                 | O    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Barphiphenus ruficollis          | O    | L    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Nyctalus chachurra               | I    | S    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Nonnula rubecula                 | I    | S    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Pteroglossus castanotis          | O    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Ramphastos dicolorus            | O    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Ramphastos toco                 | O    | L    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Picumnus nebulosus               | I    | V    | B        | R                |                   |             |           |       |          |        |        |              |            |
| Picumnus cirratus                | I    | V    | I        | R                |                   |             |           |       |          |        |        |              |            |
| Melanerpes flavifrons            | O    | S    | E        | R                |                   |             |           |       |          |        |        |              |            |
| Piculus aurulentus               | O    | M    | B        | R                |                   |             |           |       |          |        |        |              |            |

**Figure 2**: Ecological characteristics and distribution of forest birds along the gallery forest of the Uruguay River and in the first part of the Río de la Plata. The black lines indicate the distance that each species advances from the source area to its southernmost record.
| Species                           | Diet | Site | Habitat use | Migratory status | Rainforest border | Santa Maria | Guarachos | Colón | Iguazú | Laguna del Sauce | Patasópolis | Alto Uruguá | Lower Paraná Delta | Punta Loma |
|----------------------------------|------|------|-------------|------------------|------------------|-------------|------------|-------|--------|-----------------|-------------|----------------|---------------------|------------|
| Colaptes melanochloros           | O    | M    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Dryocopus galeatus               | O    | L    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Dryocopus lineatus               | O    | L    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Campephilus robustus             | O    | L    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Dendrocincla fuliginosa          | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Sittasomus griseicapillus        | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Xiphocolaptes albicollis         | I    | M    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Dendrocolaptes platyrostris      | I    | M    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Lepidocolaptes fuscus            | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Lepidocolaptes squamatus         | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Campylorhamphus falcarius        | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Clibanornis dendrocolaptoide     | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Synallaxis cinerascens           | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Synallaxis ruficapilla           | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Synallaxis spix                   | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| CraniTECTura obsolata            | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Sydactyla rufosuperlicata         | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phlydor lichtensteinii           | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phlydor rufus                     | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Automolus leucophthalmus         | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| HelioIetus contaminatus          | I    | V    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Xenops minutus                    | I    | V    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Xenops rutilans                  | I    | V    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Sclerusus scissor                | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Hypoedaleus guttatus             | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Batara cinerea                   | I    | L    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Mackenzaena leachi               | I    | M    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Mackenzaena severa               | I    | M    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Thamnophilus ruficapillus        | I    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Dusicyamus mentalis              | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Herpsilochmus ruficollaris        | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Drymarchon rufifringens          | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Drymarchon malagasya             | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Pyrgilena leucoptera             | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Chamaea ceylonica                | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Grallaria varia                  | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Hlyopectes ochroleucus           | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Conopophaga lineata              | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phyllophanthus burmeisteri       | I    | V    | E           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Phyllophanthus fasciatus         | I    | V    | E           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Phyllophanthus virgatus          | I    | V    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Myiopagis caniceps               | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Myiopagis viridicata             | I    | V    | I           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Elaenia mesoleuca                | F    | S    | B           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Elaenia obscura                  | F    | S    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Mionectes rufiventris            | O    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Leptopus amaurocephalus           | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phylloscortes eximius            | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phylloscortes flavoacus          | I    | V    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Phylloscortes ventralis          | I    | V    | B           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Corythopus delalandi             | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Myiornis auricularis             | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Hemiphractus diops               | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Todirostrum plumbeiceps          | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Tolmophyrs sulphurens            | I    | S    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Platyrinchus mystaceus           | I    | V    | I           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Cnemotricus fusca                | I    | S    | B           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Knipolegus cataphractus           | I    | S    | B           | M                |                  |             |            |       |        |                  |             |               |                     |            |
| Colonia colonus                  | I    | M    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Muscipirra vetula                | I    | M    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Attila phoenicurus               | I    | S    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |
| Sirystes sibilator               | I    | S    | E           | R                |                  |             |            |       |        |                  |             |               |                     |            |

Figure 2 Continued
| Species                     | Diet | Size | Habitat use | Migration status | Rancho Sante Fé | Santa María | Guaymas | Catavi, Guaymas | Sanlúcar Tamez | Territorial | Alvece | Yorponi | Cuba | Lower Nuño | Paraná Delta | Patos Lanús |
|----------------------------|------|------|-------------|------------------|-----------------|-------------|---------|----------------|----------------|-------------|--------|---------|-------|---------|-------------|------------|
| Myiozetetes similis        | I    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Conopias trivirgata        | I    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Legatus leucophaius        | I    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pachyrhamphus castaneus    | O    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pachyrhamphus validus      | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pachyrhamphus viridis      | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Titira cayana              | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Titira inquisition         | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Schistura virensensis      | F    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Piprites chloris           | F    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Manacus manacus            | F    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Chiroxipta caudata         | F    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pyroderus scutatus         | F    | L    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Procnias nudicollis        | F    | M    | B           | M                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Atticora melanoleuca       | I    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tachycinetes albiventer    | I    | S    | E           | M                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Turdus albicollis          | O    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Turdus leucomeles          | O    | M    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Turdus nigriceps           | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Poliopilota lactea         | I    | V    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Haplospiza unicolor         | G    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Poospiza lateralis         | G    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Oryzoborus angolensis       | G    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Amaurispa moesta           | G    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Arremon flavirostris       | G    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pitylus fuliginosus        | G    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Saltator similis           | G    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Passerina glaucocaelulea    | G    | S    | B           | M                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Cissopis leveriana         | O    | M    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pyrrhocoma ruficeps        | O    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Thlypospis sordida         | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Hemithraupis guira         | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Nemosia pileata            | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tachyphonus coronatus      | O    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Trichothraupis melanopect  | O    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Habia rubica               | O    | S    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Stephanoporus diadematus   | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Pipraeidea melanonota      | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Euphonia chalybea          | F    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Euphonia musica            | F    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Euphonia violacea          | F    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Chlorophonia cyanea        | F    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tangara cayana             | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tangara preciosa           | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tangara seledon            | O    | S    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Dacnis cayana              | O    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Tersina viridis            | O    | S    | E           | M                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Basileuterus culcivorus    | I    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Basileuterus leucoblepharus| I    | V    | I           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Conirostrum speciosum      | O    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Coereba flavicollis        | N    | V    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Hylophilus poecilus        | O    | S    | B           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Cicada haemorrhous         | O    | M    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Psarocolius decumanus       | O    | L    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Scaphidura oryzivora       | O    | L    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Cyanocorax cyanomelas      | O    | L    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |
| Cyanocorax caeruleus        | O    | L    | E           | R                |                 |             |         |                |                 |             |        |         |       |         |             |            |

Figure 2 Continued
For trees we classified each taxon in categories of water dependence (riparian and non-riparian species) and dispersal mechanism: V: vegetative reproduction, Z: zoochorous species, A: anemochorous species, H: hydrochorous species.

The order of the families and the generic and specific names of bird species follow Stotz et al. (1996). Tree families are arranged following the Angiosperm Phylogeny Group II (APG II, 2003), and genera and species are in alphabetical order. Nomenclature follows Zuloaga et al. (1994), and Zuloaga & Morrone (1996–99).

We used a semilog regression to determine the relation between the number of species and distance of birds and trees along the river and a chi-square analysis to compare the number of riparian and non-riparian species of trees that go into the gallery forest or reach the end of the gallery forest.

**RESULTS**

Satellite images and survey data reveal that the Uruguay River formerly had a continuous gallery forest from southern Misiones and north-western Río Grande do Sul to its mouth in the Río de la Plata, with a maximum width of 1000 m on each side of the river. We found only one apparently natural short interruption, where the gallery forest is replaced by xerophytic woodland. It is located in Monte Caseros (Corrientes) and is about 2 km long. From the mouth of the Uruguay River, the gallery forest extends for 100 km more along the Argentine coast of the Río de la Plata to Punta Lara (Cabrera & Dawson, 1944) and for 60 km along the Uruguayan side to 7 km upstream of the city of Colonia de Sacramento (pers. obs.).

During the 20th century, human constructions and forest exploitation interrupted the gallery forest in several places or changed the floristic composition of the vegetation. The most important disturbance by far is the Salto Grande reservoir which flooded and destroyed 100 km of gallery forest (Fig. 1). In spite of the fact that more than 20 years have passed since Salto Grande was constructed, there is no evidence that gallery forest is forming on its margins.

Hundred and twenty five (68.7%) of the 182 species of forest birds recorded in the Paranense forest in southern Misiones and north-western Río Grande do Sul (Belton, 1984, 1985, 1994; Chebez, 1996) go into the gallery forest of the Uruguay River and only 13 (7.1%) reach Punta Lara (Fig. 2). The number of species is inversely correlated ($r^2 = 0.942$) with distance and the slope of the regression is $-58.10 \pm 4.81$ (Fig. 3). This means a decline in diversity with 32% of species lost per unit distance.

A clear association pattern was found for birds between size, diet, habitat use and distance reached into the gallery forest. Species of smaller body size, granivores, insectivores and those that use both the interior and exterior parts of the gallery forest advanced markedly longer distances along the river than the other groups (Table 1). Eleven migratory species (Columba cayennensis, Lurocalis semitorquatus, Anthracothorax nigricollis, Phyllosotus burmeisteri, Myioagis viridicata, Elaenia mesoleuca, Cnemotriccus fuscatus, Knipolegus cyanirostris, Tityra cayana, 

**Table 1** Distribution of forest birds by categories of diet, size, habitat use migratory status and distance reached into the gallery forest of the Uruguay River and the Río de la Plata

| Diet            | Size | Habitat | Migratory Status |
|-----------------|------|---------|------------------|
|                 | VS   | S       | M    | L       | I    | E    | B    | M     | R   |
| Rainforest border | 182  | 77      | 29   | 14     | 8    | 8    | 46   | 45    | 72  | 31  | 34  | 61  | 71  | 50  | 17   | 165 |
| Santa María     | 125  | 63      | 17   | 3     | 5     | 4    | 33   | 33    | 52  | 25  | 15  | 46  | 39  | 40  | 11   | 114 |
| Garruchos       | 107  | 52      | 14   | 3     | 5     | 4    | 29   | 29    | 46  | 18  | 14  | 38  | 35  | 34  | 11   | 96  |
| Cnia. Garabí    | 84   | 40      | 10   | 2     | 5     | 3    | 24   | 23    | 36  | 16  | 9   | 30  | 26  | 28  | 7    | 77  |
| Santo Tomé      | 55   | 27      | 4    | 0     | 4     | 3    | 17   | 13    | 24  | 12  | 6   | 19  | 16  | 20  | 4    | 51  |
| Torrent         | 48   | 23      | 4    | 0     | 3     | 2    | 16   | 10    | 21  | 11  | 6   | 13  | 16  | 19  | 4    | 44  |
| Alvear          | 39   | 18      | 4    | 0     | 3     | 1    | 13   | 7     | 19  | 8   | 5   | 11  | 10  | 18  | 3    | 36  |
| Yapeyú         | 25   | 12      | 2    | 0     | 3     | 0    | 8    | 5     | 14  | 3   | 3   | 7   | 4   | 14  | 2    | 23  |
| Colón           | 16   | 8       | 2    | 0     | 3     | 0    | 3    | 3     | 10  | 1   | 2   | 3   | 3   | 10  | 2    | 14  |
| Lower Paraná Delta | 15  | 8       | 1    | 0     | 3     | 0    | 3    | 3     | 10  | 0   | 2   | 2   | 3   | 10  | 2    | 13  |
| Punta Lara     | 13   | 8       | 0    | 0     | 3     | 0    | 2    | 3     | 9   | 0   | 1   | 2   | 2   | 2   | 9    | 11  |
| %              | 7.1  | 10.39   | 0    | 0     | 37    | 0    | 4.35 | 6.66  | 12.5 | 0  | 2.94 | 3.28 | 2.81 | 18  | 11.76 | 6.66 |

**Figure 3** Species/distance curve for forest birds and trees on the Uruguay River and in the first part of the Río de la Plata.
correlated (of the gallery forest (Fig. 4). The number of species is inversely
of which 43 are restricted to riparian habitats (Martínez Crovetto,
western Rio Grande do Sul 180 forest tree species were recorded,
exception of
species are in this category.
that reach Punta Lara, all of them only penetrate a short distance
(maximum 180 km) along the Uruguay River.
In the Paranense forest in southern Misiones and north-
western Rio Grande do Sul 180 forest tree species were recorded,
of which 43 are restricted to riparian habitats (Martínez Crovetto,
from the total of species recorded 113 (62.8%) go into the
gallery forest of the Uruguay River and 28 (15.6%) reach the end
1963). From the total of species recorded 113 (62.8%) go into the
gallery forest of the Uruguay River and the Rió de la Plata
V: vegetative reproduction, Z: zoochorous, A: anemochorous,
H: hydrochorous. R: riparian, NR: non-riparian
Tachycineta albiventer, and Paserina glaucocaerulea) were
recorded in the gallery forest of the Uruguay River. With the
exception of Knipolegus cyanirostris and Paserina glaucocaerulea
that reach Punta Lara, all of them only penetrate a short distance
(maximum 180 km) along the Uruguay River.

In the Paranense forest in southern Misiones and north-
western regions of gallery forests, the number of species recorded
113 (62.8%) go into the
gallery forest of the Uruguay River and 28 (15.6%) reach the end
of the gallery forest (Fig. 4). The number of species is inversely
correlated\(^2\) with distance and the slope of the regression
is \(-45.62; SE 3.11\) (Fig. 3). This means a decline in diversity
with 25% of species lost per unit distance.

A clear association pattern was also found for trees between
ecological characteristics and distance reached into the gallery
forest (Table 2). Vegetative reproduction species, zoochorous
species and riparian species advanced markedly greater distances
along the river than anemochorous species and non-riparian
species. The species that reproduce mainly vegetatively were
those that advanced more distance along the Uruguay River.
However, this has little influence on the system because only four
species are in this category.

**DISCUSSION**

The distribution of forest birds and trees along the Uruguay
River shows that the river enables many species to disperse from
the rain forest. But, as expected in this type of study (Silva &
Oniki, 1988; Nores, 1992; Silva, 1996), the importance of the river
decreases with increasing distance from the source area.

The passage from the Paranense forest to the gallery forest
of the Uruguay River implies that species must not only pass
the bottleneck of the change from the broad rain forest to the
narrow gallery forest but must also meet all the biological
requirements of a small and narrow area. This constitutes a ‘filter’
which 31.3% of birds and 37.2% of tree species do not pass
through. Lastly, to advance down the Uruguay River implies
that species must at least have a tolerance for cooler and drier
environments.

Although distribution patterns along the Uruguay River are
similar for birds and trees, trees have a higher percentage of species
reaching the end of the gallery forest (15.6% vs. 7.1%) and a
less steep species/distance slope (\(-45.62 vs. -58.10\)).

Riparian species of trees advanced markedly longer distances
along the river than non-riparian species (Table 2). A question
arising from this pattern is whether being a riparian species facil-
ates passage from the Paranense forest to the gallery forest, or
makes advance along the river easier. The results suggest the second
option. Although the percentage of species entering the gallery
forest is somewhat higher among riparian species (69.7%) than
non-riparian species (60.6%), the difference is not significant
\(\chi^2 = 1.18; \text{Df} = 1; P = 0.277\), but the percentage of riparian species
(30.2%) that reach the end of the gallery forest is significantly
higher \(\chi^2 = 9.26; \text{Df} = 1; P = 0.0023\) than that of non-riparian
species (10.9%). The presence of a relatively high number of
riparian species of trees would explain why trees have a higher
percentage of species reaching the end of the gallery forest and a
less steep species/distance slope than birds. In the Paranense
forest there are also some riparian species of birds but only one
(Knipolegus cyanirostris) reaches the end of the gallery
forest.

Silva (1996) studied distribution along gallery forests in the
Cerrado region of forest birds from two sources: Atlantic–
Paranense forest and Amazonia. To compare our results with
those of Silva’s Atlantic–Paranense forest, we grouped the bird
data according to his distance categories (0 –250 km, 251–500 km,
501–750 km, and more than 750 km). In the Uruguay River the
first category (0 –250 km) is approximately in the subtropical
zone and the remaining categories are in the temperate zone.

One unexpected difference between the two systems is that
the number of species of Atlantic–Paranense birds recorded in
the gallery forests of the Cerrado rivers (78) is much lower than the
number of species recorded in the Uruguay River (125), even
though the source area species pool is larger in the former than in
the latter. Another difference is in the bird distribution pattern.
In the Cerrado only 50% of the species that go into the gallery
forests maintain their ranges within 0–250 km, while in the
Uruguay River 87% of the species are restricted to this distance
category. This is probably because gallery forests of the Cerrado
region are in the tropical zone with a more uniform temperature,
while in the Uruguay River the gallery forest occurs in the
subtropical and temperate zone and follows a decreasing tem-
perature gradient.

Of the 16 remaining species that go beyond 250 km in the
Uruguay River, one extends to 500 km, two extend to 750 km,
and 13 exceed 750 km and reach Punta Lara. This means that
most of the species which pass the first 250 km reach the end
of the gallery forest. These are species with higher adaptability and
most of them can sometimes go some distance outside gallery
forests and colonize isolated — natural or exotic — forest habitats
(e.g. Synallaxis spixi, Syndactyla rufosuperciliata, Thamnophilus

| Water dependence | Dispersal mechanism | Total | V | Z | A | R | NR |
|------------------|-------------------|------|---|---|---|---|----|
| Rainforest border | 180               | 4    | 142 | 1  | 34 | 43 | 137|
| Northern Corrientes | 112              | 2    | 85  | 26 | 30 | 83 | 30  |
| Southern Corrientes | 69                 | 2    | 56  | 12 | 25 | 45 | 45  |
| Northern Entre Ríos | 56                | 2    | 47  | 4  | 21 | 36 | 36  |
| Southern Entre Ríos | 50                | 1    | 43  | 7  | 19 | 32 | 32  |
| Lower Paraná Delta | 35                 | 1    | 29  | 5  | 15 | 20 | 20  |
| Punta Lara        | 28                 | 1    | 24  | 3  | 13 | 15 | 15  |
| %                 | 15.6              | 25   | 16.9 | 8.8  | 30.2 | 10.9 |

V: vegetative reproduction, Z: zoochorous, A: anemochorous,
H: hydrochorous. R: riparian, NR: non-riparian
Dispersal of forest species along the Uruguay River

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| Species                              | Reproduction | Habitat | Rainforest Forest | N Corrientes | S Corrientes | N Entre Rios | S Entre Rios | Lower Paraná | Delta Parna Bala |
|--------------------------------------|--------------|---------|-------------------|--------------|--------------|--------------|--------------|---------------|----------------|
| Nectandra angustifolia               | Z            | R       |                   |              |              |              |              |               |                |
| Nectandra lanceolata                 | Z            | NR      |                   |              |              |              |              |               |                |
| Nectandra megapotamica               | Z            | NR      |                   |              |              |              |              |               |                |
| Ocotea dysopyrifolia                 | Z            | NR      |                   |              |              |              |              |               |                |
| Ocotea lancifolia                    | Z            | R       |                   |              |              |              |              |               |                |
| Ocotea puberula                      | Z            | NR      |                   |              |              |              |              |               |                |
| Rollinia emarginata                  | Z            | NR      |                   |              |              |              |              |               |                |
| Rollinia salicifolia                 | Z            | NR      |                   |              |              |              |              |               |                |
| Acrocomia total                      | Z            | NR      |                   |              |              |              |              |               |                |
| Allagoptera campestris               | Z            | NR      |                   |              |              |              |              |               |                |
| Syagrus romanzoffiana                | Z            | NR      |                   |              |              |              |              |               |                |
| Guadua angustifolia                  | V            | R       |                   |              |              |              |              |               |                |
| Guadua chacoensis                    | V            | NR      |                   |              |              |              |              |               |                |
| Guadua triniti                       | V            | NR      |                   |              |              |              |              |               |                |
| Merostachys clauseni                 | V            | NR      |                   |              |              |              |              |               |                |
| Achatocalyx praecox                  | Z            | NR      |                   |              |              |              |              |               |                |
| Phytolacca dioica                   | Z            | NR      |                   |              |              |              |              |               |                |
| Pisonia aculeata                     | Z            | NR      |                   |              |              |              |              |               |                |
| Coccoloba cordata                    | Z            | NR      |                   |              |              |              |              |               |                |
| Ruprechtia brachysepala              | A            | NR      |                   |              |              |              |              |               |                |
| Ruprechtia laxiflora                 | A            | NR      |                   |              |              |              |              |               |                |
| Ruprechtia salicifolia               | A            | R       |                   |              |              |              |              |               |                |
| Acanthosyris spinescens              | Z            | R       |                   |              |              |              |              |               |                |
| Terminalia australis                 | A            | R       |                   |              |              |              |              |               |                |
| Terminalia triflora                  | A            | R       |                   |              |              |              |              |               |                |
| Miconia pusilliflora                 | Z            | NR      |                   |              |              |              |              |               |                |
| Blepharocalyx salicifolius           | Z            | R       |                   |              |              |              |              |               |                |
| Calycos retus tetisiflora            | Z            | NR      |                   |              |              |              |              |               |                |
| Calyptranthes concinna               | Z            | NR      |                   |              |              |              |              |               |                |
| Campomanesia guazumifolia            | Z            | NR      |                   |              |              |              |              |               |                |
| Campomanesia xanthocarpa              | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia burkartiana                  | Z            | R       |                   |              |              |              |              |               |                |
| Eugenia hyemalis                     | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia involucrata                  | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia mansonii                     | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia pyriflora                    | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia repanda                      | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia uniflora                     | Z            | NR      |                   |              |              |              |              |               |                |
| Eugenia uruguayensis                 | Z            | NR      |                   |              |              |              |              |               |                |
| Guapuriun pervianum                  | Z            | NR      |                   |              |              |              |              |               |                |
| Hexachlamis edulis                   | Z            | R       |                   |              |              |              |              |               |                |
| Myrcocenous euosma                   | Z            | NR      |                   |              |              |              |              |               |                |
| Myrcocenousic euosma                 | Z            | R       |                   |              |              |              |              |               |                |
| Myrcia bombycina                     | Z            | NR      |                   |              |              |              |              |               |                |
| Myrcia laroenteana                   | Z            | NR      |                   |              |              |              |              |               |                |
| Myrcia zeloi                         | Z            | R       |                   |              |              |              |              |               |                |
| Paramyrciaria delicatula             | Z            | NR      |                   |              |              |              |              |               |                |
| Plinia rivarari                       | Z            | NR      |                   |              |              |              |              |               |                |
| Psidium guajava                      | Z            | R       |                   |              |              |              |              |               |                |
| Psidium guineense                     | Z            | NR      |                   |              |              |              |              |               |                |
| Psidium kennedyanum                  | Z            | NR      |                   |              |              |              |              |               |                |
| Psidium nutans                        | Z            | NR      |                   |              |              |              |              |               |                |
| Maytenus ilicifolia                  | Z            | NR      |                   |              |              |              |              |               |                |
| Schaeferia argentinensis              | Z            | R       |                   |              |              |              |              |               |                |
| Acochaim sublegans                   | Z            | NR      |                   |              |              |              |              |               |                |
| Aeschynomene sensitiva               | Z            | NR      |                   |              |              |              |              |               |                |
| Albizia inanda                       | Z            | NR      |                   |              |              |              |              |               |                |
| Anadenanthera colubrina               | Z            | NR      |                   |              |              |              |              |               |                |
| Apuleia leioarpa                      | A            | NR      |                   |              |              |              |              |               |                |
| Bauhinia forficata                    | Z            | NR      |                   |              |              |              |              |               |                |
| Bauhinia uruguayensis                | Z            | NR      |                   |              |              |              |              |               |                |
| Caliandra foliolosa                   | Z            | NR      |                   |              |              |              |              |               |                |
| Choroleuson tenuiflorum               | Z            | NR      |                   |              |              |              |              |               |                |
| Enterolobium contortisiliquum         | Z            | NR      |                   |              |              |              |              |               |                |

Figure 4 Ecological characteristics and distribution of forest trees along the Uruguay River and in the first part of the Río de la Plata. The black line indicates for each species the distance from the source area to its southernmost record.
| Species                             | Z | R | Z | Z | Z | Z |
|------------------------------------|---|---|---|---|---|---|
| Gleditsia amorphaides             | Z | NR|    |    |    |    |
| Holocalyx balansae               | Z | NR|    |    |    |    |
| Inga semialata                    | Z | NR|    |    |    |    |
| Inga verna                        | Z | R |    |    |    |    |
| Lonchocarpus leucanthus           | A | NR|    |    |    |    |
| Lonchocarpus muehlenbergianus     | A | NR|    |    |    |    |
| Lonchocarpus nitidus              | A | NR|    |    |    |    |
| Machaerium aculeatum             | A | R |    |    |    |    |
| Machaerium minutiflorum           | A | R |    |    |    |    |
| Machaerium nyctitans             | A | NR|    |    |    |    |
| Machaerium paraguariense         | A | R |    |    |    |    |
| Mimosa bimucronata                | Z | R |    |    |    |    |
| Myrcarpus frondosus               | A | NR|    |    |    |    |
| Parapiptadenia rigida             | A | NR|    |    |    |    |
| Peltophorum dubium                | A | NR|    |    |    |    |
| Poecilanthe parviflora           | Z | R |    |    |    |    |
| Pterogyne nitens                 | A | NR|    |    |    |    |
| Rheedia brasiliensis             | Z | NR|    |    |    |    |
| Alchornea triplinervia            | Z | NR|    |    |    |    |
| Croton urucurana                  | Z | R |    |    |    |    |
| Jatropha curcas                   | Z | NR|    |    |    |    |
| Manihot grahamii                  | Z | NR|    |    |    |    |
| Margaritaria nobilis              | Z | NR|    |    |    |    |
| Sebastiania brasiliensis         | Z | NR|    |    |    |    |
| Sebastiania commersoniana        | Z | R |    |    |    |    |
| Sebastiania schottiana            | Z | R |    |    |    |    |
| Banara tomentosa                  | Z | NR|    |    |    |    |
| Casearia decandra                 | Z | NR|    |    |    |    |
| Casearia sylvestris               | Z | R |    |    |    |    |
| Xylosma venosa                    | Z | R |    |    |    |    |
| Jacaranda spinosa                 | Z | NR|    |    |    |    |
| Ficus adhatodaefolia             | Z | NR|    |    |    |    |
| Ficus exima                       | Z | NR|    |    |    |    |
| Ficus luschnathiana               | Z | NR|    |    |    |    |
| Maclura tinctoria                 | Z | NR|    |    |    |    |
| Soroea bonplandii                 | Z | NR|    |    |    |    |
| Cecropia pachystachya             | Z | NR|    |    |    |    |
| Colubrina retusa                  | Z | NR|    |    |    |    |
| Quillaja brasiliensis             | A | NR|    |    |    |    |
| Celtis iguanaea                   | Z | R |    |    |    |    |
| Celtis pubescens                  | Z | R |    |    |    |    |
| Trema micrantha                   | Z | NR|    |    |    |    |
| Boehmeria caudata                 | Z | NR|    |    |    |    |
| Urera baccifera                   | Z | NR|    |    |    |    |
| Bastardiopsis densiflora          | Z | NR|    |    |    |    |
| Ceiba insignis                    | A | NR|    |    |    |    |
| Helicarpus popayanensis           | A | NR|    |    |    |    |
| Neoluea divaricata                | A | NR|    |    |    |    |
| Guazuma ulmifolia                 | Z | NR|    |    |    |    |
| Schinus ferox                     | Z | NR|    |    |    |    |
| Schinus lenticicifolia             | Z | NR|    |    |    |    |
| Schinus terebintholus             | Z | NR|    |    |    |    |
| Cabralea canjerana                | Z | NR|    |    |    |    |
| Cedrela fissilis                  | A | NR|    |    |    |    |
| Cedrela odorata                   | A | NR|    |    |    |    |
| Guarea macrophylla                | Z | NR|    |    |    |    |
| Trichilia clausenii               | Z | NR|    |    |    |    |
| Trichilia elegans                 | Z | NR|    |    |    |    |
| Trichilia pallida                 | Z | NR|    |    |    |    |
| Balfouriodendron riedelianum       | A | NR|    |    |    |    |
| Eisenbeckia grandiflora           | Z | NR|    |    |    |    |
| Fagara hyemalis                   | Z | R |    |    |    |    |
| Fagara rhofolia                   | Z | NR|    |    |    |    |
| Helietta apiculata                | A | NR|    |    |    |    |

Figure 4 Continued
Dispersal of forest species along the Uruguay River

Thirty-three bird species are shared by the two systems, but no clear pattern of the use of gallery forests is observed. Thirteen species maintain their ranges within 0–250 km in the two systems, while the 20 remaining species differ in the distance that they advance along the rivers. For example, *Basileuterus leucoblepharus* and *Phylloscartes ventralis*, that reach the end of the gallery forest of the Uruguay River, do not go beyond 250 km in the gallery forests of the Cerrado region, while *Philydor lichtensteini*, *Automolus leucophthalmus*, *Sclerurus scansor*, *Conopophaga lineata*, *Mionectes rufiventris* and *Schiffornis virescens*, which

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**Figure 4 Continued**

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advance a long distance in the gallery forest of the Cerrado region, only advance a short distance (maximum 60 km) in the Uruguay River. The avifauna of the Uruguay River showed a clear association pattern between size, diet, habitat use and distance reached into the gallery forest. On the contrary, no clear pattern of association was found between ecological characteristics of birds and distance reached into the Cerrado rivers (Silva, 1996).

Despite its large size, the Salto Grande dam apparently has not caused the extinction of any species because it is located at a point in the river were only a few, adaptable species reach. All the species that extended past that point are now present downstream of the dam. A proposed dam at Colonia Garabí, northeastern Corrientes, however, constitutes a great potential hazard for the forest species of the Uruguay River. As Colonia Garabí is only 60 km downstream from the Paranense forest border, the construction of this dam would eliminate this first 60 km of gallery forest and would isolate the rest for most of the species.

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