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ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

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Pulp Mill and Port in Concepción – Paraguay

VOLUME II – Book II – ENVIRONMENTAL DIAGNOSIS OF THE BIOTIC ENVIRONMENT

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Distribution	
PARACEL	E
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Orig.	05/08/20 – hbo	05/08/20 – bvv	05/08/20 – hfw	05/08/20 – hfw	For information
Rev.	date/Author	Date/Verified	Date/Aproved	Date/Authorized	Observation
a	31/05/21 - hbo	31/05/21 - bvv	31/05/21 - hfw	31/05/21 - hfw	For information
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9 ENVIRONMENTAL DIAGNOSIS

9.2 Biotic Environment

The diagnosis of the biotic environment provides the opportunity to observe the current state of flora and fauna (mammals, birds, herpetofauna, ichthyofauna and aquatic organisms) in the areas of influence of the region and thus obtain an adequate evaluation of the environmental impacts related to the construction and operation of the PARACEL pulp mill.

For the collection of primary and secondary data, the areas of influence were considered, as following:

- IIA (Indirect Influence Area) – The ecoregions that the Department of Concepción intercepts and, in part, the Aquidabán and Pilcomayo river basins, namely the Cerrado, Alto Paraná, Chaco Húmedo and Chaco Seco ecoregions. The systematization of information by ecoregions in the available bibliography justified the choice of this criterion;
- DIA (Direct Influence Area) – 5 km radius is being considered in the surroundings of PARACEL pulp mill and 25 meters range of transmission line. The impacts of port, wood transportation and accommodation camps on the Direct Influence Area were also considered, although they are not included in the map. The DIA was determined based on atmospheric dispersion study, water effluent discharge (the distance of effluent is smaller than boundary) and industrial noise impacts (in 5 km the noise emitted by the mill will be practically the same as the environment).
- DAA (Directly Affected Area) - It includes the internal area owned by PARACEL, where the industrial unit will be properly established, in addition to the water intake system and the emissary for treated effluents disposal. It includes the accesses roads and support areas (port and transmission line) and also 6 accommodation camps.

9.2.1 Flora

The studies of vegetation carried out as part of the diagnosis aim to present the current situation of the flora at the areas of indirect, direct and directly affected influence of the pulp mill through the study of primary and secondary data, serving as a reference to evaluate the effects of the implantation and operation of the mill. In this sense, the aim of this diagnosis was to highlight the types of plant formations existing in the region, indicating the state of conservation of the most significant areas and the configuration of the biotic conditions of the Direct Influence Area (DIA) and the Directly Affected Area (DAA) of PARACEL pulp mill.

9.2.1.1 Methods

The methodology used for the mapping of land use and vegetation cover consisted of the use of visual interpretation techniques of the products of the analysis of satellite images of the study area (satellite images) and the integrated analysis of the information extracted from these products; the data obtained in the field work and the existing digital databases.

For the diagnosis, secondary data were obtained from sources such as: An approximation of knowledge of plant formations in the Chaco Boreal, Paraguay (Mereles, 2005); GIS/CIF/FCA/UMA Laboratory Technical Report (Map of Coverage of Paraguay, 2011); Servicio Paz y Justicia Paraguay (SERPAJ PY 2013), Reference Level of Forest Emissions from Deforestation in the Republic of Paraguay (2015), National Land Monitoring System Results of the Satellite Land Monitoring System (2016), and other studies in the area of influence.

For the digital bases of the vegetation insertion maps, data from the project "Development of Methodologies for Monitoring Carbon Stored in Forests for REDD+ in Paraguay" (GIS/CIF/FCA/UMA Laboratory Technical Report, 2011) and from the Paraguayan Ecoregions - definition of conservation priorities (LIFE, 2016) were used.

Based on this analysis, sampling points were selected, including in forests that protect watercourses, to verify the existence of the characteristic aspects of the vegetation complexes in Paraguay. These areas in the AID were identified on maps, with its UTM (Universal Transverse Mercator) coordinates in the Datum SIRGAS 2000 system. The protective forests of watercourses in Paraguay are defined according to the Table as following.

Table 1 – Parameters for the establishment of protective forests for water channels in the eastern region of Paraguay.

Channel width	Minimum width of protective forest on each river margin
Greater or equal to 100m	100 m
50 to 99 m	60 m
20 to 49 m	40 m
5 to 19 m	30 m
1.5 to 4.9 m	20 m
Less than 1.5 m	10 m
River rising in area of influence	In each case, provision shall be made for the following types of headwater (with a minimum of 30 m)

Source: Manual Técnico para la administración y aplicación of Law n. 4241/10 "On the re-establishment of forests protecting watercourses within the national territory" and its Decree 9,824/12.

The following documents were consulted for the identification of endangered plant species: SEAM Resolution n. 524/2006 (List of Endangered Flora and Fauna Species of Paraguay), SEAM Resolution n. 2,243/2006 - List of Endangered Wildlife Species, as amended by Resolution n. 2,531/2006, and the Taxonomic List of Endemic Flora of Paraguay (Chocarro & Egea, 2018).

For the qualitative & quantitative investigation of the flora present in the areas of influence of the PARACEL mill, carried out from October 17 to 21, 2019 and March 4 to 8, 2020, the walking method was used (Filgueiras et al., 1994) and the Rapid Ecological Assessment method (Sayre et al., 2000), which consists of the description of the vegetation of the sampled area, listing the species found (Figure 1 and Figure 2).

For the quantitative study, the phytosociological study was carried out, which has as its main objective the knowledge of the ecological importance of each species and the degree of floristic diversity of the area studied. The botanical material that was not identified in the field was collected with the help of pruning shears, herborized and pressed into newsprint and cardboard, for subsequent identification with consultation of the specialized literature. The material was classified according to the botanical nomenclature of the classification system: Angiosperm Phylogeny Group - APG IV (2016).

Figure 1 – Detail of the registration with the use of binoculars type Solognac 10x42 series 100.

Figure 2 – Detail of the photographic record of the species found.

9.2.1.2 Flora in Paraguay

Paraguay is a geographically located in the heart of the South American continent, with two main regions of different topography and geology; to the east is the eastern region, also known as the Paraná region (which represents 39% of the total area and is home to over 90% of the population) and to the west is the Chaco (which represents 61% of the total area and is home to less than 10% of the population) (Chocarro and Aegean, 2018).

According to Chocarro and Aegean (2018), Paraguay's floristic richness has been attributed to the confluence of different ecoregions, the mosaic of habitat types that occur throughout the country, and the geographical position of Paraguay near the Tropic of Capricorn, or which divides the country in two, resulting in many tropical plants being found in their most southern distributions and temperate plants in the south being found in their most northern distributions. Huang and others (2009 apud Chocarro & Egea, 2018) also noted that Paraguay is an ecologically unique country, located at the confluence of five ecoregions: Mata Atlántica, Chaco Húmedo, Bosque Chaco, Pantanal and Cerrado, which contributes to its floral richness, while Spichiger and others (2009 apud Chocarro & Egea, 2018) referred to the richness of its flora. (2011 apud Chocarro & Egea, 2018) and Bueno and others (2017 apud Chocarro & Egea, 2018) state that Paraguay can be considered a huge and diverse ecotone in South America, where diverse flora is mixed: Chaco, Parana, Cerrado and Pampa.

The total number of vascular plant species in Paraguay is estimated to be between 6500-7000 species (Mereles, 2007). Zuloaga et al. (2008) mention a total of 5099 species, 103 subspecies, 375 varieties and 20 forms, distributed among 201 families and 1231 genera registered in Paraguay. The official list of species endemic to the country published in 2006 by SEAM (Secretariat of the Environment) presented 25 species, of which only 10 are strictly restricted to Paraguayan territory. The publication of the Catálogo de Plantas Vasculares del Cono Sur in 2008 provided more reliable and updated information, with a list of 399 species endemic to the country (Zuloaga & Belgrano, 2015; Chocarro & Egea, 2018).

Nevertheless, since the 1970s, excessive human activity has drastically accelerated the destruction of natural vegetation, mainly through the establishment of extensive agricultural activity aimed primarily at promoting high-yield monocultures (Spichiger et al., 2011).

According to the National Land Monitoring System Results of the Satellite Land Monitoring System (2016) regarding forest cover, the country can be divided into five major eco-areas or bio-geographic regions (Figure 3): Bosque Húmedo de la Región Oriental (BHRO), Bosque Sub humedo del Cerrado (BSHC), Bosque Sub humedo Inundable del Río Paraguay (BSIRP), Bosque Seco Chaqueño (BSCH) and Bosque Palmar (BP), and the Plantaciones Forestales (PF) that have been considered as forest cover, but are not native.

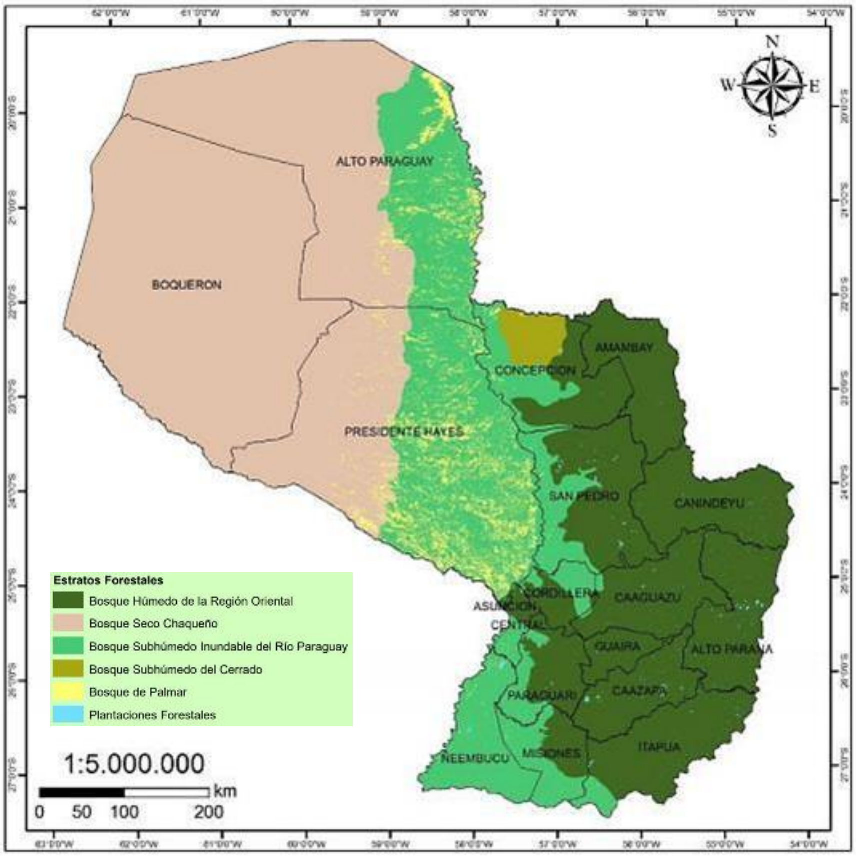


Figure 3 – Map of Paraguay's Forestry Stratum (2016). Source: Sistema Nacional de Monitoreo Terrestre Resultados del Sistema Satelital de Monitoreo Terrestre (2016).

According to INFONA (2011) the identification of these ecozones or biogeographic regions was done considering biophysical variables, such as climate, temperature and soil type, and they have the following characteristics:

Bosque Húmedo de la Región Oriental - BHRO

This formation includes the high native forests of the eastern region of Paraguay classified as subtropical rainforest (Hueck, 1978 apud INFONA, 2011), warm temperate rainforest of Holdridge (1969 apud INFONA, 2011) and high forest of the Paraná de Tortorelli (1966 apud INFONA, 2011), with heights that can reach 30 or 40 meters and whose structure has three vertical layers and an understory, considered the most biodiverse in the country, in the floristic composition predominate *Cedrela* spp, *Tabebuia* spp, *Apuleia leiocarpa*, *Balfourodendron riedelianum*, *Myrocarpus frondosus*, *Peltophorum dubium*, *Pterogine nitens*, *Nectandra* spp, *Ocotea* spp, *Patagonula americana*, *Enterolobium contortisiliquum*, *Albizia hassleri*, *Cabralea* sp, *Aspidosperma polyneuron*, Among others, the forest also has a high number of species of lianas, epiphytes, tree ferns and palms (*Syagrus romanzofianna* y *Euterpe edulis*). The natural communities are made up of swamps, gallery forests, tall and medium semi-deciduous forests, bamboo groves, savanna (cerrado), caves, rocky areas and cliffs. The soils are well-drained and predominantly derived from basalt and sandstone (INFONA, 2011).

Bosque Subhúmedo del Cerrado - BSHC

It includes the native woods of the Concepción ravine, whose structure has 2 vertical strata and an understory with a predominance of grasses, the floristic composition includes *Amburana cearensis, Peltophorum dubium, Anadenanthera colubrina, Enterolobium contortisiliquum, Schinopsis balansae, Calycophillum multiflorum, Phyllostylon rhamnoides, Astronium urundeuva, Anadenanthera peregrina, Guibourtia rhodatiana, Butia yatay, Axonopus affinis, Psidium arasa, Andropogon lateralis y Elyonorus latiflorus*, among others. The natural communities are made up of gallery forests, caves, medium and low semi-deciduous forests, enclosures, wooded savannas and cliffs. The soils are predominantly derived from granite and limestone (INFONA, 2011).

Bosque Subhúmedo Inundable del Río Paraguay - BSHIRP

It includes forests in islets, forests associated with palm groves throughout the plain of the Paraguay River, the floristic composition includes *Peltophorum dubium, Tabebuia sp., Holocalyx balansae, Ficus sp., Nectandra sp., Ocotea sp., Sapium hematospermum, Pithecellobium scalare, Gleditzia amorphoides, Erithrina crista-galli, Salix humboldtiana, Diplokeleba floribunda, Schinopsis balansae, Handroanthus heptaphyllus, Syagrus romanzoffiana, Copernicia alba y Enterolobium contortisiliquum*, among others. The natural communities are made up of gallery forests, palm savannas, medium and low semi-deciduous forests. The soils are predominantly derived from marine and alluvial sediments, generally flooded, or poorly or imperfectly drained (INFONA, 2011).

Bosque Seco Chaqueño - BSCH

It covers the open forests of the Central Chaco up to the Bolivian border. The floristic composition includes *Ceiba insignis*, *Schinopsis quebracho-colorado*, *Aspidosperma quebracho-blanco*, *Prosopis alba*, *Prosopis nigra*, *Ruprechtia triflora*, *Quiabentia pflanzii*, *Ziziphus mistol* y *Ximenia americana*, among others. The natural communities are made up of semi-deciduous xerophytic forest, paleo-corrugated savannahs with esparto grass and cerrado. The soils are predominantly derived from wind sediments (INFONA, 2011).

Bosque Palmar - BP

It includes palm-dominated forests distributed throughout the floodplain of the Paraguay River basin, with different densities and degrees of disturbance. The dominant palm species is *Copernicia alba* (INFONA, 2011).

Plantaciones Forestales - PF

Forest plantations are characterized when predominantly (more than 50%) of the area is composed of trees established through the deliberate planting and/or sowing of native and/or exotic species, in areas of afforestation and reforestation, for production or conservation or other purposes (INFONA, 2011).

9.2.1.3 Regional Characterization (IIA)

The territory of Paraguay can be further subdivided into five ecoregions (Figure 4). According to Dinnerstein et al. (1995) an ecoregion can be defined as a set of geographically distinct natural communities that share most of their species, dynamics and ecological processes, as well as similar environmental conditions, and are so named:

"Ecorregión del Bosque Atlántico del Alto Paraná" (BAAPA), "Ecorregión Chaco Húmedo", "Ecorregión Chaco Seco", "Ecorregión Cerrado y Ecorregión Pantanal" (Dinerstein *et al*., 1995 *apud* Encinas *et al*., 2019) all of those with significative biodiversity (Cartes, 2006; Salas-Dueñas & Facetti 2007 *apud* Encinas *et al*., 2019).

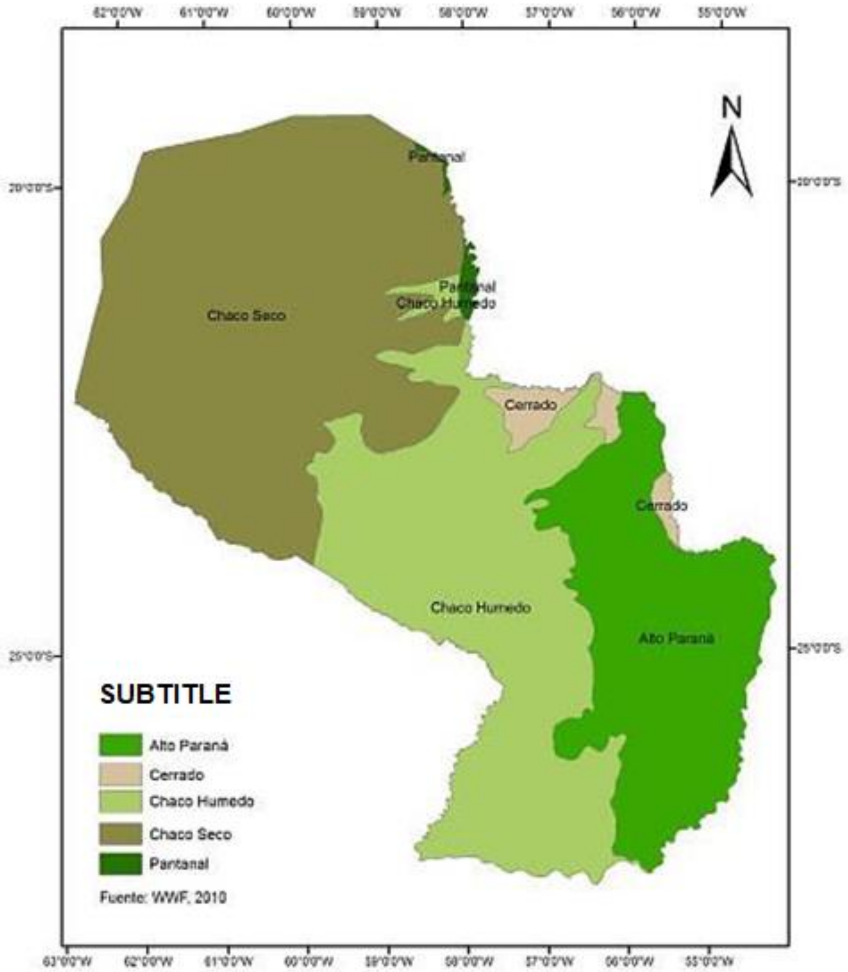


Figure 4 – Map of Paraguay's eco-regions (2011). Source: Proyecto "Desarrollo de Metodologías de Monitoreo de Carbono almacenado en los Bosques para la REDD+ en el Paraguay" (2011).

The indirect influence area (Figure 5) is located within the Department of Concepción, the second largest department in the eastern region of Paraguay, with approximately 14% of the entire forest area of the eastern region (SERPAJ PY, 2013). This department is located in the Cerrado, Atlantic Forest of the Upper Paraná and Humid Chaco ecoregions (GIS/CIF/FCA/UMA Laboratory Technical Report, 2011; LIFE Institute 2016).

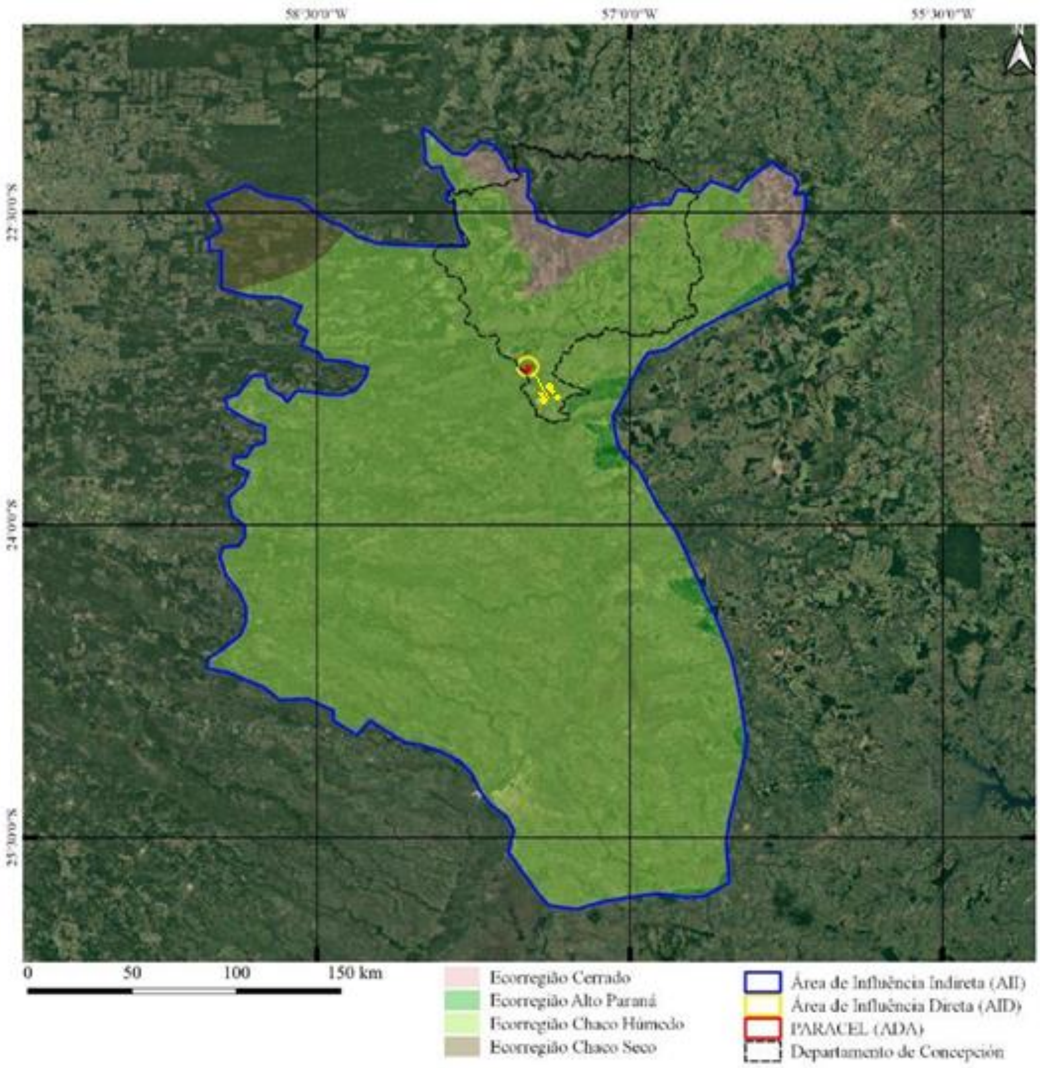


Figure 5 – Image with the location of the Indirect Influence Area of the pulp mill. Image obtained in Google Earth February/2018. Cartographic base: Map of the Ecoregions of Paraguay (Proyecto "Desarrollo de Metodologías de Monitoreo de Carbono almacenado en los Bosques para la REDD+ en el Paraguay", 2011).

Cerrado Eco-region (Brazilian Savana)

The plant formations present in this physiognomy are characterized by a transition from forests with extensive natural fields influenced by climate (Figure 6). In this ecoregion the trees are sometimes grouped into capons, which allows the appearance of extensive areas occupied by grasses, generally rhizomatous, and frequently some palms, without caules or not. In these capons the trees and shrubs, which generally do not exceed 3 or 4 m in height, can be exceptionally dense, forming the so-called Cerradón or Cerrados in transition with the forest formations, where the tree vegetation dominates the fields, or more open, forming the so-called Campos Cerrados, where the grass fields dominate the woody vegetation (Technical Report GIS/CIF/FCA/UMA Laboratory, 2011; LIFE Institute 2016; Mereles, 2005; 2007).

Figure 6 – The Cerrado's physiognomy profile. **Source: Mereles, 2005 (adapted).**

In this plant formation, the herbaceous species have xylopods, rhizomes, bulbs and other underground organs, and the trees and shrubs have suberose bark and tortuous trunks, which help the species to withstand high temperatures during savannah fires. The natural communities are composed of: lagoons, estuaries, baths, forests on saturated soils, rivers, streams, springs, caves, medium and low semi-deciduous forests, wooded savannas and rocky areas (GIS/CIF/FCA/UMA Laboratory Technical Report, 2011; LIFE Institute 2016; Mereles, 2005; 2007).

Eco-region of "Bosque Atlántico del Alto Paraná" (Alto Parana Atlantic Forest)

This ecoregion is composed mainly of tropical and subtropical forest, also described as tropical temperate rainforest. It has the following communities: peatlands, forests on saturated soils, rivers, streams, springs, waterfalls, high and medium semi-deciduous forests, Araucaria and Cerrado forests. It is undoubtedly the ecoregion with the greatest diversity of fauna in Paraguay, with more than 80% of the fauna of the eastern region concentrated in this ecoregion. (GIS/CIF/FCA/UMA Laboratory Technical Report, 2011; LIFE Institute 2016).

Eco-región of "Chaco Húmedo" (Wet Chaco)

This ecoregion is located in the western (west) and eastern (east) regions and has the following vegetation types: sub-humid and semi-deciduous forests, savannas and swamps. The fauna that occurs in general is not very different from that of other ecoregions associated with wetlands and is distinguished from the others by the abundance of aquatic species.

According to the GIS/CIF/FCA/UMA Laboratory Technical Report (2011), it is considered that in Ecorregión del Chaco Húmedo the ground cover can be categorized into: Savannah, Flooded Savannah, Forest Cover, Cultivated Land (agricultural areas - annual, perennial and mixed crops; livestock - established pastures and in combination with small wooded areas; land prepared for cultivation, fallow land and deforested areas), water bodies and urban areas. The categories of land cover vegetation considered in this study are described below:

Sabana (Savana)

According to the description by Huespe, et al., (1994 apud Informe Técnico Mapa de cobertura del Paraguay, 2011; Spichiger et al. 2011), the savannah forms a naturally formed landscape dominated by grasses and legumes with trees scattered to a lesser extent. It is distributed in places of high topography, above maximum flood levels.

This category also includes formations of the type ¨Cerrado¨ and areas with extensive livestock use (Eastern region), as well as grassland and vegetation dominated by bushes and forests. The former correspond to a type of vegetation that is found mainly in the Chaco's clogged paleo-corridors, composed predominantly of grasses and scattered trees, such as "paratodo" (*Tabebuia aurea*), "jacarandá (*Jacaranda puberula*), "algarrobo" (*Prosopis rubriflora*), "urunde'y" (*Astronium fraxinifolium* var. *glabrum*) and "quebracho colorado" (*Schinopsis lorentzii*) (Huespe, *et al*., 1994 *apud* "Informe Técnico Mapa de cobertura del Paraguay" - Technical Report Coverage Map of Paraguay, 2011; Spichiger *et al*. 2011).

Sabana inundada (Flooded Savannah)

This is a type of low topography land vegetation, characterized by soils with superficial phreatic levels and affected by flood waters, almost permanently throughout the year. In the Eastern region, the flooded savannah includes extensive wetlands, reservoirs and marshes, resulting from the overflowing of water courses (rivers and streams), on hydromorphic soils formed by the dragging of sediments. While in the Western region, this category includes marshes, swamps and reservoirs, which are the characteristic vegetation of these lowlands affected by flood water almost all year round, which are colonized by hydrophilic herbaceous species of cyperaceous, grasses, chamottes and others (Huespe et al., 1994 apud Technical Report Map of Coverage of Paraguay, 2011).

Sabana inundable (Possibly Flooded Savannah)

The vegetation is generally called herbaceous located in places with both flat topography and in the valleys affected by flood water during a certain time of the year. In this respect, it is generally distributed on soils with a superficial water table and slow drainage. In this natural formation also converges a type of combined vegetation of grasses and palms, which includes Karanda'y palms, sporadically alternating species such as Prosopis sp. (Huespe, et al., 1994 apud Technical Report Map of Coverage of Paraguay, 2011).

Cobertura forestal (Forestry Cover)

According to FAO (2009), forest is defined as areas equal to or greater than 0.5 ha; with a percentage (%) of tree crown cover equal to or greater than 10. The height of mature trees is equal to or greater than 5 m, and according to Huespe, et al. (1994 apud Technical Report Cover Map of Paraguay, 2011) the category Forest cover includes: Continuous forest cover, which consists of intermittently distributed forest stands and comprises the most important forest associations in the country; Residual forest cover, represented by fragments of non-continuous forest cover; Gallery forest cover, associated with the orientation of permanent or intermittent runoff from watercourses; and Forested and Reforested land, refers to forest cover composed predominantly of trees established by planting and/or deliberate seeding. Includes undergrowth from trees that were originally planted or seeded.

According to the secondary data obtained for the areas of influence of the PARACEL pulp mill and its surroundings, the following data are collected with the species of occurrence characteristic of the phytophysiology present in the region.

Table 2 – List of plant species that may appear in the mill's IIA.

Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
Acanthaceae	*Justicia* sp.			
	Ruellia woolstonii C. Ezcurra		x	
Amaranthaceae	*Froelichia paraguayensis* Chodat		x	
Amaryllidaceae	*Habranthus caaguazuensis* Ravenna		x	
Anacardiaceae	*Anacardium humile* A.St.-Hil.			
	Astronium fraxinifolium Schott	Urunde'y para		
	Schinus weinmannifolius Engl.	Molle'i		
	Schinus weinmannifolius Endl. var. *hassleri* (F.A. Barkley) F.A. Barkley		x	
Anemiaceae	*Anemia tomentosa* (Savigny) Sw.			
Annonaceae	*Annona calophylla* R.E.Fr.		x	
	Annona dioica A.St.-Hil.	Aratiku ñu		
	Annona glaucophylla R.E.Fr.		x	
	Annona nutans (R.E.Fr.) R.E.Fr.	Aratiku ñu		
	Annona paraguayensis R.E.Fr			
	Annona phaeoclados Mart.			
	Duguetia furfuracea (A.St.-Hil.) Saff.	Aratiku		
	Rollinia emarginata Schltdl.	Aratiku'i		
	Xylopia aromatica (Lam.) Mart.			
Apocynaceae	*Aspidosperma australe* Müll.Arg.	Kirandy		
	Aspidosperma cylindrocarpon Müll. Arg.			
	Aspidosperma pyrifolium Mart.	Palo rosa		
	Aspidosperma quebracho-blanco Schltdl.			
	Aspidosperma tomentosum Mart.			
	Forsteronia glabrescens Müll. Arg.			
	Hancornia speciosa Gomes			
	Macrosiphonia longiflora (Desf.) Müll. Arg.			
	Mandevilla petraea (A.St.-Hil.) Pichon	Eiruzu ka'a		
	Mandevilla pohliana (Stadelm.) A.H. Gentry	Jaguarova		
	Mandevilla spigeliiflora (Stadelm.) Woodson			
	Marsdenia altissima (Jacq.) Dugand supsp. faucinuda Dugand		x	
	Marsdenia guaranitica Malme		x	
	Mesechites sanctae-crucis (S. Moore) Woodson			

Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
	Oxypetalum brachystephanum (Malme) Malme		x	
	Prestonia acutifolia (Müll. Arg.) K. Schum.			
	Prestonia tomentosa R. Br.			
	Rauvolfia mollis S. Moore			
	Rhabdadenia pohlii Müll. Arg.			
	Rhabdadenia ragonesei Woodson			
	Tabernaemontana catharinensis A. DC.			
	Thevetia bicornuta Müll. Arg.			
	Thevetia peruviana (Pers.) K. Schum.			
Araceae	*Anthurium paraguayense* Engl.			
	Dracontium margaretae Bogner			
	Philodendron undulatum Engl.	Guembe		
	Taccarum weddellianum Brongn.			
Arecaceae	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.	Mbokaja		
Arecaceae	*Allagoptera leucocalyx* (Drude) Kuntze			
Arecaceae	*Butia paraguayensis* (Barb.Rodr.) L.H. Bailey	Yatai		EP
Arecaceae	*Syagrus romanzoffiana* (Cham.) Glassman	Pindo		
Aristolochiaceae	*Aristolochia* sp.	Patito		
Asparagaceae	*Herreria* sp.	Zarzaparrilla		
Aspleniaceae	*Asplenium* sp.			
Asteraceae	*Baccharis* sp.	Chirca		
	Calea formosa Chodat		x	
	Calea rojasiana Chodat		x	
	Lessigianthus concepcionis M.B. Angulo & Dematteis		x	
	Mesanthophora brunneri H.Rob		x	
	Pectis guaranitica Chodat		x	
	Porophyllum hasslerianum Chodat		x	
	Senecio sp.			
	Stevia apensis B.L. Rob.		x	
	Verbesina guaranitica Chodat		x	
Begoniaceae	*Begonia obovatistipula* C.DC.		x	
Bignoniaceae	*Arrabidaea* sp.			
	Jacaranda micrantha Cham.	Caroba		
	Jacaranda mimosifolia D. Don	Jacaranda		
	Dolichandra unguis-cati (L.) L.G. Lohmann	Mbarakaja pyape		

Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
	Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S. Moore	Paratodo		
	Handroanthus heptaphyllus (Vell.) Mattos	Lapacho rosado		EP
	Handroanthus pulcherrimus (Sandwith) S.O. Grose	Lapacho amarillo		EP
Boraginaceae	*Cordia glabrata* (Mart.) A.DC.	Peterevy moroti		EP
	Cordia trichotoma (Vell.) Arráb. ex Steud.	Peterevy hu		
	Cordia americana (L.) Gottschling & J.S. Mill.	Guajayvi		
	Euploca margaritensis (I.M. Johnst.) J.I.M. Melo & R. Degen		x	
Bromeliaceae	*Aechmea* sp.			
	Bromelia balansae Mez	Karaguata		
	Ananas sagenaria (Arruda) Schult. & Schult.f.	Karaguarta'i		
	Tillansia sp.	Clavel del aire		
	Dyckia affinis Baker		x	
	Dyckia insignis Hassl.		x	
	Dyckia vestita Hassl.		x	
Cactaceae	*Cereus stenogonus* K. Schum.	Cactus		
	Discocactus heptacanthus subsp. *magnimammus* (Buining & Brederoo) N.P. Taylor & Zappi	Tuna pe		EP
	Rhipsalis sp.	Suelda con suelda		
	Cereus sp		x	
	Harrisia hahniana (Backeb.) Kimnach & Hutchison		x	
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.	Juasy'y		
	Trema micrantha (L.) Blume	Kurundi'y		
Celastraceae	*Maytenus ilicifolia* Mart. ex Reissek	Cangorosa		EP
Combretaceae	*Terminalia argentea* Mart.	Yvyra hu		
Commelinaceae	*Commelina erecta* L.	Santa lucia hovy		
Convolvulaceae	*Evolvulus hasslerianus* Chodat		x	
Cyperaceae	*Scleria* sp.			
Erythroxylaceae	*Erythroxylum paraguariense* (Chodat & Hassl.) O.E. Schulz		x	
Euphorbiaceae	*Cnidoscolus albomaculatus* (Pax) I.M. Johnst.		x	
	Croton sp.			
	Euphorbia argillosa Chodat & Hassl		x	
	Manihot anomala Pohl subsp. *glabrata* (Chodat & Hassl.) D.J. Rogers & Appan		x	

Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
	Manihot populifolia Pax, Pflanzenr.		x	
	Sapium haematospermum Müll.Arg.	Kurupika'y		
	Stillingia scutellifera D.J. Rogers			
Fabaceae	*Aeschynomene histrix* Poir. var. apana Rudd, J. Wash.		x	
	Aeschynomene magna Rudd		x	
	Albizia niopoides var. *niopoides*	Yvyra ju		
	Amburana cearensis (Allemao)A.C.Sm.	Trébol		EP
	Anadenanthera colubrina (Vell.) Brenan	Kurupa'y		
	Anadenanthera peregrina (L.) Speg.	Kurupa'y kuru		
	Arachis hassleri Krapov., Valls & C.E. Simpson		x	
	Bauhinia sp.			
	Calliandra brevicaulis Micheli	Niño azote		
	Chamaecrista desvauxii (Collad.) Killip var. *peribebuiensis* (Chodat & Hassl.) H.S. Irwin & Barneby		x	
	Copaifera laevis Dwyer		x	
	Copaifera sp.	Quina		
	Galactia sp.			
	Holocalyx balansae Micheli	Yvyra pepe		
	Hymenaea courbaril L.	Jatay'va		
	Macroptilium chacoensis (Hassl.) S.I. Drewes & R.A. Palacios		x	
	Mimosa centurionis Barneb		x	
	Mimosa fiebrigii Hassl.		x	
	Mimosa monadelpha Chodat & Hassl. var. *glabrata* (Hassl.) Barneby		x	
	Myroxylon peruiferum L.f.	Incienso colorado		EP
	Parapiptadenia rigida (Benth.) Brenan	Kurupa'y ra		
	Parkinsonia praecox (Ruiz & Pav.) Hawkins	Verde olivo		
	Peltophorum dubium (Spreng.) Taub.	Yvyra pyta		
	Prosopis sp.			
	Pterogyne nitens Tul.	Yvyra'ro		
	Senegalia polyphylla (DC.) Britton & Rose	Jukeri guasu		
Iridaceae	*Sisyrinchium igatimiense* Ravenna		x	
Lamiaceae	*Leonotis nepetifolia* (L.) R.Br.	Cordón de fraile		
	Hyptis pachyarthra Briq.		x	

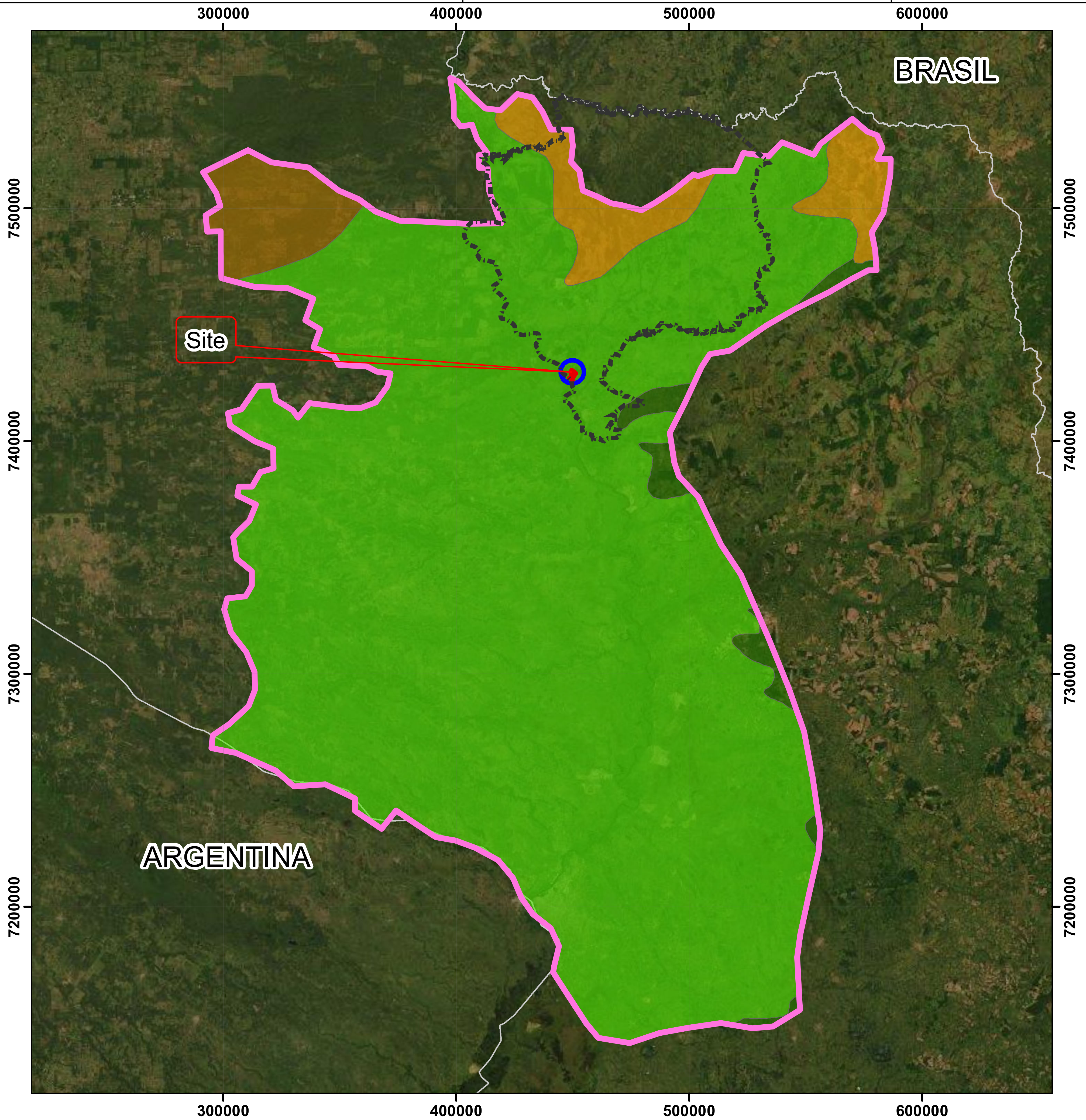
Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
Lygodiaceae	*Lygodium* sp.			
Lythraceae	*Cuphea corisperma* Koehne subsp. *hexasperma* (Koehne) Duré & Molero		x	
Malpighiaceae	*Heteropterys cultriformis* Chodat		x	
	Tetrapterys hassleriana Nied.		x	
Malvaceae	*Ceiba speciosa* (A.St.-Hil.) Ravenna	Samu'u		
	Pseudobombax sp.			
	Ayenia spinulosa R.E.Fr.		x	
	Luehea microcarpa R.E.Fr. var. *polymorpha* Hassl.		x	
	Malvastrum sp.	Typycha hu		
	Sida gracillima Hassl.		x	
	Sida pseudocymbalaria (Hassl.) Hassl.		x	
	Sida sp.			
	Guazuma ulmifolia Lam.	Kamba aka guasu		
	Sterculia striata A. St.-Hil. & Naudin	Manduvi guasu		
	Luehea candicans Mart.	Ka'a oveti		
	Luehea grandiflora Mart.	Ka'a oveti		
Melastomataceae	*Miconia* sp.		x	
Meliaceae	*Cedrela fissilis* Vell.	Cedro o ygary		
	Trichilia sp.	Cedrillo		
Moraceae	*Dorstenia* sp.	Taropé		
	Ficus enormis (Miq.) Miq.	Guapo'y		
	Maclura tinctoria (L.) D. Don ex Steud.	Tatajyva		
Myrtaceae	*Campomanesia pubescens* (Mart. ex DC.) O. Berg	Guavirami		
	Eugenia sp.			
Nyctaginaceae	*Guapira paraguayensis* (Heimerl) Lundell		x	
Orchidaceae	*Campylocentrum neglectum* (Rchb.f. & Warm.) Cogn.	Vandita		
	Cyrtopodium sp.	Tamanakuna		
	Pelexia collocaliae Szlach.		x	
Orobanchaceae	*Agalinis linarioides* (Cham. & Schltdl.) D'Arcy subsp. *rojasii* Barringer		x	
Passifloraceae	*Passiflora* sp.	Mburukuja'i		
	Turnera grandidentata (Urb.) Arbo		x	
Piperaceae	*Piper amalago* L.	Tuja renymy'a		
Plantaginaceae	*Angelonia integerrima* Spreng.			
Poaceae	*Andropogon* sp.			

Family	Scientific Nomenclature	Common name in Paraguay	End.	SEAM 524/06
	Axonopus sp.			
	Elionurus sp.	Espartillo		
Polygalaceae	*Polygala guaranitica* Chodat		x	
Polypodiaceae	*Microgramma* sp.	Anguja nambi		
Rubiaceae	*Calycophyllum multiflorum* Griseb.	Palo blanco		
	Genipa americana L.	Ñandypa		
	Spermacoce verticillata L.	Typycha corredor		
	Spermacoce viridiflora (Chodat & Hassl.) Govaerts		x	
Rutaceae	*Balfourodendron riedelianum* (Engl.) Engl.	Guatambu		EP
	Helietta apiculata Benth.	Yvyra ovi		
	Pilocarpus pennatifolius Lem.	Yvyra ta'i		
Salicaceae	*Banara arguta* Briq.	Mbavy		
Sapindaceae	*Allophylus edulis* (A.St.-Hil., A. Juss. & Cambess.) Radlk.	Koku		
	Melicoccus lepidopetalus Radlk.	Yvapovo		
	Serjania sp.			
	Talisia esculenta (A. St.-Hil.) Radlk.	Karaja bola		
Sapotaceae	*Chrysophyllum gonocarpum* (Mart. & Eichler ex Miq.) Engl.	Aguai		
Selaginellaceae	*Selaginella* sp.			
Smilacaceae	*Smilax goyazana* A.DC.			
Solanaceae	*Solanum granuloso-leprosum* Dunal			
	Solanum sisymbriifolium Lam.	Ñuati pyta		
Urticaceae	*Cecropia pachystachya* Trécul	Amba'y		
Verbenaceae	*Lippia lupulina* Cham.			
Vochysiaceae	*Qualea grandiflora* Mart.			

Source: Management Plan of the Natural Reserve Tagatiya mi (2008-2012); Ramella & Perret (2011). Legend: End.: endemic; Resolution SEAM 524/06 approving the list of endangered species of flora and fauna in Paraguay: EP – endangerous.

The physiognomy map of the Indirect Influence Area (IIA) (Figure 7) below identifies the types of vegetation found.

Figure 7 – Map of physiognomy of the IIA.



Sistema de Coordenadas: SIRGAS 2000 - UTM Zona 23S
Proyección: UTM - Transversal de Mercator
Datum: SIRGAS 2000

- DGEEC, 2012 (Dirección General de Estadística, Encuestas y Censos). Informe Técnico Mapa de cobertura del Paraguay año 2011

Subtitle

- Departamento de Concepcíón
- DAA
- DIA
- IIA
- Ecorregión Alto_Parana
- Ecorregión Chaco Húmedo
- Ecorregión Chaco_Seco
- Ecorregión Cerrado

N

0 25 50 100 150 Kilometer0s

PARACEL PÖYRY

TÍTULO DEL MAPA: IIA Physiognomy Map	
TÍTULO DEL PROYECTO: BIOTIC ENVIRONMENT - IIA	
PROCESO DE LICENCIA: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT	
TIPO DE LICENCIA: ENVIRONMENT PROCESS PERMIT	
UBICACIÓN: CONCEPCIÓN-PY	UGHRI: CIH8 Aquidaban y CIH18 Rio Pilcomayo

ESCALA:	REVISIÓN:	RESPONSABLE TÉCNICO:	CRBio Nº:
1:1.750.000	25/05/2020	EDUARDO MARTINS Biologo	26.063/01-D

9.2.1.4 Local Characterization – Direct Influence Area and Directly Affected Area

Direct Influence Area (DIA)

In a generalized way, DIA is represented by a matrix in which the flora is strongly anthropized, with suppression of native phytophysiology for the use of cattle rising, being formed by different typologies of plants interspersed by anthropic zones.

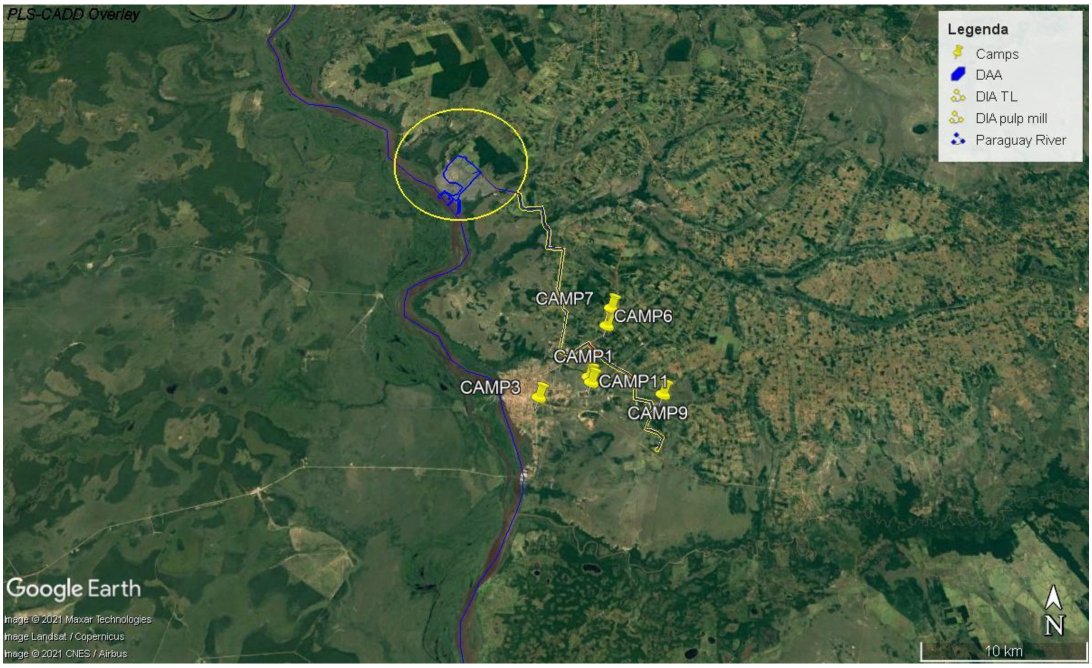


Figure 8 – Aerial image with the location of the mill's DIA. Image: Google Earth feb/2021.

It should be noted that from the 23,10 ha Transmission Line DIA only 3,5 ha is vegetation area, being most of the area composed by roads and pasture lands, as it is shown the figure below (Figure 9-13). Other than that most of the camps are located in the urban area (Figure 14, 15 and 16), therefore the vegetation analysis took place specially within the 5 km radius of the mill influence area. Hightlighting that the vegetation found in the TL DIA and camps doesn’t differ much from the ones found within the 5 km radius.

Figure 9 – Transmission Line Sections 1/5 (from the mill). Image: Google Earth jul/2021.

Figure 10 – Transmission Line Sections 2/5 (from the mill). Image: Google Earth jul/2021.

Figure 11 – Transmission Line Sections 3/5 (from the mill). Image: Google Earth jul/2021.

Figure 12 – Transmission Line Sections 4/5 (from the mill). Image: Google Earth jul/2021.

Figure 13 – Transmission Line Sections 5/5 (from the mill). **Image: Google Earth jul/2021.**

Figure 14 – Camp 1, 3 and 11 location. **Image: Google Earth jul/2021.**

Figure 15 – Camp 9 location. Image: Google Earth jul/2021.

Figure 16 – Camp 7 and Camp 6 location. Image: Google Earth jul/2021.

Thus, it can be said that the DIA region is represented by a complex where the vegetation layer is made up of varied communities, which appear in the landscape forming a heterogeneous mosaic, where the phytophysiological features are very close to each other, in such a way that elements of different types of vegetation are interrelated, making it difficult to delimit them exactly. Thus, it is possible to recognize basically the following categories for the area's vegetation cover: Savannah, Flooded Savannah and Semideciduous Forest.

Sabana (SAV-1, Savannah)

Located to the northwest of the area where the PARACEL pulp mill is located, about 200 meters away, this portion of vegetation is in contact with extensive areas used for cattle raising.

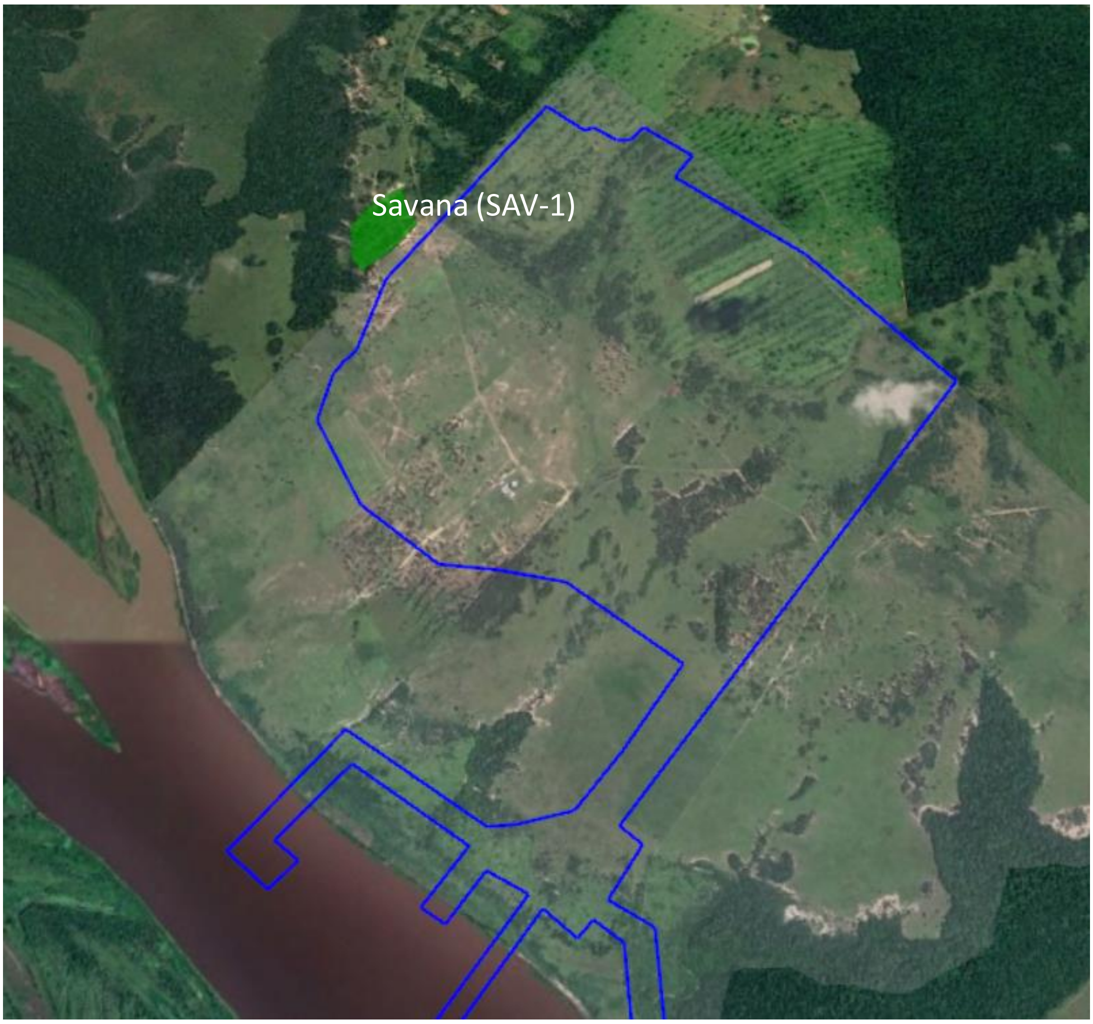


Figure 17 – Image with location of the Savannah (SAV-1). Image: Google Earth feb/2018 (Coordinates UTM 21K - midway point : 448922.15 E/ 7429694.55 S).

Figure 18 – Aerial image of the area with Savannah (SAV-1), in contact extensive cattle farming.

This plant formation is essentially structured in three layers: an upper part composed mainly of palms, with a Diameter At Breast Height (DBH) varying from 20 to 40 cm and a height of 10 to 12 meters, an intermediate one, with predominance of arboreal individuals and shrubs up to approximately 5 m with a Diameter At Base Height (DAB)[1] with variation between 5 to 20 cm, grouped in "capones" that occur in sandy soils; and a lower stratum consisting mainly of small palms such as the *Butia paraguayensis* (jatai), herbaceous and grass plants.

Figure 19 – General view of the area with Savannah (SAV-1). Coordinates UTM 21K 448922.15 E/ 7429694.55 S.

[1] DAB: Diameter At Base Height (0,50 cm from ground level)

Figure 20 – Detail of the spaced trees and bushes grouped in "capones", which occur in sandy soils.

Figure 21 – Another point of view of the spaced trees and bushes grouped in "capones", which occur in sandy soils.

Figure 22 – Detail of the groupings formed by terrestrial bromeliads and palm trees of the species*Butia paraguayensis* (jatai).

Figure 23 – Detail of the dense stratum formed by terrestrial bromeliads between tree and shrub spacings.

Among the species of trees and shrubs that are: *Schinopsis balansae* (quebracho), *Copernicia alba* (karanda'y), *Butia paraguayensis* (jatai), *Acrocomia aculeata* (mbokaja), *Ziziphus mistol* (mistol), *Duguetia furfuracea*, *Plenckia populnea*, *Cereus* sp (tuna), *Prosopis rubriflora* (algarrobo), *Schinus weinmannifolius* (aguara yva), *Randia* sp. y el *Eugenia involucrata* (ñangapiry), among the terrestrial bromeliads the *Bromelia balansae*, among the subbushes *Waltheria indica*, and among the herbaceous two different genera stand out in abundance: *Aristida* y *Mimosa*.

Figure 24 – View of the sample of the species *Schinopsis balansae* (quebracho).

Figure 25 – Detail of the fruit of the species *Schinopsis balansae* (quebracho).

Figure 26 – View of specie sampling *Duguetia furfuracea*.

Figure 27 – Detail of the fruit of *Duguetia furfuracea*.

Figure 28 – View of Sampling *Prosopis rubriflora* (algarrobillo).

Figure 29 – (A) Detail of the fruit of fruit; (B) Details of the inflorescences of the species *Prosopis rubriflora* (algarrobillo).

Figure 30 – View of the sample of the species *Randia* sp.

Figure 31 – Detail of the fruit of the species *Randia* sp.

Figure 32 – View of the sample of the species *Bromelia balansae*.

Figure 33 – Detail of the fruits of the species *Bromelia balansae*.

Savannah (SAV-2)

Located near the implantation area of the site of the future PARACEL pulp mill, this physiognomy is inserted in an extensive area with pastures and adjacent to the remaining forest that forms the continuous vegetation on the banks of the Paraguay River.

Figure 34 – Image with the location of the Savannah (SAV-2). Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 450492.83 E/ 7427479.93 S).

Figure 35 – Aerial image of the Savanna (SAV-2), view of shrub individuals sometimes grouped in capones or isolated within a dense stratum of grass.

This physiognomy presents a predominance of shrubby individuals up to approximately 3 m with DABs (basal diameter height) ranging from 5 to 15 cm, arranged either alone or grouped in a dense stratum formed by the *Elionurus*, *Eragrostis* e *Aristida*.

Figure 36 – General view of the Savannah portion (SAV-2) where shrub individuals are grouped together, giving an "island" aspect to these formations.

Figure 37 – General view of the portion of the Savannah (SAV-2) where shrub individuals are separated within a dense stratum of grass.

Among the species of occurrence are *Annona spinescens*, *Ziziphus mistol* (mistol), *Ximenia americana* (Indian kurupa'y), *Acacia* sp, *Prosopis rubriflora* (algarrobo), *Ipomoea carnea*, *Hyptis* sp, *Schyzachyrium condensatum* (capi'í), *Senecio grisebachii* (agosto poty), *Setaria parvifolia* (pasto), *Borreria* sp, *Malvastrum* sp, *Clhoris polydactyla*, *Cyperus* sp, *Piriqueta* sp and *Senna* sp.

Figure 38 – View of a sample of the species *Annona spinescens*.

Figure 39 – Detail of the species' fruit *Annona spinescens*.

Figure 40 – View of a sample of the species *Acacia* sp.

Figure 41 – D Detail of the species' fruit *Acacia* sp.

Figure 42 – View of a sample of the species *Ipomoea carnea*.

Figure 43 – Flower detail of the species *Ipomoea carnea*.

Figure 44 – View of a sample of the species *Borreria* sp.

Figure 45 – Flower detail of the species *Malvastrum* sp.

Figure 46 – View of a sample of the species *Piriqueta* sp.

Figure 47 – Flower detail of the species *Senna* sp.

Floodable Savannah (SAVi-1)

Located to the northwest of the area of implantation of the future pulp mill of PARACEL at about 1,000 meters, this physiognomy occupies an extensive portion of the Direct Influence Area (DIA), where water and soil factors clearly delimited the border between the forest formations and the floodable Savanna.

Figure 48 – Image with the location of the floodable Savannah (SAVi-1).
Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 448269.33 E/ 7430154.83 S).

Figure 49 – Aerial image of the area with flooded Savannah (SAVi-1).

This vegetal formation is basically structured in two layers: an upper one formed mainly by the palm tree (*Copernicia alba*) with a DBH varying between 20 and 50 cm and a height between 8 and 20 m and a lower stratum formed by plants of the Poaceae and Cyperaceae families reaching a height of about 50 to 70 cm.

Figure 50 – Flooding Savannah Area Overview(SAVi-1). Coordenadas UTM 21K 448269.33 E/ 7430154.83 S.

Figure 51 – Another angle of the area with the flooded savannah (SAVi-1), detail of the dense stratum formed by herbs and grasses. Coordinates UTM 21K 448269.33 E/ 7430154.83 S.

Among the species that make up the lower stratum are: *Heteropterys* sp., *Mimosa* sp., *Croton* sp, *Eleocharis* sp, *Cnidoscolus* sp, *Melochia* sp, *Cyperus* sp and *Eleocharis elegans*.

Figure 52 – View of a sample of the species *Heteropterys* sp.

Figure 53 – Detail of the fruits of the species *Heteropterys* sp.

Figure 54 – View of a sample of the species *Mimosa* sp.

Figure 55 – Detail of the fruits of the species *Mimosa* sp.

Figure 56 – View of a sample of the species *Cnidoscolus* sp.

Figure 57 – Detail of the fruits of the species *Cnidoscolus* sp.

Figure 58 – View of a sample of the species *Melochia* sp.

Figure 59 – Detail of the fruits of the species *Melochia* sp.

Figure 60 – View of a sample of the species *Eleocharis elegans*.

Figure 61 – Detail of the fruits of the species *Eleocharis elegans*.

Semideciduous Forest (FS-1)

Located in the northwest of the area where the PARACEL pulp mill is located, about 400 meters away, this physiognomy borders on the physiognomy of the floodable Savannah and the areas designated for cattle farming, forming an extensive mosaic of vegetation.

Figure 62 – Image with the location of the Semideciduous Forest (FS-1). Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 448509.78 E/ 7429971.58 S).

This plant formation is structured in two layers: a top layer consisting mainly of tree species with DBH of 10 to 50 cm and a height of 8 to 15 meters, and an understory composed mainly of shrubs, bushes and herbaceous, the layer of organic matter when it is present is little decomposed. Inside the remnant there are signs of selective cutting of vegetation.

Figure 63 – General view of the area with semi decidual forest (FS-1). Coordinates UTM 21K 448509.78 E/ 7429971.58 S.

Figure 64 – View of the vegetation inside the remaining semi decidual forest - FS-1.

Figure 65 – Another angle of vegetation within the remaining semi decidual forest - FS-1.

Figure 66 – Detail of the large tree found after cutting down the tree.

Figure 67 – Another angle of the large tree sample found that was cut into the remaining FS-1.

Among the species of occurrence are *Myracrodruon urundeuva* (urunde'y), *Maytenus ilicifolius* (cangorosa), *Balfourodendron riedelianum* (guatambu), *Celtis iguanaea* (juasy'y), *Campomanesia xanthocarpa* (guavira), *Enterolobium contortisiliquum* (oreja de negro), *Anadenanthera colubrina* (kurupa'y kuru), *Chloroleucon tenuiflorum* (tatare), *Guazuma ulmifolia* (kamba akã guasu), *Schinopsis balansae* (quebracho), *Microlobius foetidus* (yvyra ne), *Ficus* sp., *Croton* sp, *Dalbergia frutescens* (ysypo kopi), *Handroanthus heptaphyllus* (lapacho rosado), *Peltophorum dubium* (canafístula).

Figure 68 – Sample view of the species *Maytenus ilicifolius* (cangorosa).

Figure 69 – Detail of the edges of the leaves, often with thorns, characteristic of the species *Maytenus ilicifolius* (cangorosa).

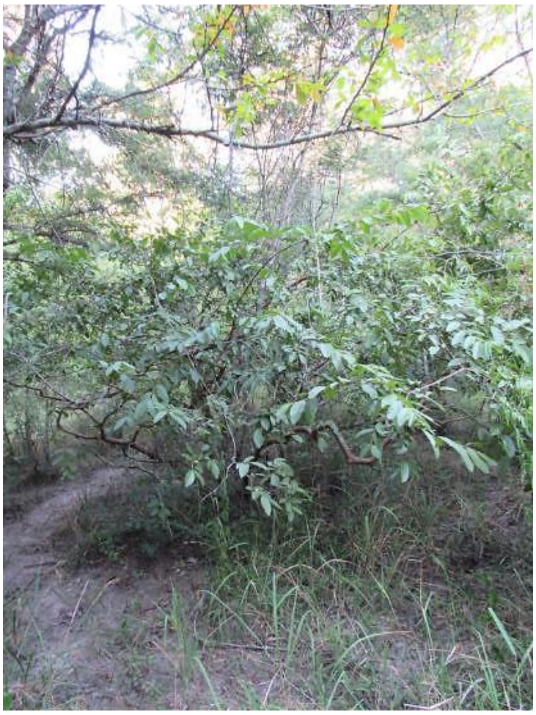


Figure 70 – Sample view of the species *Campomanesia xanthocarpa* (guavira).

Figure 71 – Detail of the fruits of the species *Campomanesia xanthocarpa* (guavira).

Figure 72 – Sample view of the species *Microlobius foetidus* (yvyra ne).

Figure 73 – Detail of the fruits and seeds of the species *Microlobius foetidus* (yvyra ne).

Semi-deciduous Forest (FS-2)

Located southwest of the area where PARACEL's pulp mill is located, about 500 meters away, this area is connected to the Paraguay River's ciliary forest continuum. However, part of it borders on the areas used for cattle raising.

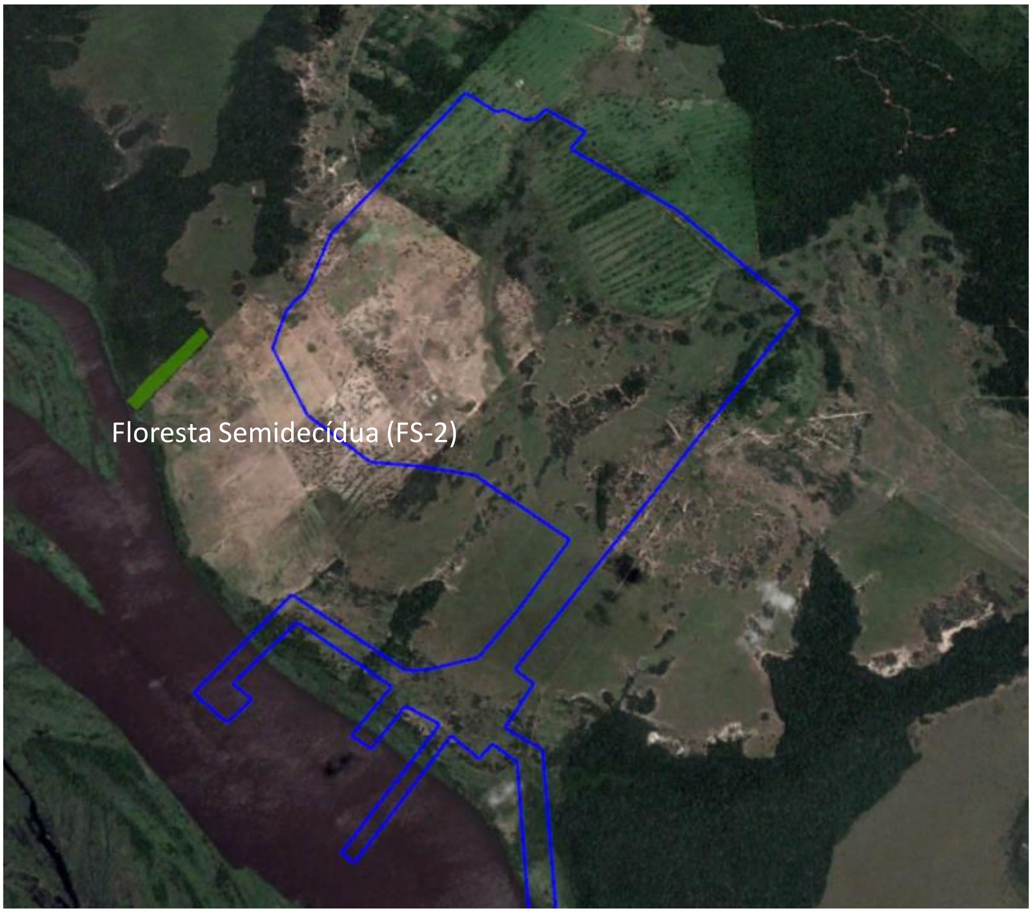


Figure 74 – Image with the location of the Semideciduous Forest (FS-2). Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 448187.50 E / 7428636.95 S).

Figure 75 – Aerial image of the area with Semideciduous Forest (FS-2), the remnant that forms the continuum of the Ciliary Forest of the Paraguay River, however, part of it borders on areas destined for cattle ranching.

This area of forest has two strata: an upper stratum composed mainly of tree species with heights between 8 and 10 meters and DBHs that vary between 20 and 40 cm and form a dense canopy, with emerging species that occur between 10 and 15 meters, and an understory that forms shrubs, bushes and herbaceous, the layer of organic matter is little decomposed.

Figure 76 – General view of the area with semideciduous forest (FS-2), contact portion of the grazing area. Coordinates UTM 21K 448187.50 E / 7428636.95 S.

Figure 77 – General view of the margins of the Paraguay river, part of contact with the Semideciduous forest (FS-2). Coordinates UTM 21K 447963.45 E / 7428368.50 S.

Figure 78 – View of the vegetation within the remaining Semideciduous Forest - FS-2.

Figure 79 – Another view of the vegetation within the remaining Semideciduous Forest - FS-2.

Within some of these species, there are *Tabebuia aurea* (lapacho branco), *Anadenanthera colubrina* (kurupa'y kuru), *Handroanthus heptaphyllus* (lapacho rosado), *Enterolobium contortisiliquum* (oreja de negro), *Caesalpinia paraguariensis* (guajakan), *Tapirira guianensis* (ka'ambota), *Guapira* sp., *Chrysophyllum gonocarpum* (aguai), *Zanthoxylum rhoifolium* (tembetary sayju), *Trema micranta* (kurundi'y), *Lithraea molleoides* (molle guasu), *Allophylus edulis* (koku), *Myrsine balansae* (kanelon), *Cordia ecalyculata* (tamana-kuna), *Tabernaemontana catharinensis* (sapirangy), *Bauhinia* sp., *Schinus weinmannifolius* (aguara yva), *Balfourodendron riedelianum* (guatambu), *Sapium haematospermum* (kurupika'y), *Jacaratia spinosa* (jakaratiíh), *Celtis iguanaea* (juasy'y), *Cabralea canjerana* (cancharana) and *Luehea divaricata* (ka'a oveti), among epiphytes *Tillandsia* sp. and among the herbaceous *Pacourina edulis*.

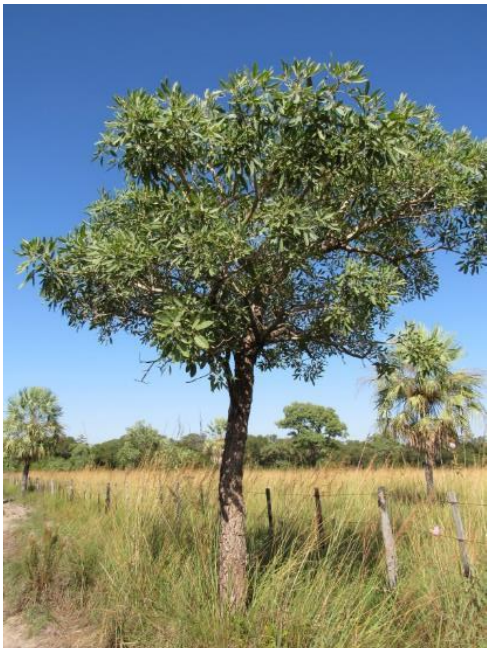


Figure 80 – View of a specimen of the species *Tabebuia aurea* (lapacho blanco).

Figure 81 – Detail of winged seeds characteristics gives species*Tabebuia aurea* (lapacho blanco).

Figure 82 – View of a specimen of the species *Caesalpinia paraguariensis* (guajakan).

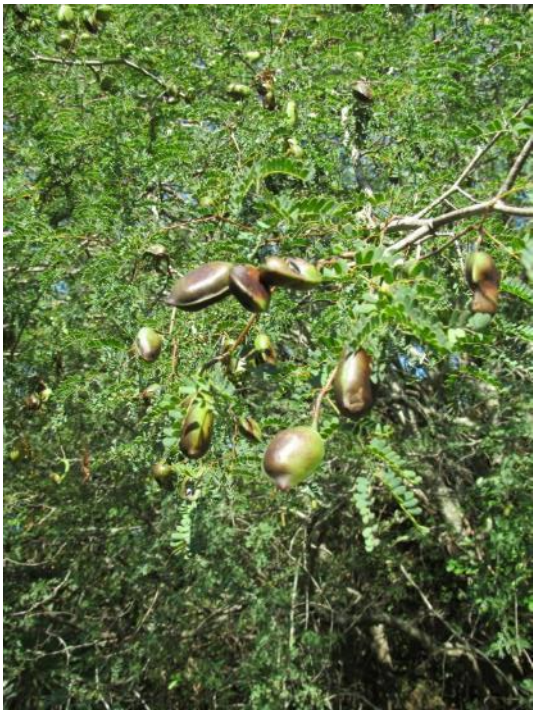


Figure 83 – Detail of the fruits of the species*Caesalpinia paraguariensis* (guajakan).

Figure 84 – View of an epiphytic specimen of the genus *Tillandsia* sp., presented in the area.

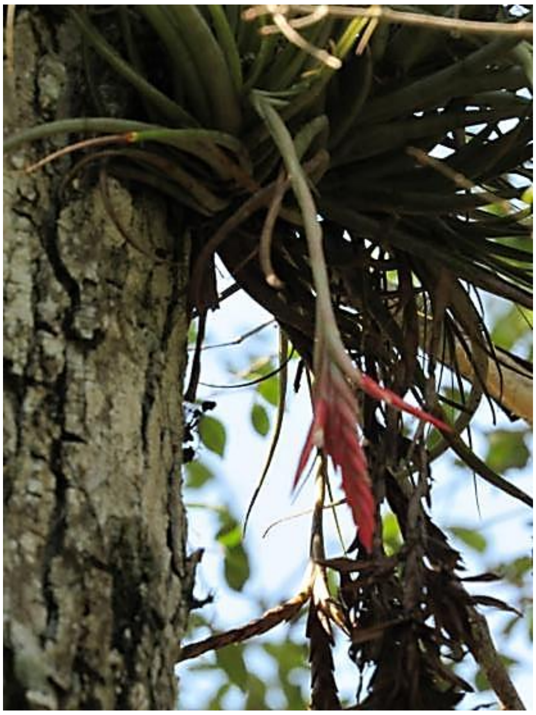


Figure 85 – Detail of the inflorescences of the genus *Tillandsia* sp.

Figure 86 – View of a specimen of the species *Pacourina edulis*.

Figure 87 – Detail of the inflorescences of the species *Pacourina edulis*.

Bosque Semideciduous (FS-3)

Located to the south of the area of the future pulp mill of PARACEL, at about 300 meters, this physiognomy is connected with the continuous forest of the margin of the Paraguay river, however, part of it limits with the extensive areas destined to the cattle raising.

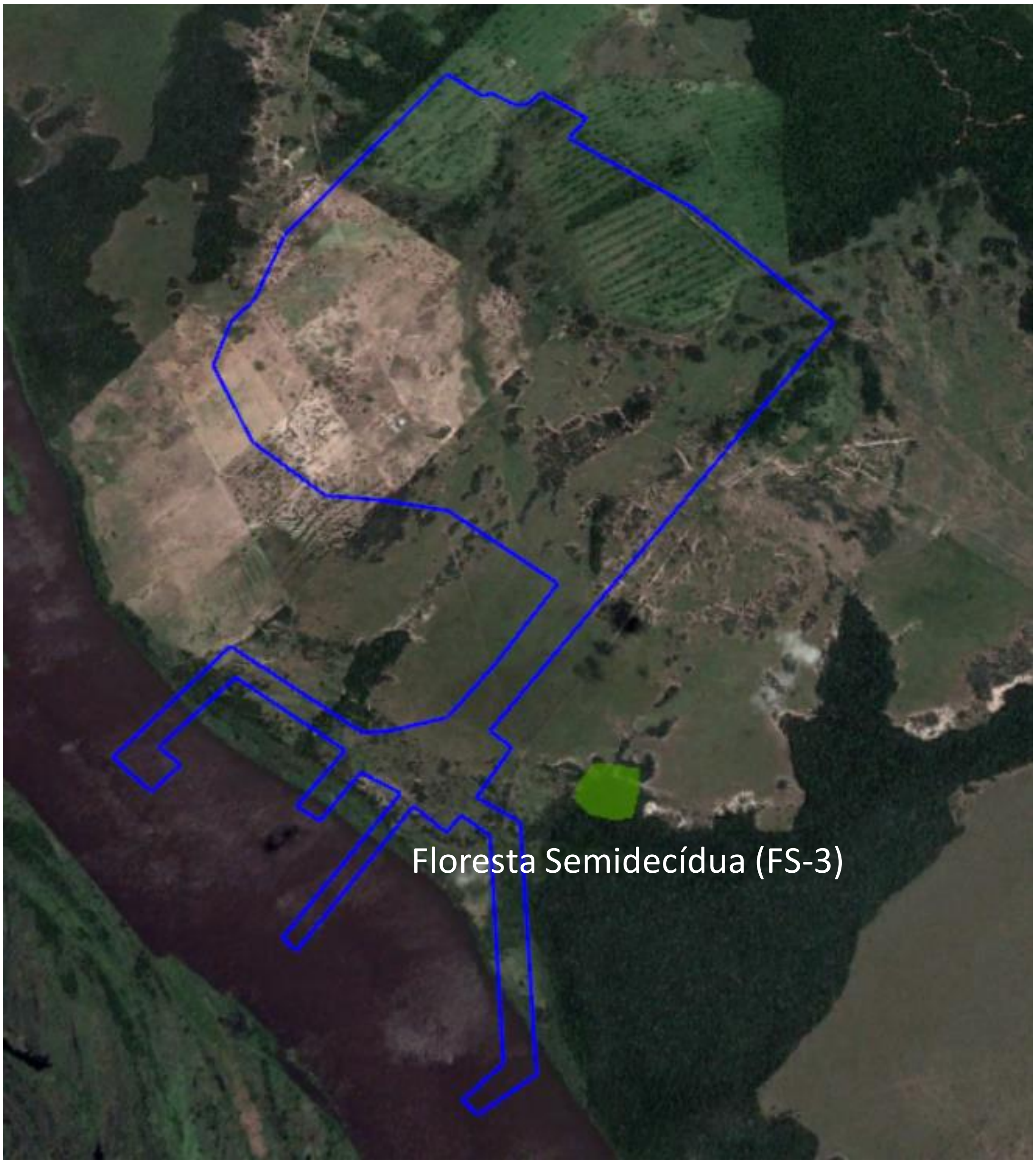


Figure 88 – Aerial image with the location of the Semideciduous Forest (FS-3).
Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 450389.17 E/ 7426715.95 S).

Figure 89 – Aerial image of the area with Semideciduous Forest (FS-3), which forms the continuous forest on the banks of the Paraguay River.

Figure 90 – Another angle of the area with semideciduous forest (FS-3), the remnant that forms the riparian forest continuum of the Paraguay River.

This remnant of forest has two layers: an upper one composed mainly of tree species with heights between 8 and 10 meters, with DBH varying between 15 and 30 cm and forming a dense canopy, with emerging species that present between 10 and 15 meters as *Tabebuia aurea* (lapacho blanco), and an understory made up of shrubs, grasses and dense clumps of terrestrial bromeliads. The layer of organic material when present is slightly decomposed, and the presence of woody creepers is observed on the arboreal individuals.

Figure 91 – General view of the area with Semideciduous Forest (FS-3). Coordinates UTM 21K - 450389.17 E/ 7426715.95 S.

Figure 92 – Overview of the Paraguay River contact portion of the Semideciduous Forest (FS-3). Coordinates UTM 21K 449815.00 E/ 7426174.00 S.

Figure 93 – Another angle of the portion in contact with the Paraguay River of the Semideciduous Forest (FS-3). **Coordinates UTM 21K 449815.02 E/ 7426174.05 S.**

Figure 94 – General view of the portion in contact with the areas intended for cattle (Semideciduous Forest - FS-3). **Coordinates UTM 21K 450056.03 E/ 7426879.76 S.**

Figure 95 – View of the vegetation inside the Semideciduous Forest (FS-3).

Figure 96 – Another angle of vegetation inside the Semideciduous Forest (FS-3).

Figure 97 – View of the terrestrial bromeliad groups present in the interior of the remnant (Semideciduous forest - FS-3).

Figure 98 – Detail of the terrestrial bromeliads present in the interior of the remnant (Semideciduous forest - FS-3).

Figure 99 – View of the wooden species *Pyrostegia venusta*.

Figure 100 – Details of the inflorescences of the species *Pyrostegia venusta*.

Among the species of occurrence are *Schinus weinmannifolius* (aguara yva), *Handroanthus heptaphyllus* (lapacho rosado), *Ziziphus mistol* (mistol), *Maytenus ilicifolius* (cangorosa), *Croton* sp., *Prosopis rubriflora* (algarrobo), *Cabralea canjerana* (cancharana), *Luehea divaricata* (ka'a oveti), *Schinopsis balansae* (quebracho), *Copernicia alba* (karanda'y), *Erythroxylum cuneifolium*, *Samanea tubulosa* (manduvirã), *Tapirira guianensis* (ka'ambota), *Cordia ecalyculata* (tamana-kuna), *Guapira* sp., *Enterolobium contortisiliquum* (oreja de negro), *Anadenanthera colubrina* (kurupa'y kuru), *Acrocomia aculeata* (mbokaja), epiphytes such as *Philodendron tweedianum*.

Figure 101 - View of a sample of the species *Samanea tubulosa* (manduvira).

Figure 102 – Details of the inflorescences of the species *Samanea tubulosa* (manduvira).

Figure 103 - View of a sample of the species *Acrocomia aculeata* (mbokaja).

Figure 104 – Detail of the fruits of the species *Acrocomia aculeata* (mbokaja).

Figure 105 – Detail of a sample of the epiphyte *Philodendron tweedianum*.

Semideciduous Forest (FS-4)

Located to the northeast of the area where the PARACEL pulp mill is located, at about 1,000 meters, this remnant occupies a large portion of the DIA. However, part of its surface is bordered by areas used for agriculture and livestock, and inside it there are several roads used for wood extraction.

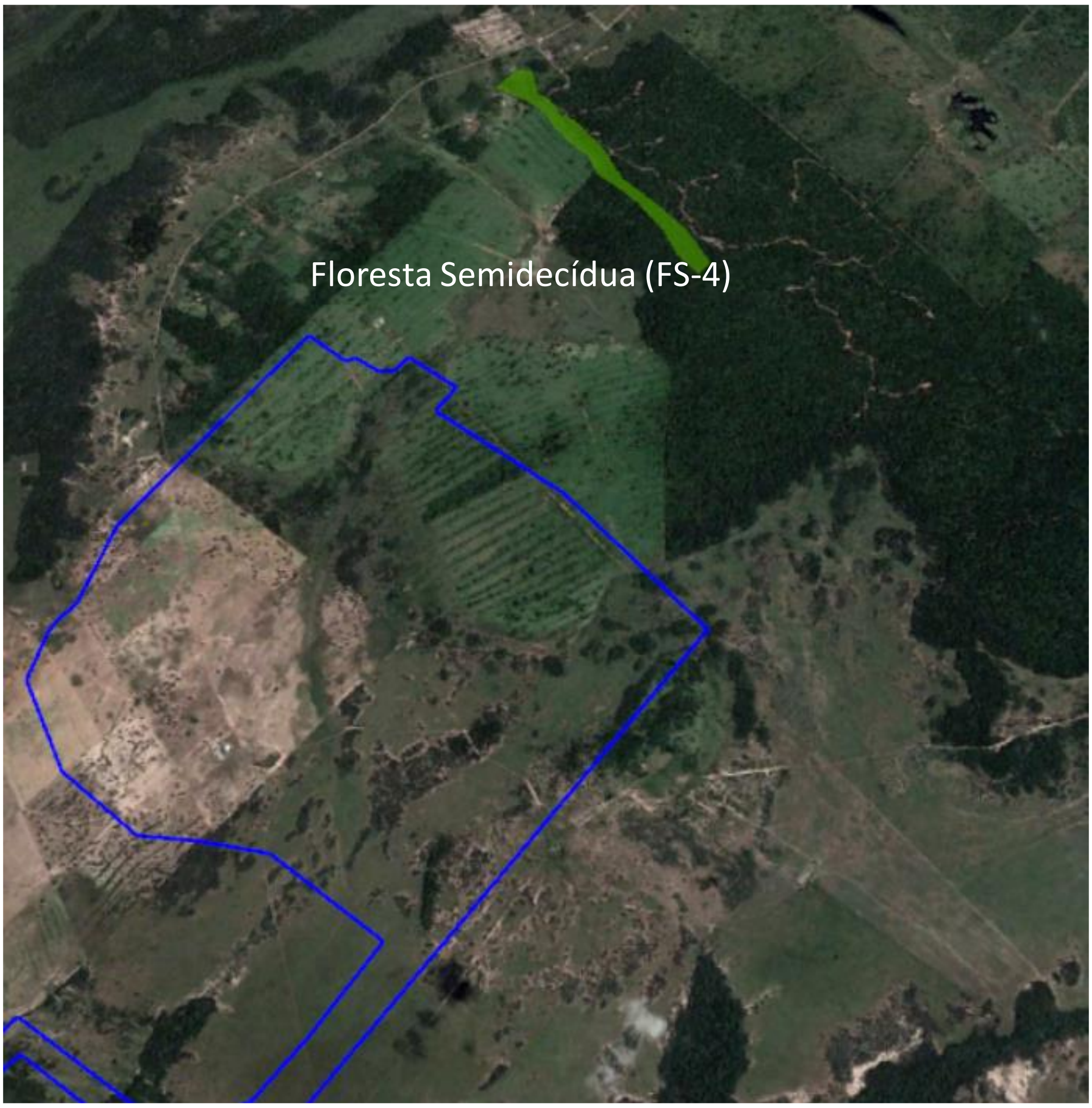


Figure 106 – Image with the location of the Semideciduous Forest (FS-4). Image: Google Earth feb/2018 (Coordinates UTM 21K - midway point: 451179.24 E/ 7431285.43 S).

Figure 107 – Aerial image of the area with Semideciduous Forest (FS-4), the remainder occupies a large portion in the DIA.

This remnant of forest has two layers: an upper one composed of tree species that form the canopy and vary in height between 8 and 12 meters and DBH between 15 and 45 cm, where emerging species that present between 10 and 20 meters as *Aspidosperma polyneuron* (guatambu sayju) e *Balfourodendron riedelianum*, and an underbrush formed by the bushes as *Rhamnidium elaeocarpum* (taruma'i)and herbaceous, the litter of organic matter when present is not entirely decomposed.

Figure 108 – General view of the area with Semideciduous Forest (FS-4), bordering portion with rural property.

Figure 109 – View of an emergent individual specimen of the species *Aspidosperma polyneuron* (guatambu sayju).

Figure 110 – View of an emergent individual specimen of the species *Balfourodendron riedelianum*.

Figure 111 – View of the vegetation inside the Semideciduous Forest (FS-4).

Figure 112 – Another angle of vegetation inside the Semideciduous Forest (FS-4).

Figure 113 – View of the existing roads inside the Semideciduous Forest (FS-4).

Figure 114 – Another angle of the existing trails within the Semideciduous Forest (FS-4).

Among the species of occurrence are *Balfourodendron riedelianum* (guatambu), *Schinopsis balansae* (quebracho), *Schinus weinmannifolius* (aguara yva), *Cecropia pachystachya* (amba'y), *Croton* sp., *Tabernaemontana catharinensis* (sapirangy), *Zanthoxylum rhoifolium* (tembetary sayju), *Trema micranta* (kurundi'y), *Anadenanthera colubrina* (kurupa'y kuru), *Lithraea molleoides* (molle guasu), *Allophylus edulis* (koku), *Guazuma ulmifolia* (kamba akã guasu), *Aspidosperma polyneuron* (guatambu sayju), *Handroanthus heptaphyllus* (lapacho rosado), *Myrsine balansae* (kanelon), *Jacaratia spinosa* (jakaratiíh), *Roupala meisneri* (ka'ati ka'e), *Celtis iguanaea* (juasy'y), *Ceiba speciosa* (palo borracho), *Sapium haematospermum* (kurupika'y), *Gleditsia amorphoides* (espina de corona), *Astronium fraxinifolium* (urunde'y pichai), *Xylosma pseudosalzmanii*, *Schinopsis lorentzii* (koronillo), *Tapirira guianensis* (ka'ambota), *Cordia ecalyculata* (tamana-kuna), *Protium heptaphyllum* (yvyra ysy), *Acrocomia aculeata* (mbokaja), *Guapira* sp., *Priogymnanthus hasslerianus* (ka'a vera), *Dalbergia frutescens* (ysypo kopi), *Enterolobium contortisiliquum* (oreja de negro), *Ximenia americana* (indio kurupa'y) y *Capsicum* cf. *chacoense*.

Figure 115 – Detail of a sample of the species *Balfourodendron riedelianum* (guatambu).

Figure 116 – Detail of the fruits of the species *Balfourodendron riedelianum* (guatambu).

Figure 117 – Detail of a sample of the species *Tabernaemontana catharinensis* (sapirangy).

Figure 118 – Detail of the fruits of the species *Tabernaemontana catharinensis* (sapirangy).

Figure 119 – Detail of a sample of the species *Gleditsia amorphoides* (espina de corona).

Figure 120 – Detail of the characteristic spines of the species *Gleditsia amorphoides* (crown spine).

Figure 121 – Detail of a sample of the species *Xylosma pseudosalzmannii*.

Figure 122 – Detail of the characteristic spines of the species *Xylosma pseudosalzmannii*.

Figure 123 – Detail of a sample of the species *Capsicum* cf. *chacoense*.

Figure 124 – Detail of the fruits of the species *Capsicum* cf. *chacoense*.

Chaco

Located west of the PARACEL pulp mill site at approximately 2,000 meters, this site occupies a large portion of the DIA. However, it is on the right riverbank of the Paraguay River, opposite the location of PARACEL's pulp mill project.

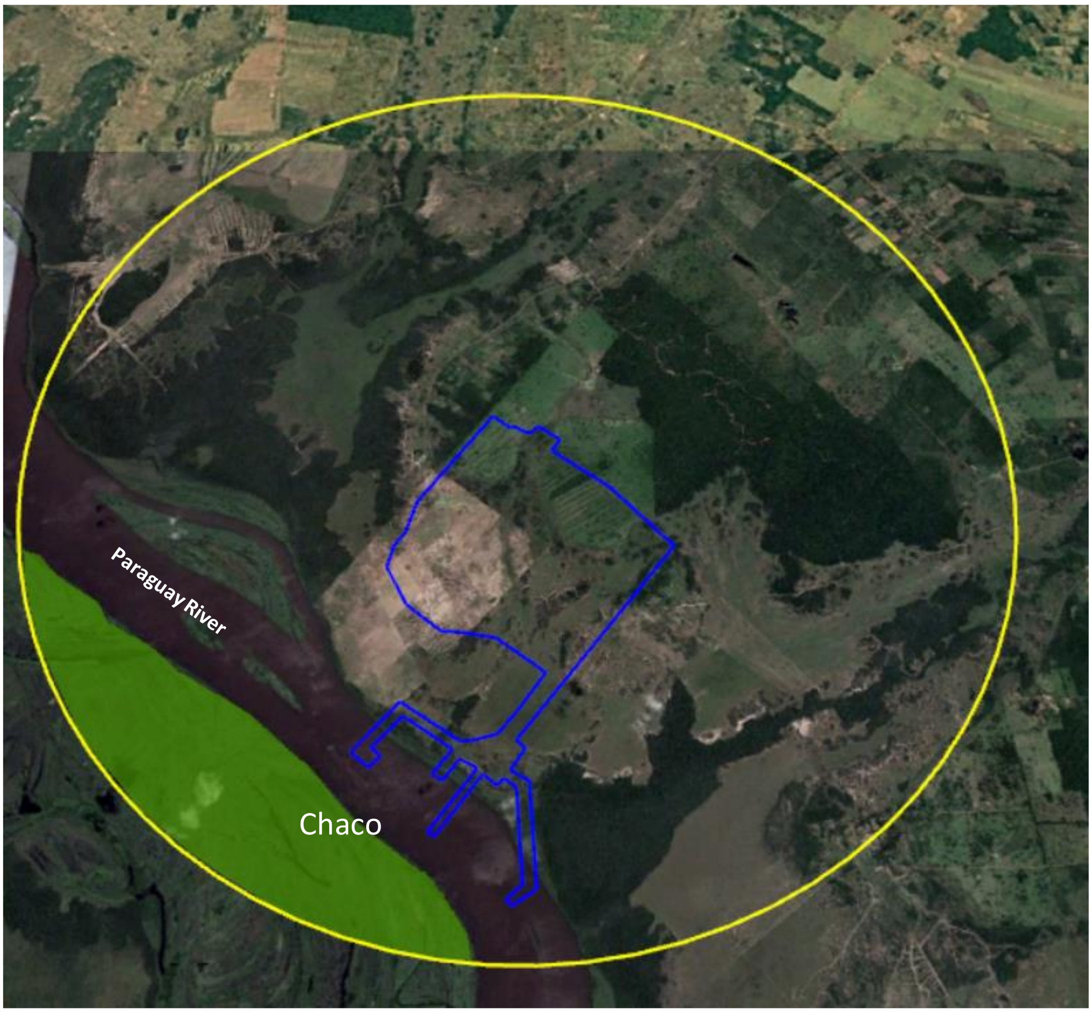


Figure 125 – Image with the location of the wide area with Chaco physiognomy present in the DIA of the PARACEL pulp mill. **Image: Google Earth feb/2018.**

Figure 126 – Aerial view of the extensive area with the physiognomy of the Chaco. UTM - 21k 447302.78 E/ 7426631.89 S (reference point).

The Chacos are physiognomies linked to water, floods or rains; they occur near large rivers such as the Paraguay. In some cases, forests are formed, and these are found in depressions in the terrain, where the soils are generally very rich in clays. The species are characterized by being considerably plastic, since they resist a certain degree of asphyxiation in the soil, caused by the temporary floods to which they are subjected (Mereles, 2007).

According to Mereles (2007) in the areas of the Chaco are common species such as *Albizia inundata* (timbóý), *Phyllanthus chacoensis*, *Calycophyllum multiflorum* (palo blanco), *Celtis iguanaea* (yuasy'y), *Chloroleucon tenuiflorus* (tataré), *Chrysophyllum marginatum* (pycasú rembi'ú), *Croton urucurana* (sangre de drago), *Cynometra bauhinifolia*, *Enterolobium contortisiliquum* (timbó), *Eritrina crista-galli* (ceibo), *Geoffroea decorticans* (chamar), *Geoffroea spinosa*, *Inga uruguensis* (ingá), *Ocotea dyospirifolia* (laurel), *Phyllostylon rhamnoides* (palo lanza), *Prosopis ruscifolia* (vinal), *Salix humboldtiana* var. *martiana* (sauce criollo), *Senna scabriuscula*, *Tabebuia nodosa* (labón), *Tessaria integrifolia* (palo bobo), *Sapium haematospermum* (curupica'y), *Vitex megapotamica* (tarumá) and *Vochysia tucanorum* (cuati'y).

Cultivated land (rural properties)

The so-called Cultivated Lands, which include agricultural and livestock areas, occupy large portions of the DIA of the future pulp mill of PARACEL, and are found around other types of plants, thus forming a heterogeneous mosaic of physiognomies. Considering these aspects, and in order to characterize a wider area, sampling points were made along the unpaved road that gives access to the area of the future pulp mill. In the surroundings of these areas, the savannahs are predominantly made up of a stratum of trees and bushes with the appearance of the genera *Aspidosperma*, *Schinopsis* e *Prosopis*, and a layer of grass formed by the genera *Elionurus*, *Eragrostis*, *Aristid*a, *Cenchrus*, *Stachytarpheta* and *Pfaffia*.

Figure 127 – Image with the location of the sampling points. Imag: Google Earth feb/2018.

Figure 128 – General view of a rural property present in the DIA. Coordinates UTM - 21k 449021.77 E/7430667.35 S (P1).

Figure 129 – View of the unpaved access present in the DIA. Coordinates UTM - 21k 449021.77 E/7430667.35 S (P1).

Figure 130 – Another unpaved access angle present in DIA. Coordinates UTM - 21k 449021.77 E/7430667.35 S (P1).

Figure 131 – General view of the surroundings of the rural property. Coordinates UTM - 21k 449021.77 E/7430667.35 S (P1).

Figure 132 – Another angle of the rural property environment. Coordinates UTM - 21k 449021.77 E/7430667.35 S (P1).

Figure 133 – Overview of a rural property in DIA. Coordinates UTM - 21k 449202.10 E/ 7431096.85 S (P2).

Figure 134 – View of the unpaved access present in DIA. Coordinates UTM - 21k 449202.10 E/ 7431096.85 S (P2).

Figure 135 – General view of surroundings of the rural property. Coordinates UTM - 21k 449202.10 E/ 7431096.85 S (P2).

Figure 136 – Overview of a rural property in DIA. Coordinates UTM - 21k 450673.02 E/ 7432212.86 S (P3).

Figure 137 – General view of the surroundings of the rural property. Coordinates UTM - 21k 450673.02 E/ 7432212.86 S (P3).

Figure 138 – General view of the sampling point located at the coordinates UTM - 21k 451657.45 E/ 7433121.34 S (P4).

Figure 139 – Other angle of the sampling point in the coordinates UTM - 21k 451657.45 E/ 7433121.34 S (P4).

Directly Affected Area (DAA)

The Directly Affected Area by the project is characterized by the implementation of the PARACEL pulp mill, the river port, water intake and the discharge of treated effluents into the Paraguay River.

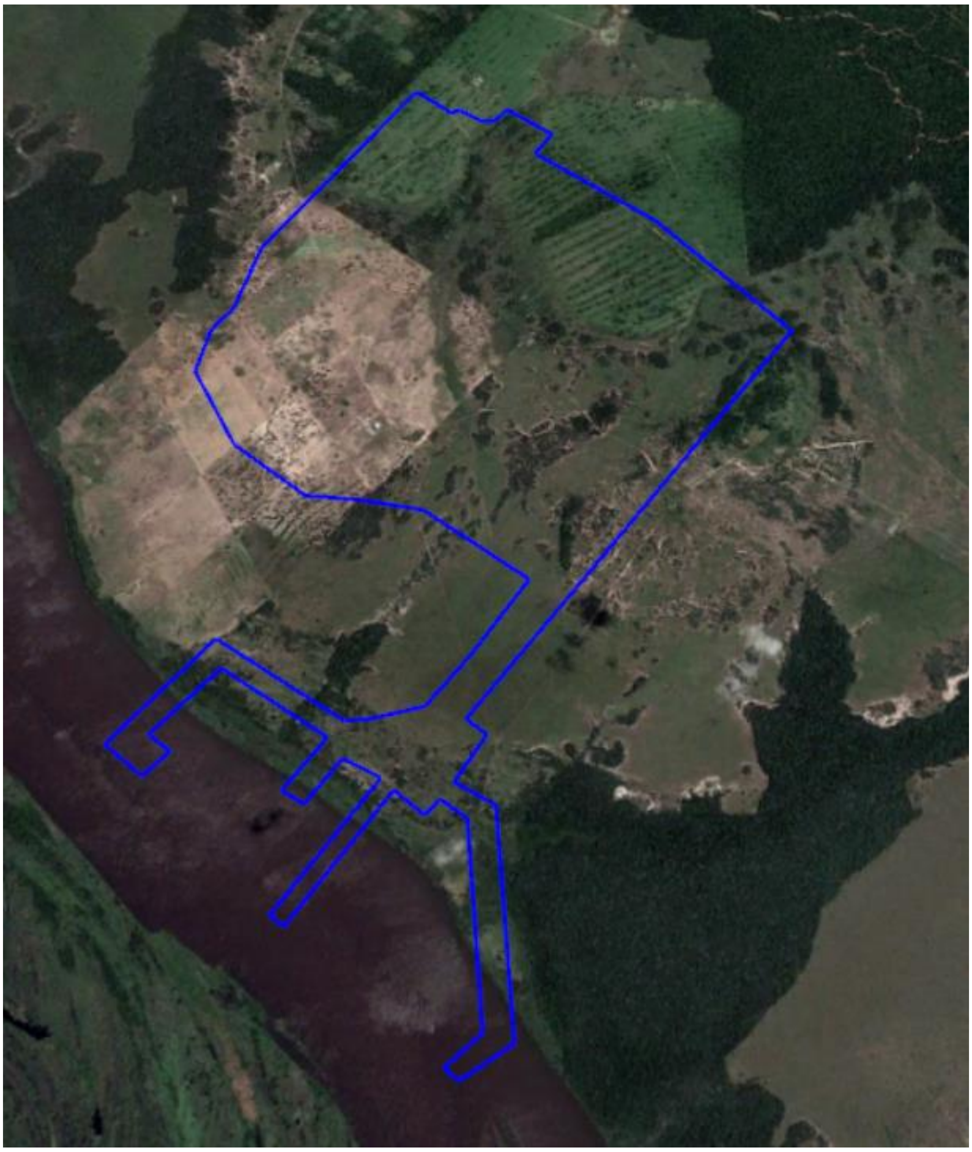


Figure 140 – Image with the location of the DAA of the pulp mill. Imag: Google Earth feb/2018.

The area where the pulp mill will be installed is considerably anthropized by the use of cattle and extensive areas with pastures, however, there are remnants formed by the typology of savannah and isolated trees located in this area.

Figure 141 – Image with the location of the DAA of the PARACEL pulp mill. Image: Google Earth feb/2018.

Figure 142 – View of the sampling point (P1) in the DAA (water intake) in the Paraguay River. Coordinates UTM - 21k 449817.46 E/ 7426175.07 S.

Figure 143 – Another angle of the sampling point in the DAA (water intake). UTM coordinates - 21k 449817.46 E/ 7426175.07 S.

Figure 144 – View of the sampling point in the DAA (water intake) and the Paraguay River in the background. UTM coordinates - 21k 449839.72 E/ 7426218.47 S.

Figure 145 – Another angle of the sampling point in the DAA (water intake). UTM coordinates - 21k 449839.72 E/ 7426218.47 S.

Figure 146 – View of the sampling point in the DAA (flooded area) UTM coordinates - 21k 449905.03 E/ 7428488.03 S.

Figure 147 – Another angle of the sampling point in the DAA (flooded area). UTM coordinates - 21k 449905.03 E/ 7428488.03 S.

Figure 148 – View of the sampling point in the DAA (pasture area). Coordinates UTM - 21k 449786.71 E/ 7428464.56 S.

Figure 149 – Another angle of the sampling point in the DAA (pasture area), in the background the headquarters of the Farmhouse Zapatero Cue. Coordinates UTM - 21k 449786.71 E/ 7428464.56 S.

Figure 150 – View of the sampling point in the DAA (pasture area). Coordinates UTM - 21k 449262.98 E/ 7429329.73 S.

Figure 151 – View of the sampling point in the DAA (pasture area) with isolated trees. Coordinates UTM - 21k 449443.88 E/ 7429583.74 S.

Figure 152 – Another angle of the sampling point in the DAA (pasture area) with isolated trees. Coordinates UTM - 21k 449443.88 E/ 7429583.74 S.

Savannah (SAV-1)

Located within the ADA, this group of tree vegetation is surrounded by an extensive area with field vegetation and areas for cattle raising.

Figure 153 – Image with the location of the Savannah (SAV-1). Imag: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 450483.74 E/ 7428462.29 S).

Figure 154 – Aerial image of the Savannah area (SAV-1), surrounded by a large area with field vegetation and areas for cattle farming.

This vegetation formation is structured in three layers: an upper one with predominance of arboreal individuals of up to approximately 14 m emerging, with DBH between 30 and 60 cm; an intermediate one with specimens of between 4.0 and 6.0 m high with DBH ranging between 10 and 70 cm, and a lower gramino-lenous stratum, generally discontinuous and of scarce physiognomic expression.

Figure 155 – General view of the savannah area (SAV-1), part in contact with the cattle farming area.

Figure 156 – View of the vegetation inside the savannah (SAV-1).

Figure 157 – Another angle of vegetation in the interior of the Savannah (SAV-1).

Species of occurrence include *Ziziphus mistol* (mistol), *Croton* sp., *Prosopis ruscifolia y Prosopis rubriflora* (algarrobos), *Erythroxylum cuneifolium*, *Pseudobombax* sp., *Anadenanthera colubrina* (kurupa'y kuru), *Psidium guajava* (arasa), *Parapiptadenia rigida* (kurupa'y rã), *Samanea tubulosa* (manduvirã), *Ximenia americana* (indio kurupa'y) and *Schinopsis balansae* (quebracho).

Figure 158 – Detail of a sample of the species *Psidium guajava* (arasa).

Figure 159 – Detail of the species' fruit *Psidium guajava* (arasa).

Savannah (SAV-2)

Located inside the ADA, this remaining vegetation is inserted in a wide area destined to cattle raising.

Figure 160 – Image with the location of the Savannah (SAV-2). Image: Google Earth feb/2018 (Coordinates UTM 21K – midway point: 449509.25 E/ 7429567.11 S).

Figure 161 – Aerial image of the Sabana area (SAV-2).

In this remaining, the vegetation is structured in two layers: one formed by heterogeneous and dispersed groups of shrubs with heights around 4 to 6 m, interspersed by large and small cactuses, and the other by small and medium trees.

Figure 162 – Overview of the Savannah area (SAV-2).

Figure 163 – View of the vegetation inside the Savannah (SAV-2).

Figure 164 – Another angle inside the Savannah (SAV-2).

Among the species of trees and shrubs that are produced are *Prosopis rubriflora* (algarrobo), *Copernicia alba* (karanda'y), *Ziziphus mistol* (mistol), *Croton* sp., *Myracrodruon urundeuva* (urunde'y), *Prosopis rubriflora* (algarrobo), *Erythroxylum cuneifolium*, *Pseudobombax* sp., *Anadenanthera colubrina* (kurupa'y kuru), *Parapiptadenia rigida* (kurupa'y rã), *Samanea tubulosa* (manduvirã), *Ximenia americana* (indio kurupa'y) e *Schinopsis balansae* (quebracho), among cactuses *Cereus* sp and *Monvillea* sp, among the terrestrial bromeliads *Bromelia balansae* and among the epiphytes *Tillandsia duratii*.

Figure 165 – Detail of a sample of specie *Ziziphus mistol* (mistol).

Figure 166 – Detail of inflorescences and fruits of specie *Ziziphus mistol* (mistol).

Figure 167 – Detail of a sample of specie *Erythroxylum cuneifolium*.

Figure 168 – Detail of fruit of specie (*Erythroxylum cuneifolium*).

Figure 169 – Detail of a sample of specie *Cereus* sp.

Figure 170 – Detail of fruit of specie *Cereus* sp.

Figure 171 – Detail of a sample of specie *Monvillea* sp.

Figure 172 – Detail of fruit of specie *Monvillea* sp.

Figure 173 – Detail of a sample of specie *Bromelia balansae*.

Figure 174 – Detail of inflorescence of specie *Bromelia balansae*.

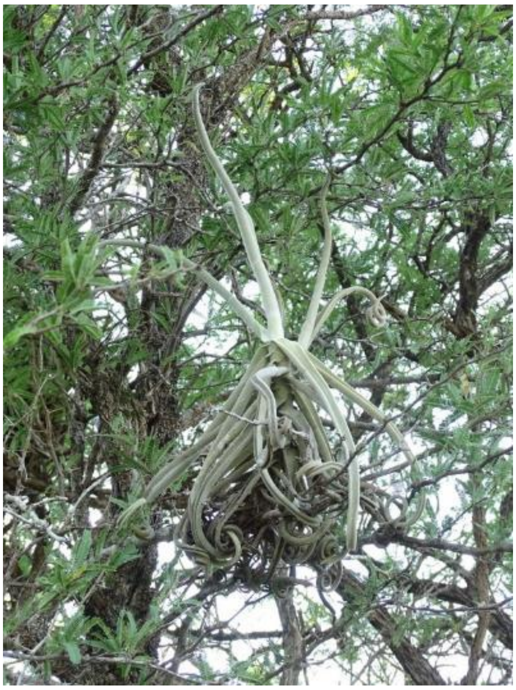


Figure 175 – Detail of a sample of the specie *Tillandsia duratii*.

Figure 176 – – Detail of inflorescence of specie *Tillandsia duratii.*

Endangerous species

From the species sampled in this study, five are listed in the lists of flora species in danger of extinction consulted (SEAM Resolution 524/2006 and SEAM Resolution 2,243/2006): the "jatai" *(Butia paraguayensis*),"grapia"*(Apuleia leiocarpa*), "algarrobo" (*Prosopis alba*), "preto carob" (*Prosopis nigra*) and the "guatambu" (*Balfourodendron riedelianum*).

The table below shows the list of species sampled in the DIA and DAA of the future pulp mill.

Then, DIA and DAA physiognomy map locates where the types of vegetation were found.

Table 3 – List of species sampled in the DIA and DAA of the future pulp mill.

Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
Achatocarpaceae	*Achatocarpus praecox* Griseb.		x	x	Tree			LC
Amaranthaceae	*Pfaffia* sp.		x		Herbaceous			-
Anacardiaceae	*Astronium fraxinifolium* Schott	urunde'y pichai	x		Tree			-
	Lithraea molleoides (Vell.) Engl.	molle guasu	x		Tree			LC
	Myracrodruon urundeuva Allemão	urunde'y	x	x	Tree			-
	Schinopsis balansae Engl.	quebracho	x	x	Tree			LC
	Schinopsis lorentzii (Griseb.) Engl.		x		Tree			-
	Schinus weinmannifolius Engl.	koronillo	x		Tree			-
	Tapirira guianensis Aubl.	ka'ambota	x		Tree			LC
Annonaceae	*Annona spinescens* Mart.		x		Tree			LC
	Duguetia furfuracea (A.St.-Hil.) Saff.	aratiku	x		Bush			LC
	Rollinia salicifolia Schltdl.	aratiku'i	x	x	Tree			-
Apocynaceae	*Aspidosperma quebracho-blanco* Schltdl.	quebracho-branco	x	x	Tree			-
	Aspidosperma polyneuron Müll.Arg.	guatambu sayju	x	x	Tree			EN
	Aspidosperma triternatum N.Rojas		x	x	Tree			NT
	Tabernaemontana catharinensis A.DC.	leiteiro	x	x	Bush			LC
Araceae	*Anthurium* sp.		x	x	Herbaceous			-
	Philodendron undulatum Engl.		x	x	Epiphyte			-
	Philodendron tweedieanum Schott		x		Herbaceous			-
Arecaceae	*Acrocomia aculeata* (Jacq.) Lodd. ex Mart.	mbokaja	x	x	Tree			-
	Butia paraguayensis (Barb.Rodr.) L.H.Bailey	jatai	x	x	Tree	x		-
	Copernicia alba Morong	karanda'y	x	x	Tree			-
	Syagrus campylospatha (Barb.Rodr.) Becc.		x	x	Tree			-
	Syagrus romanzoffiana (Cham.) Glassman	pindo	x	x	Tree			-

Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
Asteraceae	*Pacourina edulis* Aubl		x		Herbaceous			-
Bignoniaceae	*Handroanthus albus* (Cham.) Mattos	lapacho amarillo	x	x	Tree			LC
	Handroanthus heptaphyllus (Vell.) Mattos	lapacho rosado	x	x	Tree			LC
	Pyrostegia venusta (Ker Gawl.) Miers		x		Herbaceous			-
	Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	paratodo	x		Tree			-
	Tabebuia nodosa (Griseb.) Griseb.		x		Tree			LC
Boraginaceae	*Cordia ecalyculata* Vell.	tamana-kuna	x		Tree			-
Bromeliaceae	*Aechmea distichantha* Lem.		x	x	Epiphyte			-
	Ananas sagenaria (Arruda) Schult. & Schult.f.		x		Herbaceous			-
	Bromelia balansae Mez		x	x	Epiphyte			-
	Tillandsia duratii Vis.		x	x	Epiphyte			-
	Tillandsia sp.		x		Epiphyte			-
Burseraceae	*Commiphora* sp.		x	x	Tree			-
	Protium heptaphyllum (Aubl.) Marchand	yvyra ysy	x		Tree			LC
Cactaceae	*Brasiliopuntia* sp.		x	x	Bush			-
	Cereus sp.		x	x	Bush			-
	Rhipsalis baccifera (J.S.Muell.) Stearn		x	x	Epiphyte			LC
Cannabaceae	*Celtis iguanaea* (Jacq.) Sarg.	juasy’y	x	x	Tree			LC
	Trema micrantha (L.) Blume		x		Tree			LC
Capparaceae	*Anisocapparis speciosa* (Griseb.) Cornejo & Iltis	pajagua naranja	x		Bush			-
	Cappariicordis tweediana (Eichler) Iltis & Cornejo	ñandu apysa	x	x	Tree			-
Caricaceae	*Jacaratia spinosa* (Aubl.) A.DC.	jakaratiíh	x		Tree			LC
Caryocaraceae	*Caryocar brasiliense* A.St.-Hil.		x		Tree			LC
Celastraceae	*Maytenus ilicifolia* Mart. ex Reissek	cangorosa	x	x	Bush			-

Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
Celastraceae	*Plenckia populnea* Reissek		x	x	Tree			-
	Schaefferia argentinensis Speg		x	x	Tree			LC
Convolvulaceae	*Ipomoea carnea* Jacq.		x		Bush			-
	Ipomea sp.		x	x	Herbaceous			-
Cyperaceae	*Cyperus* sp.		x	x	Herbaceous			-
	Eleocharis elegans (Kunth) Roem. & Schult.		x	x	Herbaceous			-
	Fimbristylis dichotoma (L.) Vahl		x	x	Herbaceous			LC
Erythroxylaceae	*Erythroxylum cuneifolium* (Mart.) O.E.Schulz		x	x	Tree			-
Euphorbiaceae	*Cnidoscolus* sp.		x		Herbaceous			-
	Croton argenteus L.		x	x	Tree			LC
	Croton urucurana Baill.	sangue de drago	x	x	Tree			-
	Croton sp.		x	x	Bush			-
	Jatropha sp.		x	x	Bush			-
	Sapium haematospermum Müll.Arg.	kurupika'y	x	x	Tree			LC
Fabaceae	*Acacia farnesiana* (L.) Willd.		x	x	Tree			LC
	Acacia sp.		x		Bush			-
	Albizia inundata (Mart.)Barneby & J.W.Grimes		x	x	Tree			LC
	Anadenanthera colubrina (Vell.)Brenan	kurupa'y kuru	x	x	Tree			LC
	Apuleia leiocarpa (Vogel) J.F.Macbr.	grapia	x	x	Tree	x		LC
	Bauhinia sp.	pata de buey	x	x	Tree			-
	Bowdichia virgilioides Kunth		x		Tree			LC
	Parkinsonia praecox (Ruiz & Pav.) Hawkins	verde olivo	x	x	Tree			LC
	Caesalpinia paraguariensis (Parodi)Burkart	guajakan,	x		Tree			VU
	Chloroleucon tenuiflorum (Benth.)Barneby & J.W.Grimes	tatare	x	x	Bush			LC

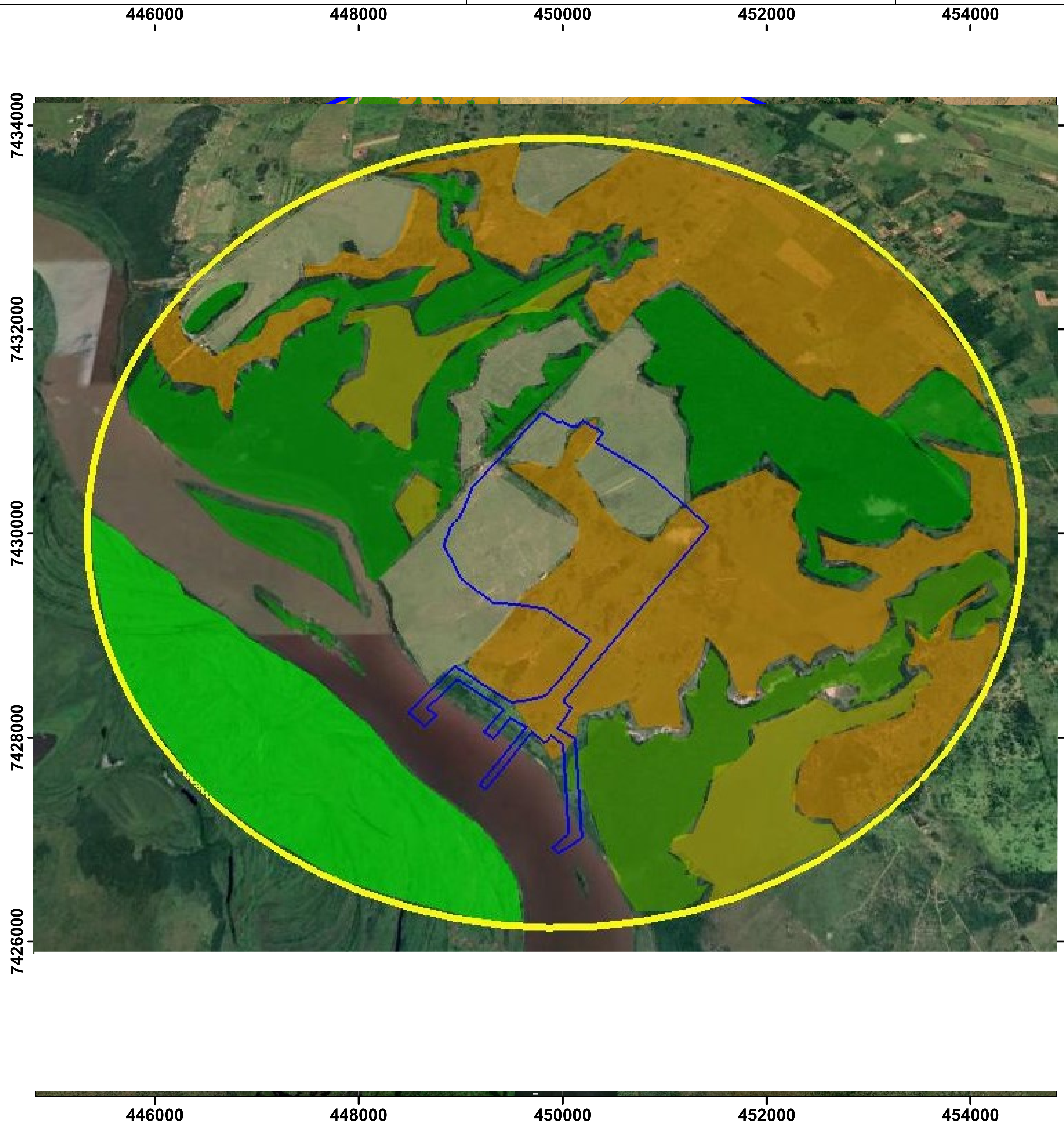
Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
	Dalbergia frutescens (Vell.)Britton	ysypo kopi	x	x	Tree			-
	Enterolobium contortisiliquum (Vell.)Morong	oreja de negro	x	x	Tree			LC
	Gleditsia amorphoides (Griseb.) Taub.	espina de corona	x		Tree			-
	Microlobius foetidus (Jacq.)M.Sousa & G.Andrade	yvyra ne	x		Tree			-
	Mimosa sp.		x	x	Bush			-
	Peltophorum dubium (Spreng.) Taub.	yvyra pytã	x	x	Tree			LC
	Prosopis alba Griseb.	algarrobo	x	x	Tree	x		NT
	Prosopis nigra Hieron.	algarrobo	x	x	Tree	x		DD
	Prosopis rubriflora Hassl.	algarrobo	x	x	Tree			-
	Prosopis ruscifolia Griseb.	algarrobo	x	x	Tree			LC
	Pterocarpus santalinoides DC.	pajaguá manduví	x	x	Tree			LC
	Samanea tubulosa (Benth.)Barneby & J.W.Grimes	manduvirã	x	x	Tree			LC
	Senegalia martii (Benth.) Seigler & Ebinger		x	x	Bush			LC
	Senna sp.		x		Bush			-
	Sesbania virgata (Cav.)Pers.		x	x	Tree			LC
	Zygia inaequalis (Willd.)Pittier	guara pepe	x	x	Tree			LC
Lamiaceae	*Hyptis* sp.		x	x	Herbaceous			-
Malpighiaceae	*Heteropterys* sp.		x		Bush			-
Malvaceae	*Ceiba pubiflora* (A.St.-Hil.) K.Schum.	palo borracho	x	x	Tree			-
	Ceiba speciosa (A.St.-Hil.) Ravenna	samu'u	x		Tree			-
	Ceiba sp.		x	x	Tree			-
	Guazuma ulmifolia Lam.	kamba akã guasu	x	x	Tree			LC
	Luehea divaricata Mart.	ka'a oveti	x	x	Tree			DD
	Malvastrum sp.		x	x	Herbaceous			-

Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
	Melochia sp.		x		Herbaceous			-
	Waltheria indica L.		x		Subarbust			-
Meliaceae	*Cabralea canjerana* (Vell.) Mart.	cancharana	x		Tree			LC
	Trichilia catigua A.Juss	katigua pytã	x	x	Tree			-
Moraceae	*Ficus enormis* (Miq.) Miq.	guapoy moroti	x	x	Tree			LC
	Ficus sp.		x		Tree			-
Myrtaceae	*Campomanesia xanthocarpa* (Mart.) O.Berg	guavira	x		Tree			-
	Eugenia involucrata DC.	ñangapiry	x		Tree			LC
	Eugenia pitanga (O.Berg) Nied.		x	x	Bush			-
	Eugenia sp.		x		Tree			-
	Psidium striatulum DC.		x	x	Tree			LC
Nyctaginaceae	*Guapira* sp.		x		Tree			-
Olacaceae	*Priogymnanthus hasslerianus* (Chodat) P.S.Green	ka'a vera	x	x	Tree			-
Passifloraceae	*Turnera* sp.		x		Herbaceous			-
	Piriqueta sp.		x		Herbaceous			-
Poaceae	*Aristida* sp.		x	x	Herbaceous			-
	Cenchrus sp.		x	x	Herbaceous			-
	Chloris virgata Sw.		x		Herbaceous			-
	Elionurus muticus (Spreng.) Kuntze	capim-carona	x	x	Herbaceous			-
	Elionurus sp.		x	x	Herbaceous			-
	Eragrostis sp.		x	x	Herbaceous			-
	Schizachyrium condensatum (Kunth) Nees		x		Herbaceous			-
	Setaria palmifolia (J.Koenig) Stapf		x		Herbaceous			-
Polygonaceae	*Coccoloba* sp.		x	x	Tree			-
Portulacacee	*Portulaca* sp.		x	x	Herbaceous			-
Primulaceae	*Myrsine balansae* (Mez) Otegui	kanelon	x		Tree			-

Family	Scientific names	Popular name in Paraguay	DIA	DAA	Habit	SEAM n. 524/06	SEAM n. 2,243/06	IUCN
Proteaceae	*Roupala meisneri* Sleumer	ka'ati ka'e	x		Tree			LC
Rhamnaceae	*Rhamnidium elaeocarpum* Reissek	taruma'i	x		Bush			LC
	Ziziphus mistol Griseb.	mistol	x	x	Tree			DD
Rubiaceae	*Calycophyllum multiflorum* Griseb.	palo-blanco	x	x	Tree			-
	Randia sp.		x		Bush			-
Rutaceae	*Balfourodendron riedelianum* (Engl.) Engl.	guatambu	x	x	Tree		x	EN
	Zanthoxylum rhoifolium Lam.	tembetary sayju	x	x	Tree			LC
Salicaceae	*Casearia sylvestris* Sw.	mbavy guasu	x	x	Tree			LC
	Xylosma pseudosalzmanii Sleumer		x		Tree			-
Sapindaceae	*Allophylus edulis* (A.St.-Hil., A.Juss. & Cambess.) Radlk.	koku	x		Tree			LC
Sapotaceae	*Chrysophyllum gonocarpum* (Mart. & Eichler ex Miq.) Engl.	aguai	x		Tree			LC
	Pouteria torta (Mart.) Radlk.	aguai guasu	x	x	Tree			LC
	Sideroxylon obtusifolium (Roem. & Schult.) T.D.Penn.	guajayvi rai	x	x	Tree			LC
Solanaceae	*Brunfelsia australis* Benth.	manaka	x	x	Bush			LC
	Capsicum chacoense Hunz.		x		Bush			-
	Solanum sp.		x	x	Bush			-
Ulmaceae	*Phyllostylon rhamnoides* (J.Poiss.) Taub.	juasy'y guasu	x	x	Tree			LC
Urticaceae	*Cecropia pachystachya* Trécul	amba'y	x	x	Tree			-
Verbenaceae	*Lantana* sp.		x	x	Herbaceous			-
	Lippia sp.		x	x	Herbaceous			-
	Stachytarpheta sp.		x	x	Herbaceous			-
Ximeniaceae	*Ximenia americana* L.	indio kurupa'y	x	x	Tree			LC

Subtitle: DIA: Direct Influence Area; ADA: Area Directly Affected; SEAM n 524/06 - Species of Native Flora Threatened with Extinction in Paraguay; SEAM n 2.243/06 - Species of Native Flora Threatened with Extinction in Paraguay.

Figure 177 – Map of DIA and DAA features.



Sistema de Coordenadas: SIRGAS 2000 - UTM Zona 21K
Proyección: UTM - Transversal de Mercator
Datum: SIRGAS 2000

- DGEEC, 2012 (Dirección General de Estadística, Encuestas y Censos). Informe Técnico Mapa de cobertura del Paraguay año 2011

Subtitle

- DAA
- DIA
- Departamento de Concepcíón
- Anthropic Area
- Chaco
- Floodable Savannah
- Savannah
- Semideciduous Forest

N

0 500 1,000 2,000 3,000 Meter0s

PARACEL PÖYRY

TÍTULO DEL MAPA: DAA and DIA Physiognomy Map

TÍTULO DEL PROYECTO: BIOTIC ENVIRONMENT - DAA and DIA

PROCESO DE LICENCIA: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

TIPO DE LICENCIA

UBICACIÓN	UGHRI
CONCEPCiÓN-PY	CIH8 Aquidaban y CIH18 Rio Pilcomayo

ESCALA:	REVISIÓN:	RESPONSABLE TÉCNICO:	CRBio Nº:
		EDUARDO MARTINS Biologo	26.063/01-D

Form the total 7.785ha of the DIA area about 33,10% is Savannah, 27,80% is Semideciduous Forest, 13,96% is antropic area, 10,57% corresponds the Paraguay river, 9,17% is the Chaco in the other margin of the river and 5,4% is Floodable Savannah.

Intervention in forests protecting watercourses

For the implementation of the water intake system and the treated effluent emissary, as well as for the river port, it will be necessary to intervene in the protective forests of the Paraguay River, considering the 100 m limit established in Decree 9,824/12, which regulates Law 4,241/10.

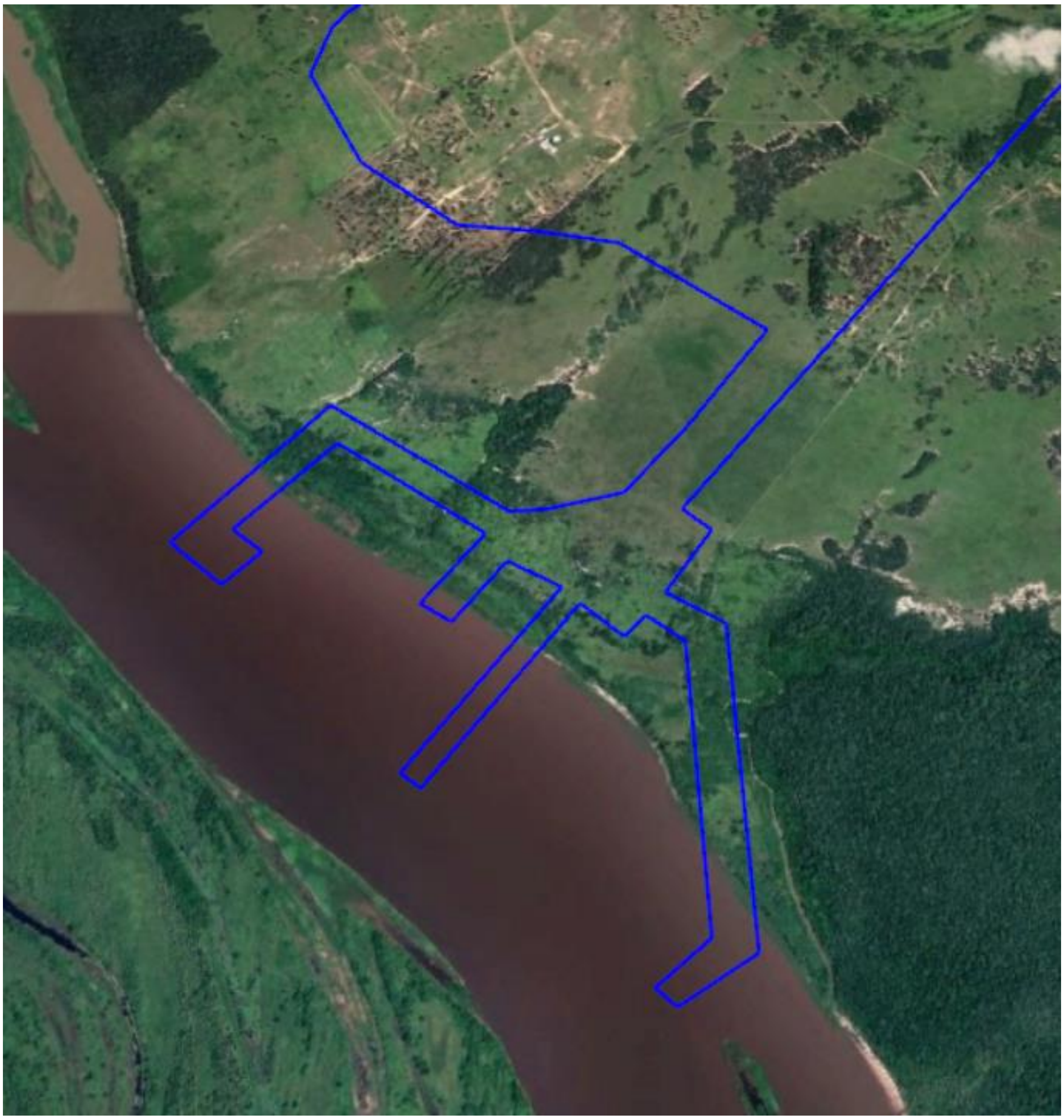


Figure 178 – Image with the location of the intervention areas in the protective forest of the Paraguay River (100m).

Figure 179 – Aerial image of the intervention area – water intake and discharge of treated effluents.

The following table lists the area, civil structure and vegetation that will be removed for the implementation of the project.

Table 4 – Intervention in protective forests for the implementation of raw water and discharge of treated effluents.

Structure	Area (ha) of intervention	Vegetation
Water intake system	0,62	Semideciduous Forest
	0,31	Savannah
Emissary of treated effluents	0,87	Semideciduous Forest
River port	2,50	Semideciduous Forest

Natural and modified areas

The figure below shows the satellite image of the mill site property, identifying modified and natural existing areas. These area total approximately 1,206 ha. About 83% of the area is modified and 17% is natural forest and bodies of water.

Figure 180 – Natural and Modified Habitat at Mill site.

As mentioned, the implementation of the pulp mill will require the suppression of approximately 3.99 ha of remaining vegetation of the Semideciduous Forest and 0.31 ha of remaining vegetation of the Savannah at riparian area for the implantation of the water intake system and the terrestrial emissary of treated effluents. Knowing that this area currently contains some 150 ha of native forest remnants, so the suppression will correspond only to 2,86% of the existing native forest. Paracel has committed to compensate the suppression by increasing the native area in relation to the current situation, specially enlarging the riparian areas, with approximately 250 ha, so that the total area will represent approximately 400 ha. The implementation of the project will determine a native forest coverage in 30% of the mill site, compared to the 12% that it currently occupies. This compensation measure thus determines an increase in the native area of approximately 150% in relation to the current situation.

Moreover that 30% will also regenerate the riparian forest, now highly fragmented, and also connect the native areas of the neighbouring properties to the NW and SE acting as a biological corridor, now non-existent. Therefore, **it can be said that the positive impact on biodiversity would be well over 150% in relation to the current situation**.

Transmission Line

Likewise the figure below shows the image of the transmission line easement lane, identifying modified and natural existing areas. These area total approximately 23,1 ha. About 84,3% of the area is modified and 15,7% is natural forest and bodies of water.

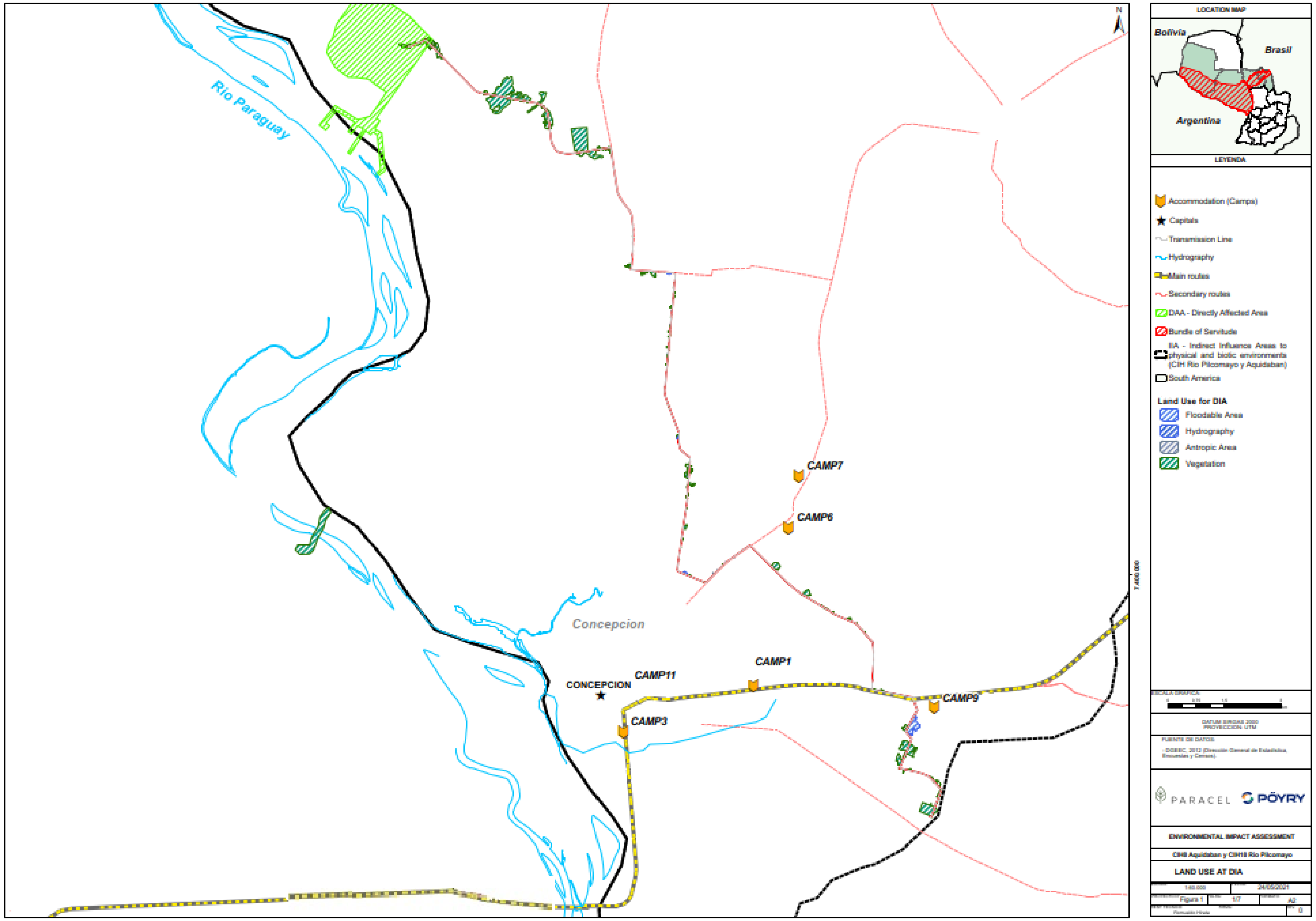


Figure 181 – Natural and Modified Habitat at Transmission line easement lane

Vegetation cover and PS 6 Type in Transmission Line DIA is divided in 3 classes type: native forest, Floodable/Waterland area, Grassland/Pasture/Roads area. The percentage of vegetation cover in DIA is presented at the table and figure below:

Table 5 – Vegetation cover and PS 6 Type in TL DIA

Class ID	Class type	Area (ha)	Percentage	Nat/ Mod	Area (ha)	Percentage
1	Native forest	3,53	15.3%	Natural	3,63	15.7%
2	Floodable/ Waterland	0,10	0.40%			
3	Grassland/Pasture/Roads	19,47	84.3%	Modified	19,47	84.3%
Total		**23,10**	**100%**		**23,10**	

Phytosociological study

The phytosociological study is one of the tools of plant ecology that allows the description of a plant community or association. Its objective is to characterize these communities through their composition, quantitative measures of their attributes (density, dominance, frequency and cover), spatial distribution and interrelations between their populations.

Methods

For the phytosociological study, the segmentation method was adopted, which consists of the establishment in the field of small sampling units distributed throughout the study area, allowing for an adequate representation of local diversity (Durigan, 2003). Twenty-three stationary units were installed, systematically distributed in both the DIA (15 plots) and the DAA (8 plots), with dimensions of 20 x 10 m with an area of 200 m² each, totaling 4,600 m² sampled.

In the plots all individuals of the trees with a CAP ≥ were sampled 15 cm (CAP = circumference at breast height - 1.30 m from the ground), measured and the CAP was later converted using the formula ($DAP = CAP/\pi$) into DAP (diameter at breast height). For profiled individuals, they were included when at least one of the branches met the minimum inclusion diameter. For bush formation, due to the highly branched character of the individuals, the CAB (Circumference at Base Height) and not the CAP (Circumference at Breast Height) were used to measure the perimeter, being sampled the bush and tree individuals inserted with a CAB greater or equal to 10 cm and a height of 2m or more. In the case that one of the branches of a tree had the adopted criterion, the other branches were measured. For each individual sampled, the CAP and/or CAB values, the height (estimated by comparison of known heights) and the dead individuals were recorded.

Figure 182 – The assembly of the plots/units

Figure 183 – Detail of measurements.

Figure 184 – Measurement of the CAP (circumference at breast height - 1.30m from the ground).

Figure 185 – Measurement detail.

When necessary, field material was obtained for identification. Identification keys, original descriptions, specialized bibliography and comparison with herbarium materials available in online archives were used to identify the plants. Botanical material not identified in the field was collected with pruning shears, herborized and pressed into cardboard paper for later identification.

The classification system used APG IV (2016) and the correct spelling of the names was checked on the websites “TROPICOS” (https://www.tropicos.org/home) and “The Plant List” (http://www.theplantlist.org/).

With the data, the quantitative parameters proposed by Mueller-Dombois and Ellenberg (1974): absolute density, absolute frequency, absolute dominance expressed by basal area, relative density, relative frequency, relative dominance, importance value and coverage value. The Shannon diversity (H') and Pielou equitability (J') indices were also calculated. For the construction of the species-area curve (accumulation and rarefication curve) the data on species richness and the Jackknife estimator were used.

The data was analyzed using the FITOPAC2 (G.J. Shepherd – UNICAMP, 2010); EstimateSWin910 and the Past3. The following is a description of the quantitative parameters and the diversity indices calculated:

Abundance (n): is the number of individuals sampled per species or for the community;

Density (D): is the number of individuals per unit area (ind.ha-1);

Absolute Density (DA): is the number of individuals (n) of a given species in the area:

AD = n/area

Measurement unit: $ind.ha^{-1}$

Relative Density (DR): is the relationship between the number of individuals of a species (n) and the total number of individuals sampled (N)

RD = (n/N) x 100
Measurement unit: %

Frequency (F): is the number of plots where a given species is found and indicates the average dispersion of each species;

Absolute frequency (FA): the relationship between the number of plots on which a given species is found and the total number of plots sampled:

AF = (Pi / P) x 100
Pi: n. of plots in which the species takes place
P: n. total plots sampled
Unit of measurement: %

Relative frequency (FR): relationship between FA of a certain species with the sum of FA of all species sampled:

FR = (FAi / ∑ FA) x 100
FAi: absolute frequency of a specie
Unit of measurement: %

Dominance (Do): is the rate of occupation of the environment by the individuals sampled. It is calculated from the basal area (AB):

$AB = \pi / 4 \times d^2$
d: single diameter...
Unit of measurement: cm^2 or m^2 (divide by 10.000)

Absolute dominance (DoA): is the basal area (AB) of a species per area:

DoA = AB / area
Unit of measurement: m^2.ha-1

Relative Dominance (DoR): is the relationship between the basal area (AB) of a species and the total basal area (AB) of the species sampled.

DoR = (AB/ ∑AB) x 100
Unit of Measurement: %

Importance Value Index (IVI): provides an idea of the density, spatial dispersion and size reached by a species, reflecting its ecological importance.

VI = DR + DoR + FR
VI = maximum value of 300
VI % = maximum value 100, expressed in %

Index of Coverage Value (IVC): provides information related to the number of individuals and the biomass of each species.

VC = DR + DoR
VC = Maximum value of 200

VC % = maximum value 100, expressed in %

Diversity Index: The Shannon diversity index (H') assumes that individuals are randomly sampled from an infinitely large population, also assuming that all species are represented in the sampling. It is an index based on the proportional abundance of species in the community.

Equitability or Pielou Index (J): represents the distribution of the number of individuals in relation to the species. It varies between 0 and 1.0, and the value 1.0 represents the situation in which all species have the same abundance, i.e. the same number of individuals.

For each phytophysiognomy sampled, a species cumulative curve was made according to the number of sample units (collection curve), a procedure that is indicative of the sufficiency of the sample.

The characterization of the vegetation was based on the descriptions established by the: Informe Técnico del Laboratorio SIG/CIF/FCA/UMA (Mapa de cobertura del Paraguay, 2011), Flora del Paraguay (2011) y del Manual de Familias y Géneros de Árboles del Paraguay (2015). For the presence of rare, endemic or endangered species, it was based on SEAM Resolution 524/06 (approving the list of endangered flora and fauna species of Paraguay), SEAM Resolution 2,243/06 (updating the list of protected endangered wildlife species) (Chocarro & Egea, 2018).

Characterization of the sampled areas

The sample units were installed in both the DIA and the DAA. In the plots installed in the Directly Affected Area (DAA), the savannah is characterized by heterogeneous and scarce groupings of shrubs with heights between 4 and 6 m, interspersed with large and small cactus and small trees. In the Direct Influence Area (DIA), the savannah is structured in three strata: an upper stratum, with a predominance of tree individuals up to approximately 14 m, with DBHs between 30 and 60 cm; an intermediate stratum with specimens between 4.0 and 6.0 m high with DBHs varying between 10 and 70 cm, and a lower stratum of woody grasses, generally discontinuous and of scarce physiognomic expression. The following table lists the UTM coordinates of the vertices of the sampling units.

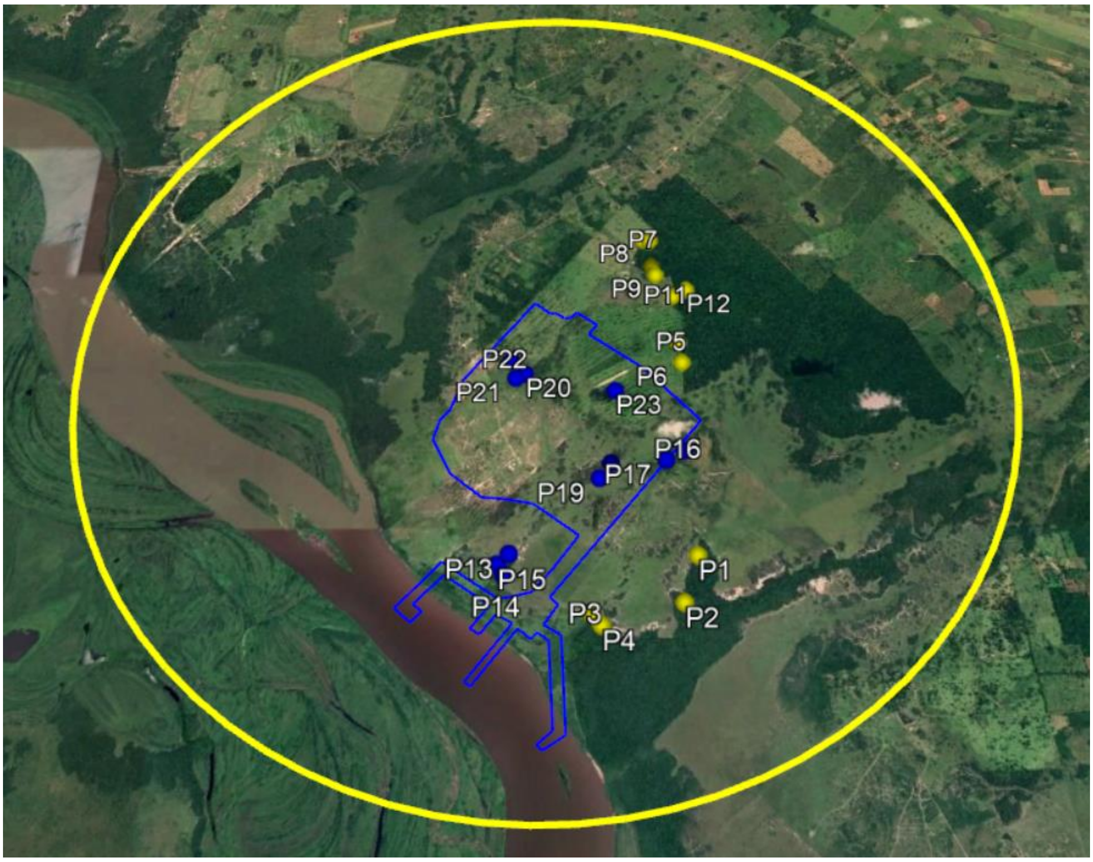


Figure 186 – Image with the location of the plots in the DIA and DAA of the future mill site. Image: Google Earth feb/2018.

Figure 187 – View of the vegetation in the DAA.

Figure 188 – Another angle of the vegetation in the DAA

Figure 189 – Detail of the dense stratum formed by bushes and grasses present in the areas sampled in the ADA.

Figure 190 – Another angle of the dense stratum formed by bushes and grasses sampled in the ADA.

Figure 191 – View of the vegetation in the AID.

Figure 192 – Another angle of the vegetation in the AID

Table 6 – UTM coordinates of the vertices of the plots in the DAA and DIA of the future PARACEL pulp mill.

Location	Plots	WGS 84 - 21K (UTM)	
		E	S
DIA	1	451437,00	7427356,00
	2	451285,00	7426866,00
	3	450347,00	7426688,00
	4	450402,00	7426646,00
	5	451343,00	7429958,00
	6	451363,00	7429712,00
	7	451021,00	7431361,00
	8	451012,00	7431308,00
	9	451082,00	7430888,00
	10	451051,00	7431010,00
	11	451290,00	7430561,00

Location	Plots	WGS 84 - 21K (UTM)	
		E	S
	12	451437,00	7430665,00
DAA	13	449460,00	7427375,00
	14	449451,00	7427258,00
	15	449382,00	7427162,00
	16	451336,00	7428602,00
	17	451091,00	7428462,00
	18	450545,00	7428460,00
	19	450410,00	7428334,00
	20	449660,00	7429513,00
	21	449509,00	7429543,00
	22	449417,00	7429696,00
	23	449345,00	7429715,00

Results

Directly Area Affected (DAA)

In the phytosociological study, 167 individuals belonging to nine families and 17 species were sampled. Of the total number of individuals sampled, three were found dead and one species was identified to the genus only. The absolute values of density and basal area obtained for 1600 m2 of sampling were, respectively, 1043.75 ind/ha and 1.12 m²/ha. The average diameter recorded was 8.25 cm, the average height corresponded to 4.28 m and the Shannon diversity index calculated for this study was 1.94.

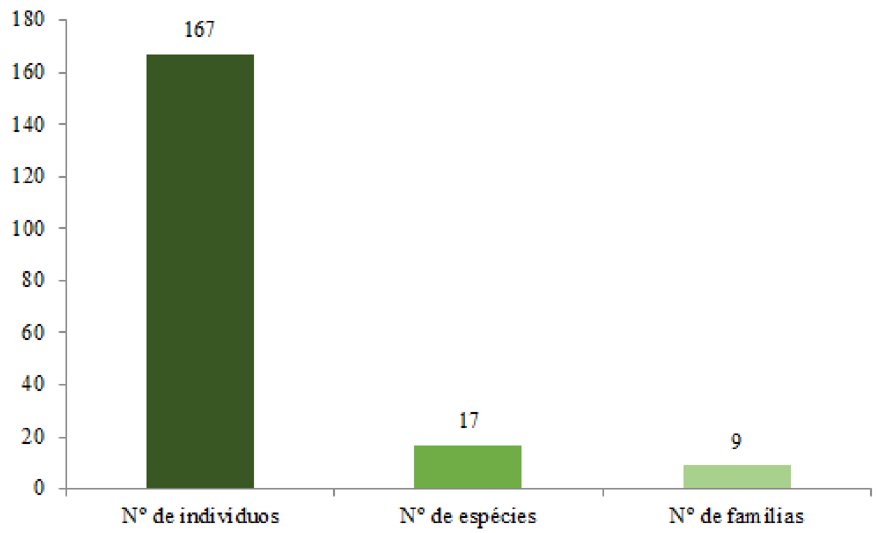


Figure 193 – Comparative table between the number of individuals, species and families found in the sample.

Table 7 – General characteristics of the stratum of trees and bushes sampled in the plots

Parameters	
Number of individuals	167
Number of species	17
Number of families	9
Absolute density (ind/ha)	1.043,75
Total basal area (m2/ha)	1,12
Diameter - average	8,25
Height - medium	4,28
Shannon-Wiener (H')	1,94
Equitability (J')	0,67

The species with the highest Importance Value Index - IVI in descending order are: *Prosopis rubriflora* (92,58%), *Schinopsis balansae* (82,16%), *Ziziphus mistol* (20,87%), *Plenckia populnea* (14,12%) and *Chloroleucon chacoense* (9,39%), however, the dead samples found represent 12.17% of the sample.

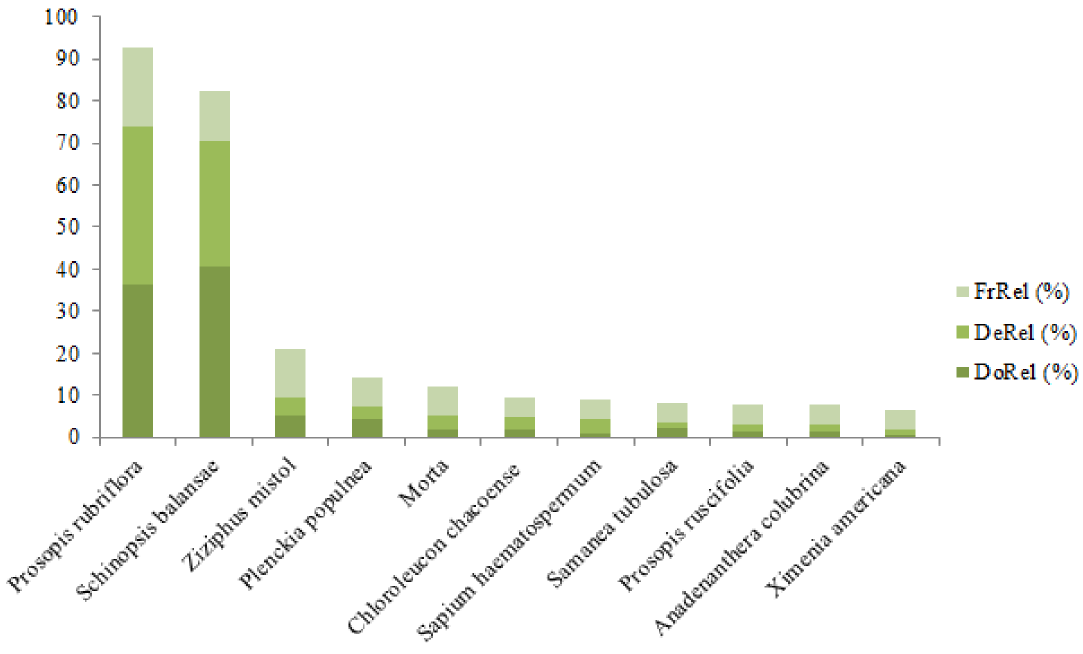


Figure 194 – Graph showing the distribution of the structural parameters of the 10 species with the highest IVI value. Legend: FrRel: Relative Frequency; DeRel: Relative Density; DoRel: Relative Dominance.

With regard to the species sampled in this study, the *Prosopis rubriflora* was the most abundant, represented by 63 individuals, and was present in all sample units, however, the *Schinopsis balansae* and *Schaefferia argentinensis* have been presented as the highest average height (5.41 m and 4.88 m, respectively) and the *Samanea tubulosa* is presented as the one with the largest average diameter (12.17 cm).

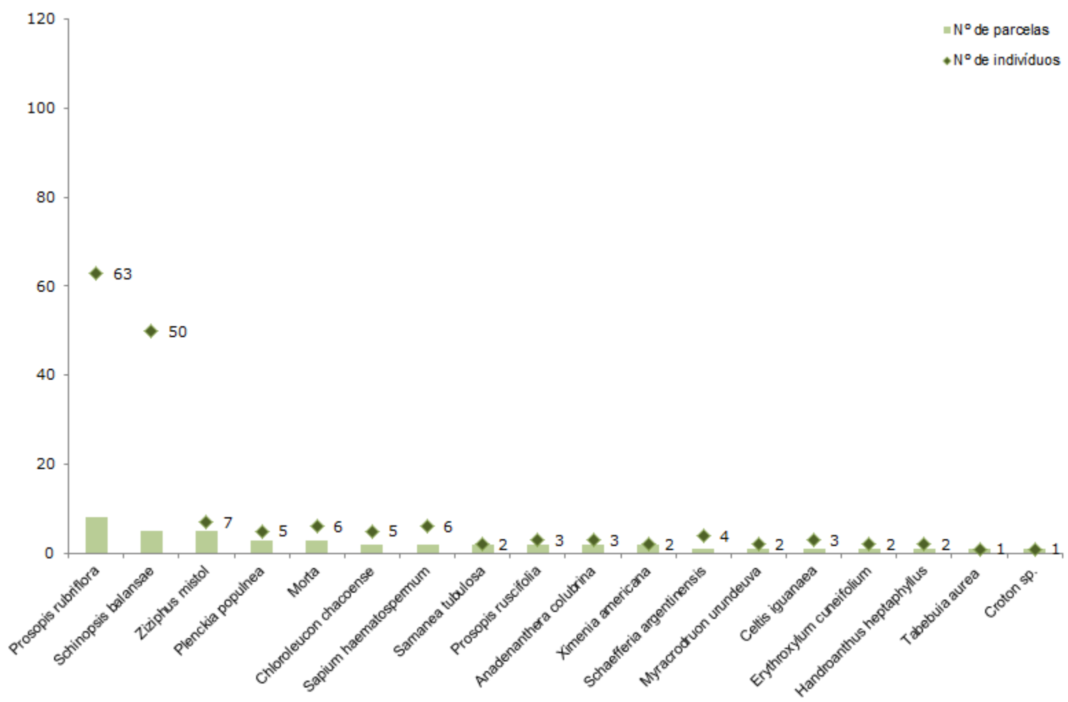


Figure 195 – Representative graphics of the number of individuals per sampled plot.

Among the 17 species sampled in this study, none is found exclusively in the physiognomy of the savannah, being identified in other biogeographic regions as the table below.

Table 8 – Native forest strata of Paraguay and the species found in the most

Species	BHRO	BSHC	BSHIRP	BSCH	BP
Prosopis rubriflora			x	x	x
Schinopsis balansae	x	x	x	x	
Ziziphus mistol	x		x	x	
Plenckia populnea	x	x	x	x	
Chloroleucon chacoense			x	x	x
Sapium haematospermum	x	x		x	x
Samanea tubulosa	x	x	x		

Species	BHRO	BSHC	BSHIRP	BSCH	BP
Prosopis ruscifolia			x	x	x
Anadenanthera colubrina	x		x	x	
Ximenia americana			x	x	
Schaefferia argentinensis			x	x	
Myracrodruon urundeuva	x	x	x	x	
Celtis iguanaea	x		x	x	
Erythroxylum cuneifolium	x	x	x		
Handroanthus heptaphyllus	x		x	x	
Tabebuia aurea	x	x	x	x	x
Croton sp.					

Source: Manual de Familias y Géneros de Árboles del Paraguay (2015). **BHRO**: Bosque Húmedo de la Región Oriental; **BSHC**: Bosque Subhúmedo del Cerrado; **BSHIRP**: Bosque Subhúmedo Inundado del Río Paraguay; **BSCH**: Bosque Seco del Chaco; **BP**: Bosque Palmar. (The text used native names).

The families with the highest IVC (index of coverage value) values were Fabaceae (87,93) and Anacardiaceae (72,70). Of the nine families sampled, the Fabaceae with five species (27,78 %) represents the richest species, followed by Anacardiaceae, Celastraceae, Euphorbiaceae y Bignoniaceae (11,11%), the other families were represented by one species each. Considering dominance, density and relative frequency, the following figure presents the IVI (Importance Value Index) of the most representative families of the sampling.

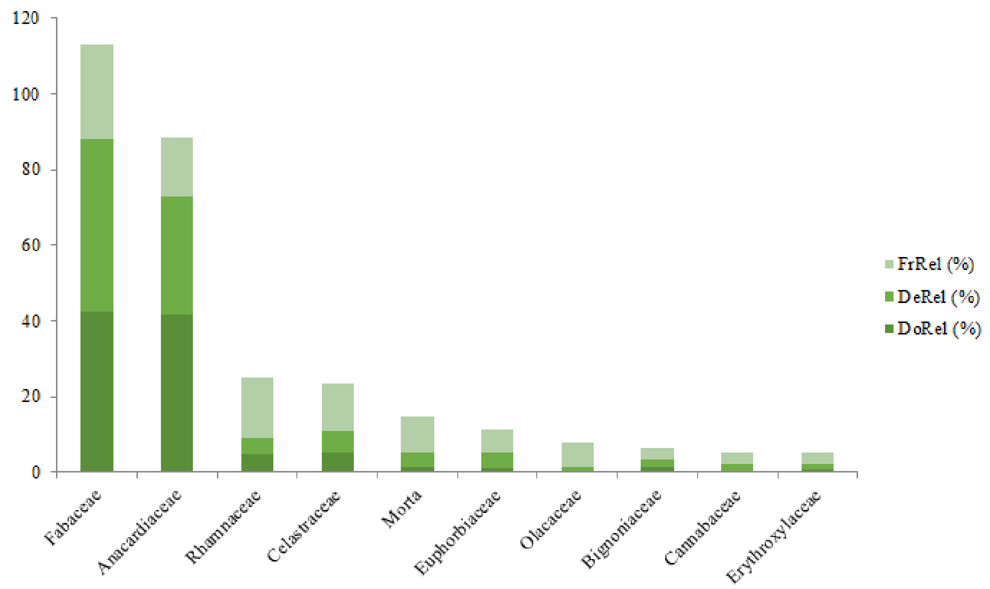


Figure 196 – Graph showing the distribution of the structural parameters related to the IVI of the points sampled. Legend: FrRel: Relative Frequency; DeRel: Relative Density; DoRel: Relative Dominance.

Regarding the structure, this phytophysiology has an average diameter of 8.25 cm. The diametric distribution indicates that this phytophysiology is composed of small trees with a high concentration of individuals between 3 and 7 cm in trunk diameter (63.5%).

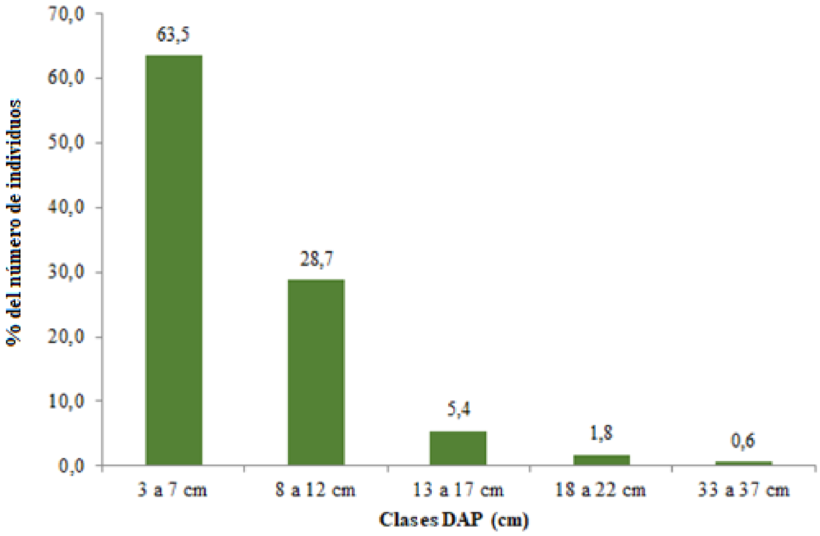


Figure 197 – Distribution of diameter classes (DAP) of individuals sampled in the ADA.

The average height was 4.28 m and the distribution of the total height indicates that 53.3% of the individuals have heights between 4.0 and 6.0 m.

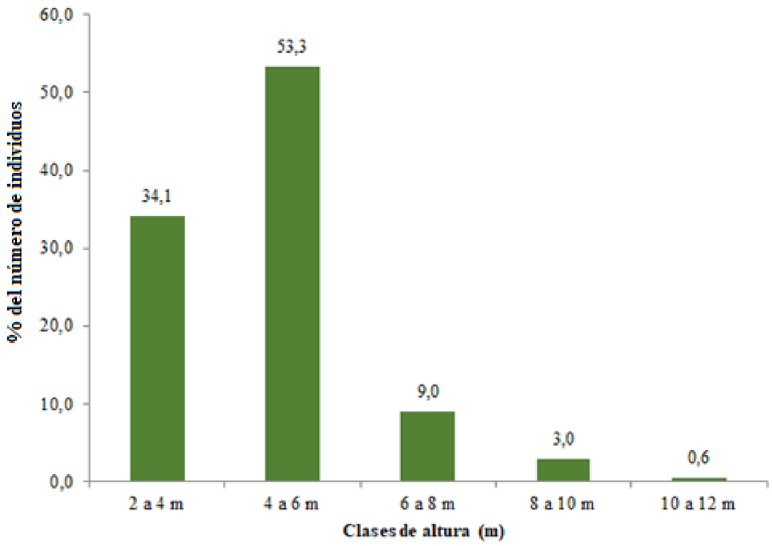


Figure 198 – Distribution of height classes of individuals sampled in the ADA.

The phytosociological parameters of the sampled tree species are presented in the table below.

Table 9 – Phytosociological parameters of the tree community. NInd – number of individuals; NAm – sample number; AbsDe – Absolute Density; RelDe – Relative Density; AbsFr – Absolute frequency; RelFr – Relative frequency; AbsDo – Absolute Dominance; RelDo – Relative Dominance; IVI – Importance value index; IVC – Coverage value index

Species	NInd	NAm	AbsDe	RelDe	AbsFr	RelFr	AbsDo	RelDo	IVI	IVC
Prosopis rubriflora Hassl.	63	8	393,80	37,72	100,00	18,60	2,54	36,25	92,58	73,97
Schinopsis balansae Engl.	50	5	312,50	29,94	62,50	11,63	2,84	40,60	82,16	70,54
Ziziphus mistol Griseb. [sin. *Ziziphus oblongifolius* S.Moore]	7	5	43,80	4,19	62,50	11,63	0,35	5,05	20,87	9,24
Plenckia populnea Reissek	5	3	31,30	2,99	37,50	6,98	0,29	4,15	14,12	7,15
Morta	6	3	37,50	3,59	37,50	6,98	0,11	1,60	12,17	5,19
Chloroleucon chacoense (Burkart) Barneby & J.W.Grimes	5	2	31,30	2,99	25,00	4,65	0,12	1,74	9,39	4,74
Sapium haematospermum Müll.Arg.	6	2	37,50	3,59	25,00	4,65	0,06	0,89	9,14	4,48
Samanea tubulosa (Benth.) Barneby & J.W.Grimes	2	2	12,50	1,20	25,00	4,65	0,15	2,09	7,94	3,29
Prosopis ruscifolia Griseb.	3	2	18,80	1,80	25,00	4,65	0,09	1,22	7,67	3,02
Anadenanthera colubrina (Vell.) Brenan	3	2	18,80	1,80	25,00	4,65	0,08	1,12	7,56	2,91
Ximenia americana L.	2	2	12,50	1,20	25,00	4,65	0,03	0,39	6,24	1,59
Schaefferia argentinensis Speg.	4	1	25,00	2,40	12,50	2,33	0,09	1,26	5,98	3,65
Myracrodruon urundeuva Allemão	2	1	12,50	1,20	12,50	2,33	0,07	0,96	4,48	2,16
Celtis iguanaea (Jacq.) Sarg. [sin. *Celtis pubescens* (Humboldt & Bonpl	3	1	18,80	1,80	12,50	2,33	0,02	0,35	4,47	2,15
Erythroxylum cuneifolium (Mart.) O.E.Schulz	2	1	12,50	1,20	12,50	2,33	0,06	0,84	4,36	2,03
Handroanthus heptaphyllus (Vell.) Mattos	2	1	12,50	1,20	12,50	2,33	0,06	0,79	4,32	1,99
Tabebuia aurea (Silva Manso) Benth. & Hook.f. ex S.Moore	1	1	6,30	0,60	12,50	2,33	0,04	0,61	3,54	1,21
Croton sp.	1	1	6,30	0,60	12,50	2,33	0,01	0,09	3,01	0,68

In terms of floristic similarity between the plots, of the 11 tree species found, only *Prosopis rubriflora* was common to all of them, followed by the species *Schinopsis balansae* y *Ziziphus mistol* sampled in five plots.

Cluster analysis is a method of numerical classification, with the objective of defining groups with different degrees of similarity, that is, it identifies objects that are sufficiently similar to be placed in the same group (Legendre, P; Legendre, L, 1998 apud Felfili, et al, 2011). The coefficient adopted was the Bray-Curtis, which is a similarity index for abundance data.

In accordance Mueller-Dombois & Ellenberg (1974) two or more areas are considered similar in terms of floristic composition when they have at least 25% of common species.

The similarity dendrogram between the study plots showed the tendency to form three groups, one formed by plots P15, P18, P19 and P20, one formed by plots P21, P22 and P23 and one formed only by P14. The highest similarity index obtained was 85% between plots P18 and P19.

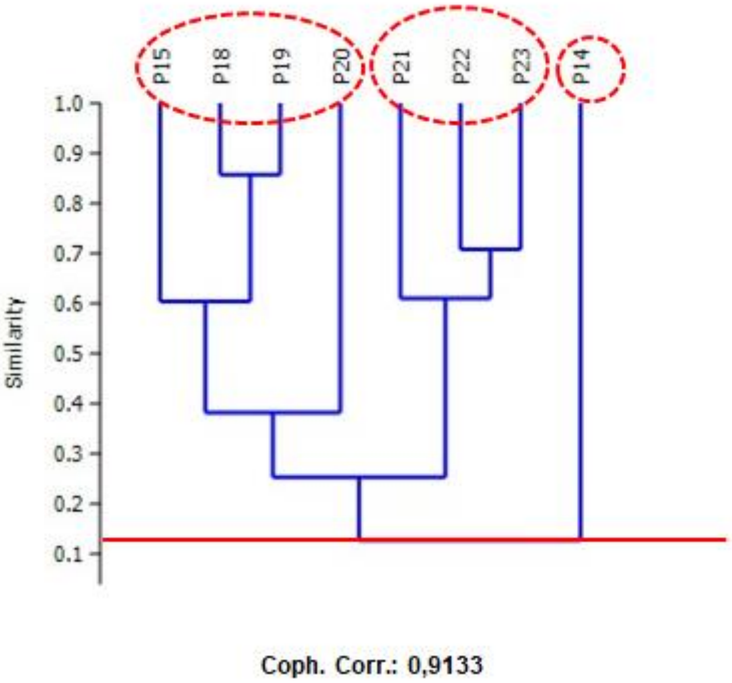


Figure 199 – Bray-Curtis similarity dendrogram in the sampled areas Legend: P: plot (20x10 m).

Equitability is derived from the Shannon diversity index, and makes it possible to represent the way in which the number of individuals is distributed among the different species (Pielou, 1966), that is, it indicates whether the different species have a similar or divergent abundance (number of individuals). Its value presents a range from 0 (minimum uniformity) to 1 (maximum uniformity).

The following figure presents the Pielou (J') equation diagram generated for the sampling carried out, where the index variation was from the lowest 0.56, found in plot P22, to 0.88, found in plot P14.

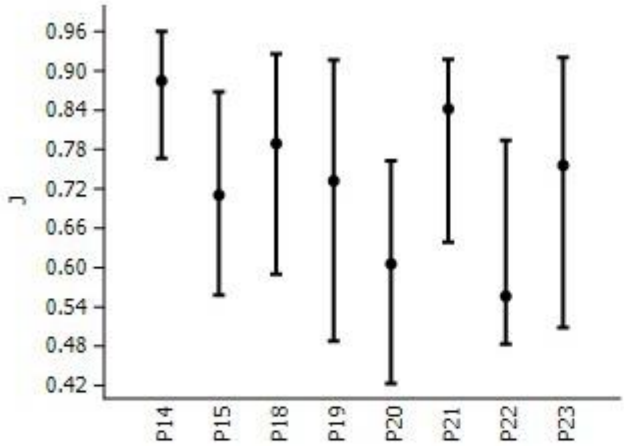


Figure 200 – Pielou Equitability Diagram (J'). Legend: P – plot (20 x10m).

Regarding the efficiency of the study, a random species accumulation curve was constructed, taking into account the cumulative number of species recorded by the graph method, in which a total of 17 species were added.

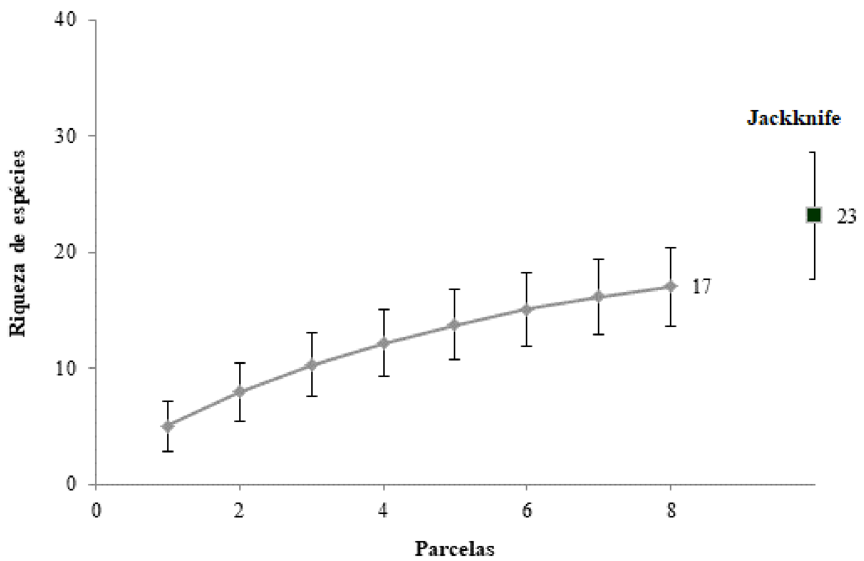


Figure 201 – Random accumulation curve of observed and expected species by the Jackknife estimator.

The Jackknife estimator assumes a total of 23 species for the areas sampled, with a deviation of 5.47 for major and minor. When considering the number of species recorded in the floristic study (144 spp) it is understood that increasing the sampling effort will always increase the richness value and approach the maximum number of species, so the greater the sampling effort performed, the more likely it is that a new species will be recorded. Therefore, the sampling effort is considered satisfactory for this study.

Direct Influence Area (DIA)

In the phytosociological study, samples were taken from 216 individuals belonging to 20 families and 31 species. Of the total number of individuals sampled, 13 were found dead, three species were identified only up to the genus and five species were not identified. The absolute values of density and basal area obtained for 3,000 m^2 of sampling were, respectively, 720.00 ind/ha and 5.07 m^2/ha. The average diameter recorded was 13.13 cm, the average height corresponded to 4.87 m and the Shannon diversity index calculated for this study was 2.67.

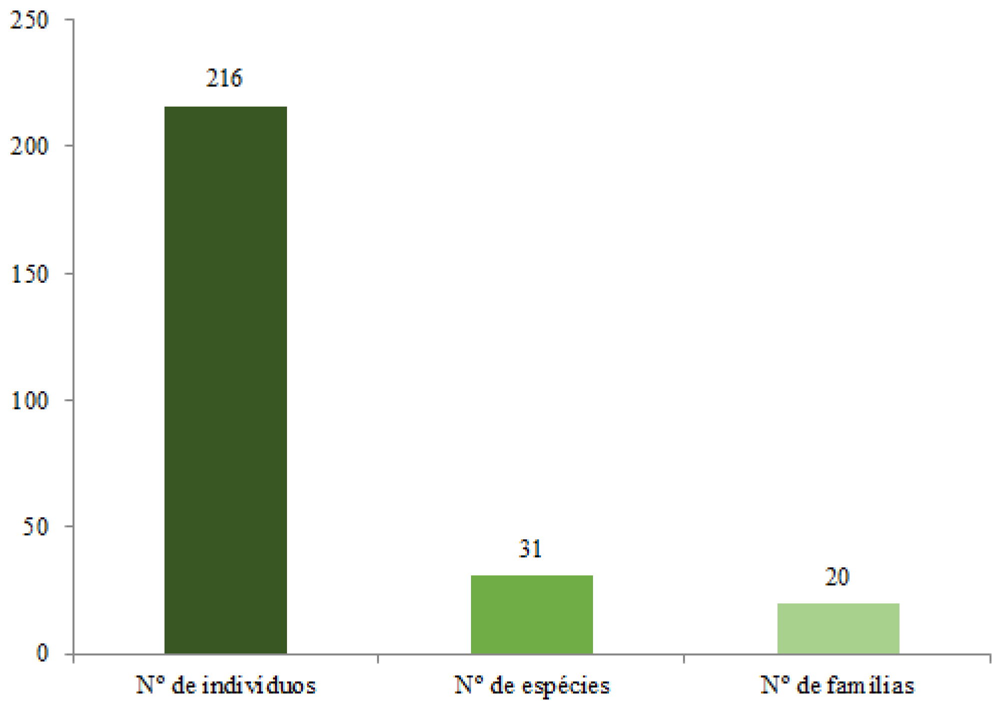


Figure 202 – Comparative table between the number of individuals, species and families found in the sample.

Table 10 – General characteristics of the stratum of trees and shrubs sampled in the plots

Parameters	
Number of individuals	216
Number of species	31
Number of families	20
Absolute density (ind/ha)	720,00
Total basal area (m2/ha)	5,07
Diameter - average	13,13
Height - medium	4,87
Shannon-Wiener (H')	2,67
Fairness (J')	0,74

The species with the highest Importance Value Index - IVI in decreasing order are: *Dalbergia frutescens* (74,02%), *Enterolobium contortisiliquum* (30,61%) and the *Priogymnanthus hasslerianus* (24,74%), however, the samples found dead represent 15.05% of the sampling.

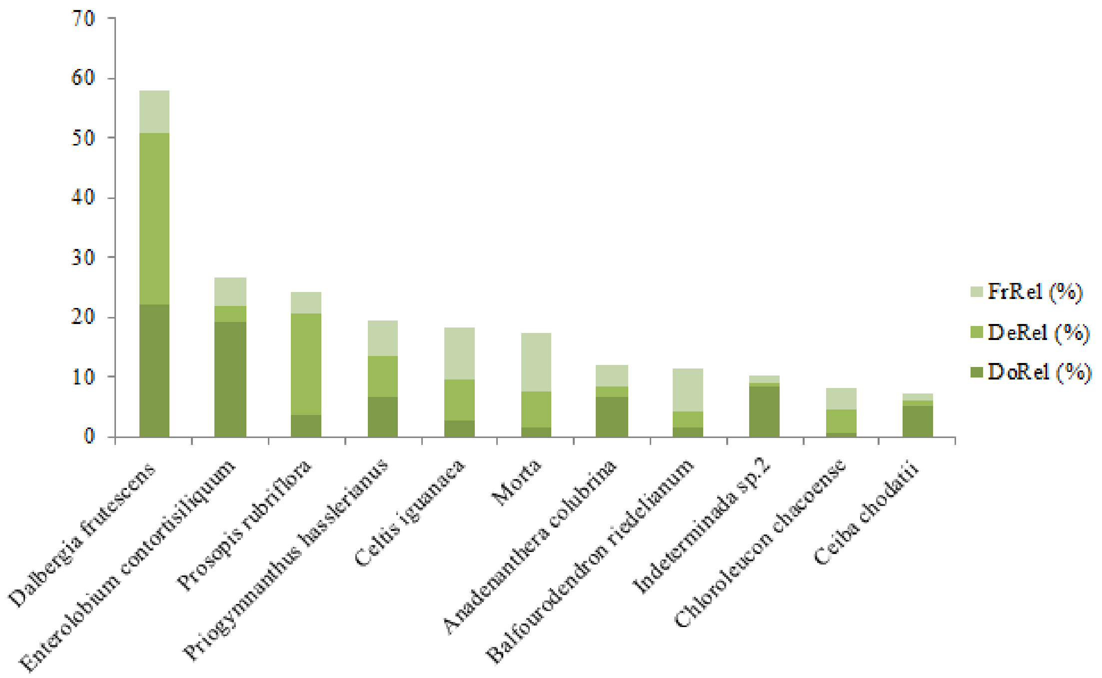


Figure 203 – Graph showing the distribution of the structural parameters of the 10 species with the highest IVI. Legend: FrRel: relative frequency; DeRel: Relative Density; DoRel: relative Dominance.

Of the species sampled in this study *Dalbergia frutescens* was the most abundant, represented by 62 individuals, and was present in six of the fifteen sample units, however, the *Ceiba chodatii* y *Croton* sp. both with 11.00 meters and the species *Enterolobium contortisiliquum* at 10.83 m presented the highest average height and a species here called *Indeterminado sp*.2 had the largest average diameter (73,53 cm).

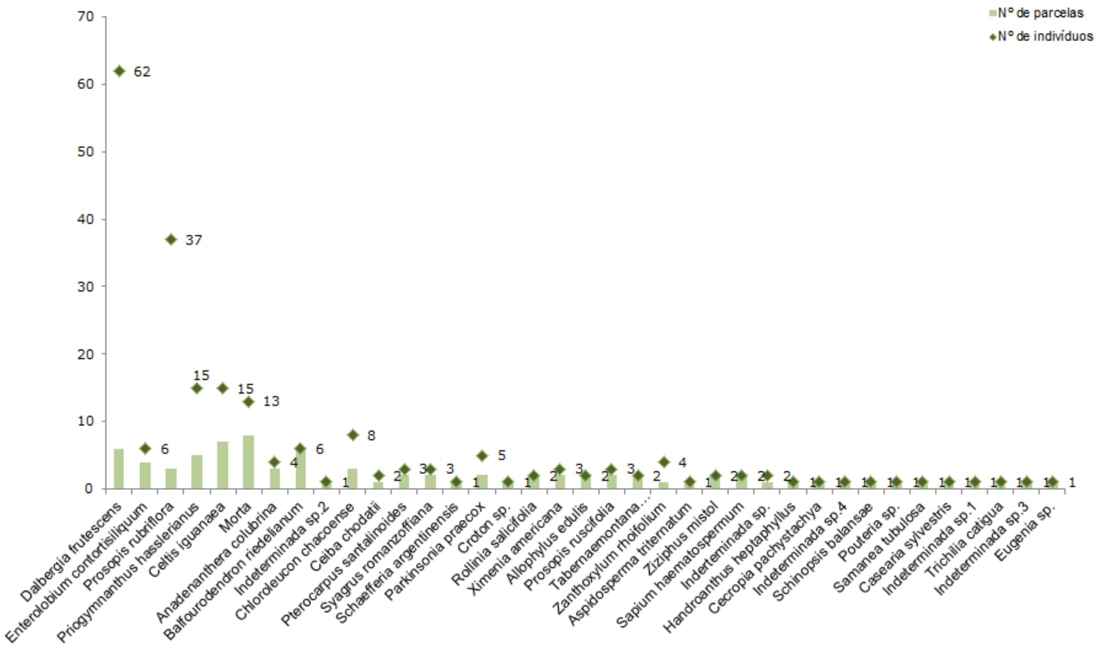


Figure 204 – A representative chart of the number of individuals per plot sampled.

Among the 31 species identified in this study *Balfourodendron riedelianum* takes place exclusively in the Bosque Húmedo de la Región Oriental (BHRO), according to the Manual of Families and Genders of Trees of Paraguay (2015), the others are in the other biogeographical regions, as presented in the table below.

Table 11 – Strata of native forest in Paraguay and the species found in the sampling

Species	BHRO	BSHC	BSHIRP	BSCH	BP
Dalbergia frutescens	x	x			
Enterolobium contortisiliquum	x		x		
Prosopis rubriflora			x	x	x
Priogymnanthus hasslerianus	x	x			
Celtis iguanaea	x		x	x	
Anadenanthera colubrina	x		x	x	
Balfourodendron riedelianum	x				

Species	BHRO	BSHC	BSHIRP	BSCH	BP
Chloroleucon chacoense			x	x	x
Ceiba chodatii	x	x	x	x	
Pterocarpus santalinoides	x		x		
Syagrus romanzoffiana	x		x		
Schaefferia argentinensis			x	x	
Parkinsonia praecox			x	x	
Croton sp.					
Rollinia salicifolia	x		x		
Ximenia americana			x	x	
Allophylus edulis	x		x		
Prosopis ruscifolia			x	x	x
Tabernaemontana catharinensis	x	x	x		
Zanthoxylum rhoifolium	x		x	x	
Aspidosperma triternatum	x	x	x	x	
Ziziphus mistol	x		x	x	
Sapium haematospermum	x		x	x	x
Handroanthus heptaphyllus	x		x	x	
Cecropia pachystachya	x		x		
Schinopsis balansae	x	x	x	x	
Pouteria sp.					
Samanea tubulosa	x	x	x		
Casearia sylvestris	x		x		
Trichilia catigua	x		x		
Eugenia sp.					

Source: Manual de Familias y Géneros de Árboles del Paraguay (2015) BHRO: Eastern Region Humid Forest; BSHC: Cerrado Subhumid Forest; BSHIRP: Paraguay River Flooded Subhumid Forest; BSCH: Chaco Dry Forest; BP: Palmar Forest.

Families with the highest values of IVC (index of coverage value) were Fabaceae (114.81) and Oleaceae (13.47). Of the 20 families in the sample, the Fabaceae with nine species (24,32%) represents the richest species, followed by Rutaceae, Euphorbiaceae, Apocynaceae, Annonaceae y Sapindaceae all with two species (5,41%), the other families were represented by one species each. Considering the dominance, density and relative frequency, the following figure presents the IVI (index of value of importance) of the most representative families in the sample.

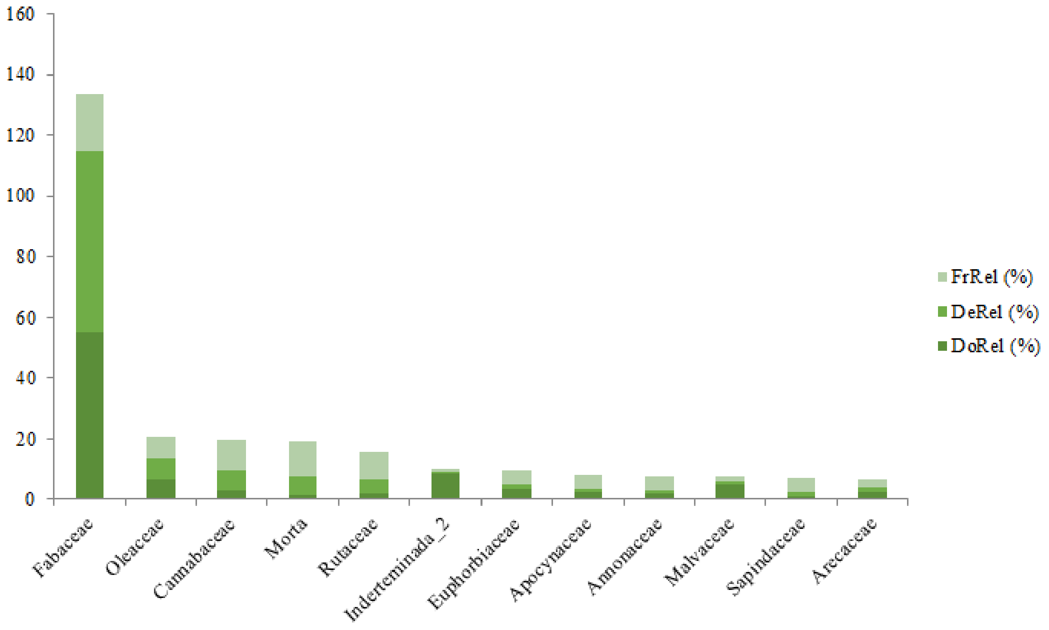


Figure 205 – Graph showing the distribution of the structural parameters related to the IVI of the points sampled. Legend: FrRel: Relative frequency; DeRel: Relative density; DoRel: Relative dominance.

In relation to the structure, this phytophysiology has an average diameter of 13.13 cm. The diametric distribution shows that this phytophysiology is composed of small trees with a high concentration of individuals between 4 and 13 cm of trunk circumference (49.5%).

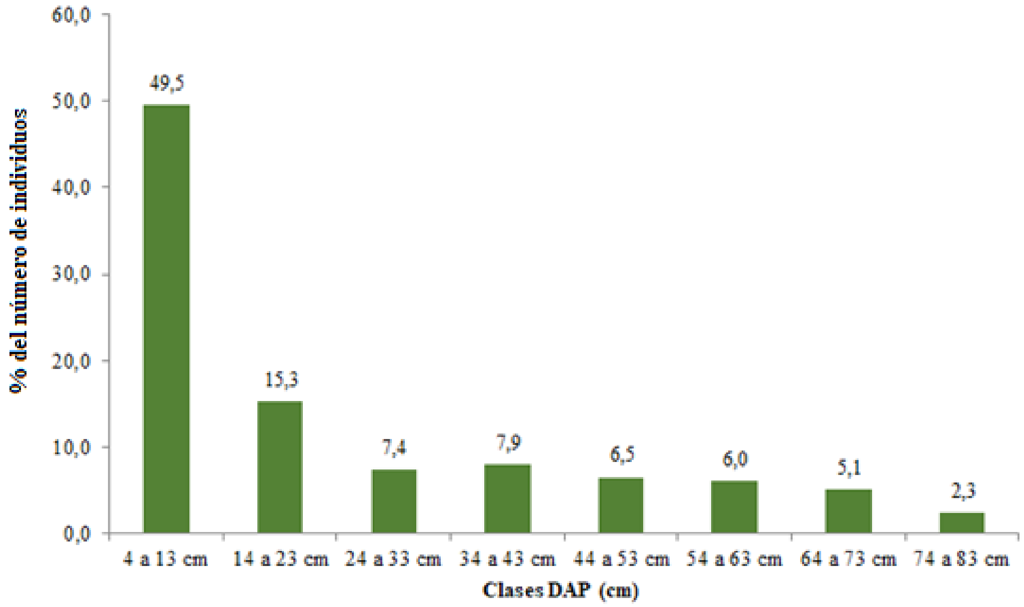


Figure 206 – Distribution of diameter classes (DBH) of individuals sampled in the ADA.

The average height was 4.87 m and the distribution of the total height indicates that 49.5% of the individuals have heights between 4.0 and 6.0 meters.

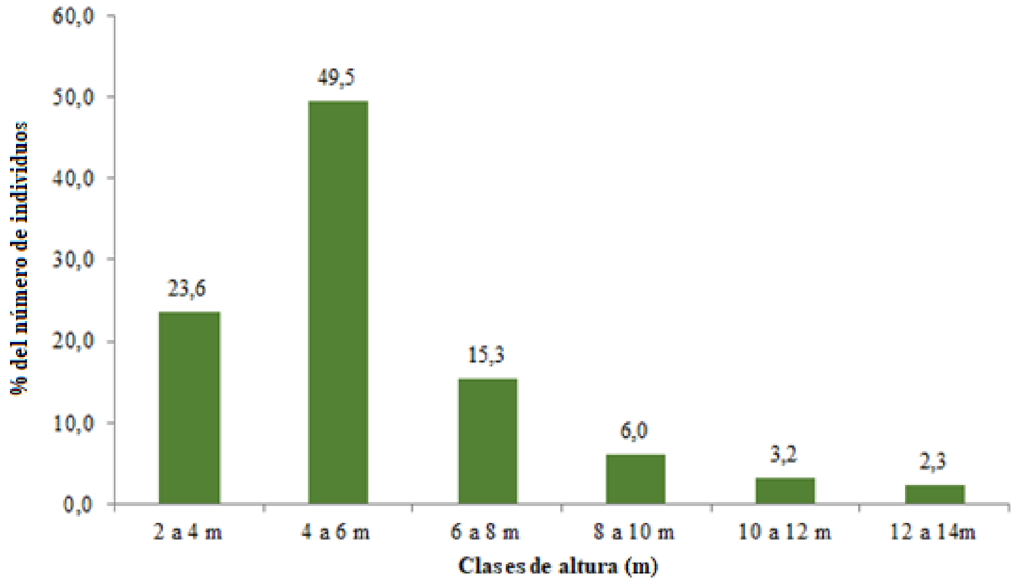


Figure 207 – Distribution of height classes of individuals sampled in the ADA.

The phytosociological parameters of the sampled tree species will be presented in the table below.

Table 12 – Phytosociological parameters of the tree community NInd - Number of individuals; NAm - Number of samples; AbsDe - Absolute density; RelDe - Relative density; AbsFr - Absolute frequency; RelFr - Relative frequency; AbsDo - Absolute dominance; RelDo - Relative dominance; IVI - Importance value index; IVC - Coverage value index

Species	NInd	NAm	AbsDe	RelDe	AbsFr	RelFr	AbsDo	RelDo	IVI	IVC
Dalbergia frutescens (Vell.) Britton	62	6	206,70	28,70	40,00	7,23	3,72	22,00	57,94	50,71
Enterolobium contortisiliquum (Vell.) Morong	6	4	20,00	2,78	26,67	4,82	3,21	19,02	26,62	21,80
Prosopis rubriflora Hassl.	37	3	123,30	17,13	20,00	3,61	0,59	3,51	24,25	20,63
Priogymnanthus hasslerianus (Chodat) P.S.Green	15	5	50,00	6,94	33,33	6,02	1,10	6,53	19,49	13,47
Celtis iguanaea (Jacq.) Sarg. [sin. *Celtis pubescens* (Humboldt & Bonpland) Sprengel]	15	7	50,00	6,94	46,67	8,43	0,46	2,75	18,13	9,69
Morta	13	8	43,30	6,02	53,33	9,64	0,26	1,56	17,22	7,58
Anadenanthera colubrina (Vell.) Brenan	4	3	13,30	1,85	20,00	3,61	1,12	6,65	12,12	8,50
Balfourodendron riedelianum Engl.	6	6	20,00	2,78	40,00	7,23	0,25	1,48	11,49	4,26
Indeterminate sp.2	1	1	3,30	0,46	6,67	1,20	1,42	8,38	10,05	8,84
Chloroleucon chacoense (Burkart) Barneby & J.W.Grimes	8	3	26,70	3,70	20,00	3,61	0,12	0,72	8,04	4,43
Ceiba chodatii (Hassl.) Ravenna	2	1	6,70	0,93	6,67	1,20	0,85	5,01	7,14	5,93
Pterocarpus santalinoides L'Hér. ex DC.	3	2	10,00	1,39	13,33	2,41	0,41	2,44	6,24	3,83
Syagrus romanzoffiana (Cham.) Glassman	3	2	10,00	1,39	13,33	2,41	0,41	2,41	6,21	3,80
Schaefferia argentinensis Speg.	1	1	3,30	0,46	6,67	1,20	0,61	3,62	5,28	4,08
Parkinsonia praecox (Ruiz & Pav.) Hawkins [sin. *Cercidium praecox* (Ruiz & Pav.) Harms]	5	2	16,70	2,31	13,33	2,41	0,08	0,49	5,21	2,80
Croton sp.	1	1	3,30	0,46	6,67	1,20	0,60	3,53	5,20	4,00
Rollinia salicifolia Schltdl.	2	2	6,70	0,93	13,33	2,41	0,29	1,74	5,08	2,67
Ximenia americana L.	3	2	10,00	1,39	13,33	2,41	0,16	0,92	4,72	2,31
Allophylus edulis (A.St.-Hil., A.Juss. & Cambess.) Radlk.	2	2	6,70	0,93	13,33	2,41	0,12	0,71	4,04	1,63
Prosopis ruscifolia Griseb.	3	2	10,00	1,39	13,33	2,41	0,02	0,14	3,94	1,53

Species	NInd	NAm	AbsDe	RelDe	AbsFr	RelFr	AbsDo	RelDo	IVI	IVC
Tabernaemontana catharinensis A.DC.	2	2	6,70	0,93	13,33	2,41	0,05	0,32	3,65	1,24
Zanthoxylum rhoifolium Lam.	4	1	13,30	1,85	6,67	1,20	0,09	0,55	3,61	2,40
Aspidosperma triternatum Rojas Acosta	1	1	3,30	0,46	6,67	1,20	0,32	1,90	3,57	2,36
Ziziphus mistol Griseb. [sin. *Ziziphus oblongifolius* S.Moore]	2	2	6,70	0,93	13,33	2,41	0,04	0,21	3,54	1,13
Sapium haematospermum Müll.Arg.	2	2	6,70	0,93	13,33	2,41	0,02	0,10	3,43	1,02
Inderteminada sp.	2	1	6,70	0,93	6,67	1,20	0,08	0,46	2,59	1,39
Handroanthus heptaphyllus (Vell.) Mattos	1	1	3,30	0,46	6,67	1,20	0,14	0,81	2,48	1,28
Cecropia pachystachya Trécul	1	1	3,30	0,46	6,67	1,20	0,10	0,60	2,27	1,07
Indeterminate sp.4	1	1	3,30	0,46	6,67	1,20	0,07	0,44	2,11	0,90
Schinopsis balansae Engl.	1	1	3,30	0,46	6,67	1,20	0,05	0,32	1,99	0,78
Pouteria sp.	1	1	3,30	0,46	6,67	1,20	0,05	0,28	1,94	0,74
Samanea tubulosa (Benth.) Barneby & J.W.Grimes	1	1	3,30	0,46	6,67	1,20	0,02	0,11	1,78	0,58
Casearia sylvestris Sw.	1	1	3,30	0,46	6,67	1,20	0,02	0,11	1,78	0,58
Indeterminate sp.1	1	1	3,30	0,46	6,67	1,20	0,01	0,06	1,72	0,52
Trichilia catigua A.Juss.	1	1	3,30	0,46	6,67	1,20	0,01	0,05	1,72	0,51
Indeterminate sp.3	1	1	3,30	0,46	6,67	1,20	0,01	0,04	1,70	0,50
Eugenia sp.	1	1	3,30	0,46	6,67	1,20	0,01	0,04	1,70	0,50

With regard to floristic similarity between the plots, of the 31 species identified, only *Celtis iguanaea* was found in 7 sampling units, followed by the species *Dalbergia frutescens*e e *Balfourodendron riedelianum* sampled in 6 plots, *Priogymnanthus hasslerianus* sampled in 5 plots, and finally the species *Enterolobium contortisiliquum* sampled in 4 plots.

Cluster analysis is a method of numerical classification, with the objective of defining groups with different degrees of similarity, that is, it identifies objects that are sufficiently similar to be placed in the same group (Legendre, P; Legendre, L, 1998 *apud* Felfili, *et al*, 2011). The coefficient adopted was Bray-Curtis which is a similarity index for abundance data.

In accordance with Mueller-Dombois & Ellenberg (1974) two or more areas are considered similar in terms of floristic composition when they have at least 25% of common species.

The similarity dendrogram between the study plots showed the tendency to form two groups, one composed of the plots P9, P11, P7, P8, P10 and P12 and another composed of the plots P2, P4, P3, P5, P1, P6, P13, P16 and P17. The highest similarity rate obtained was 84% between plots P10 and P12.

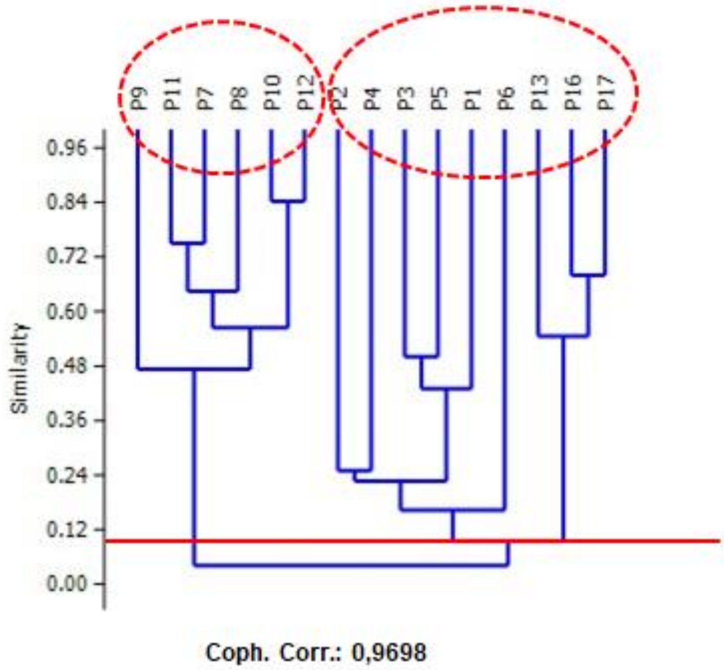


Figure 208 – Bray-Curtis similarity dendrogram between sampled areas. Legend: P: plot (20x10 m).

Equitability is derived from the Shannon diversity index, and makes it possible to represent the way in which the number of individuals is distributed among the different species (Pielou, 1966), which indicates whether the different species have a similar or divergent abundance (number of individuals). Its value presents a range from 0 (minimum uniformity) to 1 (maximum uniformity).

The following figure presents the Pielou (J') equation diagram generated for the sampling carried out, where the index variation was from the lowest 0.50, found in plot P16 to 0.98, found in plot P6.

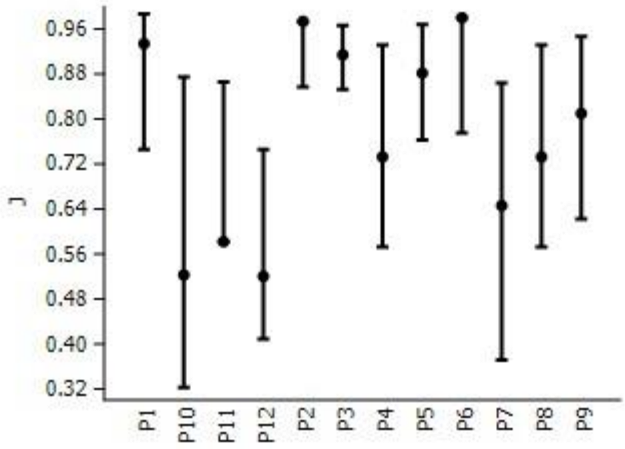


Figure 209 – Diagram Pielou (J'). Legend: P - parcela (20 x10m).

Regarding the efficiency of the study, a random species accumulation curve was constructed, considering the accumulated number of species recorded by the method of the diagram, in which a total of 31 species were added.

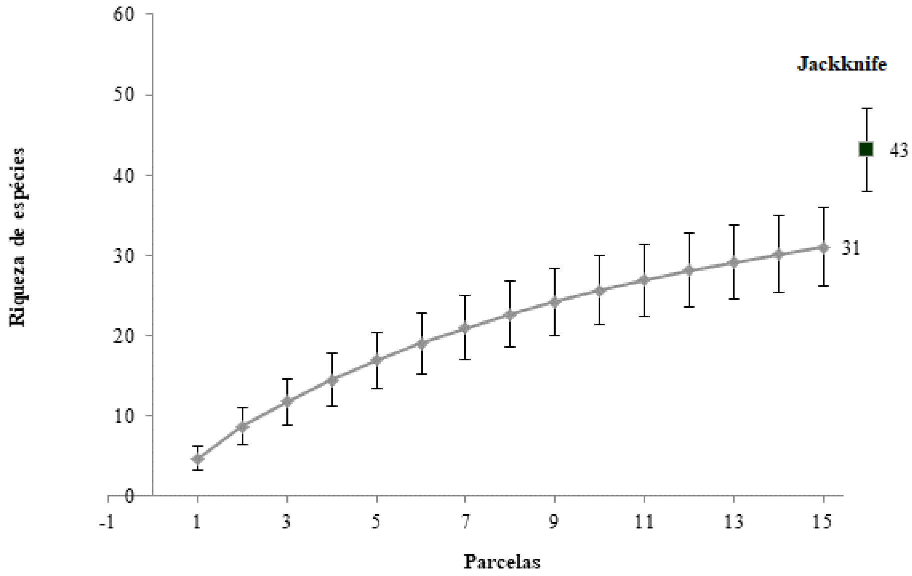


Figure 210 – Random accumulation curve of observed and expected species by the Jackknife estimator.

The Jackknife estimator assumes a total of 43 species for the areas sampled, with a deviation of about 5.27. However, it should be noted that in the present study five specimens were called indeterminate, because they did not present structures such as flowers and/or fruits that would help in their identification. When considering the number of species recorded in the floristic survey (144 spp) it is understood that increasing the sampling effort will always increase the value of richness and approach the maximum number of species, so the greater the sampling effort made, the greater the probability of increasing the record of a new species. Therefore, the sampling effort is considered satisfactory for this study.

Final considerations about Flora

The vegetation cover of a certain region is directly linked to the regulatory functions of the environment. Environmental factors such as temperature, altitude and the availability of nutrients in the soil are decisive for its physiognomy, its floristic composition and the grouping and distribution of species. Therefore, the identification of species occurring in a given geographical area represents an important step in the knowledge of an ecosystem by providing basic information for environmental studies.

From the species sampled in this study, five are listed in the lists of flora species in danger of extinction consulted (SEAM Resolution 524/2006 and SEAM Resolution 2,243/2006): the "jatai" *(Butia paraguayensis)*,"grapia"*(Apuleia leiocarpa)*, "algarrobo" (*Prosopis alba*), "preto carob" (*Prosopis nigra*) and the "guatambu" (*Balfourodendron riedelianum*) is endangered by IUCN 2021.

One of the greatest pressures on ecosystems is related to the reduction of natural environments due to deforestation. The areas of influence of the PARACEL pulp mill are highly anthropized and with low connectivity between the remaining vegetation, intensive use for livestock is another major pressure factor on these environments. Regarding vegetation cover, it is partly affected by anthropogenic occupations and economic activities already consolidated in the region.

The implementation of the pulp mill will require the suppression of approximately 3.99 ha of remaining vegetation of the Semideciduous Forest and 0.31 ha of remaining vegetation of the Savannah (african grasses) at riparian area for the implantation of the water intake system, the terrestrial emissary of treated effluents and the river port. Knowing that this area currently contains some 150 ha of native forest remnants, so the suppression will correspond only to 2,7% of the existing native forest. Paracel has committed to compensate the suppression by increasing the native area in relation to the current situation, specially enlarging the riparian areas, with approximately 250 ha, so that the net increase will represent approximately 400 ha. The implementation of the project will determine a native forest coverage in 30% of the mill site, compared to the 12% that it currently occupies. This compensation measure thus determines an increase in the native area of approximately 150% in relation to the current situation.

Vegetation suppression tends to cause loss of wildlife habitat, loss of critical areas for certain wildlife groups that use the area as breeding grounds, stopping of migratory animals and dispersion of corridors, which may impact on the genetic variability of some populations.

The adoption of ecological corridors between remaining fragments, especially those associated with waterways, which will not be affected by the project, can promote the movement of these species by ensuring their permanence and reproduction.

Considering the results obtained in this study, it is concluded that the implementation of the industrial plant and associated civil structures of the PARACEL Pulp Mill will have a local impact on the vegetation, however, there will be no impact on the connectivity of the remaining environment; the fragments and dispersed tree specimens affected are located within the site - Zapatero Cue Farm.

In conclusion, the project forecasts the suppression of and/or interference with the remaining fragments of the Savannah and Semideciduous forest located within the DAA and the intervention in the protective forest of the Paraguay River, where the ciliary vegetation fulfills an environmental function, which is to protect the margins of these and other bodies of water. It should be noted that, despite evidences of the effects of human activities on the remaining native vegetation, these continue to support the maintenance of native fauna and flora species. Therefore, any removal must be duly authorized in accordance with environmental law in force.

Paracel has committed to compensate the suppression by increasing the native area in relation to the current situation, specially enlarging the riparian areas, with approximately 250 ha, so that the total area will represent approximately 400 ha. The implementation of the project will determine a native forest coverage in 30% of the mill site, compared to the 12% that it currently occupies. This compensation measure thus determines an increase in the native area of approximately 150% in relation to the current situation.

Moreover that 30% will also regenerate the riparian forest, now highly fragmented, and also connect the native areas of the neighbouring properties to the NW and SE acting as a biological corridor, now non-existent. Therefore, **it can be said that the positive impact on biodiversity would be well over 150% in relation to the current situation**.

As summary of what will happen within Paracel pulp mill property is as follows:

Table 13 – Vegetation cover and PS 6 Type in pulp mill property

Class ID	Class type	Area (ha)	Percentage	Nat/ Mod	Area (ha)	Percentage
1	Native forest	192.96	16%	Natural	205.02	17%
2	Floodable/ Waterland	12.06	1%			
3	Grassland/Pasture/Roads	1,000.98	83%	Modified	1,000.98	83%
Total		**1,206**	**100%**		**1,206**	

It should be noted that most part of the area where the mill will be located is a Savanna area (African grass), however, currenty used for pasture.

But Paracel has committed to compensate the suppression of 3.99 ha by increasing the native area in relation to the current situation, specially enlarging the riparian areas, with approximately 250 ha, by converting Grassland/Pasture lands to native forest. So the vegetation cover in the future will be as follows:

Table 14 – Future Vegetation cover and PS 6 Type in pulp mill property

Class ID	Class type	Area (ha)	Percentage	Nat/ Mod	Area (ha)	Percentage
1	Native forest	438.97	36.4%	Natural	451.03	37.4%
2	Floodable/ Waterland	12.06	1%			
3	Grassland/Pasture/Roads	754.94	62,6%	Modified	754.94	62,6%
Total		**1,206**	**100%**		**1,206**	

9.2.2 Fauna

9.2.2.1 Mammal fauna

9.2.2.1.1 Regional Characterization (IIA)

The Republic of Paraguay is a country located in the center of South America, bordered by Bolivia to the north, Argentina to the south and west, and Brazil to the northeast (LEVI, 1873). Due to its geographical position in the center of South America, important biomes of the continent extend to Paraguay, so the country is home to a great diversity of environments. According to the work of Dinerstein et al. (1995), Paraguay is divided into five phytogeographical regions: the Humid Chaco, the Dry Chaco, the Pantanal, the Upper Paraná Atlantic Forest and the Cerrado, resulting in a more diverse fauna and flora than expected (SANCHA et al., 2019).

Mammals are an important group in terms of the biological control mechanisms of communities, since their species have great potential to influence human life, acting on the regeneration of forest areas through seed dispersal, pollination and the herbivore level (SANTOS & LIMA, 2016). Paraguay has played an important role in the history of mammal taxonomy in South America, being one of the first sites in the Americas to be explored (SAINZ OLLERO et al., 1989). The first publication on Paraguay's natural history had a considerable impact on the mammal-zoological community and was written by Féliz de Azara (1742-1821), who described the basis of numerous currently recognized taxon, many of which are widely distributed mammal species (SANCHA et al., 2017). Six currently recognized marsupial species (GARDNER, 2008), two armadillos (GARDNER, 2008), one cat, two canids (WOZENCRAFT, 2005), three primates (GROVES, 2005), two deer (GRUBB, 2005), seven bats (LÓPEZ-GONZÁLEZ, 2005; SIMMONS, 2005) and 17 species of rodents (PATTON et al, 2015) were described on the basis of Paraguayan specimens (SANCHA et al. , 2017). Despite the long history of mammal research, basic knowledge about mammals in the country remains limited (SANCHA et al., 2017).

For the study of regional mammal fauna, secondary data were collected through the literature (MORALES, 2007; SANCHA et al., 2017; RUMBO, 2010). Thus, 185 species of mammals were recorded in Paraguay, distributed among winged and land mammals (small, medium and large), 30 families and 11 orders. Of this total, 19 species are classified as "threatened with extinction" in accordance with Resolution n. 632/2017, which updates the mammal species protected by the Republic of Paraguay. Among these, the Anteater stands out (*Myrmecophaga tridactyla*), the leopard tiger (*Leopardus tigrinus*), the maned wolf (*Chrysocyon brachyurus*), the tapir (*Tapir terrestre*), el whitebearded peccary (*Tayassu pecari*), the Swamp Deer (*Blastocerus dichotomus*) and the minor roe deer (*Mazama nana*). According to the same list, there are also eight species of mammals classified as "endangered", including the armadillo carreta (*Priodontes maximus*), the Jaguar (*Panthera onca*), the vinegar fox (*Speothos venaticus*) and the Pampas Deer (*Ozotoceros bezoarticus*).

In the case of globally threatened mammals, 23 species were recorded on the IUCN Red List of Threatened Species (IUCN, 2020). Among them, the Chaco Armadillo (*Cabassous chacoensis*), the Little armadillo (*Tolypeutes matacus*), the Mountain Rabbit (*Sylvilagus brasiliensis*), Pampas Cat (*Leopardus colocolo*) and the river otter (*Lontra longicaudis*), as seen in the Table bellow.

Table 15 – List of mammal species likely to be found in the IIA of PARACEL pulp mill

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Order Didelphimorphia Gill, 1872						
Family Didelphidae Gray, 1821						
Caluromys lanatus (Olfers, 1818)	Comadreja lanuda	X	X	X	AM	LC
Chironectes minimus (Zimmermann, 1780)	Lámpara de agua		X	X		LC
Cryptonanus chacoensis (Tate, 1931)	-		X			LC
Cryptonanus unduaviensis (Tate, 1931)	-		X			DD
Didelphis albiventris Lund, 1841	Comadreja común		X	X		LC
Didelphis aurita Wied-Neuwied, 1826	Comadreja orejuda	X	X	X		LC
Gracilinanus agilis (Burmeister, 1854)	Marmosa ágil		X	X		LC
Lutreolina crassicaudata (Desmarest, 1804)	Comadreja colorada		X	X		LC
Metachirus nudicaudatus (Desmarest, 1817)	Zorra morena	X	X	X	AM	LC
Marmosa constantiae (Thomas, 1904)	-		X			LC
Micoureus demerarae (Thomas, 1905)	Comadrejita grande gris	X				LC
Marmosa paraguayana (Tate, 1931)	Marmosa grande gris		X	X		LC
Monodelphis domestica (Wagner, 1842)	Colicorto gris		X	X		LC
Monodelphis kunsi Pine, 1975	Colicorto pigmeo		X			LC
Monodelphis sorex (Hensel, 1872)	Colicorto rojizo	X		X		LC
Philander frenatus (Olfers, 1818)	Comadreja		X	X		LC
Philander opossum (Linnaeus, 1758)	Comadreja		X			LC
Thylamys macrurus (Olfers, 1818)	Comadrejita cola corta	X	X	X		NT
Thylamys pusillus (Desmarest, 1804)	-		X	X		LC
Order Cingulata Illiger, 1811						
Family Dasypodidae Gray, 1821						
Dasypus hybridus (Desmarest, 1804)	Armadillo	X	X	X		NT
Dasypus novemcinctus Linnaeus, 1758	Mulita grande		X	X		LC
Euphractus sexcinctus (Linnaeus, 1758)	Tatú peludo		X	X		LC
Cabassous chacoensis Wetzel, 1980	Armadillo chaqueño de cola desnuda	X	X	X		NT
Cabassous tatouay (Desmarest, 1804)	Armadillo cola desnuda	X	X	X		LC
Calyptophractus retusus (Burmeister, 1863)	Pichiciego chaqueño	X	X	X		DD
Priodontes maximus (Kerr, 1792)	Tatú carreta	X	X	X	EP	VU
Tolypeutes matacus (Desmarest, 1804)	Tutú bolita	X	X	X		NT
Order Pilosa Flower, 1883						
Family Bradypodidae Gray, 1821						

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Bradypus variegatus (Schinz, 1825)	Peresozo de tres dedos	X				LC
Order Xenarthra						
Family Myrmecophagidae Gray, 1825						
Myrmecophaga tridactyla (Linnaeus, 1758)	Oso hormiguero	X	X	X	AM	VU
Tamandua tetradactyla (Linnaeus, 1758)	Oso melero		X	X		LC
Order Primates Linnaeus, 1758						
Family Cebidae Gray, 1831						
Callithrix argentata (Linnaeus, 1771)	Ca'i eléctrico	X		X		LC
Callithrix melanura (É. Geoffroy, 1812)	tití de cola negra		X		AM	-
Sapajus apella Linnaeus, 1758	Mono capuchino	X		X		LC
Sapajus cay (Illiger, 1815)	Mono Ka´i		X			LC
Family Atelidae Gray, 1825						
Alouatta caraya (Humboldt, 1812)	Mono aullador negro	X	X	X		LC
Family Aotidae Elliot, 1913						
Aotus azarae (Humboldt, 1811)	Mono nocturno	X	X	X		LC
Family Pitheciidae Mivart, 1865						
Callicebus pallescens Thomas, 1907	Mono Titi		X	X		LC
Plecturocebus donacophilus (D'Orbigny, 1836)	Ca'i ygáu	X				LC
Order Rodentia Bowdich, 1821						
Family Sciuridae G. Fischer, 1817						
Guerlinguetus ignitus (Gray, 1867)	-		X			-
Guerlinguetus spadiceus Olfers, 1818	-		X			-
Family Cricetidae G. Fischer, 1817						
Akodon azarae (J. Fischer, 1829)	-		X	X		LC
Akodon montensis (Thomas, 1913)	-		X	X		LC
Akodon paranaensis Christoff, Fagundes, Sbalqueiro, Mattevi e Yonenaga-Yassuda, 2000	-		X	X		LC
Akodon toba Thomas, 1921	-		X	X		LC
Bibimys chacoensis (Shamel, 1931)	Rata acuática	X	X	X	AM	LC
Calomys callosus (Rengger, 1830)	Laucha grande		X	X		LC
Calomys laucha (G. Fischer, 1814)	Laucha chica		X	X		LC
Calomys tener (Winge, 1887)	-		X			LC
Calomys musculinus (Thomas, 1913)	Laucha bimaculada		X	X		LC
Holochilus brasiliensis (Desmarest, 1819)	-		X	X		LC
Holochilus chacarius Thomas, 1906	-		X	X		LC
Juliomys pictipes Osgood, 1933	Laucha de pies manchados		X	X	AM	LC
Necromys lasiurus (Lund, 1841)	-		X	X		LC
Necromys lenguarum (Thomas, 1898)	Ratón cavador		X			LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Nectomys rattus Pelzeln, 1883	-		X			LC
Nectomys squamipes (Brants, 1827)	-			X		LC
Oecomys mamorae (Thomas, 1906)	-		X	X		LC
Oecomys franciscorum (Pardiñas et al. 2016)	-		X			-
Oligoryzomys chacoensis (Myers e Carleton, 1981)	-		X	X		LC
Oligoryzomys flavescens (Waterhouse, 1837)	-		X	X		LC
Oligoryzomys microtis (J. A. Allen, 1916)	-		X	X		LC
Oligoryzomys nigripes (Olfers, 1818)	-		X	X		LC
Oryzomys angouya Fischer, 1814	-		X	X		LC
Oryzomys maracajuensis Langguth e Bonvicino, 2002	-		X	X		LC
Oryzomys megacephalus Fischer, 1814	-		X	X		LC
Oryzomys russatus Wagner, 1848	-		X	X		LC
Oryzomys scotti Langguth e Bonvicino, 2002	-		X			LC
Graomys chacoensis (J. A. Allen, 1901)	Pericote común		X			DD
Graomys griseoflavus (Waterhouse, 1837)	-			X		LC
Oxymycterus delator Thomas, 1903	Ratón hocicudo negro	X	X	X		LC
Oxymycterus quaestor Thomas, 1903	-		X			LC
Oxymycterus misionalis Sanborn, 1931	-			X		-
Pseudoryzomys simplex (Winge, 1887)	-		X	X		LC
Rhipidomys macrurus Gervais, 1855	Cerrado Rhipidomys		X		AM	LC
Scapteromys tumidus (Waterhouse, 1837)	-		X			LC
Scapteromys aquaticus Thomas, 1920	-			X		LC
Thaptomys nigrita (Lichtenstein, 1829)	-		X			LC
Ctenomys dorsalis Thomas, 1900	Tuco-tuco		X	X	EP	DD
Ctenomys conoveri Osgood, 1946	Tuca-tuca		X	X		LC
Ctenomys paraguayensis	Tuco-tuco	X	X		EP	-
Ctenomys pilarensis Contreras, 1993	Tuco-tuco	X	X			EN
Ctenomys boliviensis Waterhouse, 1848	Tuco-tuco			X		LC
Family Echimyidae Gray, 1825						
Clyomys laticeps (Thomas, 1909)	Ratón espinoso	X	X	X		LC
Euryzygomatomys spinosus (G. Fischer, 1814)	Ratón espinoso	X	X	X		LC
Proechimys longicaudatus (Rengger, 1830)	-		X	X		LC
Thrichomys apereoides (Lund, 1839)	-		X	X		LC
Kannabateomys amblyonyx (Wagner, 1845)	Rata tacuarera	X	X	X		LC
Family Erethizontidae Bonaparte, 1845						

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Coendou prehensilis (Linnaeus, 1758)	Puercoespín		X	X		LC
Sphiggurus spinosus (F. Cuvier, 1823)	Puerco espín	X	X	X		-
Family Caviidae G. Fischer, 1817						
Cavia aperea Erxelben, 1777	Cuis		X	X		LC
Galea leucoblephara (Burmeister, 1861)	-		X			LC
Dolichotis salinicola Burmeister, 1876	Conejo Del Palo		X	X		LC
Hydrochoerus hydrochaeris (Linnaeus, 1766)	Carpincho		X	X		LC
Family Dasyproctidae Bonaparte, 1838						
Dasyprocta azarae (Lichtenstein, 1823)	Agutí de Azara	X	X	X		DD
Family Cuniculidae Miller e Gidley, 1918						
Cuniculus paca (Linnaeus, 1766)	Paca	X	X	X		LC
Family Myocastoridae Ameghino, 1904						
Myocastor coypus (Molina, 1782)	Falsa nutria		X	X		LC
Order Lagomorpha Brandt, 1855						
Family Leporidae G. Fischer, 1817						
Sylvilagus brasiliensis (Linnaeus, 1758)	Conejito de monte		X	X		EN
Order Chiroptera Blumenbach, 1779						
Family Phyllostomidae Gray, 1825						
Chrotopterus auritus (Peters, 1856)	Falso vampiro orejón		X	X		LC
Lophostoma brasiliense (Peters, 1867)	Murciélago oreja redonda	X				LC
Lophostoma silvicolum d'Orbigny, 1836	Murciélago oreja redonda	X	X	X		LC
Macrophyllum (schinz, 1821)	Falso vampiro pata larga	X	X	X	AM	LC
Mimon crenulatum (É. Geoffroy, 1810)	-		X			LC
Phyllostomus discolor (Wagner, 1843)	-		X			LC
Phyllostomus hastatus (Pallas, 1767)	-		X			LC
Tonatia bidens (Spix, 1823)	Murciélago oreja redonda	X	X	X		DD
Artibeus fimbriatus (Gray, 1838)	Frutero grande oscuro		X	X		LC
Artibeus lituratus (Olfers, 1818)	Frutero grande de listas blancas		X	X		LC
Chiroderma doriae (Thomas, 1891)	Murciélago de ojos grandes	X	X		AM	LC
Platyrrhinus lineatus (É. Geoffroy, 1810)	Murciélago de listado de Geoffroy	X	X	X		LC
Pygoderma bilabiatum (Wagner, 1843)	Murciélago de hombros blancos		X	X		LC
Vampyressa pusilla (Wagner, 1843)	Murciélago frutero de oreja amarilla	X	X	X	AM	DD
Sturnira lilium (É. Geoffroy, 1810)	Frutero común		X	X		LC
Desmodus rotundus (É. Geoffroy, 1810)	Vampiro común		X	X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Diaemus youngi (Jentink, 1893)	Vampiro de alas blancas		X	X		LC
Anoura caudifer (É. Geoffroy, 1818)	Falso vampiro hocicudo	X				LC
Glossophaga soricina (Pallas, 1766)	Murciélago nectarivoro		X	X		LC
Carollia perspicillata (Linnaeus, 1758)	Murcielago frutero		X	X		LC
Peropteryx macrotis (Wagner, 1843)	Muerciélago canino cola larga	X	X	X	AM	LC
Saccopteryx leptura (Schreber, 1774)	-		X			LC
Family Molossidae Gervais, 1856						
Cynomops abrasus (Temminck, 1827)	-		X	X		DD
Cynomops planirostris (Peters, 1866)	Moloso de pecho blanco		X	X		LC
Eumops auripendulus (Shaw, 1800)	Moloso oscuro		X	X		LC
Eumops bonariensis (Peters, 1874)	Moloso orejas anchas pardo		X	X		LC
Eumops glaucinus (Wagner, 1843)	Moloso acanelado		X	X		LC
Eumops patagonicus Thomas, 1924	Moloso gris de orejas anchas		X			LC
Eumops perotis (Schinz, 1821)	Moloso orejón grande		X	X		LC
Eumops dabbenei (Thomas, 1914)	Moloso grande		X	X		LC
Molossops temminckii (Burmeister, 1854)	Moloso pigmeo		X	X		LC
Molossus currentium Thomas, 1901	Molosso cola gruesa Correntino		X			LC
Molossus (Pallas, 1766)	Moloso cola gruesa chica		X	X		LC
Molossus rufus É. Geoffroy, 1805	Moloso cola gruesa grande		X	X		LC
Nyctinomops laticaudatus (É. Geoffroy, 1805)	Moloso labios arrugados chico		X	X		LC
Nyctinomops macrotis (Gray, 1840)	Moloso labios arrugados grande		X			LC
Promops centralis Thomas, 1915	Moloso cola larga grande		X	X		LC
Promops nasutus (Spix, 1823)	Moloso cola larga chica		X	X		LC
Tadarida brasiliensis (I. Geoffroy, 1824)	Moloso común		X	X		LC
Family Vespertilionidae Gray, 1821						
Eptesicus brasiliensis (Desmarest, 1819)	Murciélago pardo		X	X		LC
Eptesicus diminutus Osgood, 1915	Murciélago pardo chico		X	X		LC
Eptesicus furinalis (d'Orbigny, 1847)	Murciélago pardo común		X	X		LC
Lasiurus blossevillii (Lesson e Garnet, 1826)	-		X	X		LC
Lasiurus cinereus (Palisot de Beauvois, 1796)	Murciélago escarchado grande		X	X		LC
Lasiurus ega (Gervais, 1856)	-		X	X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Histiotus macrotus (Poeppig, 1835)	Murciélago orejón grande	X	X			LC
Histiotus velatus (I. Geoffroy, 1824)	Murciélago orejón tropical	X	X	X		DD
Myotis albescens (É. Geoffroy, 1805)	Murciélaguito de vientre blanco		X	X		LC
Myotis levis (I. Geoffroy, 1824)	Murciélaguito amarillento		X	X		LC
Myotis midastactus Moratelli and Wilson, 2014	-		X			-
Myotis nigricans (Schinz, 1821)	Murciélaguito oscuro		X	X		LC
Myotis riparius Handley, 1960	Murciélaguito ochráceo		X	X		LC
Myotis ruber (É. Geoffroy, 1906)	Murciélago acanelado de Azara	X	X	X	AM	NT
Myotis simus Thomas, 1901	Murciélaguito afelpado		X	X		DD
Family Noctilionidae Gray, 1821						
Noctilio albiventris Desmarest, 1818	Murciélago pescador chico		X	X		LC
Noctilio leporinus (Linnaeus, 1758)	Murciélago pescador grande		X	X		LC
Family Natalidae Miller, 1899						
Natalus stramineus Gray, 1838	Murciélago oreja de embudo	X	X	X		LC
Order Carnivora Bowdich, 1821						
Family Felidae G. Fischer, 1817						
Leopardus colocolo (Molina, 1782)	Gato del pajonal	X	X	X		NT
Leopardus geoffroyi (Gervais e d'Orbigny, 1844)	Tirica	X	X	X		LC
Leopardus pardalis (Linnaeus, 1758)	Gato onza	X	X	X		LC
Leopardus tigrinus (Schreber, 1775)	Leopardo tigre	X	X	X	AM	VU
Leopardus wiedii (Schinz, 1821)	Gato tigrillo	X	X	X	AM	NT
Puma concolor (Linnaeus, 1771)	Puma	X	X	X		LC
Puma yagouaroundi (Lacépède, 1809)	Yaguarundí	X	X	X		LC
Panthera onca (Linnaeus, 1758)	Yaguareté	X	X	X	EP	NT
Family Canidae G. Fischer, 1817						
Cerdocyon thous (Linnaeus, 1766)	zorro de monte	X	X	X		LC
Chrysocyon brachyurus (Illiger, 1815)	lobo de crin	X	X	X	AM	NT
Lycalopex gymnocercus (G. Fischer, 1814)	Zorro de las pampas	X	X	X		LC
Lycalopex vetulus Lund, 1842	Yaguá yvyguy	X				LC
Speothos venaticus (Lund, 1842)	Zorro vinagre		X	X	EP	NT
Family Mustelidae G. Fischer						
Eira barbara (Linnaeus, 1758)	Hurón mayor	X	X	X		LC
Galictis cuja (Molina, 1782)	Grisón menor		X	X		LC
Galictis vittata (Schreber, 1776)	Grisón mayor		X			LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY (2017)	IUCN (2020)
Lontra longicaudis (Olfers, 1818)	Nutria de río	X	X	X		NT
Pteronura brasiliensis (Gmelin, 1788)	Nutria gigante	X	X	X	EP	EN
Family Mephitidae Bonaparte, 1845						
Conepatus humboldtii Gray, 1837	Huroncito	X				LC
Conepatus chinga (Molina, 1782)	Zorrino		X	X		LC
Family Procyonidae Gray, 1825						
Nasua (Linnaeus, 1766)	Coati	X	X	X		LC
Procyon cancrivorus (G. Cuvier, 1798)	Mapache comedor de cangrejos		X	X		LC
Order Perissodactyla Owen, 1848						
Family Tapiridae Gray, 1821						
Tapirus terrestris (Linnaeus, 1758)	Tapir	X	X	X	AM	VU
Order Artiodactyla Owen, 1848						
Family Tayassuidae Palmer, 1897						
Catagonus wagneri (Rusconi, 1930)	Taguá	X	X	X	EP	EN
Pecari tajacu (Linnaeus, 1758)	Pecarí de collar	X	X	X		LC
Tayassu pecari (Link, 1795)	Pecarí barbiblanco	X	X	X	AM	VU
Family Cervidae Goldfuss, 1820						
Blastocerus dichotomus (Illiger, 1815)	Ciervo de los pantanos	X	X	X	AM	VU
Mazama americana (Erxleben, 1777)	Corzuela roja	X		X		DD
Mazama gouazoubira (G. Fischer, 1814)	-		X	X		LC
Mazama nana (Hensel, 1872)	Corzuela menor	X	X	X	AM	VU
Ozotoceros bezoarticus (Linnaeus, 1758)	Ciervo de las pampas	X	X	X	EP	NT

References: (A) – MORALES, 2007; **(B)** – SANCHA *et al*., 2017; **(C)** – RUMBO, 2010. **Categories of threats: PY 2017** – Resolution n 632/2017 of *Paraguay Environmental Secretariat*. **IUCN 2020** – *The IUCN Red List of Threatened Species*, versión 2020-11 **caption: EP** – endangered of extinction; **AM** – threatened of extinction; **EN** – endangerous; **VU** – vulnerable; **NT** – not threatened ; **LC** – Less concern; **DD** – deficient data.

9.2.2.2 Avifauna

9.2.2.2.1 Regional Characterization (IIA)

Birds are a notoriously important group in environmental analysis, as they are considered powerful bio-indicators due to their relative ease of study, the specific requirements of the territory and habitat, and the levels of sensitivity to changes in the environment (ALGER-DE-OLIVEIRA, 1993), and are widely used in environmental studies and the implementation of mitigation measures.

Paraguay's avifauna has been little explored scientifically for many years, and its first study of occurrence and distribution was published in 1995 (HAYES, 1995), with 645 species catalogued in the country. In 2004, this total was modified to 685 species (GUYRA PARAGUAY, 2004) and, in 2013, to 701 confirmed bird species (DEL CASTILLO, 2013). Currently, the biodiversity database of the Guyra Paraguay Association has 836 birds, among which are confirmed and not yet evaluated species. Although this figure is slightly lower than that of other Neotropical countries, it is considerably higher than that of areas of similar size in neighboring countries (CARTES & CLAY, 2009).

The convergence of five ecoregions in Paraguay gives rise to an abundant diversity of fauna and flora. These five phytogeographic regions (the Humid Chaco, Dry Chaco, Pantanal, Upper Paraná Atlantic Forest and Cerrado) are of great value for conservation (OLSON & DINERSTEIN, 2002; MITTERMEIER et al., 1999; DINERSTEIN, 1995) and have numerous globally threatened bird species (CARTES & CLAY, 2009). According to Birdlife International (2007), in Paraguay there are a total of 27 globally threatened bird species and 23 species classified as Near Threatened, of which five are probably extinct in the country: *Taoniscus nanus*, *Mergus octosetaceus*, *Leucopternis polionotus*, *Numenius borealis* and *Anodorhynchus glaucus*.

Among the phytogeographic regions of the country, the Atlantic Forest and the Cerrado are considered biodiversity hot spots due to the high concentration of endemic species, added to the exceptional loss of habitat (MYERS et al., 2000). However, because Paraguay is an ecotone country with ecoregions shared with neighboring countries, only one species of dubious taxonomic validity is endemic to Paraguay: *Nothura chacoensis* (CARTES & CLAY, 2009). The Gran Chaco and the Pantanal are recognized as the last natural areas due to their relatively not altered status, their rich diversity and their low rate of human occupation (MITTERMEIER et al., 2002). The Chaco wetland in eastern Paraguay is an important resting place for migratory birds during their movements between the breeding grounds in northern Argentina and southern Paraguay and their largely unknown wintering grounds in central Brazil (CARTES & CLAY, 2009).

For the characterization of regional birdlife through literature, the surveys conducted by BENITES et al (2017) and STRAUBE et al (2006) were consulted. In addition, the global eBird database was consulted for the inclusion of birds in the region of Concepción, PY. In total, 477 bird species were studied, distributed among 71 families and 25 orders. Among these, 70 are included in Resolution MADES 254/19, which lists the bird species considered "endangered" and "threatened with extinction" of the national fauna. In addition, of the total number of birds studied, 27 appear in some category of global threat according to the IUCN Red List of Threatened Species (IUCN, 2020), as shown in Table bellow. It is worth mentioning the registration of 21 regional species that are threatened both at the national level (Resolution 254/19) and at the global level (IUCN, 2020), such as *Tinamus solitarius*, *Crax fasciolata*, *Urubitinga* *coronata*, *Morphnus guianensis*, *Harpia harpyja*, *Spizaetus ornatus*, *Laterallus xenopterus*, *Hydropsalis anomala*,), *Primolius maracana*, *Pyrrhura devillei*, *Alipiopsitta xanthops*, *Procnias nudicollis*, *Phylloscartes paulista*, *Culicivora caudacuta*, *Polystictus pectoralis*, *Alectrurus tricolor*, *Alectrurus risora*, *Neothraupis fasciata*, *Sporophila palustris* and *Sporophila cinnamomea*.

Table 16 – List of probable bird species for the IIA of PARACEL's pulp mill

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Order Rheiformes Forbes, 1884						
Family Rheidae Bonaparte, 1849						
Rhea americana (Linnaeus, 1758)	Ñandú Común	X	X	X		NT
Order Tinamiformes Huxley, 1872						
Family Tinamidae Gray, 1840						
Tinamus solitarius (Vieillot, 1819)	Tinamú Macuco			X	EP	NT
Crypturellus obsoletus (Temminck, 1815)	Tinamú Café			X	AM	LC
Crypturellus undulatus (Temminck, 1815)	Tinamú ondeado	X	X	X		LC
Crypturellus parvirostris (Wagler, 1827)	Tinamú piquicorto	X	X	X		LC
Crypturellus tataupa (Temminck, 1815)	Tinamú Tataupá	X	X	X		LC
Rhynchotus rufescens (Temminck, 1815)	Tinamú alirrojo	X		X		LC
Nothura boraquira (Spix, 1825)	Tinamú Ventriblanco	X	X			LC
Nothura maculosa (Temminck, 1815)	Tinamú chaqueño	X	X	X		LC
Order Anseriformes Linnaeus, 1758						
Family Anhimidae Stejneger, 1885						
Chauna torquata (Oken, 1816)	Chajá Común	X	X	X		LC
Family Anatidae Leach, 1820						
Dendrocygna viduata (Linnaeus, 1766)	Suirirí Cariblanco		X	X		LC
Dendrocygna autumnalis (Linnaeus, 1758)	Suirirí Piquirrojo	X	X	X		LC
Neochen jubata (Spix, 1825)	Pato de Crin		X			NT
Cairina moschata (Linnaeus, 1758)	Pato Criollo	X	X	X		LC
Callonetta leucophrys (Vieillot, 1816)	Pato Acollarado	X		X		LC
Amazonetta brasiliensis (Gmelin, 1789)	Pato Brasileño	X	X	X		LC
Nomonyx dominicus (Linnaeus, 1766)	Malvasía Enmascarada	X		X		LC
Order Galliformes Linnaeus, 1758						
Family Cracidae Rafinesque, 1815						
Penelope superciliaris Temminck, 1815	Pava Yacupemba	X		X		LC
Aburria cumanensis (Jacquin, 1784)	Pava Goliazul	X	X	X		LC
Ortalis canicollis (Wagler, 1830)	Chachalaca Charata	X	X	X		LC
Crax fasciolata Spix, 1825	Pavón Muitú	X		X	AM	VU
Family Odontophoridae Gould, 1844						
Odontophorus capueira (Spix, 1825)	Corcovado Urú			X	AM	LC
Order Podicipediformes Fürbringer, 1888						
Family Podicipedidae Bonaparte, 1831						

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Tachybaptus dominicus (Linnaeus, 1766)	Zampullín Macacito	X		X		LC
Podilymbus podiceps (Linnaeus, 1758)	Zampullín Picogrueso			X		LC
Order Ciconiiformes Bonaparte, 1854						
Family Ciconiidae Sundevall, 1836						
Ciconia maguari (Gmelin, 1789)	Cigüeña Maguari	X	X	X		LC
Jabiru mycteria (Lichtenstein, 1819)	Jabirú Americano	X	X	X		LC
Mycteria americana Linnaeus, 1758	Tántalo Americano	X	X	X		LC
Order Suliformes Sharpe, 1891						
Family Phalacrocoracidae Reichenbach, 1849						
Nannopterum brasilianus (Gmelin, 1789)	Cormorán Biguá	X	X	X		LC
Family Anhingidae Reichenbach, 1849						
Anhinga anhinga (Linnaeus, 1766)	Anhinga Americana	X	X	X		LC
Order Pelecaniformes Sharpe, 1891						
Family Ardeidae Leach, 1820						
Tigrisoma lineatum (Boddaert, 1783)	Avetigre Colorada	X	X	X		LC
Cochlearius cochlearius (Linnaeus, 1766)	Martinete Cucharón	X	X			LC
Nycticorax nycticorax (Linnaeus, 1758)	Martinete Común	X	X	X		LC
Butorides striata (Linnaeus, 1758)	Garcita Verdosa	X	X	X		LC
Bubulcus ibis (Linnaeus, 1758)	Garcilla Bueyera	X	X	X		LC
Ardea cocoi Linnaeus, 1766	Garza Cuca	X	X	X		LC
Ardea alba Linnaeus, 1758	Garceta Grande	X	X	X		LC
Syrigma sibilatrix (Temminck, 1824)	Garza Chiflona	X	X	X		LC
Pilherodius pileatus (Boddaert, 1783)	Garza Capirotada	X	X	X		LC
Egretta thula (Molina, 1782)	Garceta Nívea	X	X	X		LC
Family Threskiornithidae Poche, 1904						
Plegadis chihi (Vieillot, 1817)	Morito Cariblanco	X		X		LC
Mesembrinibis cayennensis (Gmelin, 1789)	Ibis Verde	X	X	X		LC
Phimosus infuscatus (Lichtenstein, 1823)	Ibis Afeitado	X	X	X		LC
Theristicus caerulescens (Vieillot, 1817)	Bandurria Mora	X	X	X		LC
Theristicus caudatus (Boddaert, 1783)	Bandurria Común	X	X	X		LC
Platalea ajaja Linnaeus, 1758	Espátula Rosada	X	X	X		LC
Order Cathartiformes Seebohm, 1890						
Family Cathartidae Lafresnaye, 1839						
Cathartes aura (Linnaeus, 1758)	Aura Gallipavo	X	X	X		LC
Cathartes burrovianus Cassin, 1845	Aura Sabanera	X	X	X		LC
Coragyps atratus (Bechstein, 1793)	Zopilote Negro	X	X	X		LC
Sarcoramphus papa (Linnaeus, 1758)	Zopilote Rey	X	X	X		LC
Order Accipitriformes Bonaparte, 1831						
Family Pandionidae Bonaparte, 1854						
Pandion haliaetus (Linnaeus, 1758)	Águila Pescadora	X	X	X		LC
Family Accipitridae Vigors, 1824						
Leptodon cayanensis (Latham, 1790)	Milano Cabecigrís	X	X	X		LC
Chondrohierax uncinatus (Temminck, 1822)	Milano Picogarfio	X		X		LC
Elanoides forficatus (Linnaeus, 1758)	Elanio Tijereta			X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Gampsonyx swainsonii Vigors, 1825	Elanio Enano	X		X		LC
Elanus leucurus (Vieillot, 1818)	Elanio Maromero	X	X	X		LC
Harpagus diodon (Temminck, 1823)	Milano Muslirrufo			X		LC
Circus buffoni (Gmelin, 1788)	Aguilucho de Azara		X			LC
Accipiter striatus Vieillot, 1808	Gavilán Americano	X		X		LC
Accipiter bicolor (Vieillot, 1817)	Gavilán Bicolor			X	AM	LC
Ictinia mississippiensis (Wilson, 1811)	Elanio del Misisipi			X		LC
Ictinia plumbea (Gmelin, 1788)	Elanio Plomizo	X	X	X		LC
Busarellus nigricollis (Latham, 1790)	Busardo Colorado	X	X	X		LC
Rostrhamus sociabilis (Vieillot, 1817)	Caracolero Común	X	X	X		LC
Geranospiza caerulescens (Vieillot, 1817)	Azor Zancón	X	X	X		LC
Heterospizias meridionalis (Latham, 1790)	Busardo Sabanero	X	X	X		LC
Urubitinga (Gmelin, 1788)	Busardo Urubitinga	X	X	X		LC
Urubitinga coronata (Vieillot, 1817)	Águila de Azara	X		X	AM	EN
Rupornis magnirostris (Gmelin, 1788)	Busardo Caminero	X	X	X		LC
Parabuteo unicinctus (Temminck, 1824)	Busardo Mixto		X	X		LC
Parabuteo leucorrhous (Quoy & Gaimard, 1824)	Busardo Culiblanco			X		LC
Geranoaetus albicaudatus (Vieillot, 1816)	Busardo Coliblanco	X	X	X		LC
Geranoaetus melanoleucus (Vieillot, 1819)	Águila Mora			X		LC
Buteo nitidus (Latham, 1790)	Busardo Gris Meridional		X			LC
Buteo brachyurus Vieillot, 1816	Busardo Colicorto			X		LC
Buteo swainsoni Bonaparte, 1838	Busardo Chapulinero			X		LC
Buteo albonotatus Kaup, 1847	Busardo Aura			X		LC
Morphnus guianensis (Daudin, 1800)	Arpía Menor			X	EP	NT
Harpia harpyja (Linnaeus, 1758)	Arpía Mayor			X	EP	NT
Spizaetus tyrannus (Wied, 1820)	Águila Negra		X		EP	LC
Spizaetus melanoleucus (Vieillot, 1816)	Águila Blanquinegra			X	AM	LC
Spizaetus ornatus (Daudin, 1800)	Águila Galana		X	X	EP	NT
Order Eurypygiformes Furbringer, 1888						
Family Aramidae Bonaparte, 1852						
Aramus guarauna (Linnaeus, 1766)	Carrao	X	X	X		LC
Family Rallidae Rafinesque, 1815						
Aramides ypecaha (Vieillot, 1819)	Cotara Ipacaá	X	X	X		LC
Aramides cajaneus (Statius Muller, 1776)	Cotara Chiricote	X	X	X		LC
Aramides saracura (Spix, 1825)	Cotara Saracura			X	AM	LC
Laterallus melanophaius (Vieillot, 1819)	Polluela Burrito	X		X		LC
Laterallus exilis (Temminck, 1831)	Polluela Pechigrís		X	X		LC
Laterallus xenopterus Conover, 1934	Polluela Guaraní			X	AM	VU
Mustelirallus albicollis (Vieillot, 1819)	Polluela Turura	X	X	X		LC
Pardirallus maculatus (Boddaert, 1783)	Rascón Overo	X				LC
Pardirallus nigricans (Vieillot, 1819)	Rascón Negruzco	X	X	X		LC
Pardirallus sanguinolentus (Swainson, 1837)	Rascón Gallineta			X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Gallinula galeata (Lichtenstein,1818)	Gallineta Americana	X		X		LC
Porphyrio martinicus (Linnaeus, 1766)	Calamoncillo Americano	X	X	X		LC
Family Heliornithidae Gray, 1840						
Heliornis fulica (Boddaert, 1783)	Avesol Americano	X		X		LC
Order Charadriiformes Furbringer, 1888						
Family Charadriidae Leach, 1820						
Vanellus cayanus (Latham, 1790)	Avefría de Cayena	X	X	X		LC
Vanellus chilensis (Molina, 1782)	Avefría Tero	X	X	X		LC
Pluvialis dominica (Statius Muller, 1776)	Chorlito Dorado Americano		X			LC
Charadrius collaris Vieillot, 1818	Chorlitejo de Azara	X	X	X		LC
Family Recurvirostridae Bonaparte, 1831						
Himantopus mexicanus (Statius Muller, 1776)	Cigüeñuela Cuellinegra			X		LC
Himantopus melanurus Vieillot, 1817	-	X	X			-
Family Scolopacidae Rafinesque, 1815						
Gallinago paraguaiae (Vieillot, 1816)	Agachadiza Paraguaya	X		X		LC
Gallinago undulata (Boddaert, 1783)	Agachadiza Gigante			X	AM	LC
Bartramia longicauda (Bechstein, 1812)	Correlimos Batitú	X	X	X		LC
Actitis macularius (Linnaeus, 1766)	Andarríos Maculado			X		LC
Tringa solitaria Wilson, 1813	Andarríos Solitario	X	X	X		LC
Tringa melanoleuca (Gmelin, 1789)	Archibebe Patigualdo Grande	X	X	X		LC
Tringa flavipes (Gmelin, 1789)	Archibebe Patigualdo Chico	X	X	X		LC
Calidris fuscicollis (Vieillot, 1819)	Correlimos Culiblanco	X		X		LC
Calidris melanotos (Vieillot, 1819)	Correlimos Pectoral	X	X	X		LC
Calidris himantopus (Bonaparte, 1826)	Correlimos Zancolín	X				LC
Phalaropus tricolor (Vieillot, 1819)	Falaropo Tricolor		X	X		LC
Family Jacanidae Chenu & Des Murs, 1854						
Jacana (Linnaeus, 1766)	Jacana Suramericana	X	X	X		LC
Family Rostratulidae Mathews, 1914						
Nycticryphes semicollaris (Vieillot, 1816)	Aguatero Americano			X		LC
Family Sternidae Vigors, 1825						
Sternula superciliaris (Vieillot, 1819)	Charrancito Amazónico	X	X	X		LC
Phaetusa simplex (Gmelin, 1789)	Charrán Picudo	X	X	X		LC
Family Rynchopidae Bonaparte, 1838						
Rynchops niger Linnaeus, 1758	Rayador Americano	X	X	X		LC
Order Columbiformes Latham, 1790						
Family Columbidae Leach, 1820						
Columbina minuta (Linnaeus, 1766)	Columbina Menuda	X		X		LC
Columbina talpacoti (Temminck, 1811)	Columbina Colorada	X	X	X		LC
Columbina squammata (Lesson, 1831)	Tortolita Escamosa	X	X	X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Columbina picui (Temminck, 1813)	Columbina Picuí	X	X	X		LC
Claravis pretiosa (Ferrari-Perez, 1886)	Tortolita Azulada	X		X		LC
Columba livia Gmelin, 1789	Paloma Bravía	X		X		LC
Patagioenas speciosa (Gmelin, 1789)	Paloma Escamosa			X	AM	LC
Patagioenas picazuro (Temminck, 1813)	Paloma Picazuró	X	X	X		LC
Patagioenas cayennensis (Bonnaterre, 1792)	Paloma Colorada	X	X	X		LC
Zenaida auriculata (Des Murs, 1847)	Zenaida Torcaza	X	X	X		LC
Leptotila verreauxi Bonaparte, 1855	Paloma Montaraz Común	X	X	X		LC
Leptotila rufaxilla (Richard & Bernard, 1792)	Paloma Montaraz Frentiblanca	X		X		LC
Geotrygon montana (Linnaeus, 1758)	Paloma Perdiz Común			X	AM	LC
Order Cuculiformes Wagler, 1830						
Family Cuculidae Leach, 1820						
Piaya cayana (Linnaeus, 1766)	Cuco-ardilla Común	X	X	X		LC
Coccyzus melacoryphus Vieillot, 1817	Cuclillo Canela	X		X		LC
Coccyzus americanus (Linnaeus, 1758)	Cuclillo Piquigualdo			X		LC
Crotophaga major Gmelin, 1788	Garrapatero Mayor	X	X	X		LC
Crotophaga ani Linnaeus, 1758	Garrapatero Aní	X	X	X		LC
Guira (Gmelin, 1788)	Pirincho	X	X	X		LC
Tapera naevia (Linnaeus, 1766)	Cuclillo Crespín	X	X	X		LC
Dromococcyx phasianellus (Spix, 1824)	Cuclillo Faisán			X		LC
Dromococcyx pavoninus Pelzeln, 1870	Cuclillo Pavonino			X		LC
Order Strigiformes Wagler, 1830						
Family Tytonidae Mathews, 1912						
Tyto furcata (Scopoli, 1769)	Lechúza Común	X	X	X		LC
Family Strigidae Leach, 1820						
Megascops choliba (Vieillot, 1817)	Autillo Chóliba	X	X	X		LC
Megascops atricapilla (Temminck, 1822)	Autillo Capirotado			X	AM	LC
Pulsatrix perspicillata (Latham, 1790)	Lechuzón de Anteojos	X		X		LC
Bubo virginianus (Gmelin, 1788)	Búho Americano	X	X	X		LC
Glaucidium brasilianum (Gmelin, 1788)	Mochuelo Caburé	X	X	X		LC
Athene cunicularia (Molina, 1782)	Mochuelo de Madriguera	X	X	X		LC
Asio clamator (Vieillot, 1808)	Búho Gritón		X			LC
Order Nyctibiiformes Yuri, Kimball, Harshman, Bowie, Braun, Chojnowski, Han, Hackett, Huddleston, Moore, Reddy, Sheldon, Steadman, Witt & Braun, 2013						
Family Nyctibiidae Chenu & Des Murs, 1851						
Nyctibius griseus (Gmelin, 1789)	Nictibio Urutaú	X	X	X		LC
Order Caprimulgiformes Ridgway, 1881						
Family Caprimulgidae Vigors, 1825						
Antrostomus rufus (Boddaert, 1783)	Chotacabras Colorado	X		X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Lurocalis semitorquatus (Gmelin, 1789)	Añapero Colicorto		X	X		LC
Nyctidromus albicollis (Gmelin, 1789)	Chotacabras Pauraque	X	X	X		LC
Hydropsalis parvula (Gould, 1837)	Chotacabras Chico	X	X	X		LC
Hydropsalis anomala (Gould, 1838)	Chotacabras Pantanero		X		EP	NT
Hydropsalis maculicaudus (Lawrence, 1862)	Chotacabras Colipinto	X			AM	LC
Hydropsalis torquata (Gmelin, 1789)	Chotacabras Tijereta	X	X	X		LC
Podager nacunda (Vieillot, 1817)	Añapero Ñacundá	X	X	X		LC
Chordeiles minor (Forster, 1771)	Añapero Yanqui			X		LC
Chordeiles acutipennis (Hermann, 1783)	Añapero Guarrapena			X		LC
Order Apodiformes Peters, 1940						
Family Apodidae Olphe-Galliard, 1887						
Cypseloides fumigatus (Streubel, 1848)	Vancejo Negruzco			X		LC
Chaetura cinereiventris Sclater, 1862	Vancejo Ceniciento			X		LC
Chaetura meridionalis Hellmayr, 1907	Vencejo de tormenta	X		X		LC
Family Trochilidae Vigors, 1825						
Phaethornis subochraceus Todd, 1915	Ermitaño Ocráceo	X				LC
Phaethornis pretrei (Lesson & Delattre, 1839)	Ermitaño del Planalto			X		LC
Eupetomena macroura (Gmelin, 1788)	Colibrí Golondrina	X	X	X		LC
Anthracothorax nigricollis (Vieillot, 1817)	Mango Gorjinegro			X		LC
Chlorostilbon lucidus (Shaw, 1812)	Esmeralda Ventridorada	X	X	X		LC
Thalurania furcata (Gmelin, 1788)	Zafiro Golondrina	X		X		LC
Thalurania glaucopis (Gmelin, 1788)	Zafiro Capirotado			X	AM	LC
Hylocharis sapphirina (Gmelin, 1788)	Amazilia Gorjirroja			X		LC
Hylocharis chrysura (Shaw, 1812)	Zafiro Bronceado	X	X	X		LC
Polytmus guainumbi (Pallas, 1764)	Colibrí Guainumbí			X		LC
Heliomaster longirostris (Audebert & Vieillot, 1801)	Colibrí Piquilargo			X		LC
Heliomaster furcifer (Shaw, 1812)	Colibrí de Barbijo	X	X	X		LC
Order Trogoniformes A. O. U., 1886						
Family Trogonidae Lesson, 1828						
Trogon surrucura Vieillot, 1817	Trogón Surucuá			X		LC
Trogon curucui Linnaeus, 1766	Trogón Curucuí	X	X	X		LC
Trogon rufus Gmelin, 1788	Trogón Amarillo			X	AM	LC
Order Coraciiformes Forbes, 1844						
Family Alcedinidae Rafinesque, 1815						
Megaceryle torquata (Linnaeus, 1766)	Martín Gigante Neotropical	X	X	X		LC
Chloroceryle amazona (Latham, 1790)	Martín Pescador Amazónico	X	X	X		LC
Chloroceryle aenea (Pallas, 1764)	Martín Pescador Enano	X				LC
Chloroceryle americana (Gmelin, 1788)	Martín Pescador Verde	X	X	X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Chloroceryle inda (Linnaeus, 1766)	Martín Pescador Verdirrufo	X		X		LC
Family Momotidae Gray, 1840						
Baryphthengus ruficapillus (Vieillot, 1818)	Momoto Yeruvá Oriental			X		LC
Momotus momota (Linnaeus, 1766)	Momoto Amazónico	X				LC
Order Galbuliformes Fürbringer, 1888						
Family Galbulidae Vigors, 1825						
Galbula ruficauda Cuvier, 1816	Jacamará Colirrufo	X				LC
Family Bucconidae Horsfield, 1821						
Notharchus swainsoni (Gray, 1846)	Buco de Swainson			X	AM	LC
Nystalus chacuru (Vieillot, 1816)	Buco Chacurú	X		X		LC
Nystalus maculatus (Gmelin, 1788)	Buco Durmilí			X		LC
Nystalus striatipectus (Sclater, 1854)	Buco Durmilí	X	X			-
Nonnula rubecula (Spix, 1824)	Monjilla Macurú		X	X	AM	LC
Order Piciformes Meyer & Wolf, 1810						
Family Ramphastidae Vigors, 1825						
Ramphastos toco Statius Muller, 1776	Tucán Toco	X	X	X		LC
Ramphastos dicolorus Linnaeus, 1766	Tucán Bicolor			X		LC
Selenidera maculirostris (Lichtenstein, 1823)	Tucanete Piquimaculado			X	AM	LC
Pteroglossus castanotis Gould, 1834	Arasarí Caripardo	X		X		LC
Family Picidae Leach, 1820						
Picumnus cirratus Temminck, 1825	Carpinterito Variable	X	X	X		LC
Picumnus temminckii Lafresnaye, 1845	Carpinterito Cuellicaneca			X	AM	LC
Picumnus albosquamatus d'Orbigny, 1840	Carpinterito Albiescamoso	X	X		EP	LC
Melanerpes candidus (Otto, 1796)	Carpintero Blanco	X	X	X		LC
Melanerpes flavifrons (Vieillot, 1818)	Carpintero Arcoiris			X		LC
Melanerpes cactorum (d'Orbigny, 1840)	Carpintero de Los Cardones	X	X			LC
Veniliornis passerinus (Linnaeus, 1766)	Carpintero Chico	X	X	X		LC
Veniliornis mixtus (Boddaert, 1783)	Pico Bataraz Chico	X	X	X		LC
Piculus chrysochloros (Vieillot, 1818)	Carpintero Verdiamarillo	X	X	X		LC
Colaptes melanochloros (Gmelin, 1788)	Carpintero real norteño	X	X	X		LC
Colaptes campestris (Vieillot, 1818)	Carpintero Campestre	X	X	X		LC
Celeus flavescens (Gmelin, 1788)	Carpintero Amarillento			X	AM	LC
Celeus lugubris (Malherbe, 1851)	Carpintero Lúgubre	X	X	X		LC
Dryocopus lineatus (Linnaeus, 1766)	Picamaderos Listado	X		X		LC
Campephilus robustus (Lichtenstein, 1818)	Picamaderos Robusto			X	AM	LC
Campephilus melanoleucos (Gmelin, 1788)	Picamaderos Barbinegro	X	X	X		LC
Campephilus leucopogon (Valenciennes, 1826)	Picamaderos Dorsiblanco	X	X			LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Order Cariamiformes Furbringer, 1888						
Family Cariamidae Bonaparte, 1850						
Cariama cristata (Linnaeus, 1766)	Chuña Patirroja	X	X	X		LC
Order Falconiformes Bonaparte, 1831						
Family Falconidae Leach, 1820						
Caracara plancus (Miller, 1777)	Carancho meridional	X	X	X		LC
Milvago chimachima (Vieillot, 1816)	Caracara Chimachima	X	X	X		LC
Milvago chimango (Vieillot, 1816)	Caracara Chimango			X		LC
Herpetotheres cachinnans (Linnaeus, 1758)	Halcón Reidor	X	X	X		LC
Micrastur ruficollis (Vieillot, 1817)	Halcón Montés Agavilanado		X	X		LC
Micrastur semitorquatus (Vieillot, 1817)	Halcón Montés Collarejo	X		X		LC
Falco sparverius Linnaeus, 1758	Cernícalo Americano	X	X	X		LC
Falco rufigularis Daudin, 1800	Halcón Murcielaguero	X	X	X		LC
Falco femoralis Temminck, 1822	Halcón Aleto	X	X	X		LC
Falco peregrinus Tunstall, 1771	Halcón Peregrino			X		LC
Order Psittaciformes Wagler, 1830						
Family Psittacidae Rafinesque, 1815						
Anodorhynchus hyacinthinus (Latham, 1790)	Guacamayo Jacinto	X	X	X	EP	VU
Ara ararauna (Linnaeus, 1758)	Guacamayo Azuliamarillo			X	EP	LC
Ara chloropterus Gray, 1859	Guacamayo Aliverde	X	X	X	EP	LC
Primolius maracana (Vieillot, 1816)	Guacamayo Maracaná		X	X	EP	NT
Primolius auricollis (Cassin, 1853)	Guacamayo Acollarado	X	X	X		LC
Thectocercus acuticaudatus (Vieillot, 1818)	Aratinga Cabeciazul	X	X	X		LC
Psittacara leucophthalmus (Statius Muller, 1776)	Aratinga Ojiblanca	X	X	X		LC
Aratinga nenday (Vieillot, 1823)	Aratinga Ñanday	X	X	X		LC
Eupsittula aurea (Gmelin, 1788)	Aratinga Frentidorada	X	X	X		LC
Pyrrhura devillei (Massena & Souancé, 1854)	Cotorra de Deville	X	X	X	AM	NT
Pyrrhura frontalis (Vieillot, 1817)	Cotorra Chiripepé		X	X		LC
Pyrrhura molinae (Massena & Souancé, 1854)	Cotorra de Molina			X		LC
Myiopsitta monachus (Boddaert, 1783)	Cotorra Argentina	X	X	X		LC
Forpus xanthopterygius (Spix, 1824)	Cotorrita Aliazul	X		X		LC
Brotogeris chiriri (Vieillot, 1818)	Catita Chirirí	X	X	X		LC
Pionopsitta pileata (Scopoli, 1769)	Lorito Pileado			X	AM	LC
Alipiopsitta xanthops (Spix, 1824)	Amazona del Cerrado			X	AM	NT
Pionus maximiliani (Kuhl, 1820)	Loro Choclero	X	X	X		LC
Amazona amazonica (Linnaeus, 1766)	Amazona Alinaranja			X	EP	LC
Amazona aestiva (Linnaeus, 1758)	Amazona Frentiazul	X	X	X		LC
Order Passeriformes Linnaeus, 1758						

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Family Thamnophilidae Swainson, 1824						
Formicivora rufa (Wied, 1831)	Hormiguerito Dorsirrufo	X	X			LC
Dysithamnus mentalis (Temminck, 1823)	Batarito Cabecigrís			X		LC
Herpsilochmus atricapillus Pelzeln, 1868	Tiluchí Plomizo			X		LC
Thamnophilus doliatus (Linnaeus, 1764)	Batará Barrado	X	X	X		LC
Thamnophilus sticturus Pelzeln, 1868	Batará Pizarroso Boliviano		X			LC
Thamnophilus caerulescens Vieillot, 1816	Batará Variable	X	X	X		LC
Taraba major (Vieillot, 1816)	Batará Mayor	X	X	X		LC
Hypoedaleus guttatus (Vieillot, 1816)	Batará Goteado			X	AM	LC
Pyriglena leucoptera (Vieillot, 1818)	Ojodefuego Aliblanco			X	AM	LC
Cercomacra melanaria (Ménétriès, 1835)	Hormiguero de Mato Grosso	X				LC
Family Formicariidae Gray, 1840						
Chamaeza campanisona (Lichtenstein, 1823)	Tovacá Colicorto			X	AM	LC
Family Dendrocolaptidae Gray, 1840						
Dendrocincla turdina (Lichtenstein, 1820)	Trepatroncos Turdino			X	AM	LC
Sittasomus griseicapillus (Vieillot, 1818)	Trepatroncos Oliváceo	X	X	X		LC
Xiphorhynchus fuscus (Vieillot, 1818)	Trepatroncos enano			X	AM	LC
Campylorhamphus trochilirostris (Lichtenstein, 1820)	Picoguadaña Piquirrojo	X	X	X		LC
Lepidocolaptes angustirostris (Vieillot, 1818)	Trepatroncos Chico	X	X	X		LC
Dendrocolaptes picumnus Lichtenstein, 1820	Trepatroncos Variable		X	X		LC
Dendrocolaptes platyrostris Spix, 1825	Trepatroncos Oscuros	X		X		LC
Xiphocolaptes albicollis (Vieillot, 1818)	Trepatroncos Gorgiblanco			X		LC
Xiphocolaptes major (Vieillot, 1818)	Trepatroncos Colorado	X	X	X		LC
Family Xenopidae Bonaparte, 1854						
Xenops rutilans Temminck, 1821	Picolezna Rojizo			X		LC
Family Furnariidae Gray, 1840						
Furnarius leucopus Swainson, 1838	Hornero Paticlaro	X	X			LC
Furnarius rufus (Gmelin, 1788)	Hornero Común	X	X	X		LC
Lochmias nematura (Lichtenstein, 1823)	Riachuelero			X	AM	LC
Clibanornis rectirostris (Wied, 1831)	Ticotico Cabecirrufo Oriental		X	X	AM	LC
Automolus leucophthalmus (Wied, 1821)	Ticotico Ojiblanco			X	AM	LC
Anabacerthia lichtensteini (Cabanis & Heine, 1859)	Ticotico Ocráceo Chico			X	AM	LC
Philydor rufum (Vieillot, 1818)	Ticotico Ocráceo Grande			X		LC
Syndactyla rufosuperciliata (Lafresnaye, 1832)	Ticotico Cejudo			X		LC
Syndactyla dimidiata (Pelzeln, 1859)	Ticotico del Planalto			X	EP	LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Pseudoseisura unirufa (d'Orbigny & Lafresnaye, 1838)	Cacholote Crestigrís	X	X			LC
Phacellodomus rufifrons (Wied, 1821)	Espinero Común	X	X	X		LC
Phacellodomus ruber (Vieillot, 1817)	Espinero Grande	X	X	X		LC
Anumbius annumbi (Vieillot, 1817)	Leñatero	X	X	X		LC
Schoeniophylax phryganophilus (Vieillot, 1817)	Pijuí Chotoy	X	X	X		LC
Certhiaxis cinnamomeus (Gmelin, 1788)	Curutié Colorado	X	X	X		LC
Synallaxis cinerascens Temminck, 1823	Pijuí Ceniciento			X	AM	LC
Synallaxis frontalis Pelzeln, 1859	Pijuí Frentigrís	X	X	X		LC
Synallaxis albescens Temminck, 1823	Pijuí Pechiblanco		X	X		LC
Synallaxis spixi Sclater, 1856	Pijuí Plomizo			X		LC
Synallaxis hypospodia Sclater, 1874	Pijuí Cenizo	X				LC
Synallaxis albilora Pelzeln, 1856	Pijuí Ocráceo	X	X	X		LC
Cranioleuca vulpina (Pelzeln, 1856)	Curutié Vulpino	X				LC
Family Pipridae Rafinesque, 1815						
Pipra fasciicauda Hellmayr, 1906	Saltarín Naranja	X	X	X		LC
Manacus manacus (Linnaeus, 1766)	Saltarín Barbiblanco			X	AM	LC
Chiroxiphia caudata (Shaw & Nodder, 1793)	Saltarín Azul			X	AM	LC
Family Oxyruncidae Ridgway, 1906 (1831)						
Oxyruncus cristatus Swainson, 1821	Picoagudo			X	AM	LC
Family Tityridae Gray, 1840						
Tityra inquisitor (Lichtenstein, 1823)	Titira Piquinegro	X		X		LC
Tityra cayana (Linnaeus, 1766)	Titira Colinegro	X	X	X		LC
Tityra semifasciata (Spix, 1825)	Titira Enmascarado			X	AM	LC
Pachyramphus viridis (Vieillot, 1816)	Anambé Verdoso	X	X	X		LC
Pachyramphus castaneus (Jardine & Selby, 1827)	Anambé Castaño			X	AM	LC
Pachyramphus polychopterus (Vieillot, 1818)	Anambé Aliblanco	X	X	X		LC
Pachyramphus validus (Lichtenstein, 1823)	Anambé grande	X	X	X		LC
Xenopsaris albinucha (Burmeister, 1869)	Amambé Chico	X		X		LC
Family Cotingidae Bonaparte, 1849						
Pyroderus scutatus (Shaw, 1792)	Yacutoro			X	EP	LC
Procnias nudicollis (Vieillot, 1817)	Campanero Meridional			X	EP	VU
Family Platyrinchidae Bonaparte, 1854						
Platyrinchus mystaceus Vieillot, 1818	Picoplano Bigotudo	X	X	X		LC
Family Rhynchocyclidae Berlepsch, 1907						
Mionectes rufiventris Cabanis, 1846	Mosquero Ladrillito			X	AM	LC
Leptopogon amaurocephalus Tschudi, 1846	Orejero Coronipardo	X	X	X		LC
Corythopis delalandi (Lesson, 1830)	Mosquero Terrestre Sureño			X		LC

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		(A)	(B)	(C)	PY 2019	IUCN 2020
Phylloscartes paulista Ihering & Ihering, 1907	Orejerito de Sao Paulo			X	EP	NT
Tolmomyias sulphurescens (Spix, 1825)	Picoplano Sulfuroso	X	X	X		LC
Todirostrum cinereum (Linnaeus, 1766)	Titirijí Común	X	X	X		LC
Poecilotriccus latirostris (Pelzeln, 1868)	Titirijí Frentirrojo		X			LC
Myiornis auricularis (Vieillot, 1818)	Mosqueta Enana			X	AM	LC
Hemitriccus striaticollis (Lafresnaye, 1853)	Titirijí Gorgiestriado		X			LC
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	Titirijí Perlado	X	X	X		LC
Family Tyrannidae Vigors, 1825						
Hirundinea ferruginea (Gmelin, 1788)	Birro Común		X	X		LC
Inezia inornata (Salvadori, 1897)	Piojito Picudo	X	X	X		LC
Euscarthmus meloryphus Wied, 1831	Tiranuelo Capetón	X	X	X		LC
Camptostoma obsoletum (Temminck, 1824)	Mosquerito Silbón	X	X	X		LC
Elaenia flavogaster (Thunberg, 1822)	Fiofío Ventriamarillo	X	X	X		LC
Elaenia spectabilis Pelzeln, 1868	Fiofío Grande	X		X		LC
Elaenia chilensis Hellmayr, 1927	Fiofío Crestiblanco	X		X		LC
Elaenia parvirostris Pelzeln, 1868	Fiofío Piquicorto	X		X		LC
Elaenia chiriquensis Lawrence, 1865	Fiofío Belicoso	X		X		LC
Suiriri suiriri (Vieillot, 1818)	Fiofío Suirirí	X	X	X		LC
Myiopagis gaimardii (d'Orbigny, 1839)	Fiofío Selvático	X				LC
Myiopagis caniceps (Swainson, 1835)	Fiofío Gris		X	X		LC
Myiopagis viridicata (Vieillot, 1817)	Fiofío Verdoso	X	X	X		LC
Capsiempis flaveola (Lichtenstein, 1823)	Mosquerito Amarillo			X		LC
Phaeomyias murina (Spix, 1825)	Piojito Pardo	X	X	X		LC
Phyllomyias reiseri Hellmayr, 1905	Mosquerito de Reiser			X	EP	LC
Culicivora caudacuta (Vieillot, 1818)	Tachurí Coludo			X	EP	VU
Polystictus pectoralis (Vieillot, 1817)	Tachurí Barbado	X		X	AM	NT
Serpophaga subcristata (Vieillot, 1817)	Piojito Tiquitiqui	X	X	X		LC
Serpophaga griseicapilla Straneck, 2007	Piojito de Straneck			X		LC
Serpophaga munda Berlepsch, 1893	Piojito Ventriblanco			X		LC
Legatus leucophaius (Vieillot, 1818)	Mosquero Pirata	X	X	X		LC
Myiarchus swainsoni Cabanis & Heine, 1859	Capetón de Swainsoni	X	X	X		LC
Myiarchus ferox (Gmelin, 1789)	Copetón Feroz	X	X	X		LC
Myiarchus tyrannulus (Statius Muller, 1776)	Copetón Tiranillo	X	X	X		LC
Sirystes sibilator (Vieillot, 1818)	Mosquero Silbador	X	X	X		LC
Casiornis rufus (Vieillot, 1816)	Burlisto Castaño	X	X	X		LC
Pitangus sulphuratus (Linnaeus, 1766)	Bienteveo Común	X	X	X		LC
Machetornis rixosa (Vieillot, 1819)	Picabuey	X	X	X		LC
Myiodynastes maculatus (Statius Muller, 1776)	Bienteveo Rayado	X	X	X		LC
Megarynchus pitangua (Linnaeus, 1766)	Bienteveo Pitanguá	X	X	X		LC
Myiozetetes cayanensis (Linnaeus, 1766)	Bienteveo de Alicastaño	X	X	X		LC

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		(A)	(B)	(C)	PY 2019	IUCN 2020
Myiozetetes similis (Spix, 1825)	Bienteveo Sociable	X		X		LC
Tyrannus melancholicus Vieillot, 1819	Tirano Melancólico	X	X	X		LC
Tyrannus savana Vieillot, 1808	Tijereta Sabanera	X	X	X		LC
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)	Tuquito Gris	X	X	X		LC
Empidonomus varius (Vieillot, 1818)	Tuquito Rayado	X	X	X		LC
Conopias trivirgatus (Wied, 1831)	Bienteveo Trilistado			X	AM	LC
Colonia colonus (Vieillot, 1818)	Mosquero Colilargo			X		LC
Myiophobus fasciatus (Statius Muller, 1776)	Mosquero Estriado	X		X		LC
Sublegatus modestus (Wied, 1831)	Mosquero Matorralero Sureño	X	X	X		LC
Pyrocephalus rubinus (Boddaert, 1783)	Mosquero Cardenal	X	X	X		LC
Fluvicola albiventer (Spix, 1825)	Viudita Dorsinegra	X	X	X		LC
Arundinicola leucocephala (Linnaeus, 1764)	Viudita Cabeciblanca	X	X	X		LC
Gubernetes yetapa (Vieillot, 1818)	Yetapá Grande	X	X	X		LC
Alectrurus tricolor (Vieillot, 1816)	Yetapá Chico			X	EP	VU
Alectrurus risora (Vieillot, 1824)	Yetapá Acollarado	X	X	X	EP	VU
Cnemotriccus fuscatus (Wied, 1831)	Mosquero Parduzco	X	X	X		LC
Lathrotriccus euleri (Cabanis, 1868)	Mosquero de Euler			X		LC
Contopus cinereus (Spix, 1825)	Pibí Tropical		X	X		LC
Hymenops perspicillatus (Gmelin, 1789)	Viudita Picoplata	X		X		LC
Satrapa icterophrys (Vieillot, 1818)	Mosquero Cejiamarillo	X	X	X		LC
Xolmis cinereus (Vieillot, 1816)	Monjita Gris	X	X	X		LC
Xolmis velatus (Lichtenstein, 1823)	Monjita Velada	X	X			LC
Xolmis irupero (Vieillot, 1823)	Monjita Blanca	X	X	X		LC
Family Vireonidae Swainson, 1837						
Cyclarhis gujanensis (Gmelin, 1789)	Vireón Cejirrufo	X	X	X		LC
Vireo olivaceus (Linnaeus, 1766)	Vireo Chiví		X			LC
Vireo chivi (Vieillot, 1817)	Vireo Chiví	X		X		LC
Family Corvidae Leach, 1820						
Cyanocorax cyanomelas (Vieillot, 1818)	Chara Morada	X	X	X		LC
*Cyanocorax cristatellus (Temminck, 1823)**	Chara Crestada	X		X	AM	LC
Cyanocorax chrysops (Vieillot, 1818)	Chara Moñuda	X	X	X		LC
Family Hirundinidae Rafinesque, 1815						
Alopochelidon fucata (Temminck, 1822)	Golondrina Cabecicastaña			X		LC
Stelgidopteryx ruficollis (Vieillot, 1817)	Golondrina Gorgirrufa	X	X	X		LC
Progne tapera (Vieillot, 1817)	Golondrina Parda	X	X	X		LC
Progne chalybea (Gmelin, 1789)	Golondrina Pechigrís	X	X	X		LC
Tachycineta albiventer (Boddaert, 1783)	Golondrina Aliblanca	X		X		LC
Tachycineta leucorrhoa (Vieillot, 1817)	Golondrina Cejiblanca	X	X	X		VU
Tachycineta leucopyga (Meyen ,1834)	Golondrina Chilena			X		LC
Riparia riparia (Linnaeus, 1758)	Avión Zaplador	X		X		LC
Hirundo rustica Linnaeus, 1758	Golondrina Común	X		X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Petrochelidon pyrrhonota (Vieillot, 1817)	Golondrina Risquera			X		LC
Family Troglodytidae Swainson, 1831						
Troglodytes musculus Naumann, 1823	Chochín Criollo	X	X	X		LC
Campylorhynchus turdinus (Wied, 1831)	Cucarachero Turdino	X	X	X		LC
Cantorchilus guarayanus (d'Orbigny & Lafresnaye, 1837)	Cucarachero del Guarayos	X		X		LC
Family Donacobiidae Aleixo & Pacheco, 2006						
Donacobius atricapilla (Linnaeus, 1766)	Angú	X	X	X		LC
Family Polioptilidae Baird, 1858						
Polioptila dumicola (Vieillot, 1817)	Perlita Azul	X	X	X		LC
Family Turdidae Rafinesque, 1815						
Catharus fuscescens (Stephens, 1817)	Zorzalito Rojizo			X		LC
Turdus leucomelas Vieillot, 1818	Zorzal Sabiá	X	X	X		LC
Turdus rufiventris Vieillot, 1818	Zorzal Colorado	X	X	X		LC
Turdus amaurochalinus Cabanis, 1850	Zorzal Chalchalero	X	X	X		LC
Turdus albicollis Vieillot, 1818	Zorzal Cuelliblanco			X		LC
Family Mimidae Bonaparte, 1853						
Mimus saturninus (Lichtenstein, 1823)	Sinsonte Calandria	X	X	X		LC
Mimus triurus (Vieillot, 1818)	Sinsonte Trescolas	X	X	X		LC
Family Motacillidae Horsfield, 1821						
Anthus lutescens Pucheran, 1855	Bisbita Amarillento	X	X	X		LC
Family Passerellidae Cabanis & Heine, 1850						
Zonotrichia capensis (Statius Muller, 1776)	Chingolo Común	X	X	X		LC
Ammodramus humeralis (Bosc, 1792)	Chingolo Pajonalero	X	X	X		LC
Arremon flavirostris Swainson, 1838	Cerquero Piquiamarillo	X	X	X		LC
Family Parulidae Wetmore, Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer 1947						
Setophaga pitiayumi (Vieillot, 1817)	Parula Pitiayumí	X	X	X		LC
Geothlypis aequinoctialis (Gmelin, 1789)	Mascarita Equinoccial	X	X	X		LC
Basileuterus culicivorus (Deppe, 1830)	Reinita Coronidorada	X	X	X		LC
Myiothlypis flaveola Baird, 1865	Reinita Amarillenta	X	X	X		LC
Myiothlypis leucoblephara (Vieillot, 1817)	Reinita Silbona			X		LC
Family Icteridae Vigors, 1825						
Psarocolius decumanus (Pallas, 1769)	Cacique Crestado	X	X	X		LC
Procacicus solitarius (Vieillot, 1816)	Cacique Solitario	X	X	X		LC
Cacicus chrysopterus (Vigors, 1825)	Cacique Aliamarillo	X	X	X		LC
Cacicus haemorrhous (Linnaeus, 1766)	Cacique Lomirrojo	X		X		LC
Cacicus cela (Linnaeus, 1758)	Cacique Lomiamarillo		X			LC
Icterus cayanensis (Linnaeus, 1766)	Turpial Boyerito		X			LC
Icterus pyrrhopterus (Vieillot, 1819)	Turpial Variable	X		X		LC
Icterus croconotus (Wagler, 1829)	Turpial Amazónico	X		X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Gnorimopsar chopi (Vieillot, 1819)	Chopí	X	X	X		LC
Amblyramphus holosericeus (Scopoli, 1786)	Federal	X	X	X		LC
Agelasticus cyanopus (Vieillot, 1819)	Varillero Negro	X	X	X		LC
Chrysomus ruficapillus (Vieillot, 1819)	Varillero Congo	X		X		LC
Pseudoleistes guirahuro (Vieillot, 1819)	Tordo Güirahuró	X		X		LC
Agelaioides badius (Vieillot, 1819)	Tordo Músico	X	X	X		LC
Molothrus rufoaxillaris Cassin, 1866	Tordo Chillón	X	X	X		LC
Molothrus oryzivorus (Gmelin, 1788)	Tordo Gigante	X	X	X		LC
Molothrus bonariensis (Gmelin, 1789)	Tordo Renegrido	X	X	X		LC
Sturnella superciliaris (Bonaparte, 1850)	Charrancito Amazónico	X	X	X		LC
Dolichonyx oryzivorus (Linnaeus, 1758)	Tordo Charlatán			X		LC
Family Mitrospingidae Barker, Burns, Klicka, Lanyon & Lovette, 2013						
Lamprospiza melanoleuca (Vieillot, 1817)	Tangara Piquirroja		X			LC
Family Thraupidae Cabanis, 1847						
Pipraeidea melanonota (Vieillot, 1819)	Tangara de Antifaz			X		LC
Neothraupis fasciata (Lichtenstein, 1823)	Tangara Bandeada			X	AM	NT
Cissopis leverianus (Gmelin, 1788)	Tangara Urraca			X		LC
Paroaria coronata (Miller, 1776)	Cardenilla Crestada	X	X	X		LC
Paroaria capitata (d'Orbigny & Lafresnaye, 1837)	Cardenilla Piquigualda	X	X	X		LC
Tangara sayaca (Linnaeus, 1766)	Tangara Sayaca	X	X	X		LC
Tangara palmarum (Wied, 1823)	Tangara Palmera	X	X	X		LC
Tangara cayana (Linnaeus, 1766)	Tangara Isabel	X				LC
Nemosia pileata (Boddaert, 1783)	Tangara Encapuchada	X	X	X		LC
Conirostrum speciosum (Temminck, 1824)	Conirrostro Culirrufo	X	X	X		LC
Sicalis flaveola (Linnaeus, 1766)	Dorado	X	X	X		LC
Sicalis luteola (Sparrman, 1789)	Chirigüe Sabanero			X		LC
Hemithraupis guira (Linnaeus, 1766)	Tangara Guirá	X	X	X		LC
Volatinia jacarina (Linnaeus, 1766)	Semillero Volatinero	X	X	X		LC
Eucometis penicillata (Spix, 1825)	Tangara Cabecigrís	X		X		LC
Trichothraupis melanops (Vieillot, 1818)	Tangara de Anteojos			X		LC
Coryphospingus cucullatus (Statius Muller, 1776)	Soldadito Crestirrojo	X	X	X		LC
Tachyphonus rufus (Boddaert, 1783)	Tangara Negra	X	X	X		LC
Tachyphonus coronatus (Vieillot, 1822)	Tangara Coronada			X	AM	LC
Ramphocelus carbo (Pallas, 1764)	Tangara Picoplata	X	X			LC
Tersina viridis (Illiger, 1811)	Tangara Golondrina	X	X	X		LC
Dacnis cayana (Linnaeus, 1766)	Dacnis Azul			X		LC
Coereba flaveola (Linnaeus, 1758)	Platanero	X				LC
Sporophila lineola (Linnaeus, 1758)	Semillero Overo	X		X		LC
Sporophila plumbea (Wied, 1830)	Semillero Plomizo			X		LC
Sporophila collaris (Boddaert, 1783)	Semillero Acollarado	X	X	X		LC

Taxon	Popular Name in Paraguay	Reference			Categories of Threat	
		(A)	(B)	(C)	PY 2019	IUCN 2020
Sporophila nigricollis (Vieillot, 1823)	Semillero Ventriamarillo			X		LC
Sporophila caerulescens (Vieillot, 1823)	Semillero Corbatita	X	X	X		LC
Sporophila leucoptera (Vieillot, 1817)	Semillero Ventriblanco	X	X	X		LC
Sporophila bouvreuil (Statius Muller, 1776)	Semillero Camachuelo			X		LC
Sporophila hypoxantha Cabanis, 1851	Semillero Ventricanela	X		X		LC
Sporophila ruficollis Cabanis, 1851	Semillero Gorjioscuro	X				NT
Sporophila palustris (Barrows, 1883)	Semillero Palustre	X		X	EP	EN
Sporophila hypochroma Todd, 1915	Semillero Culirrufo			X		NT
Sporophila cinnamomea (Lafresnaye, 1839)	Semillero Castaño		X	X	AM	VU
Sporophila angolensis (Linnaeus, 1766)	Semillero Curió	X	X	X		LC
Embernagra platensis (Gmelin, 1789)	Coludo Verdón			X		LC
Emberizoides herbicola (Vieillot, 1817)	Coludo Colicuña	X		X		LC
Emberizoides ypiranganus Ihering & Ihering, 1907	Coludo Chico			X		LC
Saltatricula atricollis (Vieillot, 1817)	Pepitero Gorjinegro	X	X	X		LC
Saltatricula multicolor (Burmeister, 1860)	Pepitero Chico	X				LC
Saltator coerulescens Vieillot, 1817	Pepitero Grisáceo	X	X	X		LC
Saltator similis d'Orbigny & Lafresnaye, 1837	Pepitero Verdoso	X	X	X		LC
Saltator aurantiirostris Vieillot, 1817	Pepitero Piquigaldo			X		LC
Microspingus melanoleucus (d'Orbigny & Lafresnaye, 1837)	Monterita Cabecinegra	X	X	X		LC
Microspingus torquatus (d'Orbigny & Lafresnaye, 1837)	Monterita Acollarada			X		VU
Thlypopsis sordida (d'Orbigny & Lafresnaye, 1837)	Tangara Cabecinaranja			X		LC
Cypsnagra hirundinacea (Lesson, 1831)	Tangara Culiblanca			X	AM	LC
Family Cardinalidae Ridgway, 1901						
Piranga flava (Vieillot, 1822)	Piranga Bermeja	X	X	X		LC
Pheucticus aureoventris (d'Orbigny & Lafresnaye, 1837)	Picogrueso Dorsinegro			X		LC
Cyanoloxia brissonii (Lichtenstein, 1823)	Picogrueso Brisson	X				LC
Family Fringillidae Leach, 1820						
Spinus magellanicus (Vieillot, 1805)	Jilguero Encapuchado	X	X	X		LC
Euphonia chlorotica (Linnaeus, 1766)	Eufonia Golipúrpura	X	X	X		LC
Euphonia violacea (Linnaeus, 1758)	Eufonia Violácea		X	X		LC
Euphonia pectoralis (Latham, 1801)	Eufonia Ventricastaña			X	AM	LC
Family Passeridae Rafinesque, 1815						
Passer domesticus (Linnaeus, 1758)	Gorrión Común	X		X		LC

References: (A) – BENITES *et al*., 2017; **(B)** – STRAUBE *et al*., 2006; eBird list for the region of Concepción/PY (available at ebird.org/explore) **(C)** – eBird list for the region of Concepción/PY (available at ebird.org/explore). **Categories of threats: PY 2019** – Resolución nº 254/2019 *do Ministerio del Ambiente y Desarrollo Sostenible* de Paraguay. **IUCN 2020** – *The IUCN Red List of*

Threatened Species, versión 2020. **Caption: EP** – endangered of extinction; **AM** – threatened of extinction; **EN** – endangerous; **VU** – vulnerable; **NT** – not threatened ; **LC** – Less concern; **DD** – deficient data.

9.2.2.3 Herpetofauna

9.2.2.3.1 Regional Characterization (IAA)

Herpetology is the science dedicated to the study of amphibians and reptiles. This union is due to the belief in the past that these animals had many similarities, being sometimes even considered as a single natural group, as suggested by Linnaeus in the 18th century. However, today, evolutionary studies suggest that birds are reptiles (constituting the sister group to crocodiles), and that, in fact, reptiles are closer to mammals than to amphibians (Vitt & Caldwell, 2009). Despite these discoveries, the centuries-old tradition continues. Birds, with their peculiar characteristics and great diversity, continue to be the object of research in ornithology, while amphibians and "reptiles", even with their different evolutionary origins, remain the focus of herpetology. One of the reasons for this is that many aspects of the life and biology of these animals are complementary and allow zoologists and ecologists to study them using the same or similar techniques (Vitt & Caldwell, 2009).

Amphibians today constitute a group of 8,159 known living species, divided into three orders: Anura (frogs, toads; 7,203 species), Caudata (salamanders and newts; 742 species) and Gymnophiona (snakes or cecilia; 214 species) (AmphibiaWeb, 2020). The reptiles (from now on excluding birds) have so far about 10,800 known living species, distributed in four orders: Cocodylia (crocodiles, gulls and caimans; 24 species), Testudines/Chelonia (turtles and tortoises; about 351 species), Sphenodontia (tuatara; one species) and Squamata (amphibians = 196, lizards = 6,512 and snakes = 3,709) (Uetz et al, 2018).

Paraguay has a great diversity of environments, represented by five major eco-regions: Dry Chaco, Humid Chaco, Atlantic Forest, Cerrado and Pantanal (Dinerstein et al., 1995). Four of these ecoregions are biodiversity hotspots according to the Nature Conservancy (2005), which highlights the number of important areas for protection in the country (Brusquetti & Lavilla, 2006). The first list of amphibians and reptiles in Paraguay was made by Cope (1862). Since then, several updates have been prepared, such as: Schouten (1931; 1939), Gatti (1955), Canese (1970), Scott & Lovett (1975), Talbot (1979) and Cabral & Weiler (2014). In Cabral & Wieler (2014), a list of 137 specimens was observed in the Zoology Collection of the Facultad de Ciencias Exactas y Naturales de Asunción, indicating the presence of two species of turtles, four amphibians, 16 lizards and 40 snakes. In Núñez and others (2019), 31 species of amphibians and 22 species of reptiles were observed and sampled in the Ypoá region. The unique works, when added to other works, highlight the importance of regularly maintaining samples in the most diverse environments.

Among the ecoregions of Paraguay, it is inevitable to mention the importance of the Chaco. The Chaco is a vast plain occupied by forests and jungles, and covers more than 60% of Paraguay's surface area (Fauna Paraguay, 2006). It is one of the least inhabited regions in South America and therefore one of the least affected by human activities, although it is not completely free of them (Baumman et al., 2017). The Gran Chaco is divided into two sub-regions, the Dry Chaco and the Humid Chaco. The Dry Chaco is located in the northwestern region of Paraguay. The rivers of this region remain without water during the winter, but transport a large amount of sediment during the warm seasons of the year, directly from their sources in the Andes (Weiler et al., 2013). The amphibians that occupy the Chaco Seco present adaptations to the dry season. For example, the frog *Lepidobatrachus llanensis* (Ceratophryidae) is endemic to this ecoregion and has the ability to build a cocoon that reduces water loss from the skin by up to 70% during periods of drought (McLanahan et al., 1976). In turn, the Humid Chaco is a large area, with constant rainfall, which covers both banks of the Paraguay River. It has a varied topography, with high regions permeated by several swamps (Weiler et al., 2013). It is an environment analogous to the swamp, presenting several animals similar to those of the Brazilian biome such as: caiman (*Caiman yacare* and *Cayman latirostris*), Teiu lizard (*Salvator merianae*), turtle (*Acanthochelys pallidipectoris*) and snakes (*Eunectes notaeus* and *Bothrops alternatus*). Although there are several amphibians in the Humid Chaco (see Weiler et al., 2013), the only species known to be endemic to this region is *Melanophryniscus paraguayensis* (Bufonidae).

Among the endemic species in the Chaco, it is possible to mention the snake *Sybinomorphus lavillai* (Colubridae), the lizard *Stenocercus doellojuradoi* (Tropiduridae) (Leynaud & Bucher, 2005), the lizard species Homonota rupicola (Phyllodactylidae) (Cacciali et al, 2018), the yearling species of the genus Lepidobatrachus (Bufonidae): *L. asper*, *laevis*, and *llanensis* (Brusquetti et al., 2018), and also *Chacophrys pierottii* (Ceratophryidae) (Prohaska, 1959). Most of these species are found in high humidity refuges, frequently associated with decomposing organic matter, and in seasonal lagoons (Tailbot, 1978). Of the species mentioned above, the anurans *L. asper, L. llanensis, C. pierotti* are in danger of extinction in the Paraguayan Chaco, according to the IUCN Red List (Weiler et al., 2013). In addition, other species that occupy the Chaco as a whole have already been shown to be threatened with extinction, such as *Chelonoidis chilensis* (Testudinidae), *Boa constrictor occidentalis* (Boidae), or vulnerable, such as *Epicrates cenchria* (Boidae) and *Polychrus acutirostris* (Polychrotidae) (Kacoliris et al., 2006). Sampling efforts in the Chaco region, along with efficient taxonomic identification, will undoubtedly be important for future conservation measures for local species.

According to the collection of secondary data through literature (Brusquetti and Lavilla, 2006; Cabral and Weiler, 2014; Núñez and others, 2019; Weiler and others, 2013), 146 species were recorded in the Paraguay river region distributed in 36 families and 10 orders (as table bellow).

Table 17 – List of herpetofauna species likely to be found in IIA in PARACEL pulp mill

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Order Anura						
Family Alsodidae						
Limnomedusa macroglossa (Duméril & Bibron, 1841)	x			x	EN	LC
Family Bufonidae						
Melanophryniscus atroluteus (Miranda-Ribeiro, 1920)	x			x	EN	LC

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Melanophryniscus devincenzii (Klappenbach, 1968)				x	EN	-
Melanophryniscus fulvoguttatus (Mertens, 1937)	x			x		LC
Melanophryniscus klappenbachi (Prigioni & Langone, 2000)	x			x		-
Melanophryniscus krauczuki (Baldo y Basso, 2004)				x	EN	-
Melanophryniscus paraguayensis (Céspedez and Motte, 2007)			x	x	VU	-
Rhinella azarai (Gallardo, 1965)	x		x	x		-
Rhinella bergi (Céspedez, 2000 "1999")	x			x		LC
Rhinella fernandezae (Gallardo, 1957)	x		x	x		LC
Rhinella icterica (Spix, 1824)	x			x	EN	LC
Rhinella major (Muller & Helmich, 1936)	x			x		-
Rhinella ornata (Spix, 1824)	x			x	VU	LC
Rhinella diptycha (Cope, 1862)	x		x	x		LC
Rhinella scitula (Caramaschi & Niemeyer, 2003)	x			x	VU	DD
Family Ceratophryidae						
Ceratophrys cranwelli (Barrio, 1980)				x		LC
Chacophrys pierottii (Vellard, 1948)	x			x		LC
Lepidobatrachus asper (Budgett, 1899)	x			x	EN	NT
Lepidobatrachus laevis (Budgett, 1899)	x			x	VU	LC
Lepidobatrachus llanensis (Reig and Cei, 1963)	x			x		LC
Family Hylidae						
Argenteohyla siemersi pederseni (Mertens, 1937)	x			x	EN	-
Dendropsophus elianeae (Napoli & Caramaschi, 2000)	x			x	EN	LC
Dendropsophus jimi (Napoli & Caramaschi, 1999)	x			x	EN	LC
Dendropsophus melanargyreus (Cope, 1887)	x			x	EN	LC
Dendropsophus minutus (Peters, 1872)	x			x		LC
Dendropsophus nanus (Boulenger, 1889)	x		x	x		LC
Dendropsophus sanborni (Schmidt, 1944)	x			x		LC
Boana albopunctata (Spix, 1824)	x			x		LC
Boana caingua (Carrizo, 1991 "1990")	x			x		LC
Boana curupi (Garcia, Faivovichi & Haddad, 2007)				x	EN	LC
Boana faber (Wied-Neuwied, 1821)	x			x		LC
Boana pulchellus (Duméril & Bibron, 1841)	x			x	EN	LC
Boana punctata (Schneider, 1799)	x		x	x		LC
Boana raniceps (Cope, 1862)	x		x	x		LC
Boana aff. semiguttatus (A. Lutz, 1925)	x					LC
Itapotihyla langsdorffii (Duméril & Bibron, 1841)	x			x	EN	LC
Pithecopus azureus (Cope, 1862)	x		x	x		DD
Phyllomedusa sauvagii (Boulenger, 1882)	x			x		LC
Phyllomedusa tetraploidea (Pombal & Haddad, 1992)	x			x	EN	LC

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Lysapsus limellum (Cope, 1862)	x		x	x		LC
Pseudis paradoxa (Linnaeus, 1758)	x					LC
Pseudis platensis (Gallardo, 1961)	x		x	x		DD
Scinax acuminatus (Cope, 1862)	x		x	x		LC
Ololygon berthae (Barrio, 1962)	x		x	x		LC
Scinax fuscomarginatus (A. Lutz, 1925)	x		x	x		LC
Scinax fuscovarius (A. Lutz, 1925)	x		x	x		LC
Scinax nasicus (Cope, 1862)	x		x	x		LC
Scinax similis (Cochran, 1952)	x			x		LC
Scinax squalirostris (A. Lutz, 1925)	x		x	x		LC
Trachycephalus typhonius (Linnaeus, 1758)	x		x	x		-
Family Hylodidae						
Crossodactylus schmidti (Gallardo, 1961)	x			x	EN	NT
Family Leiuperidae						
Physalaemus nattereri (Steindachner, 1863)	x			x		LC
Physalaemus albonotatus (Steindachner, 1864)	x		x	x		LC
Physalaemus biligonigerus (Cope, 1861 "1860")	x		x	x		LC
Physalaemus centralis (Bokermann, 1962)	x			x	EN	LC
Physalaemus cuvieri (Fitzinger, 1826)	x		x	x		LC
Physalaemus marmoratus (Reinhardt & Lütken, 1862 "1861")	x			x	EN	LC
Physalaemus riograndensis (Milstead, 1960)	x			x		LC
Physalaemus santafecinus (Barrio, 1965)				x		LC
Pleurodema bibroni (Tschudi, 1838)				x		NT
Pseudopaludicola boliviana (Parker, 1927)	x		x	x		LC
Pseudopaludicola falcipes (Hensel, 1867)	x			x		LC
Pseudopaludicola mystacalis (Cope, 1887)	x			x		LC
Pseudopaludicola ternetzi (Miranda-Ribeiro, 1937)	x			x		LC
Family Leptodactylidae						
Adenomera diptyx (Boettger, 1885)			x	x		LC
Adenomera heyeri (Boistel, Massary & Angulo, 2006)	x					LC
Leptodactylus bufonius (Boulenger, 1894)	x			x		LC
Leptodactylus chaquensis (Cei, 1950)	x		x	x		LC
Leptodactylus elenae (Heyer, 1978)	x		x	x		LC
Leptodactylus furnarius (Sazima & Bokermann, 1978)	x			x		LC
Leptodactylus fuscus (Schneider, 1799)	x		x	x		LC
Leptodactylus gracilis (Duméril & Bibron, 1841)	x		x	x		LC
Leptodactylus labyrinthicus (Spix, 1824)	x			x		LC
Leptodactylus laticeps (Boulenger, 1918)	x			x		
Leptodactylus latinasus (Jiménez de la Espada, 1875)	x			x		LC

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Leptodactylus latrans (Steffen, 1815) Leptodactylus ocellatus	x		x	x		LC
Leptodactylus mystacinus (Burmeister, 1861)	x			x		LC
Leptodactylus podicipinus (Cope, 1862)	x		x	x		LC
Leptodactylus syphax (Bokermann, 1969)	x			x	VU	LC
Family Microhylidae						
Chiasmocleis albopunctata (Boettger, 1885)	x			x		LC
Dermatonotus muelleri (Boettger, 1885)	x		x	x		LC
Elachistocleis bicolor (Valenciennes in Guérin-Menéville, 1838)	x		x	x		LC
Family Odontophrynidae						
Odontophrynus americanus (Duméril & Bibron, 1841)	x		x	x		LC
Odontophrynus lavillai (Cei, 1985)	x			x		LC
Proceratophrys avelinoi (Mercadal del Barrio & Barrio, 1993)	x			x	EN	LC
Order Gymnophiona						
Family Siphonopidae						
Luetkenotyphlus brasiliensis (Lütken, 1852 "1851")	x					DD
Siphonops paulensis (Boettger, 1892)	x					LC
Family Typhlonectidae						
Chthonerpeton indistinctum (Reinhardt & Lütken, 1862″1861″)	x					LC
Order Testudines						
Family Chelidae						
Acanthochelys macrocephala (Rhodin, Mittermeier & McMorris, 1984)		x				NT
Acanthochelys pallidipectoris (Freiberg, 1945)		x			EN	EN
Order Crocodilya						
Family Alligatoridae						
Caiman yacare (Daudin, 1802)			x			LC
Order Squamata						
Family Iguanidae						
Iguana iguana (Linnaeus, 1758)		x			EN	LC
Family Polychrotidae Fitzinger, 1843						
Polychrus acutirostris (Spix, 1825)		x	x			LC
Family Tropiduridae						
Stenocercus caducus (Cope, 1862)		x				LC
Tropidurus etheridgei (Cei, 1982)		x				LC
Tropidurus guarani (Cope, 1862)		x				LC
Tropidurus torquatus (Wied, 1820)		x				LC
Family Gekkonidae						
Hemidactylus mabouia (Moreau de Jonnès, 1818)		x				LC
Family Phyllodactylidae						

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Homonota rupicola (Cacciali, Ávila y Bauer, 2007)		x				CR
Homonota aff. borellii		x				LC
Phyllopezus pollicaris (Spix, 1825)		x				LC
Family Teiidae						
Ameiva ameiva (Linnaeus, 1758)		x	x			LC
Ameivula abalosi (Cabrera, 2012)		x				LC
Dracaena paraguayensis (Amaral, 1950)		x				LC
Salvator merianae (Duméril & Bibron, 1839)			x			LC
Family Gymnophthalmidae						
Cercosaura schreibersii (Wiegmann, 1834)		x				LC
Family Mabuyidae (antiga Scincidae)						
Aspronema dorsivittatum (Cope, 1862)			x			-
Manciola guaporicola (Dunn, 1935)		x				-
Notomabuya frenata (Cope, 1862)		x				LC
Family Amphisbaenidae						
Amphisbaena albocingulata (Boettger, 1885)			x			LC
Amphisbaena bolivica (Mertens, 1929)		x				LC
Amphisbaena camura (Cope, 1862)		x				LC
Amphisbaena mertensii (Strauch, 1881)		x				LC
Leposternon microcephalum (Wagler, 1824)		x				LC
Family Leptotyphlopidae						
Epictia albipuncta (Burmeister, 1861)		x				LC
Family Typhlopidae						
Amerotyphlops brongersmianus (Vanzolini, 1976)		x	x			LC
Family Boidae						
Eunectes notaeus (Cope, 1862)		x	x			-
Family Colubridae						
Chironius maculoventris (Dixon, Wiest y Cei, 1993)		x				LC
Leptophis ahaetulla ahaetulla (Linnaeus, 1758)		x				LC
Palusophis bifossatus (Raddi, 1820)		x				LC
Family Elapidae						
Micrurus frontalis (Duméril, Bibron & Duméril, 1854)		x				LC
Micrurus pyrrhocryptus (Cope, 1862)		x				LC
Family Viperidae						
Bothrops alternatus (Duméril, Bibron & Duméril, 1854)		x	x			-
Bothrops diporus (Cope, 1862)		x	x			LC
Bothrops jararaca (Wied, 1824)		x				LC
Bothrops mattogrossensis (Amaral, 1925)		x			EN	-
Bothrops jararacussu (Lacerda, 1884)		x				LC
Family Dipsadidae						

Taxon	(A)	(B)	(C)	(D)	Categories of Threat	
					List of Paraguay	IUCN 2020
Atractus paraguayensis (Werner, 1924)		x				LC
Atractus reticulatus (Boulenger, 1885)			x			LC
Sibynomorphus turgidus (Cope, 1868)		x				
Sibynomorphus ventrimaculatus (Boulenger, 1885)		x				LC
Apostolepis dimidiata (Jan, 1862)		x				LC
Phalotris matogrossensis (Lema, D'Agostini & Cappellari, 2005)		x				LC
Phalotris tricolor (Duméril, Bibron & Duméril, 1854)		x				LC
Hydrodynastes gigas (Duméril, Bibron & Duméril, 1854)		x	x			LC
Helicops leopardinus (Schlegel, 1837)		x	x			LC
Pseudoeryx plicatilis (Linnaeus, 1758)		x				LC
Philodryas mattogrossensis (Koslowsky, 1898)		x				LC
Philodryas olfersii (Lichtenstein, 1823)		x	x			LC
Philodryas patagoniensis (Girard, 1858)		x				LC
Philodryas psammophidea (Günther, 1872)		x				LC
Mussurana bicolor (Peracca, 1904)		x	x			LC
Oxyrhopus guibei (Hoge & Romano, 1978)			x			LC
Phimophis vittatus (Boulenger, 1896)		x				LC
Phimophis guerini (Duméril, Bibron & Duméril, 1854			x			-
Thamnodynastes chaquensis (Bergna & Alvarez, 1993)		x	x			LC
Thamnodynastes hypoconia (Cope, 1860)			x			LC
Thamnodynastes strigatus (Günther, 1858)		x				LC
Erythrolamprus almadensis (Wagler, 1824)			x			LC
Erythrolamprus jaegeri coralliventris (Boulenger, 1894)		x				LC
Erythrolamprus poecilogyrus poecilogyrus (Wied, 1825)		x				-
Erythrolamprus semiaureus (Cope, 1862)		x				LC
Erythrolamprus sagittifer (Jan, 1863)		x				LC
Lygophis dilepis (Cope, 1862)		x				LC
Xenodon merremii (Wagler, 1824)			x			LC
Xenodon pulcher (Jan, 1863)		x				LC

Key: (A): Brusquetti & Lavilla, 2006; **(B):** Cabral & Weiler, 2014; **(C):** Núñez et al., 2019; **(D):** Weiler et al., 2013. **List of Paraguay:** Resolution 433/2019 (**EN**: endangered of extinction; **VU**: vulnerable). **IUCN 2020:** The IUCN Red List for Threatened Species, 2020-1 (**CR**: critical; **EN**: endangered; **NT**: threatened ; **LC**: less concern; **DD**: deficient data).

9.2.2.4 Ichthyofauna

9.2.2.4.1 Regional Characterization (IAA)

Neotropical ecosystems are known for their diversity and richness (Leal et al. 2018). Approximately 9,000 fish species are known for this system (Birindelli & Sidlauskas, 2018). The number of fish species increases by about 11% each decade, with approximately 390 new species known each year (Nelson et al. 2016; Fricke et al. 2018). In freshwater environments, 5,160 species have already been officially described (Reis et al. 2016), more than a third of which are found in South American aquatic habitats. Of this total, 307 species are found in Paraguayan waterways, representing almost 6% of the total and 2.3% of the fish in the continental area (Koerber, 2017). Estimates based on published articles have cited the abundance of Paraguayan fish in one hundred and twenty-nine species (Ramlow, 1989), one hundred and eighty-nine (Mandelburger et al., 1996) and two hundred and ninety-eight (Bertoni, 1939). According to the unpublished data bases present in the ichthyofaunal reference sites, these estimates range from 256 (www.fishbase.org), 395 (http://www.faunaparaguay.com/fishlist.html) (www.faunaparaguay.com/fishlist.html) and 451 (www.guyra.org.pf).

The main causes of fish population decline in Paraguay, as well as in several South American environments, include habitat loss due to changes in land use, urbanization, inappropriate agricultural practices, the construction and operation of hydroelectric dams, water pollution, excessive predatory fishing and the introduction of non-native species (Allan and others, 2005; Barletta and others, 2010; Reis, 2013; Reis and others, 2016).

Paraguay has hydrological systems belonging to the fifth largest basin in the world, the Rio de la Plata basin, which has a total area of about 3.1 million km2 . In this basin, which includes the Paraná, Paraguay and Uruguay rivers, there are about 1,250 species of fish (Buckup and others, 2007; Langeani and others, 2009). Four large freshwater ecoregions of Paraguay are part of this basin: Alto y Bajo Paraná, Paraguay and Chaco (Abell and others, 2008).

The Paraguay River Basin, which is approximately 2,500 km long, covers an area of more than 1 million km2 and is characterized by a wide plain ranging from 48 m from the border with the Paraná River to 125 m in the Pantanal region (Barros et al., 2004). On the right bank of the Paraguay River, the tributaries are mostly intermittent systems that drain the Paraguayan Chaco ecoregion (Iriondo et al., 2000). The eastern Chaco is characterized by swampy environments, located in the alluvial belts that flow into the Paraguay River, while the western Chaco has more transitory channels (Iriondo, 1993). The Paraguay river drains the rivers that make up the Pantanal basin, which has 276 described fish species (Bristiki et al., 2007). Between the municipality of Concepción and the Río Negro Toledo-Piza and others (2001) have identified 173 species of fish for the Paraguay river.

According to secondary data obtained through literature (Britski, 2007; Koerber, 2017; Toledo-Piza et al., 2001), a list of fish species likely to be found in the portion of Paraguay in the region of Concepción has been prepared. There are 310 species distributed in 37 families and 11 orders, arranged in Table bellow.

Table 18 – List of ichthyofauna species likely to be found in the IIA of the pulp mill

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
E L A S M O B R A N C H I I		
Order MYLIOBATIFORMES		
Family Potamotrygonidae		
Potamotrygon amandae (Loboda & Carvalho, 2013)		-
Potamotrygon brachyura (Guenther, 1880)	DD	DD
Potamotrygon falkneri (Castex & Maciel, 1963)	DD	DD
Potamotrygon histrix (Mueller & Henle, 1841)	DD	DD
Potamotrygon motoro (Mueller & Henle, 1841)	DD	DD
Potamotrygon pantanensis (Loboda & Carvalho, 2013)	-	-
Potamotrygon schuemacheri (Castex, 1964)	DD	DD
A C T I N O P T E R Y G I I		
Order CLUPEIFORMES		
Family Engraulidae		
Lycengraulis grossidens (Agassiz, 1829)	-	LC
Family Pristigasteridae		
Pellona flavipinnis (Valenciennes, 1837)	LC	LC
Order CHARACIFORMES		
Family Hemiodontidae		
Hemiodus orthonops (Eigenmann & Kennedy, 1903)	-	-
Hemiodus semitaeniatus (Kner, 1858)	-	-
Family Parodontidae		
Apareiodon piracicabae (Eigenmann, 1907)	-	-
Apareiodon affinis (Steindachner, 1879)	-	-
Family Curimatidae		
Curimatella dorsalis (Eigenmann & Eigenmann, 1889)	-	-
Curimatopsis myersi (Vari, 1982)	-	-
Cyphocharax gillii (Eigenmann & Kennedy, 1903)	-	-
Cyphocharax modestus (Fernández-Yépez, 1948)	-	-
Cyphocharax platanus (Guenther, 1880)	-	-
Cyphocharax saladensis (Meinken, 1933)	-	-
Cyphocharax pilotus (Vari, 1987)	-	-
Cyphocharax voga (Hensel, 1870)	LC	LC
Potamorhina squamoralevis (Braga & Azpelicueta, 1983)	-	-
Psectrogaster curviventris (Eigenmann & Kennedy, 1903)	-	-
Steindachnerina brevipinna (Eigenmann & Eigenmann, 1889)	-	-
Steindachnerina conspersa (Holmberg, 1891)	-	-
Family Prochilodontidae		
Prochilodus lineatus (Valenciennes, 1837)	-	-
Family Anostomidae		

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Abramites hypselonotus (Guenther, 1868)	-	-
Leporellus pictus (Kner, 1858)	-	-
Leporinus acutidens (Valenciennes, 1837)	-	-
Leporinus lacustris (Amaral Campos, 1945)	-	-
Leporinus octofasciatus (Steindachner, 1915)	LC	LC
Leporinus striatus (Kner, 1858)	LC	LC
Megaleporinus obtusidens (Valenciennes, 1837)	-	-
Schizodon borellii (Boulenger, 1900)	-	-
Schizodon isognathus (Kner, 1858)	-	-
Schizodon nasutus (Kner, 1858)	-	-
Schizodon platae (Garman, 1890)	-	-
Family Erythrinidae		
Erythrinus erythrinus (Bloch & Schneider, 1801)		-
Hoplerythrinus unitaeniatus (Agassiz, 1829)		-
Hoplias malabaricus (Bloch, 1794)	LC	LC
Hoplias mbigua (Azpelicueta, Benítez, Aichino & Mendez, 2015)	-	-
Hoplias misionera (Rosso, Mabragaña, González-Castro, Delpiani, Avigliano, Schenone & Díaz de Astarloa, 2016)	-	-
Family Lebiasinidae		
SubFamily Pyrrhulininae		
Pyrrhulina australis (Eigenmann & Kennedy, 1903)	-	-
Family Gasteropelecidae		
Gasteropelecus sternicla (Linnaeus 1758)	-	-
Thoracocharax stellatus (Kner, 1858)	-	-
Family Serrasalmidae		
Metynnis mola (Eigenmann & Kennedy, 1903)	-	-
Metynnis otuquensis (Ahl, 1923)	-	-
Myloplus levis (Eigenmann & McAtee, 1907)	-	-
Myloplus tiete (Eigenmann & Norris, 1900)	-	-
Mylossoma duriventre (Cuvier, 1818)	-	-
Piaractus mesopotamicus (Holmberg, 1887)	-	-
Pygocentrus nattereri (Kner, 1858)	-	-
Serrasalmus maculatus (Kner, 1858)	-	-
Serrasalmus marginatus (Valenciennes, 1837)	-	-
Family Characidae		
SubFamily Acestrorhynchinae		
Acestrorhynchus pantaneiro (Menezes, 1992)	-	-
SubFamily Aphyocharacinae		
Aphyocharax anisitsi (Eigenmann & Kennedy, 1903)	-	-
Aphyocharax dentatus (Eigenmann & Kennedy, 1903)	-	-
Aphyocharax nattereri (Steindachner, 1882)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Aphyocharax rathbuni (Eigenmann, 1907)	-	-
Prionobrama paraguayensis (Eigenmann, 1914)	-	-
SubFamily Bryconinae		
Brycon hilarii (Valenciennes, 1850)	-	-
Brycon orbignyanus (Valenciennes, 1850)	-	-
Triportheus nematurus (Kner, 1858)	-	-
Triportheus pantanensis (Malabarba, 2004)	-	-
SubFamily Characinae		
*Charax leticiae (*Lucena, 1987)	-	-
Charax stenopterus (Cope, 1894)	-	-
Cynopotamus argenteus (Valenciennes, 1837)	-	-
Cynopotamus kincaidi (Schultz, 1950)	-	-
Galeocharax humeralis (Valenciennes, 1834)	-	-
Galeocharax gulo (Cope, 1870)	-	-
Phenacogaster tegatus (Eigenmann, 1911)	-	-
Roeboides affinis (Guenther, 1868)	LC	LC
Roeboides descalvadensis (Fowler, 1932)	-	-
Roeboides microlepis (Reinhardt, 1851)	-	-
SubFamily Cheirodontinae		
*Cheirodon stenodon (*Eigenmann, 1915)	-	-
Odontostilbe microcephala (Eigenmann, 1907)	LC	LC
Odontostilbe paraguayensis (Eigenmann & Kennedy, 1903)	-	-
Odontostilbe pequira (Steindachner, 1882)	-	-
Serrapinnus calliurus (Boulenger, 1900)	-	-
Serrapinnus kriegi (Schindler, 1937)	-	-
Serrapinnus microdon (Eigenmann, 1915)	-	-
Serrapinnus notomelas (Eigenmann, 1915)	-	-
SubFamily Clupeacharacinae		
Clupeacharax anchoveoides (Pearson, 1924)	-	-
SubFamily Cynodontinae		
Rhaphiodon vulpinus (Spix & Agassiz, 1829)	-	-
SubFamily Iguanodectinae		
Piabucus melanostoma (Holmberg, 1891)	-	-
SubFamily Salmininae		
Salminus brasiliensis (Cuvier, 1816)	-	-
SubFamily Stethaprioninae		
Brachychalcinus retrospina (Boulenger, 1892)	-	-
Gymnocorymbus ternetzi (Boulenger, 1895)	-	-
Poptella paraguayensis (Eigenmann, 1907)	-	-
SubFamily Stevardiinae		
Creagrutus meridionalis (Vari & Harold, 2001)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Creagrutus paraguayensis (Mahnert & Géry, 1988)	-	-
Bryconamericus exodon (Eigenmann, 1907)	-	-
Diapoma guarani (Mahnert & Géry, 1987)	-	-
Knodus moenkhausii (Eigenmann & Kennedy, 1903)	-	-
Piabarchus analis (Eigenmann, 1914)	-	-
Piabarchus stramineus (Eigenmann, 1908)	-	-
Piabarchus torrenticola (Mahnert & Géry, 1988)	-	-
Piabina argentea (Reinhardt, 1867)	-	-
Markiana nigripinnis (Perugia, 1891)	-	-
Mimagoniates barberi (Regan, 1907)	-	-
Xenurobrycon macropus (Myers & Miranda Ribeiro, 1945)	-	-
SubFamily Tetragonopterinae		
Tetragonopterus argenteus (Cuvier, 1816)	-	-
SubFamily Astyanax		
Astyanax abramis (Jenyns, 1842)	-	-
Astyanax alleni (Eigenmann & McAtee, 1907)	-	-
Astyanax eigenmanniorum (Cope, 1894)	-	-
Astyanax lacustris (Luetken, 1875)	-	-
Astyanax lineatus (Perugia, 1891)	-	-
Astyanax pellegrini (Eigenmann, 1907)	-	-
Astyanax rutilus (Jenyns, 1842)	-	-
Psellogrammus kennedyi (Eigenmann, 1903)	-	-
Oligosarcus oligolepis (Steindachner, 1867)	-	-
Oligosarcus paranensis (Menezes & Géry, 1983)	-	-
Oligosarcus pintoi (Campos, 1945)	-	-
SubFamily Bryconops		
Bryconops melanurus (Bloch, 1794)	-	-
SubFamily Hemigrammus		
Hemigrammus durbinae (Ota, Lima & Pavanelli, 2015)	-	-
Hemigrammus lunatus (Durbin, 1918)	-	-
Hemigrammus mahnerti (Uj & Géry, 1989)	-	-
Hemigrammus tridens (Eigenmann, 1907)	-	-
Hemigrammus ulreyi (Boulenger, 1895)	-	-
Hyphessobrycon anisitsi (Eigenmann, 1907)	-	-
Hyphessobrycon arianae (Uj & Géry, 1989)	-	-
Hyphessobrycon elachys (Weitzman, 1985)	-	-
Hyphessobrycon eques (Steindachner, 1882)	-	-
Hyphessobrycon luetkenii (Boulenger, 1887)	-	-
Hyphessobrycon procerus (Mahnert & Géry, 1987)	-	-
Hyphessobrycon pytai (Géry & Mahnert, 1993)	-	-
Moenkhausia dichroura (Kner, 1858)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Moenkhausia sanctaefilomenae (Steindachner, 1907)	-	-
Incertae Sedis		
Mixobrycon ribeiroi (Eigenmann, 1907)	-	-
Family Crenuchidae		
Characidium etzeli (Zarske & Géry, 2001)	-	-
Characidium laterale (Boulenger, 1895)	-	-
Order SILURIFORMES		
Family Doradidae		
Anadoras weddellii (Castelnau, 1855)	LC	LC
Ossancora eigenmanni (Boulenger, 1895)	-	-
Ossancora punctata (Kner, 1853)	-	-
Oxydoras kneri (Bleeker, 1862)	-	-
Platydoras armatulus (Valenciennes, 1840)	-	-
Pterodoras granulosus (Valenciennes, 1821)	-	-
Rhinodoras dorbignyi (Kner, 1855)	-	-
Trachydoras paraguayensis (Eigenmann & Ward, 1907)	-	-
Family Auchenipteridae		
SubFamily Auchenipterinae		
Ageneiosus inermis (Linnaeus, 1766)	-	-
Auchenipterus nigripinnis (Boulenger, 1895)	-	-
Auchenipterus osteomystax (Miranda Ribeiro, 1918)	-	-
Epapterus dispilurus (Cope, 1878)	-	-
Trachelyopterus galeatus (Linnaeus, 1766)	-	-
Trachelyopterus striatulus (Steindachner, 1877)	-	-
SubFamily Centromochlinae		
Tatia neivai (Ihering, 1930)	-	-
Family Pimelodidae		
Hemisorubim platyrhynchos (Valenciennes, 1840)	-	-
Hypophthalmus oremaculatus (Nani & Fuster, 1947)	-	-
Iheringichthys labrosus (Luetken, 1874)	-	-
Iheringichthys megalops (Eigenmann & Ward, 1907)	-	-
Megalonema argentinum (MacDonagh, 1938)	-	-
Megalonema pauciradiatum (Eigenmann, 1919)	-	-
Megalonema platanum (Guenther, 1880)	-	-
Parapimelodus valenciennis (Luetken, 1874)	-	LC
Pimelodus albicans (Valenciennes, 1840)	-	-
Pimelodus argenteus (Perugia, 1891)	-	LC
Pimelodus maculatus (Lacépède, 1803)	-	-
Pimelodus mysteriosus (Azpelicueta, 1998)	-	-
Pimelodus ornatus (Kner, 1858)	-	-
Pseudoplatystoma corruscans (Spix & Agassiz, 1829)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Pseudoplatystoma reticulatum (Eigenmann & Eigenmann, 1889)	-	-
Sorubim lima (Bloch & Schneider, 1801)	-	-
Family Pseudopimelodidae		
Microglanis carlae (Vera-Alcaraz, da Graça & Shibatta 2008)	-	-
Pseudopimelodus mangurus (Valenciennes, 1835)	-	-
Family Heptapteridae		
Heptapterus mustelinus (Valenciennes, 1835)	-	-
Pimelodella gracilis (Valenciennes, 1835)	-	-
Pimelodella griffini (Eigenmann, 1917)	-	-
Pimelodella laticeps (Eigenmann, 1917)	-	-
Pimelodella mucosa (Eigenmann & Ward, 1907)	-	-
Pimelodella parva (Guentert, 1942)	-	-
Rhamdia quelen (Quoy & Gaimard, 1824)	-	LC
Family Cetopsidae		
Cetopsis gobioides (Kner, 1858)	-	-
Family Aspredinidae		
Amaralia oviraptor (Friel & Carvalho, 2016)	-	-
Bunocephalus doriae (Boulenger, 1902)	LC	LC
Pseudobunocephalus iheringii (Boulenger, 1891)	LC	LC
Pseudobunocephalus rugosus (Eigenmann & Kennedy, 1903)	LC	LC
Pterobunocephalus depressus (Haseman, 1911)	LC	LC
Xyliphius barbatus (Alonso de Arámburu & Arámburu, 1962)	-	-
Family Trichomycteridae		
SubFamily Stegophilinae		
Homodiaetus anisitsi (Eigenmann & Ward, 1907)	-	-
Ochmacanthus batrachostoma (Miranda Ribeiro, 1912)	-	-
Pseudostegophilus maculatus (Steindachner, 1879)	-	-
SubFamily Trichomycterinae		
Ituglanis eichhorniarum (Miranda Ribeiro, 1912)	-	-
Trichomycterus boylei (Nichols, 1956)	-	-
SubFamily Vandelliinae		
Paravandellia oxyptera (Miranda Ribeiro, 1912)	-	-
Family Callichthyidae		
SubFamily Callichthyinae		
Callichthys callichthys (Linnaeus, 1758)	-	-
Hoplosternum littorale (Hancock, 1828)	-	-
Lepthoplosternum pectorale (Boulenger, 1895)	-	-
SubFamily Corydoradinae		
Corydoras aeneus (Gill, 1858)	-	-
Corydoras aurofrenatus (Eigenmann & Kennedy, 1903)	-	-
Corydoras britskii (Nijssen & Isbruecker, 1983)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Corydoras diphyes (Axenrot & Kullander, 2003)	-	-
Corydoras ellisae (Gosline, 1940)	-	-
Corydoras hastatus (Eigenmann & Eigenmann, 1888)	-	-
Corydoras polystictus (Regan, 1912)	-	-
Scleromystax macropterus (Regan, 1913)	-	EN
Family Loricariidae		
SubFamily Hypoptopomatinae		
Hisonotus maculipinnis (Regan, 1912)	-	-
Hypoptopoma inexspectatum (Holmberg, 1893)	-	-
Otocinclus arnoldi (Regan, 1909)	-	-
Otocinclus mimulus (Axenrot & Kullander, 2003)	-	-
Otocinclus vestitus (Cope, 1872)	-	-
Otocinclus vittatus (Regan, 1904)	-	-
Otothyropsis dialeukos (Calegari, Gill Morlis & Reis, 2017)	-	-
Otothyropsis piribebuy (Calegari, Lehmann & Reis, 2011)	-	-
SubFamily Hypostominae		
Ancistrus dubius (Eigenmann & Eigenmann, 1889)	-	-
Ancistrus hoplogenys (Guenther, 1864)	-	-
Ancistrus pirareta (Muller, 1989)	-	-
Ancistrus piriformis (Muller, 1989)	LC	LC
Hypostomus albopunctatus (Regan, 1906)	-	-
Hypostomus boulengeri (Eigenmann & Kennedy, 1903)	-	-
Hypostomus cochliodon (Kner, 1854)	-	-
Hypostomus commersonii (Valenciennes, 1836)	-	-
Hypostomus derbyi (Haseman, 1911)	-	-
Hypostomus dlouhyi (Weber, 1985)	-	-
Hypostomus formosae (Cardoso, Brancolini, Paracampo, Lizarralde, Covain & Montoya-Burgos, 2016)	-	-
Hypostomus latifrons (Weber, 1986)	-	-
Hypostomus meleagris (Marini, Nichols & La Monte, 1933)	DD	DD
Hypostomus microstomus (Weber, 1987)	-	-
Hypostomus paranensis (Weyenbergh, 1877)	-	-
Hypostomus paulinus (Ihering, 1905)	-	-
Hypostomus peckoltoides (Zawadzki, Weber & Pavanelli, 2010)	-	-
Hypostomus piratatu (Weber, 1986)	-	-
Hypostomus regani (Ihering, 1905)	-	-
Hypostomus ternetzi (Boulenger, 1895)	-	-
Pterygoplichthys ambrosettii (Holmberg, 1893)	-	-
Megalancistrus parananus (Peters, 1881)	-	-
SubFamily Loricariinae		
Farlowella hahni (Meinken, 1937)	-	-
Farlowella paraguayensis (Retzer & Page, 1997)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Sturisoma robustum (Regan, 1904)	-	-
Sturisoma barbatum (Kner 1853)	-	-
Loricaria apeltogaster (Boulenger, 1895)	-	-
Loricaria luciae (Thomas, Rodriguez, Cavallaro, Froehlich & Castro, 2013)	-	-
*Loricaria simillima (*Regan, 1904)	-	-
Loricariichthys labialis (Boulenger, 1895)	-	-
*Loricariichthys platymetopon (*Isbruecker & Nijssen, 1979)	-	-
Loricariichthys rostratus (Reis & Pereira, 2000)	-	-
Paraloricaria agastor (Isbruecker, 1979)	-	-
Pseudohemiodon laticeps (Regan, 1904)	-	-
Pyxiloricaria menezesi (Isbrücker & Nijssen 1984)	-	-
Rineloricaria aurata (Knaack, 2002)	-	-
Rineloricaria lanceolata (Guenther, 1868)	-	-
Rineloricaria parva (Boulenger, 1895)	-	-
Spatuloricaria evansii (Boulenger 1892)	LC	LC
SubFamily Rhinelepinae		
Rhinelepis strigosa (Valenciennes, 1840)	-	-
Family Scoloplacidae		
Scoloplax distolothrix (Schaefer, Weitzman & Britski, 1989)	LC	LC
Order GYMNOTIFORMES		
Family Sternopygidae		
Eigenmannia trilineata (López & Castello, 1966)	-	-
Eigenmannia virescens (Valenciennes, 1842)	-	-
Sternopygus macrurus (Bloch & Schneider, 1801)	-	-
Family Apteronotidae		
Apteronotus albifrons (Linnaeus, 1766)	-	-
Apteronotus brasiliensis (Reinhardt, 1852)	-	-
Apteronotus ellisi (Arámburu, 1957)	-	-
Family Rhamphichthyidae		
Rhamphichthys hahni (Meinken, 1937)	-	-
*Gymnorhamphichthys britskii (*Carvalho, Ramos & Albert, 2011)	-	-
Family Hypopomidae		
Brachyhypopomus bombilla (Loureiro & Silva, 2006)	-	-
Brachyhypopomus draco (Giora, Malabarba & Crampton, 2008)	-	-
*Brachyhypopomus gauderio (*Giora & Malabarba, 2009)	-	-
Brachyhypopomus walteri (Sullivan, Zuanon & Cox-Fernández, 2013)	-	-
Family Gymnotidae		
Gymnotus inaequilabiatus (Valenciennes, 1839)	-	-
Gymnotus pantanal (Fernandes, Albert, Daniel-Silva, Lopes, Crampton & Almeida-Toledo, 2005)	-	-
Gymnotus paraguensis (Albert & Crampton, 2003)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Order CYPRINODONTIFORMES		
Family Rivulidae”		
SubFamily Cynolebiasinae		
Austrolebias monstrosus (Huber, 1995)	-	-
Austrolebias nigripinnis (Regan, 1912)	-	-
Austrolebias paranaensis (Costa, 2006)	-	-
Austrolebias patriciae (Huber, 1995)	-	-
Austrolebias vandenbergi (Huber, 1995)	-	-
Spectrolebias chacoensis (Amato, 1986)	-	-
SubFamily “Rivulinae”		
Neofundulus paraguayensis (Eigenmann & Kennedy, 1903)	-	-
Pterolebias longipinnis (Garman, 1895)	-	-
Trigonectes aplocheiloides (Huber, 1995)	-	-
Trigonectes balzanii (Perugia, 1891)	-	-
Papiliolebias bitteri (Costa, 1989)	-	-
Melanorivulus punctatus (Boulenger, 1895)	-	-
Family Poeciliidae		
SubFamily Poeciliinae		
Cnesterodon raddai (Meyer & Etzel, 2001)	-	-
Phalloceros harpagos (Lucinda, 2008)	-	-
Phallotorynus dispilos (Lucinda, Rosa & Reis, 2005)	-	-
Phallotorynus psittakos (Lucinda, Rosa & Reis, 2005)	-	-
Phallotorynus victoriae (Oliveros, 1983)	-	-
Poecilia reticulata (Peters, 1859)	LC	LC
Order BELONIFORMES		
Family Belonidae		
Potamorrhaphis eigenmanni (Miranda Ribeiro, 1915)	-	-
Pseudotylosurus angusticeps (Guenther, 1866)	-	-
Ordem SYNBRANCHIFORMES		
Family Synbranchidae		
Synbranchus marmoratus (Bloch, 1795)	LC	LC
INCERTAE SEDIS		
Pachyurus bonariensis (Steindachner, 1879)	LC	LC
Plagioscion ternetzi (Boulenger, 1895)	DD	DD
Plagioscion squamosissimus (Heckel, 1840)	LC	LC
Order CICHLIFORMES		
Family Cichlidae		
SubFamily Cichlinae		
Astronotus crassipinnis (Heckel, 1840)	-	-
Chaetobranchopsis australis (Eigenmann & Ward, 1907)	-	-
Bujurquina vittata (Heckel, 1840)	-	-

TAXON	Category of Threat	
	List of Paraguay	IUCN (2021-1)
Cichlasoma dimerus (Heckel, 1840)	-	-
Cichlasoma pusillum (Kullander, 1983)	-	-
Laetacara dorsigera (Heckel, 1840)	-	-
Cichla kelberi (Kullander & Ferreira, 2006)	-	-
Cichla piquiti (Kullander & Ferreira, 2006)	-	-
Apistogramma borellii (Regan, 1906)	-	-
Apistogramma commbrae (Regan, 1906)	-	-
Apistogramma trifasciata (Eigenmann & Kennedy, 1903)	-	-
Crenicichla gillmorlisi (Kullander & Lucena, 2013)	-	-
Crenicichla lepidota (Heckel, 1840)	LC	LC
Crenicichla mandelburgeri (Kullander, 2009)	-	-
Crenicichla ocellata (Perugia, 1897)	-	-
Crenicichla semifasciata (Heckel, 1840)	-	-
Crenicichla vittata (Heckel, 1840)	-	-
Gymnogeophagus balzanii (Perugia, 1891)	-	-
Gymnogeophagus caaguazuensis (Staeck, 2006)	-	-
Gymnogeophagus setequedas (Reis, Malabarba & Pavanelli, 1992)	-	-
Satanoperca pappaterra (Heckel, 1840)	-	-
Australoheros guarani (Říčan & Kullander, 2008)	-	-
Mesonauta festivus (Heckel, 1840)	-	-
SubFamily Pseudocrenilabrinae		
Coptodon rendalli (Boulenger, 1897)	-	LC
Order PLEURONECTIFORMES		
Family Achiridae		
Catathyridium jenynsii (Guenther, 1862)	LC	LC
Catathyridium lorentzii (Weyenbergh, 1877)	LC	LC
S A R C O P T E R Y G I I		
Order CERATODONTIFORMES		
Family Lepidosirenidae		
Lepidosiren paradoxa (Fitzinger, 1837)	-	-

9.2.2.5 Local Characterization (DIA and DAA)

9.2.2.5.1 Sampling, Working Method and Areas of Study

Samples - Terrestrial Fauna

The study was conducted in the areas of influence of the PARACEL pulp mill - the Direct Influence Area (DIA) and the Area Directly Affected (ADA), located in the site known as "Zapatero Cue" Concepción/PY. The municipality is located in the Chaco and Savannah area.

The campaigns were carried out in October 2019 and March 2020, 10 days of sampling, in the early morning hours between 5 and 10 am, and in the afternoon/evening between 4:30 and 10:30 pm. For this purpose, the methodology of non-linear transects was used, making stops in places with greater potential for recording species, transects were recorded with GARMIN 60cs GPS. Direct observations were made, with the help of binoculars, which were recorded in the field notebook and fact sheets for further assistance. To assist in the identification and recording of the species, the Nikon P900 and D800, Canon D80 and Sony hx400v cameras were also used, in addition to recording the vocalizations with the use of the Zoom H1n recorder. Traps were also used: 10 photographic traps, 02 for each transect.

In the areas of influence (AID and ADA) five transects of approximately 2.0 km were chosen, in forest fragments (Semideciduous Forest), savannah areas, protective forest of the Paraguay River and tributary, small portions of forest near the savannah and the pastureland (anthropogenic zone). These points were called T_01 for Transect 1, T_02 for Transect 2, T_03 for Transect 3, inserted in the DAI. For the DAA area you have defined T_04 for Transect 4 and T_05 for Transect 5.

The fragments of Lowland Dense Ombrophilous Forest are secondary forests in an advanced and medium state of regeneration. As in the entire Atlantic Forest Domain, the ecosystems covered by the ecoregion studied are predominantly forest. In addition to the dense lowland forest, transitional vegetation formations, such as coastal mangrove formations and restinga (sandbank) formations, occur in the ecoregion.

Thus, a study terrestrial fauna was carried out by evaluating the numerical richness and abundance of species according to environmental conditions (temperature, relative humidity, rainfall and seasonality) taking into account the five sampling transects.

For the analysis of the data the Shannon Diversity Index was used and from a matrix of species richness and abundance, the calculation of Diversity and Equitability by the Pielou index was done using the Past ver software. 3.24 (HAMMER et al.; 2012). (HAMMER et al.; 2012).

Expected patterns of species accumulation per sampling day were compared between studies and between methods. For this purpose, the richness projection (Jackknife 1 estimator), accumulated per sampling day, was computed analytically (Mao Tau) with 95% confidence intervals, with 100x random, by the EstimateS 9.10 Software (Colwell, 2005) and mapped in curves by means of the plotter.

Ecological analyses such as food guild, habitat, environmental sensitivity, bio-indicators, endemism and degree of threat were also analyzed, which corroborates the understanding of the degree of conservation of the sampled areas.

Sampling - Aquatic fauna

Ichthyofauna surveys were conducted at two sampling points on the Paraguay River near the pulp mill (Figure bellow). The sampling was done in March 2020.

In addition to ichthyofauna, two sampling campaigns of aquatic organisms (Phytoplankton, Zooplankton and Zoobenthos) were carried out, also in two points of the Paraguay River near the pulp mill. The first campaign was carried out on October 17, 2019, in spring, and the second on March 5th, 2020, in summer.

Figure bellow shows the design of the study and sampling areas.

.

Figure 211 – Design of sampling for terrestrial and aquatic fauna in the areas of influence (DIA and DAA) of the pulp mill.

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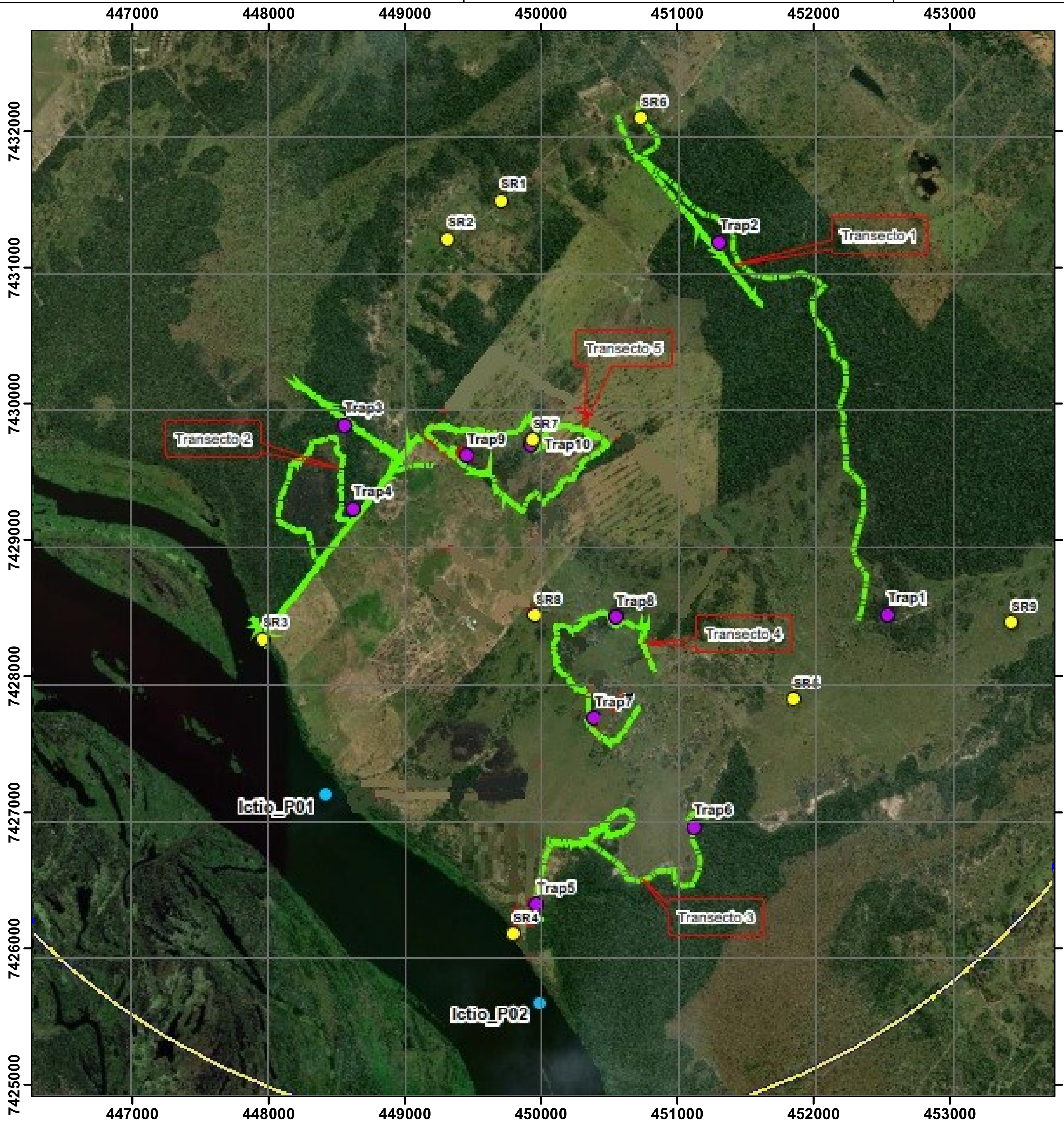

Sistema de Coordenadas: SIRGAS 2000 - UTM Zona 23S
Projección: UTM - Transversal de Mercator
Datum: SIRGAS 2000

- DGEEC, 2012 (Dirección General de Estadística, Encuestas y Censos).

Subtitle

DIA

Transections

Camera Trap

Breeding Sites

Ichthyofauna

Monitoring Points

N

0 500 1,000 2,000 Metro

PARACEL PÖYRY

TÍTULO DEL MAPA:
Sampling areas for terrestrial and aquatic fauna

TÍTULO DEL PROYECTO:
BIOTIC ENVIRONMENT - DAA and DIA

PROCESO DE LICENCIA:
PRELIMINARY ENVIRONMENTAL IMPACT STUDY (EIAp-RIMA)

TIPO DE LICENCIA
ENVIRONMENT PROCESS PERMIT

UBICACIÓN	UGHRI
CONCEPCÍON-PAR	CIH8 Aquidaban y CIH18 Rio Pilcomayo

ESCALA:	REVISIÓN:	RESPONSABLE TÉCNICO:	CRBio
1:30.000	25/05/2020	EDUARDO MARTINS Biologo	Nº:26.063/01-D

confidential

Methods – Mammal fauna

For the sampling of terrestrial mammal species, medium and large mammal groups were evaluated using non-invasive methods. Five sample transects were carried out, as described above, to obtain direct and indirect records of the mammal fauna. To complement the direct and indirect recording method, 10 photographic traps were installed along the areas of influence of the PARACEL pulp mill.

Direct and indirect observation

The method of direct observation consists of visual (including the carcass) and auditory recording of mammal specimens, while the methods of indirect observation include the recording of tracks, caves and nests, signs, marks, and feces.

Since the majority of wild mammal species have extremely discrete habits, which makes it difficult to see them through direct observation (BECKER & DALPONTE, 1991), an alternative for the diagnosis of wild mammals is the observation of signs of their daily activities, such as food remains, burrows/caves and nests, feces, and tracks (Figure 204 and Figure 205) on the trails (BECKER & DALPONTE, 1991; WEMMER et al., 1996). Since some species of the mammal move along the edges of the drains (where "sand or clay banks" are formed), these areas are considered excellent places for the visualization of footprints and tracks left by medium and large mammals. Therefore, the technique proposed by BECKER and DALPONTE (1991) and WEMMER et al. (1996) focused on these areas.

For data collection, a sampling effort of 8 hours per day has been made for each sampled transect, divided between morning (4h), twilight (2h) and night (2h). With this division of the sampling effort into different periods, we sought to record species with different activity hours and foraging period. The species diagnosed were classified according to the proposals of Wilson and Reeder, 2005

Figure 212 – Indirect recording of the mammal (tracks).

Figure 213 – Indirect recording method (tracks)

Camera Trap

Camera traps are connected to external infrared or mechanical sensors that detect movement and/or thermal variations (CHEIDA & RODRIGUES, 2010). Camera traps are a widely used and effective technique for recording hard-to-see species, especially rare and nocturnal ones, as they allow specimens to be pictured without human interference in a natural environment. This device allows the researcher to have constant access to the presence of animals at the point where it was installed, recording the day and time when it was done, and even at night, when most mammal species are active (CHEIDA & RODRIGUES, 2010).

Six photographic traps were installed in the DIA and four camera traps in the DAA of the PARACEL pulp mill (Figure 206 and Figure 207), in points where the mammal fauna is likely to occur, such as near humid environments and in the interior of forests. The camera traps remained active for 5 consecutive days in the first and second sampling campaigns.

Figure 214 – Installing the Camera Trap.

Figure 215 – Camera trap in the study area.

The UTM (Zone 21K) coordinates of the photographic trap site are in Table below

Table 19 – UTM coordinates of the camera traps for the sampling of mammals in the DIA and DAA of PARACEL pulp mill

TRAP	UTM SIRGAS 2000 Coordinates (Zone 21K)	
	Longitude	Latitude
Trap 1 AID	452521.000	7428507.000
Trap 2 AID	451297.000	7431225.000
Trap 3 AID	448560.000	7429890.000
Trap 4 AID	448626.000	7429278.000
Trap 6 AID	449962.000	7426391.000

TRAP	UTM SIRGAS 2000 Coordinates (Zone 21K)	
	Longitude	Latitude
Trap 7 ADA	451108.000	7426955.000
Trap 8 ADA	450383.000	7427752.000
Trap 9 ADA	450541.000	7428491.000
Trap 10 ADA	449454.000	7429665.000

Study Area - Mammals

From Figure 208 to Figure 223 a visual representation of the five sampling transects carried out in the DIA and DAA of the PARACEL pulp mill and the installation points of the camera traps for the sampling of medium and large mammals is shown.

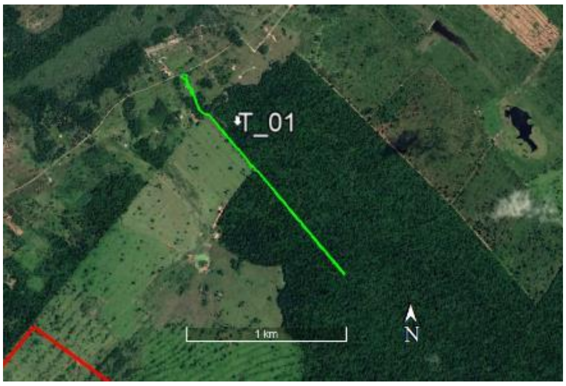

Figure 216 – Aerial image indicating transect 01.

Figure 217 – Transect overview 01.

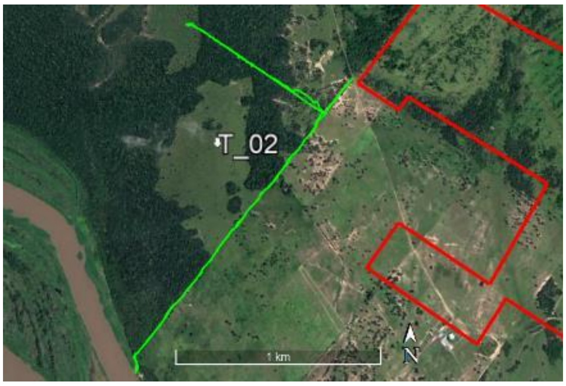

Figure 218 - Aerial image indicating transect 02.

Figure 219 – Transect overview 02.

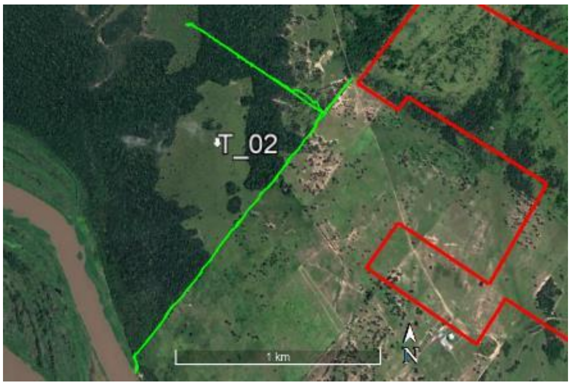

Figure 220 – Aerial image indicating transect 02.

Figure 221 – Transect overview 02.

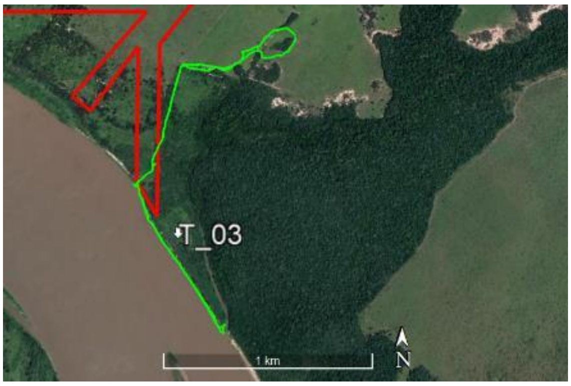

Figure 222 – Aerial image indicating transect 03.

Figure 223 – Transect overview 03.

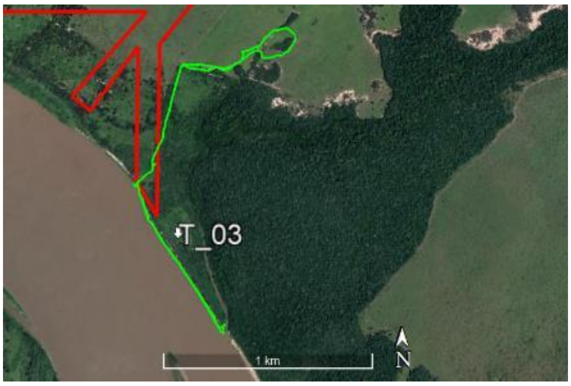

Figure 224 – Aerial image indicating transect 03.

Figure 225 – Transect overview 03.

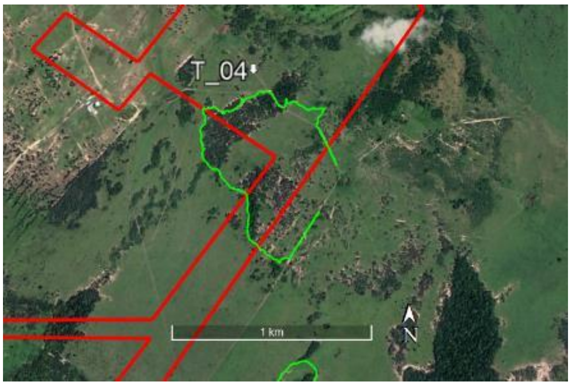

Figure 226 Aerial image indicating transect 04.

Figure 227 – Transect overview 04.

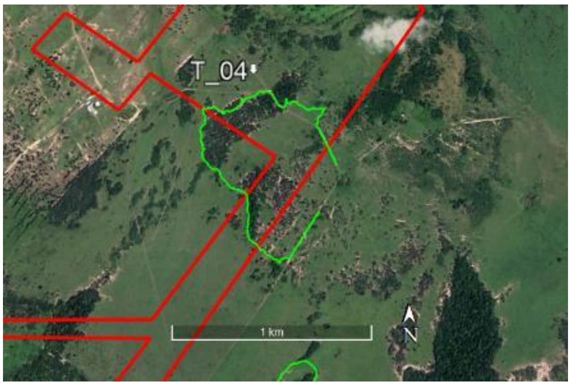

Figure 228 – Aerial image indicating transect 04.

Figure 229 – Transect overview 04.

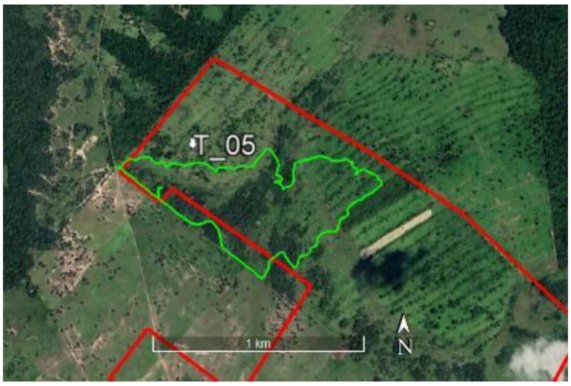

Figure 230 – Aerial image indicating transect 05.

Figure 231 – Transect overview 05.

Data presentation and analysis - Mammals

Richness

Species richness (n) was calculated by the total number of species found in each sampling area (DIA and ADA).

Relative abundance

Relative abundance (RA) represents the number of individuals of a given species at the sampling points, and is represented by N. The calculation of relative abundance was made using the following equation:

A.R. = (n/N).100

where:

n = number of individuals of each species;

N = total number of individuals of all species, represented by N %.

Shannon-Wiener Diversity Index (H')

Measures of diversity consider two factors: species richness and uniformity in the proportional distribution of each species (SEMENSATTO JR., 2003). The Shannon-Wiener (H') diversity index measures the degree of uncertainty in predicting to which species a randomly selected individual will belong from a sample with species n and individuals N. It is calculated with the following formula:

$$H' = -\sum pi.log_2 pi \text{ y } pi = \frac{n}{N}$$

where:

H'= Shannon-Wiener diversity index, in $bit.ind.^{-1}$;

pi= Relative Abundance (AR);

n= number of individuals sampled from the species;

N= total number of individuals sampled at the spot or during sampling.

The Shannon-Wiener (H') diversity index was carried out through the *Software Past 3.0.*

Pielou Equitability Index (J')

In ecology, the Equitability Index (J') makes it possible to represent the uniformity of the distribution of individuals among the species existing in a community or sample (PIELOU, 1966). Its value has a range of 0 to 1, and the closer to one, the greater the homogeneity among the species. The Pielou Equitability Index (J') is calculated using the following formula:

$$J' = \frac{H'}{Hmax}$$

where:

Hmax= ln (S);

S= total number of species sampled;

J'= Pielou's Equitability;

H'= Shannon-Wiener Diversity Index.

The Pielou Equitability Index (J') was carried out through the *Software Past 3.0.*

<u>Rarefaction curve</u>

To analyze the efficiency of the sampling campaign it is necessary to estimate the number of species present in the community, and one way to do this is to present a species scarcity curve, which represents the statistical expectation of a species accumulation curve (GOTELLI & COLWELL, 2001). The rarefaction curve (scarcity) is produced by repeated random sampling of the total data set in order to obtain an average of the number of species found in the samples (CHAO, 2004).

Sufficiency of sampling and estimator calculations were performed with the EstimateS Win 8.20 program when three or more species were recorded.

Ecological analysis

For the ecological analysis of the community in this diagnosis, the habitat preference of the studied species, the food levels (guild) present in the community, the relationship with the environment and the degree of synanthropic, the habitat and the period of activity were evaluated.

The species threatened with extinction at the national level have been classified in accordance with MADES Resolution 623/2017. In the case of globally threatened species, the IUCN Red List of Threatened Species was also consulted (IUCN, 2020).

Methods - Birdlife

Transect Census

For the execution of transect (course) surveys, the observer travels along a path of limited size in controlled time (constant speed) while visually and audibly recording the bird species (Figure 224 and Figure 225). This method also gives priority to recording the greatest number of species, since it samples an area larger than that delimited by the fixed-point method. By covering a greater variety of environments, it is possible to establish a more complete list of bird species in a given study area (ANJOS et al., 2010).

For the study of birdlife, five sample transects (courses) were defined along the DIA and DAA of PARACEL pulp mill, named T_01, T_02, T_03, T_04 and T_05. Each transect is composed of three sections of approximately 500 meters each, totaling 15 sampling sections per campaign. The transect census was conducted at a speed of approximately 1 km/h in each sample section, with a final effort of four hours in the morning, two hours in the afternoon and two hours in the twilight period, making a total of 8 hours of transect census/campaign. Acoustic and visual records were considered at a distance of 20m for each side of the path.

Figure 232 Bird sampling by transect census.

Figure 233 – Notes on bird observations in notebook.

Area of Study - Bird Life

From Figure 226 to Figure 235 is presented the visual representation of the five sampling transects carried out in the AID (T_01, T_02 and T_03) and the DAA (T_03 and T_04) of the pulp mill for the sampling of birds through the census by means of roads.

The sampling grid tried to contemplate all the environmental variation in the area that will suffer the impact, so that most of the local richness was sampled. The areas were selected according to the characteristics of the PARACEL pulp mill, the landscape, the specialist's prior knowledge of the natural history characteristics of the group to be studied and the potential of each environment.

Figure 234 – Aerial image indicating the transect 01.

Figure 235 – Overview of the transect 01.

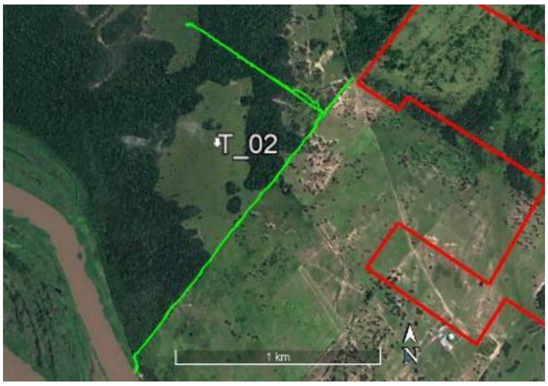

Figure 236 – Aerial image indicating the transect 02.

Figure 237 – Overview of the transect 02.

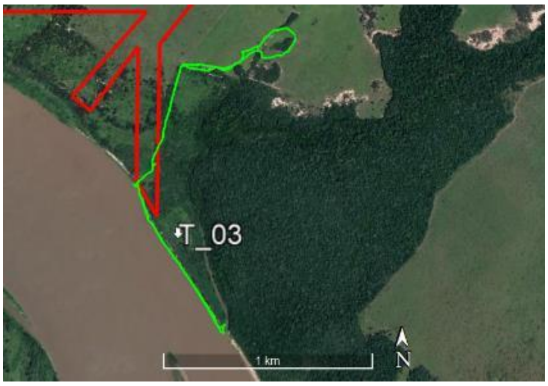

Figure 238 – Aerial image indicating the transect 03.

Figure 239 – Overview of the transect 03.

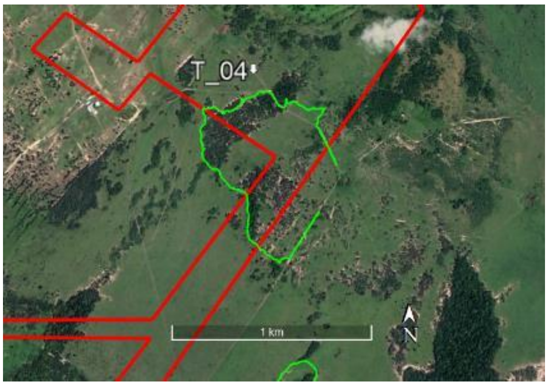

Figure 240 – Aerial image indicating the transect 04.

Figure 241 – Overview of the transect 04.

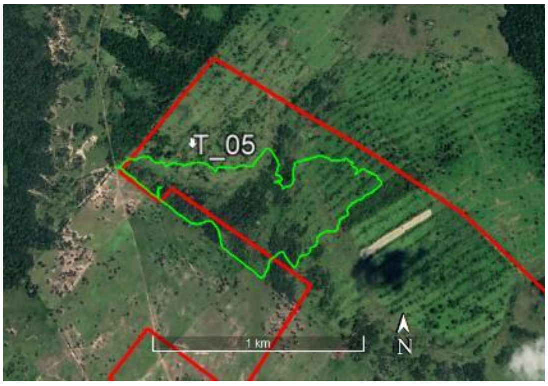

Figure 242 – Aerial image indicating the transect 05.

Figure 243 – Overview of the transect 05.

<u>Data Analysis Presentation – Avifauna</u>

Richness

Species richness (n) was calculated by the total number of species found in each sample.

Frequency of Occurrence

The frequency of occurrence (FO) of each species was determined by the equation FO=Nx100/NT (LINSDALE, 1928), where "N" is the number of sections in which the species was recorded and "NT" is the total number of sections sampled. With the calculation of FO, in percentage, the species were categorized according to Table below.

Table 20 – Abundance class distribution by frequency of occurrence as proposed by Linsdale (1928)

Class of Abundance	Frequency of Occurrence (%)
Very abundant	81 to 100
Abundant	61 to 80
Frequent	41 to 60
Occasional	21 to 40
Rare	1 to 20
Very rare	< 1

Shannon-Wiener Diversity Index (H')

Measures of diversity consider two factors: species richness and uniformity in the proportional distribution of each species (SEMENSATTO JR., 2003). The Shannon-Wiener (H') diversity index measures the degree of uncertainty in predicting to which species a randomly selected individual will belong from a sample with species n and individuals N. It is calculated with the following formula:

$$H' = -\sum pi.log_2 pi \;\; y \; pi = \frac{n}{N}$$

Where:

H'= Shannon-Wiener diversity index, in bit.ind.$^{-1}$;
pi= relative abundance (AR);
n= number of individuals sampled from the species;
N= total number of individuals sampled at the point or at the sampling.

The Shannon-Wiener (H') diversity index was carried out using the *Software Past 3.0.*

In ecology, the Equitability Index (J') makes it possible to represent the uniformity of the distribution of individuals among the species existing in a community or sample (PIELOU, 1966). Its value has a range of 0 to 1, and the closer to one, the greater the homogeneity among the species. The Pielou Equitability Index (J') is calculated using the following formula:

$$J' = \frac{H'}{Hmax}$$

Where:

Hmax= ln (S);
J' = Pielou's Equitability;
S = total number of species sampled;
H' = Shannon-Wiener diversity index.

The Pielou Equitability Index (J') was carried out through the *Software Past 3.0.*

Scarcity curve

To analyze the adequacy of sampling effort it is necessary to estimate the number of species present in the community, and one way to do this is by presenting a scarcity curve, which represents the statistical expectation of a species accumulation curve (GOTELLI & COLWELL, 2001). The curve is produced by repeated random sampling of the total data set in order to obtain an average of the number of species found in the samples (CHAO, 2004).

Sufficiency of sampling and estimator calculations were performed with the EstimateS Win 8.20 program when three or more species were recorded.

Ecological analysis

For the ecological analysis of the community in this diagnosis, we evaluated the habitat preference of the species studied, the food levels (guild) present in the community, the relationship with the environment and the degree of synanthropic, the habitat and the period of activity.

The species threatened with extinction at the national level have been classified in accordance with MADES Resolution 623/2017. In the case of globally threatened species, the IUCN Red List of Threatened Species was consulted (IUCN, 2020).

Methods - Herpetofauna

The diagnosis has been carried out by a team of specialized biologists in two campaigns of 5 days each. The first campaign took place during the dry period, from 23 to 27 October 2019, and the second during the rainy period, from 4 to 8 March 2019. To comply with the mandate of this study, sampling was carried out in the periods between 8:00 and 11:00 a.m. and resumed at 4:00 p.m., lasting until 11:30 p.m., which represents approximately 52 hours of sampling per campaign and 104 hours in the added campaigns, at the times and periods most conducive to the observation of herpetofauna in the various phytophysiognomies.

Active research and point sampling consisted of visual and audio searches conducted near previously defined sites for inspection of visually accessible microhabitats such as logs, rocks, foliage, bromeliads, hollow trees, and termites (Verdade et al., 2010). The visual and auditory search allows the recording of species with different habits (e.g., tree, aquatic, terrestrial and fossil). It is a very versatile and generalist process of detecting and capturing vertebrates in the field (Crump & Scott-Jr, 1994) and can be carried out in the daytime, twilight and nighttime periods. However, this method depends on the availability of resources (water bodies), as well as on the vocalization activity of the anurans.

Sampling of anurans species was mainly carried out during twilight and night periods (the period of most activity for these animals), in the aquatic environments used as breeding sites and also along trails. The active search was conducted randomly in the environment and the effort employed by the method was measured by the number of hours of search/research. The active search was carried out in the same areas and in different areas during the two campaigns. Interviews were also conducted with residents and nearby neighbors or residents of the sampled areas. They were conducted informally, pointing out the species spontaneously cited by the interviewees and the possible places of occurrence. These species were not included in the analyses, as it is not possible to confirm the identification of the species, since some popular names can be used for several species, so it was not possible to obtain the specific epithet, but rather to get an idea of the animals observed by the residents.

Figure 244 – Twilight search active

Figure 245 – Twilight search active

Figure 246 – Biologist doing the registration of the daytime fauna.

Figure 247 – Biologist making the recording of the nocturnal fauna.

Figure 248 – Biologist doing the registration of the daytime fauna.

Figure 249 – Biologist conducting an active search during the day.

Area of Study - Herpetofauna

The areas sampled were identified: Direct Influence Area (DIA) and Indirect Influence Area (IIA), for the quantitative analysis and to cover a larger area, 9 areas, reproductive sites (called H 01 to H 09) were investigated and 5 transects called T 01 to T 05 (Table bellow) were covered, being these, primary data collected through field searches in the area of the pulp mill and its surroundings. Three methods were used for the study of the herpetofauna: active search, point sampling and interview (Verdade et al., 2010) (the method has no collection or capture).

Table 21 – Description and location of the herpetofauna survey sampling points

Sampling points	Environment description	Sampling Area	Coordinates of sampling points (UTM, 21K - SIRGAS 2000)	
			E	S
H 01	Artificial lake with an environment formed by gramineae and other tree and bush species, with great influence of the cattle farming.	DIA	449701	7431530
H 02	Artificial lake with an environment formed by grasses and other tree and shrub species, with great influence of cattle.	DIA	449314	7431248
H 03	Breeding place located in the Paraguay river with some points that suffer great influence of the aquatic vegetation, and connected to a wide fragment of native vegetation.	DAA	447962	7428329
H 04	Breeding site located on the Paraguay River with some points that are heavily influenced by aquatic vegetation, and connected to a large fragment of native vegetation.	DAA	449790	7426177
H 05	Lake with great presence of native aquatic vegetation, with an environment formed by grasses and other tree and shrub species.	DAA	451835	7427888
H 06	Small temporary natural pool, with an environment formed by grasses and other tree and shrub species.	DIA	450723	7432129
H 07	An artificial lake with an environment formed by grasses and other native tree and shrub species, one of the shores is connected to the native vegetation fragment.	DAA	449935	7429778
H 08	Lake and extensive flooded area, with a large presence of native aquatic vegetation, with an environment formed	DAA	449954	7428504

Sampling points	Environment description	Sampling Area	Coordinates of sampling points (UTM, 21K - SIRGAS 2000)	
			E	**S**
	by grasses and other native tree and shrub species.			
H 09	Lake and extensive flooded area, with a large presence of native aquatic vegetation, with an environment formed by grasses and other tree and shrub species.	DIA	453423	7428453
T 01	Fragment of forest with presence of native trees, great amount of lianas, abundant burlap and with body of running water in some parts of its interior.	DIA	452387	7429196
T 02	Open area, with abundant grasses, trees and bushes spaced with the presence of some temporary water bodies.	DAA	450018	7430052
T 03	Fragment of forest with the presence of native trees, a large amount of lianas, abundant burlap and with a body of running water in some parts of its interior.	DIA	448311	7429819
T 04	Open area, with abundant grasses, trees and bushes spaced with the presence of some temporary water bodies.	DAA	450372	7427320
T 05	Fragment of forest with the presence of native trees, a large number of lianas, abundant sackcloth	DIA	451343	7430934

The images below are examples of the areas of study.

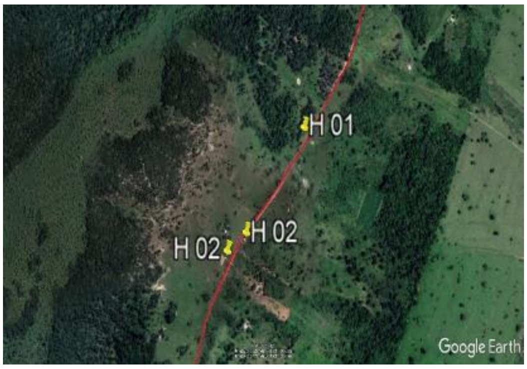

Figure 250 – Aerial image with visual representation of the point H_01.

Figure 251 – Overview of the Point H_01.

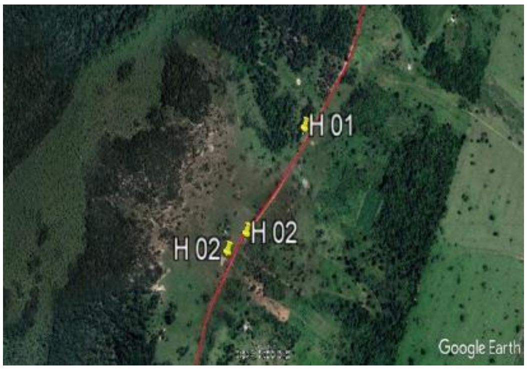

Figure 252 – Aerial image with visual representation of the point H_02.

Figure 253 – Overview of the Point H_02.

Figure 254 Aerial image with visual representation of the point H_03.

Figure 255 – Overview of the Point H_03.

Figure 256 – Aerial image with visual representation of the point H_04.

Figure 257 – Overview of the Point H_04.

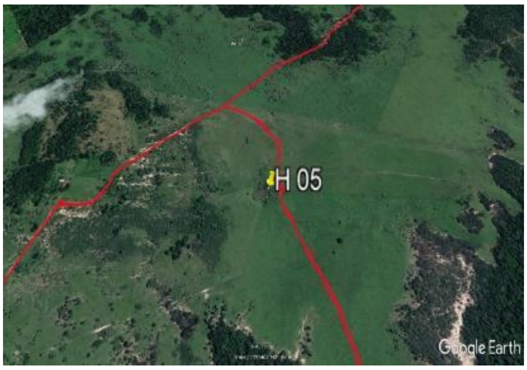

Figure 258 – Aerial image with visual representation of the point H_05.

Figure 259 – Overview of the Point H_05.

Figure 260 – Aerial image with visual representation of the point H_06.

Figure 261 – Overview of the Point H_06.

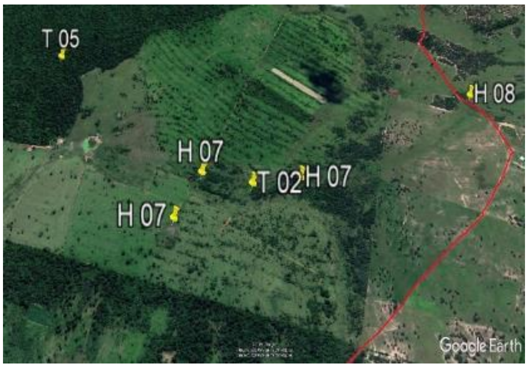

Figure 262 – Aerial image with visual representation of the point H_07.

Figure 263 – Overview of the Point H_07

Figure 264 – Aerial image with visual representation of the point H_08.

Figure 265 – Overview of the Point H_08

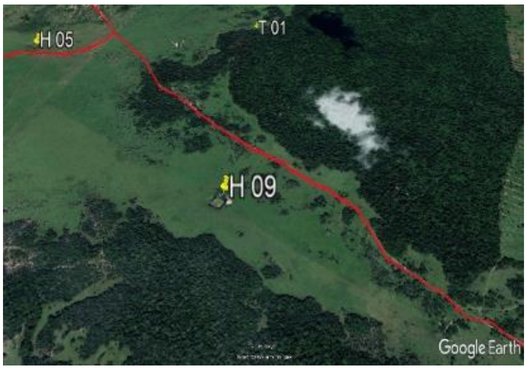

Figure 266 – Aerial image with visual representation of the point H_09.

Figure 267 – Overview of the Point H_09

Figure 268 – Aerial image with visual representation of the transect T_01.

Figure 269 – Transect Overview T_01

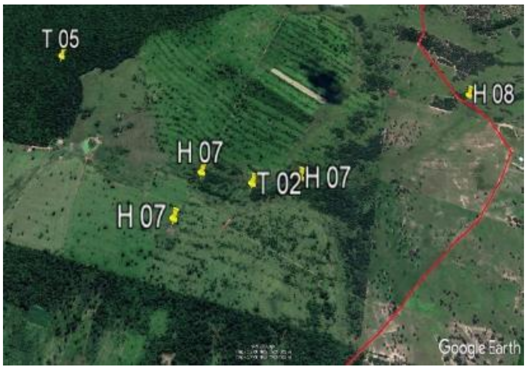

Figure 270 – Aerial image with visual representation of the transect T_02.

Figure 271 – Transect Overview T_02

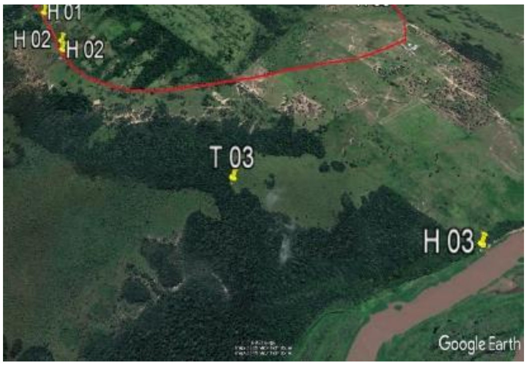

Figure 272 – Aerial image with visual representation of the transect T_03.

Figure 273 – Transect Overview T_03

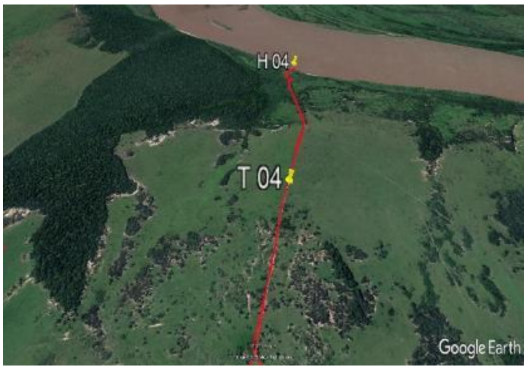

Figure 274 – Aerial image with visual representation of the transect T_04.

Figure 275 – Transect Overview T_04

Figure 276 – Aerial image with visual representation of the transect T_05.

Figure 277 – Transect Overview T_05

Data Presentation and Analysis - Herpetofauna

The registered species of the herpetofauna will be analyzed for their presence in the following lists: Endangered Species of the International Union for the Conservation of Nature (IUCN, 2020), Paraguay List: Resolution n. 433 of 14 August 2019).

The following will be used to describe amphibian and reptile diversity: a) number of individuals, b) observed and estimated species richness, c) Shannon-Wiener diversity index, equitability and dominance.

The taxonomic classification of amphibians will follow Segalla et al. (2016) and that of reptiles will follow Bérnils e Costa (2016).

- Shannon-Wiener diversity index

$$H' = -\sum pi.\log_2 pi \quad \text{y} \quad pi = \frac{n}{N}$$

where:

H' = Shannon-Wiener diversity index, in bit.ind.-1
pi = relative abundance
n = number of individuals sampled from the species
N = total number of individuals sampled at the point

- Equitability Index

This index refers to the distribution of individuals among species, being proportional to diversity and inversely proportional to dominance. The results of equitability vary from 0 to 1, with values above 0.5 indicating that individuals are well distributed among the different species. This index is obtained by the equation:

$$J=H'/H'max$$

Where:

H' = Shannon index
J = equitability,
H'max = neper logarithm of S.

The Equitability and Shannon indices will be calculated using the *Sotware PAST*.

- Similarity index
- Scarcity Curve and Estimated Richness (Jackknife 1)

The Jackknife1 richness extrapolation index will be used, Shannon will be calculated using a sample with 1,000 randomizations in the *Software EstimateS 9.10* (Colwell, 2013).

An accumulation curve of amphibian and reptile species will be constructed for all areas together.

Methods - Ichthyofauna

Two points were sampled in the mill's area of influence, distributed along the banks of the Paraguay River. The collection methods used were 8 mm trawls along the margin and underneath the macrophytes, 5 bait-armed plastic cages and 20 to 70 mm mesh waiting nets (two nets of each mesh, each 25 meters in total length) were placed in the deepest locations, above 1.5 meters.

Waiting nets and cages were mounted and baited twice a day for 4 days, and were monitored at different times, trawling was carried out during the daytime period at the margins and under the islands of aquatic macrophytes. The effort in sampling hours totaled approximately 32 hours, at each of the 3 collection points adding up the different types of fishing gear. The collected individuals were identified on site, measured, counted, recorded by photograph and returned to the river. The identification was based on the keys and descriptions in the Pantanal fish literature (Britski et al., 2007). The images below are examples of some methods of capturing and processing the captured individuals.

Figure 278 – Withdrawal from the waiting trap.

Figure 279 – Cage trap is being installed near the macrophytes on the river bank.

Figure 280 – Individual processing (metric analysis and photographic recording).

Figure 281 – Cage trap being removed.

Area of Study - Ichthyofauna

The ichthyofauna campaign was carried out at 2 points on the Paraguay River, one point upstream the effluent disposal point and one point downstream the water intake.

Table 22 – UTM coordinates of the ichthyofauna collection points in the first sampling campaign.

Points	UTM Coordinates (SIRGAS 2000) 21K	
P01 – Upstream	448425.00 m E	7427193.00 m S
P02 – Downstream	449983.00 m E	7425672.00 m S

The location of the Ichthyofauna sampling points can be seen in Figure 274 and Figure 275 below.

Figure 282 – Aerial image with visual representation of the point P_01.

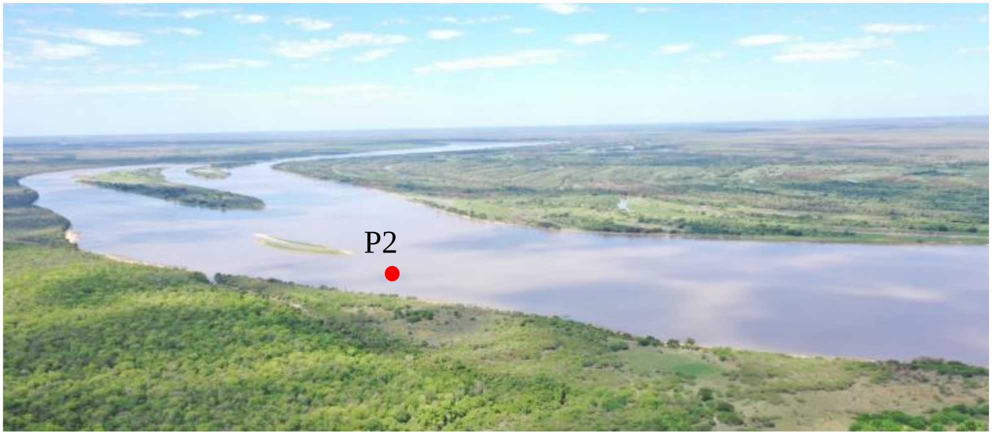

Figure 283 – Aerial image with visual representation of the point P_02

Data Analysis Presentation - Ichthyofauna

The area's ichthyofauna was analyzed with evaluations of rarity, richness, dominance, diversity, and uniformity. The species accumulation curve was developed according to the Mao Tau sampling method (Colwell et al., 2004).

The diversity of the set is addressed by two main components, species richness and equitability, represented by the absolute number of species found, and the relative abundance of these (HSIEH; LI,1998).

Species diversity was estimated using the Shannon index and the "Chao1" estimator used to estimate expected species richness for the site (CHAO et al., 2005). The analyses were carried out in the Software of the previous version 3.1

The classification of species according to their vulnerability to extinction was made considering the Official List of Threatened Fishery Species of the Ministry of Environment of Paraguay and the IUCN (2018). In the same way, species with possible economic interest were identified.

9.2.2.5.2 Results

9.2.2.5.2.1 Mammal fauna

Richness

Twenty-two species of mammals were diagnosed, distributed in 16 families in the orders Didelphimorphia, Cingulata, Rodentia, Carnivora and Artiodactyla. With regard to temporality, 19 species of land mammals were recorded during the first season (dry season) in the AID and 8 species in the ADA. For the second campaign (beginning of the rainy season), 15 species were recorded in the AID and 12 in the ADA.

In addition, it should be noted that the second campaign (rainy season) had the registration of three exclusive species, namely *Cavia aperea*, *Myocastor coypus* and *Eira barbara*.

The results obtained in the field represent 12% of the total species recorded by collecting secondary data for the region of the pulp mill, without any exclusive species not included in the regional list being recorded.

It should be noted that the data obtained through the secondary records do not include small mammals and bats. It should also be considered that the works consulted include differentiated sampling efforts, as well as habitats and hydrophilicities not sampled during the present diagnosis.

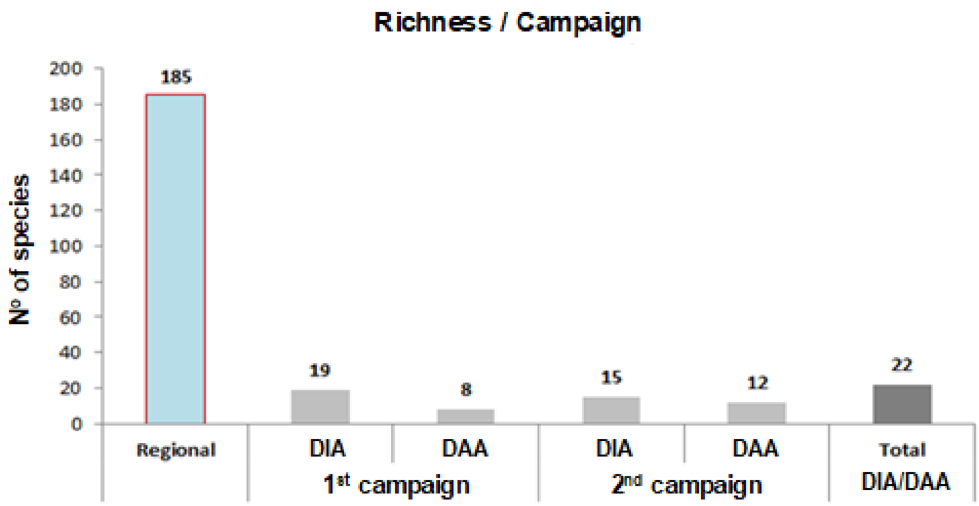

Figure 284 – Species richness of the mammal fauna recorded during the first and second sampling campaigns. SD - secondary data.

The sampling method by indirect observation is responsible for records of n= 15. Of the total 22 sp, 7 species were obtained in records through direct observation, which is expected, although the mammal has discrete habits.

Sampling through the photographic trap generated results of n= 6. An important record through the camera trap was achieved by three species: *M. tridactyla*, *E. barbara* and ‘ in the second season (rainy season).

Abundance

Before presenting data on relative abundance, it is necessary to examine what is meant by the proportion of records of a given method in relation to the actual abundance of the species associated with them. In this regard, Jorge (1986) and Walker et al. (2000) state that the frequency of records does not necessarily represent the actual abundance of the species. Although this statement seems contradictory in relation to the objectives of the present study, it points out one of the main conclusions: the need to apply several methods to access population data. It is therefore necessary to take into account the variation between the rates of obtaining the records analyzed and the actual abundance of the species (Walker et al., 2000).

During the present study, a total of 98 individuals were recorded, 50 in the first campaign and 48 in the second sampling campaign. In general, the most abundant species were: L. gymnocercus, C. thous and D. aurita, also common to all sampling areas. The other species obtained a lower occurrence, but with at least 1 record in one of the transects (**Figure 277**).

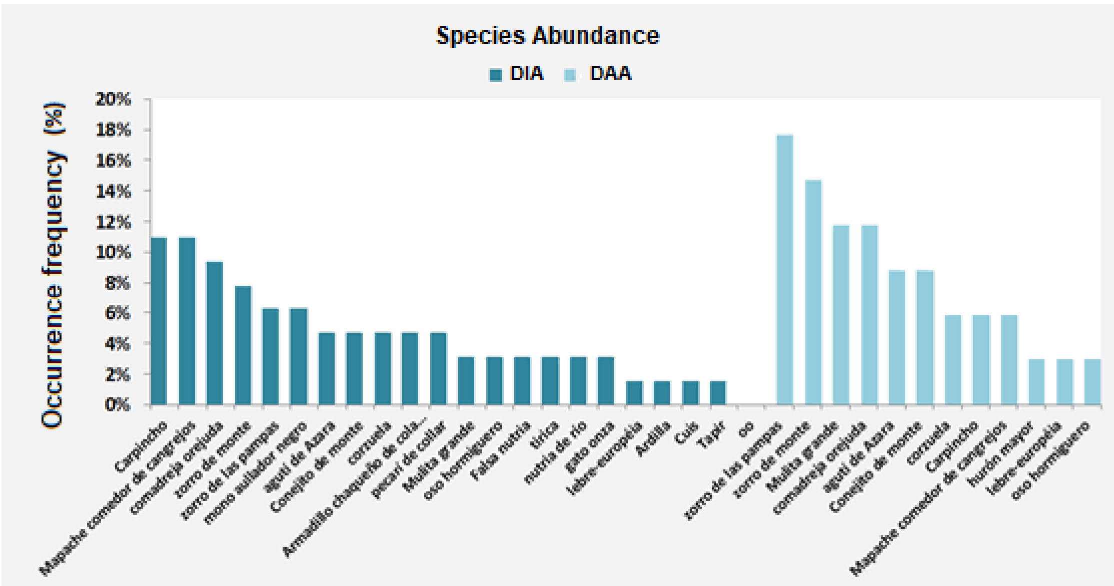

Figure 285 – Absolute abundance of mammals recorded during the first and second sampling campaigns.

Sample efficiency curve

For the analysis of the sampling effort, the rarefaction (scarcity) curve of the observed species (richness) was generated in relation to the sampling effort carried out, using the statistical program EstimateSWin version 9.1.0. The sampling units considered were composed of morning, afternoon and night periods in each transect sampled during two campaigns, making a total of 15 sampling periods. For this study we used the Jackknife 1 richness estimator, which has the function of estimating the accuracy of the statistical sample using subsets of the available data (jackknifing).

Considering the **Figure 278** is then possible to observe that, for the first sampling campaign, the rarefaction curve tends to be asymptotic, which indicates that the sampling effort carried out was satisfactory for the present study. Although the curve shows that the richness obtained was satisfactory, it should be noted that increasing the sampling effort can always result in the recording and a greater number of species. This is evidenced by the advent of the second campaign, which resulted in the registration of 03 exclusive species that had not been previously registered. It is observed that the rarefaction curve obtained for the second campaign has approached the Jackknife 1.

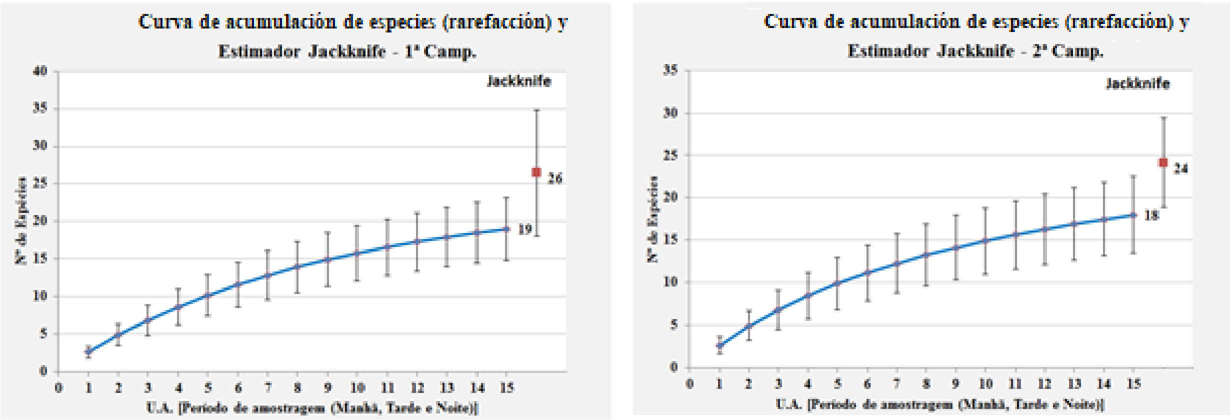

Figure 286 – Rarefaction curve and Jackknife estimator for the first and second sampling campaign.

Analyzing the curve of the two campaigns Figure 279, it can be seen that the mast cell rarefaction curve has not reached its asymptote, however, it shows a slight tendency to stabilize. Thus, a total of 22 species were diagnosed during the present study, with Jackknife 1 estimating the occurrence of 28 species. These results suggest that, with increased sampling effort, more species are expected to be recorded in the areas of interest. Observing the standard deviation of the Jacknife estimator (SD ±4), the effort carried out can be considered satisfactory.

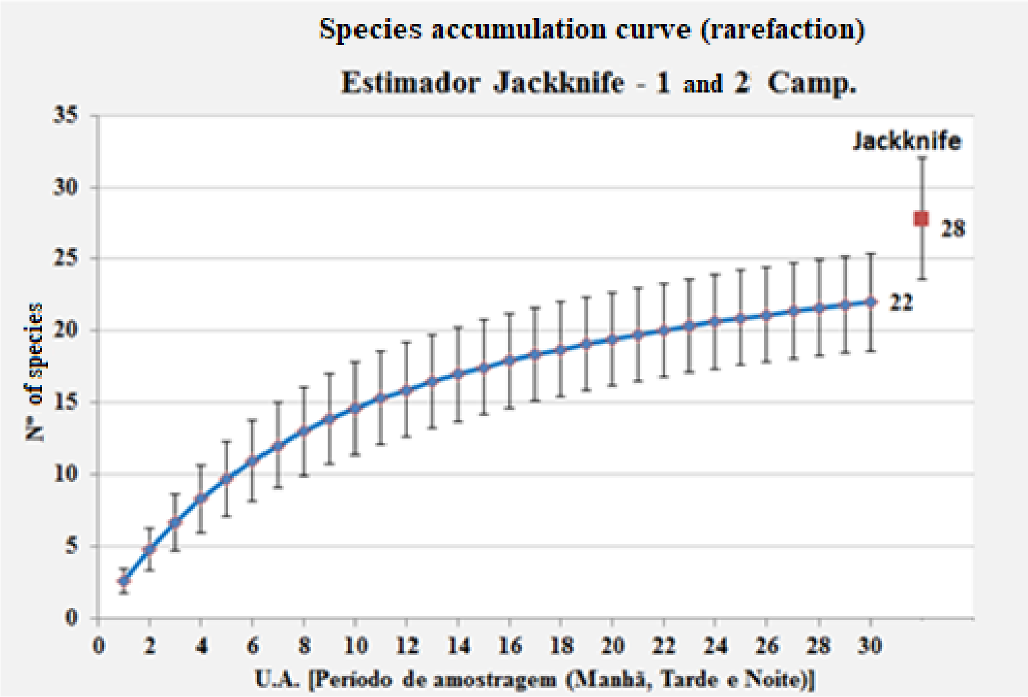

Figure 287 – Sample efficiency curve for the mammal group.

Diversity index

The diversity calculations were performed with the software of the previous version 3.1, using the natural logarithm (base e) and the results are arranged in Table below.

The total diversity of the study area was low, with Shannon H'= 1,931, and showed low equitability, demonstrating the existence of few abundant species in the sample (J'= 0,753).

Table 23 – Species diversity indices of the species diagnosed by transect during the first and second sampling season

Sampling area	Station	Richness observed	Abundance	Shannon Diversity (H')	Pielou (J') Equitability
DIA	**1st Campaign**	19	40	0.9263	0.9381
ADA		8	10	0.86	0.974
DIA	**2nd Campaign**	15	24	0.9201	0.9655
ADA		12	24	0.8889	0.936
DIA	**TOTAL**	22	98	2.837	0.9178

Analyzing the areas separately, the first and second campaigns (Figure 280), it can be seen that the DIA in the first campaign obtained the greatest diversity among the others, with the total of H'= 2.71. The lowest diversity was DAA in the first campaign with H'= 2.03. As for the difference by sampling campaign, in the second campaign the richness obtained, comparing the first and second campaigns, increased when exclusive species were recorded. However, if the objective is to verify diversity according to seasonality, the results, in this case, cannot be compared, because in the second campaign, despite the rainy season, the climatic conditions were the same as in the first campaign, because the amount of rain for the period in the region was not satisfactory.

Regarding the Equitability (J'), it can be observed that, in general, the community structure is basically composed of three dominant species. Analyzing the campaigns separately, the equitability shows that there is a certain homogeneity in the distribution of abundance among the species.

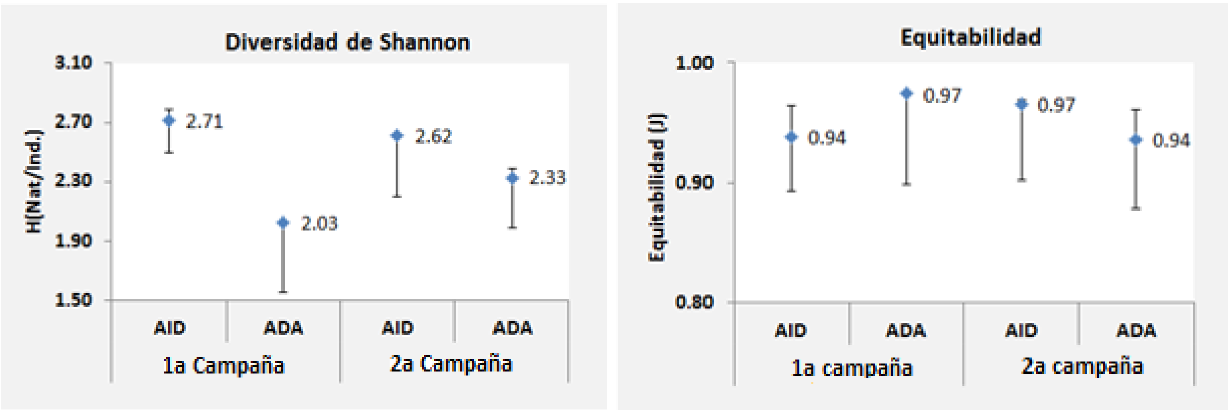

Figure 288 – Shannon Diversity Index (A) and Equivalence (B) for the mammal group during the first and second sampling campaigns.

The table below lists the species of mammal fauna recorded during the first and second sampling campaigns, as well as the categories of threat, habit, guild, period of activity, life area, relationship with the environment, degree of synanthropism and some observations.

Table 24 – List of species of mammal fauna recorded during the first and second sampling period, in October/2019 and March/2020, respectively.

Specie	Popular Name in Paraguay	1st campaign		2nd campaign		General	Record Type		Category of Threat		Habit	Eating Habit	Activity period	Life area	Environment relation	Degree of Sinanthropism	Observation
		AID	ADA	AID	ADA	1st and 2nd campaign	AID	ADA	PY Res. 632 (2017)	IUCN (2021-1)							
Order Didelphimorphia Gill, 1872																	
Family Didelphidae Gray, 1821																	
Didelphis aurita (Wied-Neuwied, 1826)	comadreja orejuda	3	1	3	3	10	OD/ CT	OD/ CT		LC	Arb	Oni	N	1,23 km^2	Eu	Sin	sp abundant
Order Cingulata Illiger, 1811																	
Family Dasypodidae Gray, 1821																	
Dasypus novemcinctus (Linnaeus, 1758)	Mulita grande	1	1	1	3	6	PE	PE		LC	Ter	Oni	C/N	0,03 a 0,15 km^2	Eu	Per	Interest cinegenic
Cabassous chacoensis (Wetzel, 1980)	Armadillo chaqueño de cola desnuda	2		1		3	PE			NT	Fos	Ins	N	3,7 km^2	Es	Per	
Order Xenarthra																	
Family Myrmecophagidae Gray, 1825																	
Myrmecophaga tridactyla (Linnaeus, 1758)	oso hormiguero	1		1	1	3	PE, CT	CT	AM	VU	Ter	Ins	D	9 a 25 km^2	Es	Alo	
Order Primates Linnaeus, 1758																	
Family Atelidae Gray, 1825																	
Alouatta guariba (Humboldt, 1812)	mono aullador negro	3		1		4	OD			VU	Arb	Fru	D	0,45 km^2	Es	Per	
Order Rodentia Bowdich, 1821																	
Family Sciuridae G. Fischer, 1817																	
Guerlinguetus ignitus (Gray, 1867)	Ardilla	1				1	OD			-	Arb	Fru	D	0,014 km^2	Eu	Per	
Family Caviidae G. Fischer, 1817																	
Cavia aperea (Erxleben, 1777)	Cuis			1		1	OD			LC	Ter	Her	D	1,7 km^2	Eu	Per	

Specie	Popular Name in Paraguay	1st campaign		2nd campaign		General	Record Type		Category of Threat		Habit	Eating Habit	Activity period	Life area	Environment relation	Degree of Sinanthropism	Observation
		AID	ADA	AID	ADA	1st and 2nd campaign	AID	ADA	PY Res. 632 (2017)	IUCN (2021-1)							
Hydrochoerus hydrochaeris (Linnaeus, 1766)	Carpincho	4	1	3	1	9	PE, FE	PE, FE		LC	Saq	Her	D	1,74 km²	Eu	Sin	Interest cinegenic
Family Dasyproctidae Bonaparte, 1838																	
Dasyprocta azarae (Lichtenstein, 1823)	agutí de Azara	1	1	2	2	6	PE	PE		DD	Ter	Her	D	0,085 km²	Eu	Per	Interest cinegenic
Family Myocastoridae Ameghino, 1904																	
Myocastor coypus (Molina, 1782)	Falsa nutria			2		2	PE			LC	Saq	Her	C/N	2,3 km²	Es	Per	
Order Lagomorpha Brandt, 1855																	
Family Leporidae G. Fischer, 1817																	
Lepus europaeus (Pallas, 1778)		1			1	2		OD		LC	Ter	Her	D/N	0,2 km²	Eu	Sin	exotic species
Sylvilagus brasiliensis (Linnaeus, 1758)	Conejito de monte	1	2	2	1	6	OD	CT		EN	Ter	Her	D/N	0,004 km²	Es	Per	
Order Carnivora Bowdich, 1821																	
Family Felidae G. Fischer, 1817																	
Leopardus pardalis (Linnaeus, 1758)	gato onza	1		1		1	PE	PE		LC	Ter	Car	N	3,5 to 17,7 km²	Es	Alo	
Leopardus tigrinus (Schreber, 1775)	tirica	2				2			AM	VU	Ter	Car	N	3,5 to 17,7 km²	Es	Alo	Skin trade
Family Canidae G. Fischer, 1817																	
Cerdocyon thous (Linnaeus, 1766)	zorro de monte	5	1		4	10	OD, PE, CT	OD, PE,CT		LC	Ter	Oni	C/N	10 km²	Eu	Sin	Skin trade
Lycalopex gymnocercus (G. Fischer, 1814)	zorro de las pampas	2	2	2	4	10	CT	CT		LC	Ter	Car	D/N	10 km²	Eu	Sin	
Family Mustelidae G. Fischer																	
Eira barbara (Linnaeus, 1758)	hurón mayor				1	1		CT		LC	Ter	Oni	D	2 to 24 km²	Es	Per	

Specie	Popular Name in Paraguay	1st campaign		2nd campaign		General	Record Type		Category of Threat		Habit	Eating Habit	Activity period	Life area	Environment relation	Degree of Sinanthropism	Observation
		AID	ADA	AID	ADA	1st and 2nd campaign	AID	ADA	PY Res. 632 (2017)	IUCN (2021-1)							
Lontra longicaudis (Olfers, 1818)	nutria de río	1		1		2	OD	PE/OD		NT	Saq	Psic	D	7 to 80 km²	Es	Alo	
Family Procyonidae Gray, 1825																	
Procyon cancrivorus (G. Cuvier, 1798)	Mapache comedor de cangrejos	5		2	2	9	PE	PE		LC	Ter	Oni	N	8 to 50 km²	Es	Per	
Order Perissodactyla Owen, 1848																	
Family Tapiridae Gray, 1821																	
Tapirus terrestris (Linnaeus, 1758)	Tapir	1				1	PE		AM	VU	Ter	Her	C/N	0,04 km²	Es	Alo	
Order Artiodactyla Owen, 1848																	
Family Tayassuidae Palmer, 1897																	
Pecari tajacu (Linnaeus, 1758)	pecarí de collar	3				3	PE			LC	Ter	Fru	D/N	0,24 to 8 km²	Es	Alo	Interest cinegetic
Family Cervidae Goldfuss, 1820																	
Mazama gouazoubira (G. Fischer, 1814)	corzuela	2	1	1	1	5	PE, CT	PE, CT		LC	Ter	Her	D	1,5 km²	Es	Alo	Interest cinegenic

Legend: Threat Categories: Py: Paraguay 2017; IUCN - The IUCN Red List for Threatened Species, version 2020.1. Record Form: E - interview; PE - footprint; TO - covo; OD - direct observation; CT - camera trap. Habitat: ARB - arboreal; ESC - scanned; FOS - semi-fossorial; SAQ - semi-aquatic; TER - terrestrial. Guilda: FRU - frugivore; HER - herbivore; ONI - omnivore; PISC - piscivore. Relationship with the environment: EU - eurieca; EN - stenocetic. Synanthropic Grade: SIN - synanthropic; PER - perianthropic; ALO - allotropic. Activity period: D - daytime; N - nighttime; C/N - twilight and nighttime. Observations (Obs.) - IC - hunting interest; IE - economic interest; CP - skin trade.

Ecological Categories

A. Habitat preference and period of activity

The species have been classified by habitat preference and period of activity according to Sigrist (2012) and Reis et al. Data obtained in the field show that most of the recorded mammals have terrestrial habits (15 sp), 03 tree and semi-aquatic species and only one fossil species, as shown in the figure below.

As for the land representatives, they are found in the area: *D. novemcinctus*, *M. tridactyla*, *C. aperea*, *D. azarae*, *L. europaeus*, *S. brasiliensis*, *L. pardalis*, *L. tigrinus*, *C. thous*, *L. gymnocercus*, *E. barbara*, *P. cancrivorus*, *T. terrestres*, *P. tajacu y M. gouazoubira.*

Of these, *C. thous* and *D. novemcinctus* have peaks of activity in the twilight and night period, moving in search of food and reproductive activity, while P. cancrivorus moves mainly at night, preferably near aquatic environments. Mammals of preferential daytime activity are represented by *M. tridactyla*, *A. guariba*, *G. ignitus*, *C. aperea*, *H. hydrochaeris*, *D. azarae E. barbara*, *L. longicaudis* and *M. gouazoubira*, which can be considered of great hunting interest since they are commonly hunted for their meat.

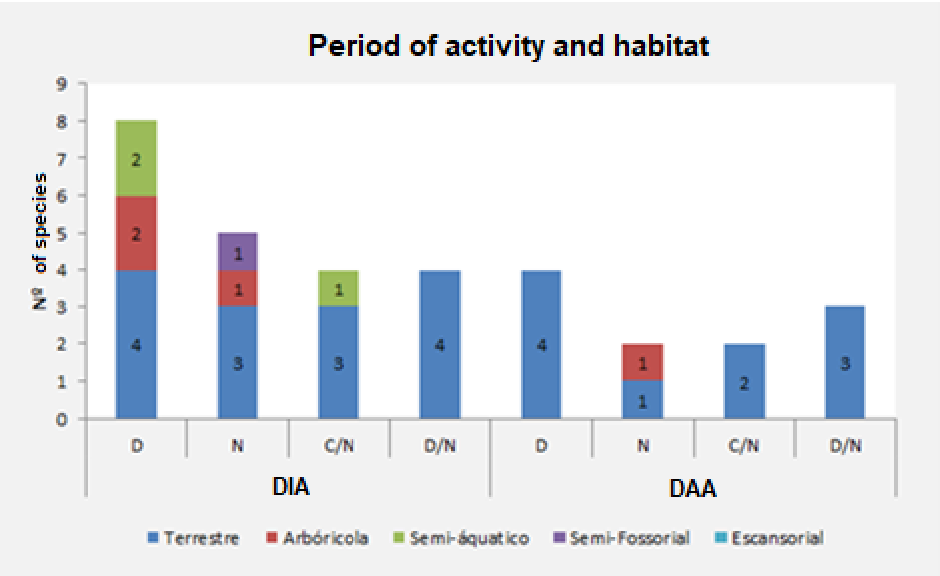

Figure 289 – Distribution of species by period of activity and habitat preference: D - daytime; N - nighttime; C/N - twilight/night; D/N - day/night.

B. Guilds

The study of trophic relationships in communities has been considered an important tool for the implementation of biodiversity conservation measures in tropical environments (Soulé & Simberloff, 1986). However, it is necessary to measure biodiversity not only through censuses of animal and plant species, but also through the study of their population and food interactions, the lack of which may prevent an integrated understanding of ecosystem functioning (Walker, 1992).

Food is an important factor because it influences fertility, development, longevity and mortality. Analysis of the framing of certain species in their respective food guilds can indicate the food supply available in the study environment and reveal whether their trophic structure is balanced.

For the present study, species representing 6 trophic guilds were recorded. Most of the identified mammals belong to the guild of herbivores with 36%, omnivores with 23% of the records, followed by frugivores and carnivores with 14%, insectivores with 9% and piscivores with 5%, as shown in the figure below.

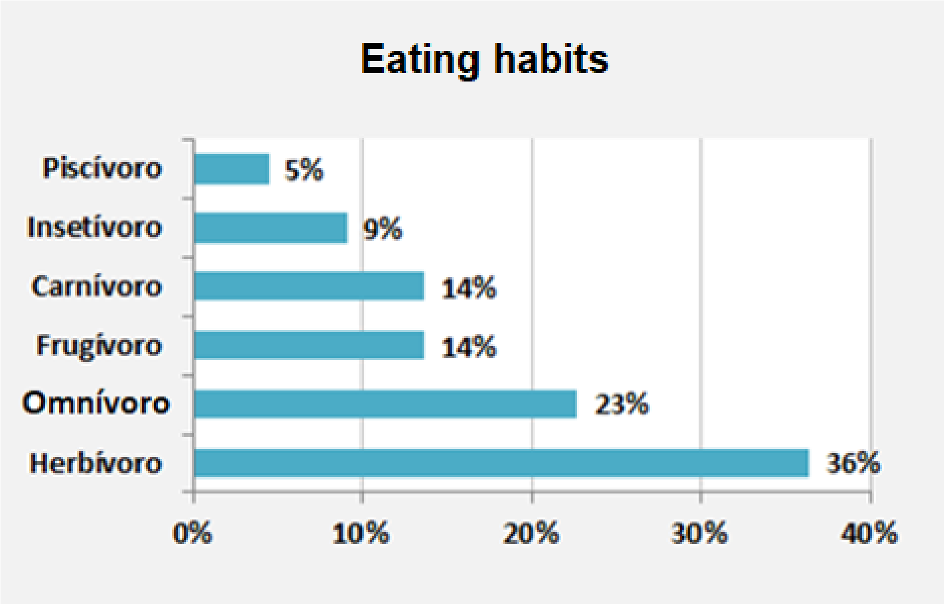

Figure 290 – Eating habits of mammal species.

Omnivorous species are known to exploit more than one trophic category, consuming both plant and animal foods. For this category some of the representatives: *D. albiventris*, o *D. novemcinctus*, *C. thous* and the *P. cancrivorus*.

The herbivorous species represented by, *D. azarae*; *M. gouazoubira* e a *H. hydrochaeris*. According to Sigrist (2012), the cutia (*D. azarae*) is a forest species and is associated with watercourses, feeding on fruits, sprouts and seeds, its habitable area is approximately 2 to 3 hectares. The capybara (*H. hydrochaeris*) is considered the largest rodent in the world and the only species represented by the family Hydrochoerinae. It has semi-aquatic habits and inhabits the most varied environments, preferably consuming grasses and aquatic vegetation, fruits and shoots. The red deer (*M. gouazoubira*) is a generalist, it eats, leaves, shoots and twigs, fruits, and can vary according to the environment and seasonality. Its living area is 1.5 km².

Among those that feed on fruits (frugivores), only coatipuru was observed (*G. ingrami*), which feeds mainly on palm coconut. Carnivorous ocelots (*L. pardalis*) have a diet ranging from small rodents, cycads, lizards, birds and insects. *L. longicaudis* feeds on fishes.

C. Environmental Quality Bioindicator Species

In the neotropics, frugivores constitute a significant portion of the vertebrate biomass (Willis, 1980. Terborg, 1986). This group is particularly vulnerable to seasonal variations in the supply and availability of food (Foster, 1977; Foster, 1982), to structural changes in their habitats, such as the fragmentation or selective elimination of plants that serve as food (Willis, 1979; Howe, 1984).

Many species of neotropical fruit-eating mammals are currently considered to be in danger of extinction (Collar et al., 1992). On the other hand, it is precisely this vulnerability that gives vertebrate frugivores the status of good ecological indicators in the detection of environmental changes (Strahl & Grajal, 1991), or in the planning of conservation measures (Powell & Bjork, 1995). Higher species are also good indicators, since they are structuring species of the food guild.

A. guariba is a forest species considered to be an important seed disperser. It mainly inhabits forests, which are found in different formations of wooded savannahs, semi-deciduous forests and riparian forests (Sigrist, 2012). Given its dependence on forest environments and its important role in maintaining ecosystems, *A. guariba* can be considered a good bioindicator of the quality of the environment.

Among the species diagnosed in the study area are 05 bioindicators of environmental quality.

Table 25 – List of mammal species bioindicators of environmental quality.

Specie	Popular Name in Paraguay	DIA	ADA
Myrmecophaga tridactyla (Linnaeus, 1758)	oso hormiguero	x	x
Leopardus pardalis (Linnaeus, 1758)	gato onza	x	x
Leopardus tigrinus (Schreber, 1775)	tirica		
Lontra longicaudis (Olfers, 1818)	nutria de río	x	x
Tapirus terrestris (Linnaeus, 1758)	Tapir	x	
Pecari tajacu (Linnaeus, 1758)	pecarí de collar	x	
Mazama gouazoubira (G. Fischer, 1814)	corzuela	x	x

D. Endangered species

Threatened species are classified according to the global list (IUCN, 2020-1) and also the classification of Paraguay - Resolution 632/2017.

During the present study 06 species were found to be listed by IUCN (2020-1) in the category of "Near Threatened" (NT), "Endangered" (EN), "Vulnerable" (VU) and "Threatened" (AM) and 03 in the list of Paraguay (Resolution 632/2017) according to the following table.

Table 26 – List of mammal species threatened with extinction.

Specie	Popular Name in Paraguay	Resolution 632/2017	IUCN (2021-1)
Cabassous chacoensis (Wetzel, 1980)	Armadillo chaqueño de cola desnuda		NT
Cabassous chacoensis (Linnaeus, 1758)	oso hormiguero	AM	NT
Sylvilagus brasiliensis (Linnaeus, 1758)	tirica		EN
Leopardus tigrinus (Schreber, 1775)	tirica	AM	VU
Lontra longicaudis (Olfers, 1818)	nutria de río		NT
Tapirus terrestris (Linnaeus, 1758)	Tapir	AM	VU

E. Species of Economic or Hunting Importance

Seven species of hunting interest can be included in this category. *D. novemcinctus* is considered, together with the limpet, the most tasty and appreciated wild animal meat by hunters (Sigrist, 2012). Similarly, *Dasyprocta sp.; H. hydrochaeris and M. gouazoubira* are usually hunted for sport or as a source of food.

C. thous; L. pardalis and L. tigrinus are under hunting pressure to obtain and market their skins.

F. Ecological Valency

In Odum (1977), the term ecological valence is the name given to a species that has the capacity to populate different environments characterized by great variations in ecological factors. According to ecological valence (Margarido, 1994), species are divided into:

Euriecio: species of great ecological value. They can inhabit several environments.

Estenecio: species of little ecological value. It supports a small variation of ecological factors and is restricted to certain environments.

Thus, some species, depending on the level of organization studied, can survive with or without the presence of vegetation, while others only survive with the presence of vegetation, so it is a good tool for the evaluation and classification of the quality of these ecosystems.

The framework of the species is given by the animal's own biology, as well as by the places and natural environmental conditions in which the establishment of populations of these organisms is feasible. Although the habitat is an element of nature, there are also artificial habitats, built by man, or which have suffered from human intervention, and therefore are subject to the increase of the population of a species or community.

For the degree of synanthropism, the following types of species can be distinguished (Margarido, 1994):

Alloanthropic: species that do not tolerate human presence.

Perianthropic: live close to humans with restrictions.

Synanthropic: They live with the humans by adaptation.

Therefore, some species can be considered as bio-indicators of environmental quality. Thus, when species information is crossed, for example, Estenaecium and Aloanthropico, the result is species that are demanding in relation to the environment, resources and not very tolerant to human presence. On the other hand, species such as Euriecio and Synanthropic and even some that are Perianthropic can benefit from changes in the environment due to the implementation of projects considered to have a relevant environmental impact.

The mammal fauna diagnosed in the study area is predominantly composed of species of estenecio considered perianthropic and alloanthropic, with 13 representatives, among these 07 alloanthropic species. Of this total, 9 species are considered euriecio. Therefore, most of the large and medium mammals in the study area can be considered sensitive to environmental changes and with little or no tolerance to human presence.

Table 27 – Relationship with the environmental quality of the species of the registered mammal fauna Legend: red - high; orange - medium; green - low.

Specie	Popular Name in Paraguay	Relationship with environmental quality and the environment
Didelphis aurita Wied-Neuwied, 1826	comadreja orejuda	Euriecio/ Synanthropic
Dasypus novemcinctus Linnaeus, 1758	Mulita grande	Euriecio/ Perianthropic
Cabassous chacoensis Wetzel, 1980	Armadillo chaqueño de cola desnuda	Estenecio/ Perianthropic
Myrmecophaga tridactyla (Linnaeus, 1758)	oso hormiguero	Estenecio / Alloanthropic
Alouatta guariba (Humboldt, 1812)	mono aullador negro	Estenecio / Perianthropic
Guerlinguetus ignitus (Gray, 1867)	Ardilla	Euriecio/ Perianthropic
Cavia aperea (Erxleben, 1777)	Cuis	Euriecio/ Perianthropic
Hydrochoerus hydrochaeris (Linnaeus, 1766)	Carpincho	Euriecio / Synanthropic
Dasyprocta azarae (Lichtenstein, 1823)	agutí de Azara	Euriecio / Perianthropic
Myocastor coypus (Molina, 1782)	Falsa nutria	Estenecio / Perianthropic
Lepus europaeus Pallas, 1778	Liebre	Euriecio / Synanthropic
Sylvilagus brasiliensis (Linnaeus, 1758)	Conejito de monte	Estenecio / Perianthropic
Leopardus pardalis (Linnaeus, 1758)	gato onza	Estenecio / Alloanthropic
Leopardus tigrinus (Schreber, 1775)	tirica	Estenecio / Alloanthropic
Cerdocyon thous (Linnaeus, 1766)	zorro de monte	Euriecio / Synanthropic
Lycalopex gymnocercus (G. Fischer, 1814)	zorro de las pampas	Euriecio / Synanthropic
Eira barbara (Linnaeus, 1758)	hurón mayor	Estenecio / Perianthropic
Lontra longicaudis (Olfers, 1818)	nutria de río	Estenecio / Alloanthropic
Procyon cancrivorus (G. Cuvier, 1798)	Mapache comedor de cangrejos	Estenecio / Perianthropic
Tapirus terrestris (Linnaeus, 1758)	Tapir	Estenecio / Alloanthropic

Specie	Popular Name in Paraguay	Relationship with environmental quality and the environment
Pecari tajacu (Linnaeus, 1758)	pecarí de collar	Estenecio / Alloanthropic
Mazama gouazoubira (G. Fischer, 1814)	corzuela	Estenecio / Alloanthropic

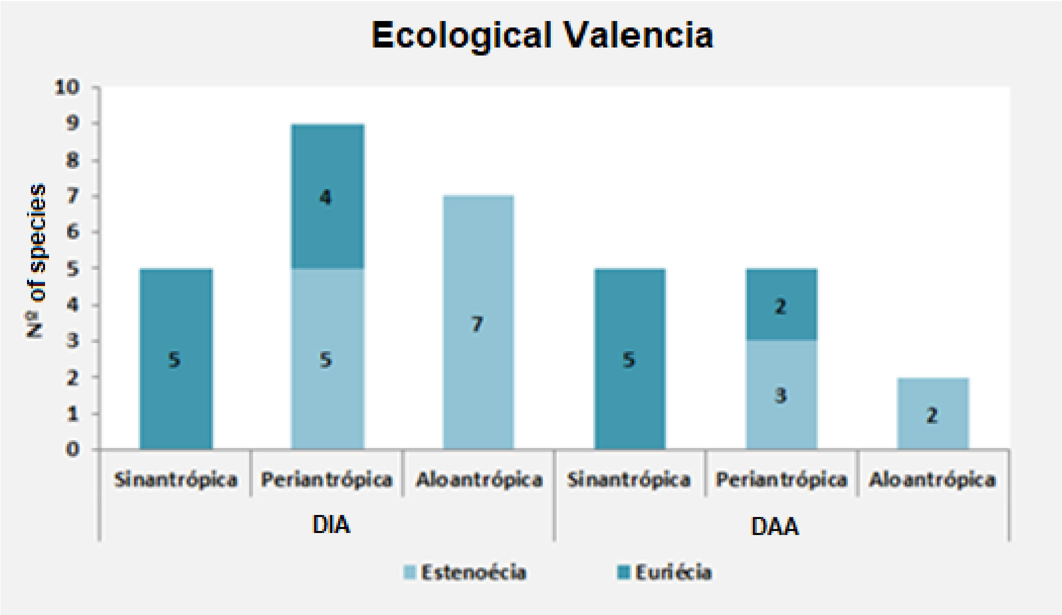

Figure 291 – Ecological value of mammal species diagnosed in the study area.

The following figures present the photographic record of some species of mammals sampled in the study area.

Figure 292 – tracks of *Cerdocyon thous*.

Figure 293 – *Didelphis aurita*.

Figure 294 – tracks of *Didelphis aurita*.

Figure 295 –*Guerlinguetus ignitus*.

Figure 296 – *Didelphis aurita*.

Figure 297 – *Leopardus pardalis*.

	
Figure 298 – *Lycalopex gymnocercus*	**Figure 299 – *Mazama gouazoubira***
	
Figure 300 – *Dasypus novemcinctus*	**Figure 301 – tracks of *Procyon cancrivorus*.**
	
Figure 302 – *Dasypus novemcinctus*.	**Figure 303 – *Hydrochoerus hydrochaeris*.**

Figure 304 – *Mazama gouazoubira*.

Figure 305 – *Lontra longicaudis*.

Figure 306 – track of *Leopardus pardalis*

Figure 307 – *Alouatta caraya*

Figure 308 – *Cerdocyon thous*.

Figure 309 – *Pecari tajacu*.

Figure 310 – *Eira barbara*

Figure 311 – *Myrmecophaga tridactyla*

Figure 312 – *Myocastor coypus*

Figure 313 – *Leopardus tigrinus*.

Figure 314 – *Tapirus terrestres*

Figure 315 – *Sylvilagus brasiliensis*.

Final considerations on mammals

Biodiversity is the complex resulting from the variations of species and ecosystems existing in a given region, and its study has a direct importance for the preservation or conservation of species, because, understanding life as a whole, one has more conditions to preserve it.

There are several reasons why there is great interest in measuring diversity, mainly because of its usefulness in conservation biology and environmental assessment. In addition, the assessment of rare species is useful for directing conservation efforts and wildlife monitoring program.

The field studies of the first and second campaigns showed that the direct influence area (DIA) and the area directly affected (ADA) of the pulp mill are predominantly composed of open areas converted to pasture, with portions of forest remnants present under the domain of the savannah biome. However, it is evident that the areas of influence investigated are capable of maintaining species associated with well-structured environments, as is the case of the mammal fauna, which has been highlighted by the presence of stenozoic and alloanthropic species, as well as those threatened with extinction.

The mammals diagnosed in the study area present species that are relatively sensitive to human actions, such as the otter *Lontra longicaudis*, or even species related to forest environments, such as the *Eira barbara*. Specifically, for the site of the mill, euriatic and generalist species predominated, such as *Cerdocyon thous* and the *Dasypus novemcinctus*. It is important to note the presence of threatened mammals in the DIA and ADA, where 06 species are included in the IUCN list (2020-1) "Near Threatened" (NT), "Endangered" (EN), "Vulnerable" (VU) and "Threatened" (AM) and 03 in the national list of Resolution 632/2017.

Fauna Monitoring

The area of influence of the PARACEL pulp mill supports a considerable richness of wildlife, with the remaining forests in the study areas being of key importance for the establishment, maintenance and refuge of wildlife populations. The presence of threatened and endemic species and the strictly forestry habits associated with the remnants in the DIA and DAA indicate the extreme need to monitor the fauna, trying to better understand the effects that may be caused during the implementation and operation phase of the pulp mill. Thus, the Wildlife Monitoring Program aims to identify the possible impacts of the mill on local wildlife, and then propose, schedule and implement appropriate mitigation measures to reduce or eliminate the impacts on wildlife, especially endemic and/or threatened wildlife.

9.2.2.5.2.2 Birdlife

Richness

During the present diagnostic, 1821 individuals of the avifauna were registered, distributed among 181 species, 49 families and 24 orders, using the standardized methodology. The first sampling campaign, in October 2019 (dry season), counted 1001 individuals distributed among 134 species in the DIA and 80 species in the ADA. The second campaign, in March 2020 (rainy season), identified 820 individuals distributed among 89 species in the DIA and 57 species in the DAA of the pulp mill (**Figure 308**).

Among the species recorded, 50.8% correspond to non-passerine birds (n= 92), while 49.2% belong to the order Passeriformes (n= 89). Of the non-passerine birds, the family Psittacidae stood out in relation to the others, with 10 species registered, followed by the families Columbidae (n= 9) and Picidae (n= 8). In the case of the Passeriformes, the families Tyrannidae (n= 27), Thraupidae (n= 14) and Icteridae (n= 9) were the most representative. A high expressivity of the Tyrannidae is already expected, since they constitute the largest taxonomic family of birds in the Neotropics, covering about 18% of the passerines in South America (SICK, 1997).

The data obtained in the field correspond to 37.9% of the species studied by compiling secondary data for the region of the PARACEL pulp mill (n= 477). This difference may be related to the greater range of phytophysiognomies sampled, the use of varied methodologies and the larger time scale in the studies consulted. However, it is worth mentioning the field record of 4 species that do not appear in the secondary list of the region: *Herpsilochmus rufimarginatus, Conopophaga lineata, Attila phoenicurus*, and *Hylophilus poicilotis*.

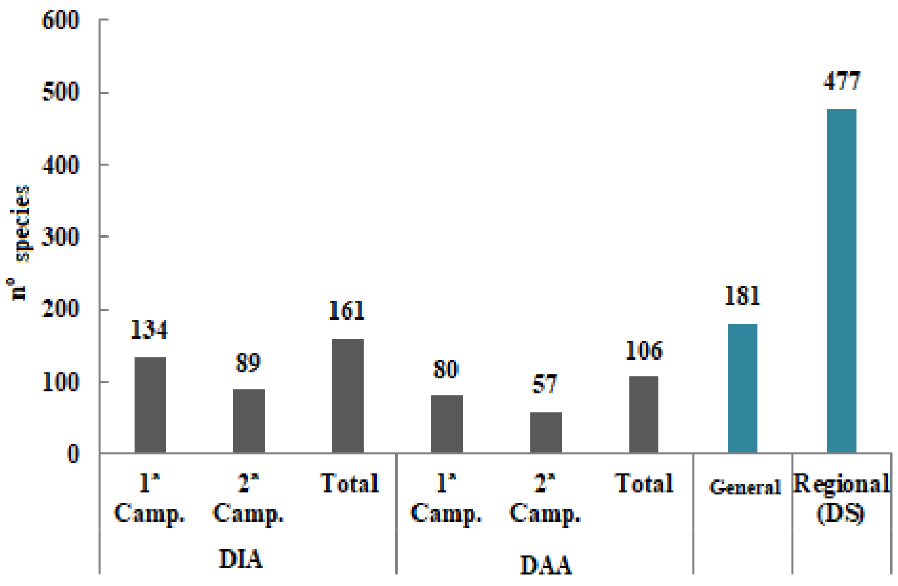

Figure 316 – Bird species richness registered in the DIA and DAA of the PARACEL pulp mill. DS - secondary data.

Abundance

The profile of a few common or dominant species with large numbers of individuals, associated with many rare species with few individuals is characteristic of avifaunal communities in the Neotropics (ODUM, 2009). In general, in nature, for the total number of groups, most of their components are rare (few individuals, small biomass, low productivity or other measure of importance), while few are dominant or common (BARROS, 2007).

Of the 87 species recorded in transect 01 of the DIA from the PARACEL pulp mill, 36.8% (n= 32) were recorded only once and 31% (n= 27) obtained an abundance that varied between 2 and 3 individuals. The most abundant species in the transect was *Psittacara leucophthalmus* with 58 individuals registered. In this case, it shall be noted that *P. leucophthalmus* is a gregarious species, and an encounter with a single band can outnumber isolated taxons. A similar pattern was observed in transect 02, where, of the 85 species found, 29 showed a single individual record, while only three species obtained a relatively high abundance: *Psittacara leucophthalmus*, with 65 individuals; *Thectocercus acuticaudatus*, with 53 individuals and *Amazona aestiva*, with 38 individuals found. In transect 03, of the 106 species recorded, only seven obtained an abundance equal to or greater than 10 individuals, with *Bubulcus ibis*, with 30 individuals found.

For the DAA from PARACEL's Pulp Mill, 56.25% of the 80 species found in transect 04 had an abundance of 1 to 2 individuals. The most abundant species in the transect were *Phacellodomus rufifrons*, with 20 individuals, and *Psittacara leucophthalmus*, with 18 individuals. Finally, for the 05 transect in the ADA, 65% had an abundance less than or equal to two individuals, while only *Psittacara leucophthalmus* had 87 individuals, being considered the most abundant species in the whole study area.

Frequency Occurrence

For the analysis of the distribution of the birds diagnosed in the DIA and DAA of the pulp mill, the frequency of appearance of each species in the sections sampled within the study area was calculated, in order to categorize them into five groups: 1) rare; 2) occasional; 3) frequent; 4) abundant and 5) very abundant (LINSDALE, 1928).

Thus, from the analysis of Figure below, it can be seen that most of the avifauna inventoried has a rare frequency of occurrence, constituting 72% of the records in the DIA and 53% of the records in the ADA. These species have occasional records in some of the sampled sections, which leads to the assumption that their dispersal capacity is relatively lower. Species classified as abundant and very abundant were more represented, and corresponded to those that occur more frequently in the sections sampled. Among them, Psittacara leucophthalmus, Lepidocolaptes angustirostris, Phacellodomus rufifrons and the Tyrannus melancholicus stand out.

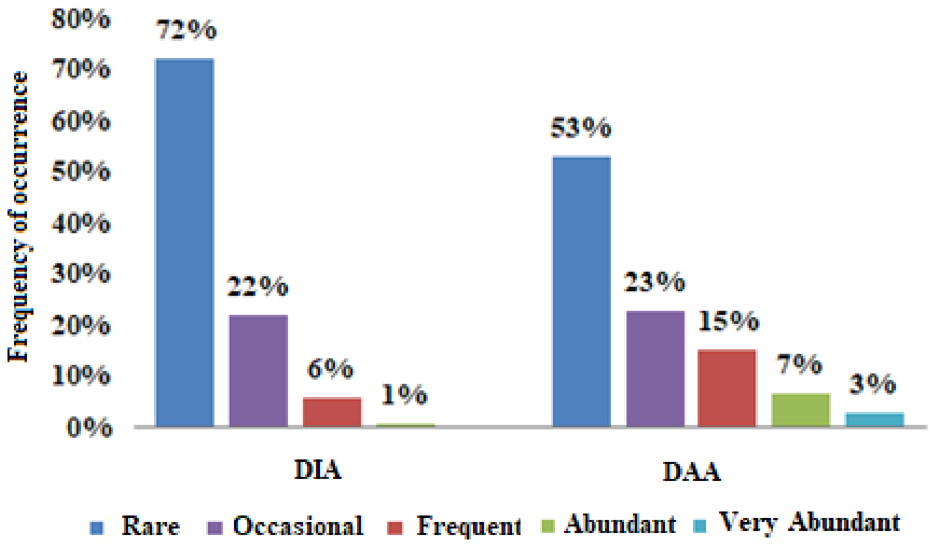

Figure 317 – Frequency of occurrence of bird species in DIA and DAA samples from the pulp mill.

<u>**Sample efficiency curve**</u>

From the analysis of Figure bellow, it can be seen that the sampling efficiency curves generated for the first and second campaigns did not reach their asymptotes, because they have a small tendency to stabilize. For the first campaign, in October 2019, a total of 161 bird species were recorded, and the Jackknife richness estimator estimated the occurrence of 233 species (PD ±29). For the second campaign, in March 2020, a total of 104 bird species were recorded, with the Jackknife estimating 144 species (PD ±17).

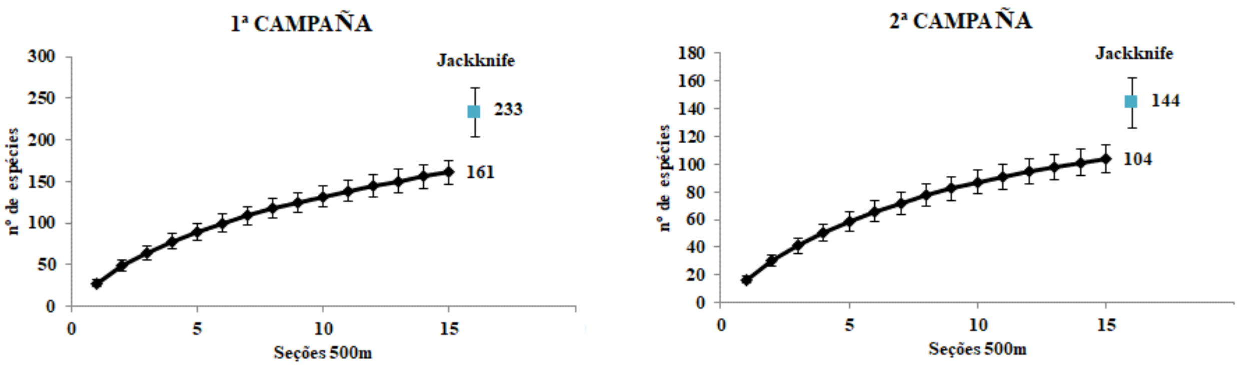

Figure 318 – Rarefaction curve and Jackknife estimator for the first and second sampling campaigns of the present study.

For the total of species studied in the two sampling campaigns (n= 181), it is observed that the rarefaction curve did not reach its asymptote either, estimating the addition of 56 more species (PD ±23) according to the Jackknife richness estimator (Figure 311). Therefore, the results indicate that, with the continuity of the studies, the number of species in the area of interest of the PARACEL pulp mill tends to increase.

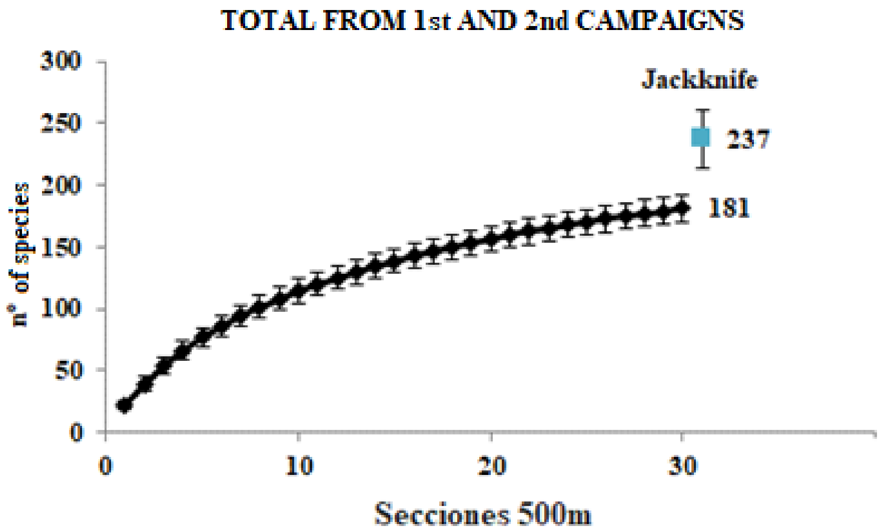

Figure 319 – Rarefaction curve and Jackknife estimator for the total species recorded in this study.

Diversity index

The table below presents the Shannon diversity (H') and Equitability (J') indices for each of the transects and the seasonality in the mill DIA and ADA.

For the PARACEL pulp mill DIA, 161 species were recorded, with a Shannon index showing high diversity for the area (H'= 4.33). Considering the sampling campaigns separately, 134 species were recorded in October 2019 (dry season), with a diversity H'= 4.19. Although sampling in the dry season registered less richness (n= 89) and diversity (H'= 3.91) compared to the rainy season, it was observed that the Shannon diversity index did not show abrupt differences between the campaigns.

For the ADA, there is also a high diversity of birds according to the Shannon index (H'= 3.80). As in the PARACEL pulp mill DIA, the campaign carried out in the dry season resulted in higher bird diversity, with Shannon H'= 3.96. However, records made during the rainy season showed significantly lower diversity (H'= 3.0), probably due to the presence of dominant specimens in the environment, as the Pielou Equivalence Index was low (J'= 0.74).

Table 28 – Shannon Diversity Index (H') and Pielou Equitability Index (J') in the DIA and DAA of the PARACEL pulp mill in the first and second sampling campaigns

Sample Area	Seasoning	Richness	Abundance	Shannon Diversity (H')	Pielou Equitability (J')
DIA	1st Camp. (dry)	134	704	4,194	0,8563
	2nd Camp (rain)	89	480	3,918	0,8729
	Total	161	1184	4,339	0,854
ADA	1st Camp. (dry)	80	297	3,967	0,9053
	2nd Camp. (rain)	89	340	3,021	0,7472
	Total	106	637	3,802	0,8153

The Pielou Equitability (J') shows that the taxonomic community recorded in the DIA and DAA is quite homogeneous, as it is predominantly composed of rare species with few recorded individuals. However, the occurrence of some dominant species is observed through the values presented by the index (J'), especially in the second sampling campaign in the DAA of the PARACEL pulp mill, with low equitability (J'= 0, 74). Among the dominant species found, it is worth mentioning the *Psittacara leucophthalmus*.

The Figure below provides a graphic representation of the Shannon and Equitability indices found during the present study in the DIA and DAA of the PARACEL pulp mill.

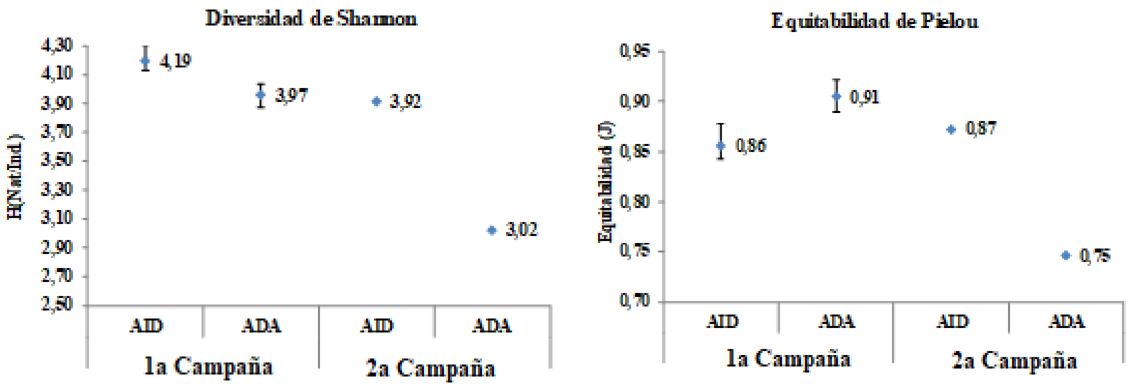

Figure 320 – Shannon Index (left) and Pielou Equitability (right) for the birdlife registered in the DIA and DAA of PARACEL pulp mill.

Ecological Categories

Preference for habitat

Knowledge of habitat preferences or characteristics that bind species and habitat is essential for wildlife management and conservation actions. Habitat preference corresponds to the place of preferential occupation of a given species, however, a bird classified as a forest may occur in open areas or vice versa.

From the analysis of Figure below, it is possible to observe that in both the DIA and the DAA of the pulp mill there is a dominance of bird species that usually inhabit the edges of forests, and correspond to 38% and 39% of the taxonomy inventoried in the DIA and the ADA respectively.

Field and open area birds obtained a similar representativeness to the species classified as forest in the study areas, as shown in Figure 313. Specifically, in the DIA, field and open area species correspond to 27% of the avifauna found, followed by 24% of the forest species. On the other hand, in the DAA of the PARACEL pulp mill 28% of the species are classified as forest, followed by 25% of the open area species.

Birds living preferably in humid environments were less representative, with 11% of the species recorded in DIA, and 8% of the DAA species.

With regard to the species known from the compilation of secondary data for the mill IIA, Figure 313 shows that 31% of the species are classified as forest species, followed by 27% of edge species, 26% of field and open area species, and 15% of wetland species.

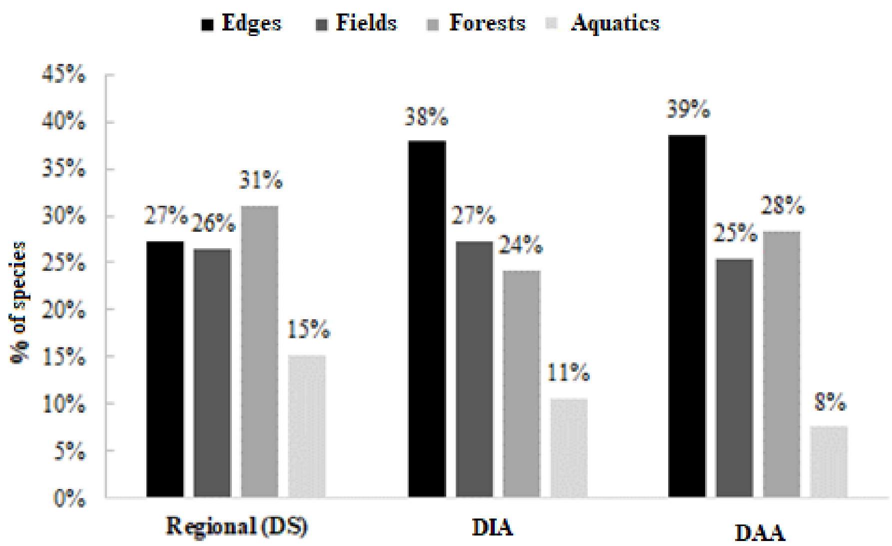

Figure 321 – Distribution of bird species by habitat preference SD - secondary data

Food Guilds

The species diagnosed in the areas of influence of the PARACEL pulp mill during the first and second campaigns were classified according to their food guilds. A food guild is defined as a group of organisms that use resources in a similar way, without considering their taxonomic relationship (JAKSIC, 1981). Thus, food is considered one of the most important aspects for determining the ecological and evolutionary processes within a community. The results obtained for regional and local birdlife are shown in Figure 314.

In the present study, ten categories of guilds were recorded for the diagnosed birdlife community: insectivores, frugivores, omnivores, carnivores, nectarivores, granivores, detritivores, piscivores, necrophages and macrophages. In general, 46% of the avifauna found in the areas of influence is considered insectivorous (n= 83). According to Bierregaard & Stouffer (1997), the high percentage of insectivorous birds is standard for the neotropical region, and the great abundance of small arthropods and insects is a resource used by several bird taxonomic groups. Among the species recorded in the field, the family Tyrannidae obtained the highest number of insectivorous representatives (n= 27), followed by the family Picidae (n= 8).

In the sequence, the most representative guild was that of omnivores, with 19% of the taxons inventoried (n= 34), highlighting the families Icteridae (n= 6) and Tinamidae (n= 5). Among the species included in this category, it is worth noting the registration in the DIA of the Rheidae, a specie typical of the pampas, closed and open forests of the Chaco (SICK, 1993). The American Rhea is classified as "Near Threatened" according to the IUCN global list (2020).

Birds have the largest number of frugivorous species in the Neotropics, with families highly dependent on fruits, such as Cracidae and Cotingidae, and others less dependent, such as Emberezidae and Tyrannidae (FADINI & MARCO JR., 2004). The fruit-eating guild indicates integrity to remaining native formations, as some fruit-eating species act as important seed dispersers (PHILLIPS, 1997). In general, frugivorous birds were represented by 10% in the areas of influence of the PARACEL pulp mill (n=18), with the Psittacidae family being the most representative in this category (55%). With respect to data obtained from literature on birds in the IIA of the pulp mill, a profile similar to that observed in the field is observed, with a predominance of insectivorous birds (47%), followed by omnivores (17%), frugivores (11%), carnivores (10%), granivores (7%) and piscivores (4%), as shown in Figure 314.

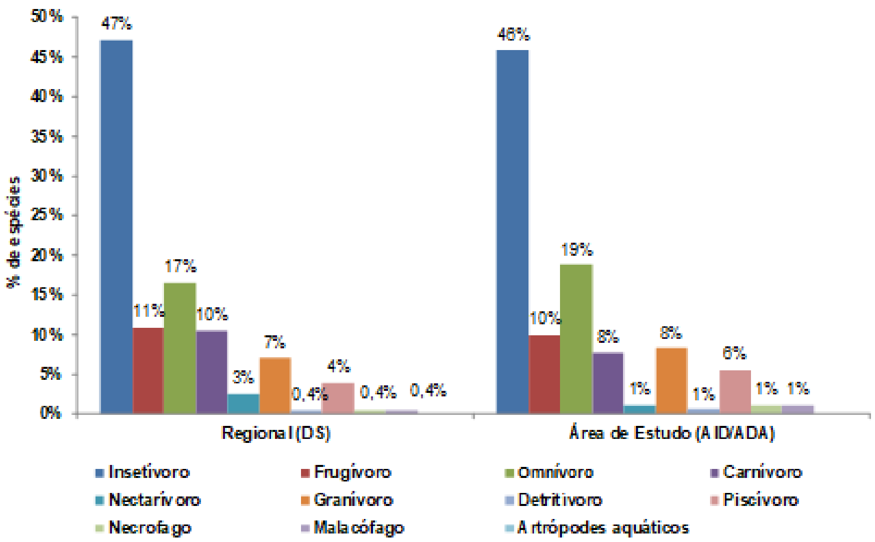

Figure 322 – Distribution of bird species by guild SD - secondary data.

Sensitivity

Using the sensitivity classification of Stotz et al (1996) as a database, the proportion of sensitive species in relation to changes in the environment was analyzed. From the analysis of Figure 315 it is possible to observe that both the DIA and the DAA of the PARACEL pulp mill have a predominance of species with low sensitivity to anthropic actions, with 67% and 70% of representativeness, respectively. These species have great plasticity (resistance) in terms of the impacts caused by anthropic activities and have a great capacity to adapt to modified environments (SICK, 1997).

Next, birds of average sensitivity obtained the second highest representation in the sample areas, with 31% of the total for DIA and 29% for ADA. Among the species included in this category is the Deville's Parrot (Pyrrhura devillei), classified as "near threatened" at the global level (IUCN, 2020). In the case of highly sensitive birds, one species was observed in the ADA, the Arasari Caripard (Pteroglossus castanotis); and two species in the ADA, the Yellow-billed Woodpecker (Piculus chrysochloros) and the Grey-headed Attila (Attila phoenicurus). It should be mentioned that Attila phoenicurus is classified as an "endangered species" by Resolution 254/2019 of the Ministry of the Environment and Sustainable Development of Paraguay.

As for the regional birdlife recorded through the compilation of secondary data, it was obtained that 51% of the bird species have a low sensitivity, followed by 41% of the medium sensitivity species and, to a lesser extent, 4% of the high sensitivity species. It should also be noted that, of the total species studied, 3% have no information on the level of sensitivity in the literature consulted.

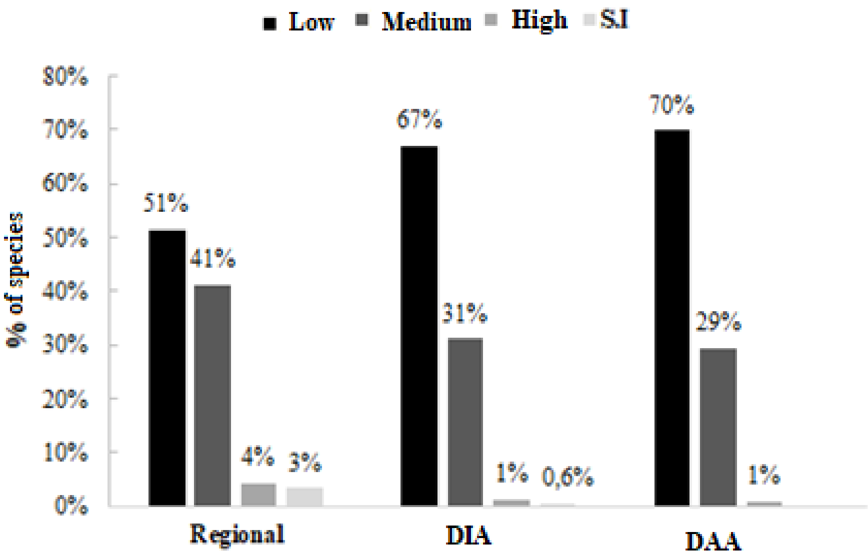

Figure 323 – Distribution of bird species by degree of sensitivity to environmental changes S.I - no information.

Bio-indicator species

Integral biological communities in need of conservation efforts can be identified through organisms considered bio-indicators, which play an important role in guiding mitigation measures. These indicator species fall into four main categories: 1) they are usually present in one or a few habitats; 2) they are relatively common; 3) they are easily detected; and 4) they are highly sensitive to environmental disturbances. Parker et al (1996) identified a group of bird species in the Chaco region that meet the requirements of the indicator, including 14 in Paraguay (GUYRA PARAGUAY, 2004).

Based on the 14 species listed in the literature (GUYRA PARAGUAY, 2004), none were identified in the areas of influence of the pulp mill during this assessment.

Rare species

For the classification of rare species, the list of Paraguayan avifauna species available in the global database Avibase (2017) was consulted.

A rare bird species was recorded in the AID of PARACEL's pulp mill, the *Attila phoenicurus*. The species can be found in the middle level and canopy of humid and secondary forests (RIDGELY & TUDOR, 1994). Its breeding period, between October and March (NACIF et al., 2018), occurs mainly in the Atlantic Forest of southeastern Brazil. Between March and September, the transition period is observed, when the species moves through central Brazil and the extreme north-east of Argentina, eastern Paraguay and Bolivia, until it reaches the wintering grounds in the north of the Brazilian Amazon and south-west Venezuela (GARCÍA et al., 2016). Given the scarce presence of *A. phoenicurus* in eastern Paraguay during the transition period, the species is considered locally rare.

Migratory species

During the present diagnosis, two species of migratory birds from the northern hemisphere were recorded: *Pluvialis dominica* and *Bartramia longicauda*.

Pluvialis dominica is a long-distance migratory bird that carries out one of the longest migrations in the world, traveling from its wintering grounds in southern South America to its breeding grounds on the tundra in North America. The migration takes place annually, when the bird migrates south between the months of September and November along the Atlantic Ocean, returning north through the center of the continent during the months of February to April (JOHNSON & CONNORS, 2010). Individuals generally arrive at their breeding grounds in northwestern Canada to northern Alaska between May and June (JOHNSON & CONNORS, 2010).

Bartramia longicauda is a specie that migrates long distances twice a year, covering up to 14,000 km from its breeding grounds in North America to wintering grounds in South America (HOUSTON & BOWEN, 2001; BLANCO & LÓPEZ-LANÚS, 2008). *B. longicauda* breeds in central North America and Alaska, and winters in southern South America, mainly in northwestern Argentina, Uruguay, Paraguay, southern Brazil and eastern Bolivia (BARROS, 2014).

Endangered, endemic or exotic species

The endangered species were classified in accordance with MADES Resolution 254/2019 of Paraguay and the IUCN global list (2020). Thus, seven species included in the above-mentioned lists were identified in the areas of influence of the PARACEL pulp mill, as set out in Table bellow.

Among the threatened birds, the presence of two species of undergrowth foraging and, therefore, dependent on the integrity of the forest should be highlighted: *Conophophaga lineata* and *Mionectes rufiventris*. Habitat loss and fragmentation, associated with a decline in environmental quality, characterize the main causes of the threat to these species.

The *Conopophaga lineata* is an insectivorous passerine that feeds on the understory of tropical and temperate forests in South America (SIGRIST, 2005), from Paraguay and northeast Argentina to northeast Brazil (SICK, 1997), and is common to the Atlantic Forest. Its wide distribution throughout the Atlantic Forest, generally in high abundance and easy to capture in mist nets, makes this species an important tool for studies on the effect of forest fragmentation in the Neotropics (DANTAS, et al., 2009).

Mionectes rufiventris is a tyranid found in Argentina, Brazil and Paraguay (STOTZ et al. 1996, SICK 1997). The species occurs in mixed groups (DEVELEY & PERES, 2000) both in tropical or subtropical lowland rainforests (MACHADO & FONSECA, 2000), and in mountain rainforests (BROOKS et al., 1999). Aguilar et al. (2000) considered *M. rufiventris* as a specie dedicated in nest building, all of them built under stream beds, fixed to the roots of trees. The high specificity of the nest site demonstrated by *M. rufiventris* denotes the importance of preserving stream beds and their associated forests (AGUILAR et al., 2000). However, it should be noted that, at present, the biology and behavior of the species are little explored.

Table 29 – Registered bird species threatened with extinction in the DIA and DAA of the Pulp Mill.

Taxon	Popular Name in Paraguay	PY (2019)	IUCN (2020)	Register
Rhea americana	Ñandú Común	-	NT	DIA
Pyrrhura devillei	Cotorra de Deville	AM	NT	DIA/ADA
Conopophaga lineata	Jejenero Rojizo	AM	LC	DIA
Mionectes rufiventris	Mosquero Ladrillito	AM	LC	DIA
Attila phoenicurus	Atila Cabecigrís	AM	LC	DIA
Hylophilus poicilotis	Verdillo Coronado	AM	LC	ADA
Cyanocorax cristatellus	Chara Crestada	AM	LC	DIA/ADA

Threat Categories: PY 2019 - Resolution n. 254/2019 of the Ministry of Environment and Sustainable Development (MADES, Paraguay). IUCN 2020 - The IUCN Red List of Threatened Species, version 2020-1 Legend: AM - threatened with extinction; NT - near threatened; LC - of little concern.

For the analysis of the endemic species of the Chaco, it was necessary to use the literature composed by Short (1975), Cracraft (1985) and Parker et al. (1996), which recognized 18 endemic species registered in Paraguay. Of these, two were diagnosed in the areas of influence of the pulp mill: *Ortalis canicollis* and *Xiphocolaptes major*.

The *Ortalis canicollis* is a forest cricket from southwestern South America and is found in the Chaco from eastern Bolivia to western Paraguay and northern Argentina (SICK, 1997), being relatively abundant (CAZIANI & PROTOMASTRO, 1994). According to Caziani and Protomastro (1994), *Ortalis canicollis* is the only year-round seed disperser in the Chaco. This fact highlights the importance of the ecological service provided by the specie, since seed dispersal allows for the integrity and regeneration of the forests.

With respect to exotic birds, one species was recorded in the DIA of PARACEL pulp mill, *Bubulcus ibis*. Native to the African continent, in its natural habitat the species lives associated with herds of large herbivores in the savannahs (BLAKER, 1969; DEAN & MACDONALD, 1981). Cattle Egret invaded the American continent at the end of the 19th century and, in both the American and African continents, has been expanding from the equatorial regions to higher latitudes (CROSBY, 1972; TELFAIR, 1993; VICENT, 1947).

Below is a list of the bird species recorded during the first and second sampling campaigns, followed by ecological data on food guilds, endemism, sensitivity, habitat and migratory habits. The categories of threat were based on MADES Resolution 254/2019 (Paraguay) and the IUCN Global List of Threatened Species 2020-1.

Table 30 – List of bird species recorded during the first and second sampling campaigns in October/2019 and March/2020.

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Order Rheiformes Forbes, 1884										
Family Rheidae Bonaparte, 1849										
Rhea americana (Linnaeus, 1758)	Ñandú Común	X			NT		B	ONI	C	
Order Tinamiformes Huxley, 1872										
Family Tinamidae Gray, 1840										
Crypturellus undulatus (Temminck, 1815)	Tinamú ondeado	X	X		LC		M	ONI	F	
Crypturellus parvirostris (Wagler, 1827)	Tinamú piquicorto	X	X		LC		B	ONI	F	
Crypturellus tataupa (Temminck, 1815)	Tinamú Tataupá	X			LC		B	ONI	F	
Rhynchotus rufescens (Temminck, 1815)	Tinamú alirrojo	X	X		LC		B	ONI	C	
Nothura maculosa (Temminck, 1815)	Tinamú chaqueño	X			LC		B	ONI	C	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Order Anseriformes Linnaeus, 1758										
Family Anhimidae Stejneger, 1885										
Chauna torquata (Oken, 1816)	Chajá Común	X			LC		B	ONI	A	
Family Anatidae Leach, 1820										
Dendrocygna autumnalis (Linnaeus, 1758)	Suirirí Piquirrojo	X			LC		B	ONI	A	
Amazonetta brasiliensis (Gmelin, 1789)	Pato Brasileño	X	X		LC		B	ONI	A	
Order Galliformes Linnaeus, 1758										
Family Cracidae Rafinesque, 1815										
Ortalis canicollis (Wagler, 1830)	Chachalaca Charata		X		LC	CH	B	FRU	F	
Order Suliformes Sharpe, 1891										
Family Phalacrocoracidae Reichenbach, 1849										
Nannopterum brasilianus (Gmelin, 1789)	Cormorán Biguá	X			LC		B	PISC	A	
Family Anhingidae Reichenbach, 1849										
Anhinga anhinga (Linnaeus, 1766)	Anhinga Americana	X			LC		M	PISC	A	
Order Pelecaniformes Sharpe, 1891										
Family Ardeidae Leach, 1820										
Tigrisoma lineatum (Boddaert, 1783)	Avetigre Colorada	X			LC		M	CAR	A	
Butorides striata (Linnaeus, 1758)	Garcita Verdosa	X	X		LC		B	PISC	A	
Bubulcus ibis (Linnaeus, 1758)	Garcilla Bueyera	X			LC	EX	B	PISC	A	
Ardea cocoi Linnaeus, 1766	Garza Cuca	X	X		LC		B	PISC	A	
Ardea alba Linnaeus, 1758	Garceta Grande	X	X		LC		B	PISC	A	
Syrigma sibilatrix (Temminck, 1824)	Garza Chiflona	X	X		LC		M	INS	C	
Family Threskiornithidae Poche, 1904										
Theristicus caerulescens (Vieillot, 1817)	Bandurria Mora	X			LC		SI	MAL	A	
Theristicus caudatus (Boddaert, 1783)	Bandurria Común	X			LC		B	ONI	C	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Platalea ajaja Linnaeus, 1758	Espátula Rosada	X			LC		M	PISC	A	
Order Cathartiformes Seebohm, 1890										
Family Cathartidae Lafresnaye, 1839										
Cathartes aura (Linnaeus, 1758)	Aura Gallipavo	X	X		LC		B	NECR	F	
Cathartes burrovianus Cassin, 1845	Aura Sabanera		X		LC		M	DET	F	
Coragyps atratus (Bechstein, 1793)	Zopilote Negro	X			LC		B	NECR	C	
Order Accipitriformes Bonaparte, 1831										
Family Accipitridae Vigors, 1824										
Chondrohierax uncinatus (Temminck, 1822)	Milano Picogarfio	X			LC		M	CAR	C	
Harpagus diodon (Temminck, 1823)	Milano Muslirrufo	X			LC		M	CAR	C	
Ictinia plumbea (Gmelin, 1788)	Elanio Plomizo	X			LC		M	INS	C	
Rostrhamus sociabilis (Vieillot, 1817)	Caracolero Común		X		LC		B	MAL	A	
Heterospizias meridionalis (Latham, 1790)	Busardo Sabanero	X	X		LC		B	CAR	C	
Urubitinga urubitinga (Gmelin, 1788)	Busardo Urubitinga	X			LC		M	CAR	F	
Rupornis magnirostris (Gmelin, 1788)	Busardo Caminero	X	X		LC		B	CAR	B	
Order Eurypygiformes Furbringer, 1888										
Family Rallidae Rafinesque, 1815										
Aramides ypecaha (Vieillot, 1819)	Cotara Ipacaá	X	X		LC		M	ONI	F	
Order Charadriiformes Furbringer, 1888										
Family Charadriidae Leach, 1820										
Vanellus chilensis (Molina, 1782)	Avefría Tero	X	X		LC		B	INS	C	
Pluvialis dominica (Statius Muller, 1776)	Chorlito Dorado Americano	X			LC		B	INS	A	VN

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Family Scolopacidae Rafinesque, 1815										
Bartramia longicauda (Bechstein, 1812)	Correlimos Batitú		X		LC		B	INS	A	VN
Family Jacanidae Chenu & Des Murs, 1854										
Jacana jacana (Linnaeus, 1766)	Jacana Suramericana	X	X		LC		B	INS	A	
Order Columbiformes Latham, 1790										
Family Columbidae Leach, 1820										
Columbina talpacoti (Temminck, 1811)	Columbina Colorada	X	X		LC		B	GRAN	B	
Columbina squammata (Lesson, 1831)	Tortolita Escamosa	X	X		LC		B	GRAN	B	
Columbina picui (Temminck, 1813)	Columbina Picuí	X	X		LC		B	GRAN	B	
Claravis pretiosa (Ferrari-Perez, 1886)	Tortolita Azulada	X	X		LC		B	GRAN	B	
Patagioenas picazuro (Temminck, 1813)	Paloma Picazuró	X	X		LC		M	FRU	B	
Patagioenas cayennensis (Bonnaterre, 1792)	Paloma Colorada	X			LC		M	FRU	F	
Zenaida auriculata (Des Murs, 1847)	Zenaida Torcaza	X	X		LC		B	GRAN	B	
Leptotila verreauxi Bonaparte, 1855	Paloma Montaraz Común	X	X		LC		B	GRAN	F	
Leptotila rufaxilla (Richard & Bernard, 1792)	Paloma Montaraz Frentiblanca	X			LC		M	GRAN	F	
Order Cuculiformes Wagler, 1830										
Family Cuculidae Leach, 1820										
Piaya cayana (Linnaeus, 1766)	Cuco-ardilla Común	X			LC		B	INS	F	
Coccyzus melacoryphus Vieillot, 1817	Cuclillo Canela		X		LC		B	INS	F	
Crotophaga major Gmelin, 1788	Garrapatero Mayor	X	X		LC		B	ONI	C	
Crotophaga ani Linnaeus, 1758	Garrapatero Aní	X	X		LC		B	ONI	C	
Guira guira (Gmelin, 1788)	Pirincho	X	X		LC		B	ONI	C	
Tapera naevia (Linnaeus, 1766)	Cuclillo Crespín	X	X		LC		B	INS	C	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Order Strigiformes Wagler, 1830										
Family Strigidae Leach, 1820										
Pulsatrix perspicillata (Latham, 1790)	Lechuzón de Anteojos	X			LC		B	CAR	F	
Glaucidium brasilianum (Gmelin, 1788)	Mochuelo Caburé	X	X		LC		B	CAR	B	
Order Nyctibiiformes Yuri, Kimball, Harshman, Bowie, Braun, Chojnowski, Han, Hackett, Huddleston, Moore, Reddy, Sheldon, Steadman, Witt & Braun, 2013										
Family Nyctibiidae Chenu & Des Murs, 1851										
Nyctibius griseus (Gmelin, 1789)	Nictibio Urutaú	X			LC		B	INS	B	
Order Caprimulgiformes Ridgway, 1881										
Family Caprimulgidae Vigors, 1825										
Antrostomus rufus (Boddaert, 1783)	Chotacabras Colorado	X			LC		B	INS	B	
Nyctidromus albicollis (Gmelin, 1789)	Chotacabras Pauraque	X			LC		B	INS	B	
Order Apodiformes Peters, 1940										
Family Apodidae Olphe-Galliard, 1887										
Chaetura meridionalis Hellmayr, 1907	Vencejo de tormenta	X			LC		B	INS	C	
Family Trochilidae Vigors, 1825										
Phaethornis pretrei (Lesson & Delattre, 1839)	Ermitaño del Planalto	X			LC		B	NEC	B	
Hylocharis chrysura (Shaw, 1812)	Zafiro Bronceado	X	X		LC		M	NEC	F	
Order Trogoniformes A. O. U., 1886										

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Family Trogonidae Lesson, 1828										
Trogon curucui Linnaeus, 1766	Trogón Curucuí	X	X		LC		M	ONI	F	
Order Coraciiformes Forbes, 1844										
Family Alcedinidae Rafinesque, 1815										
Megaceryle torquata (Linnaeus, 1766)	Martín Gigante Neotropical	X	X		LC		B	PISC	A	
Chloroceryle amazona (Latham, 1790)	Martín Pescador Amazónico	X			LC		B	PISC	A	
Chloroceryle americana (Gmelin, 1788)	Martín Pescador Verde	X			LC		B	PISC	A	
Family Momotidae Gray, 1840										
Baryphthengus ruficapillus (Vieillot, 1818)	Momoto Yeruvá Oriental	X			LC		M	ONI	F	
Order Galbuliformes Fürbringer, 1888										
Family Bucconidae Horsfield, 1821										
Nystalus striatipectus (Sclater, 1854)	Buco Durmilí	X	X		-		M	INS	F	
Order Piciformes Meyer & Wolf, 1810										
Family Ramphastidae Vigors, 1825										
Ramphastos toco Statius Muller, 1776	Tucán Toco	X	X		LC		M	ONI	C	
Pteroglossus castanotis Gould, 1834	Arasarí Caripardo		X		LC		A	FRU	F	
Family Picidae Leach, 1820										
Picumnus cirratus Temminck, 1825	Carpinterito Variable	X	X		LC		B	INS	B	
Melanerpes candidus (Otto, 1796)	Carpintero Blanco	X	X		LC		B	INS	B	
Veniliornis passerinus (Linnaeus, 1766)	Carpintero Chico	X			LC		B	INS	B	
Piculus chrysochloros (Vieillot, 1818)	Carpintero Verdiamarillo	X			LC		A	INS	F	
Colaptes melanochloros (Gmelin, 1788)	Carpintero real norteño	X			LC		B	INS	F	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Colaptes campestris (Vieillot, 1818)	Carpintero Campestre	X	X		LC		B	INS	C	
Celeus lugubris (Malherbe, 1851)	Carpintero Lúgubre	X			LC		M	INS	C	
Campephilus melanoleucos (Gmelin, 1788)	Picamaderos Barbinegro	X			LC		M	INS	B	
Order Cariamiformes Furbringer, 1888										
Family Cariamidae Bonaparte, 1850										
Cariama cristata (Linnaeus, 1766)	Chuña Patirroja	X	X		LC		B	ONI	C	
Order Falconiformes Bonaparte, 1831										
Family Falconidae Leach, 1820										
Caracara plancus (Miller, 1777)	Carancho meridional	X	X		LC		B	CAR	C	
Milvago chimachima (Vieillot, 1816)	Caracara Chimachima	X			LC		B	CAR	C	
Herpetotheres cachinnans (Linnaeus, 1758)	Halcón Reidor	X	X		LC		B	CAR	B	
Falco sparverius Linnaeus, 1758	Cernícalo Americano	X			LC		B	CAR	C	
Falco rufigularis Daudin, 1800	Halcón Murcielaguero		X		LC		B	CAR	C	
Falco femoralis Temminck, 1822	Halcón Aleto	X			LC		B	CAR	C	
Order Psittaciformes Wagler, 1830										
Family Psittacidae Rafinesque, 1815										
Thectocercus acuticaudatus (Vieillot, 1818)	Aratinga Cabeciazul	X	X		LC		M	FRU	C	
Psittacara leucophthalmus (Statius Muller, 1776)	Aratinga Ojiblanca	X	X		LC		B	FRU	B	
Aratinga nenday (Vieillot, 1823)	Aratinga Ñanday	X	X		LC		M	FRU	F	
Eupsittula aurea (Gmelin, 1788)	Aratinga Frentidorada	X	X		LC		M	FRU	B	
Pyrrhura devillei (Massena & Souancé, 1854)	Cotorra de Deville	X	X	AM	NT		M	FRU	F	
Myiopsitta monachus (Boddaert, 1783)	Cotorra Argentina	X			LC		B	FRU	C	
Forpus xanthopterygius (Spix, 1824)	Cotorrita Aliazul		X		LC		M	FRU	F	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Brotogeris chiriri (Vieillot, 1818)	Catita Chirirí	X	X		LC		M	FRU	B	
Pionus maximiliani (Kuhl, 1820)	Loro Choclero	X	X		LC		M	FRU	F	
Amazona aestiva (Linnaeus, 1758)	Amazona Frentiazul	X	X		LC		M	FRU	B	
Order Passeriformes Linnaeus, 1758										
Family Thamnophilidae Swainson, 1824										
Herpsilochmus rufimarginatus (Temminck, 1822)	Tiluchí Alirrufo		X		LC		M	INS	F	
Thamnophilus doliatus (Linnaeus, 1764)	Batará Barrado	X			LC		B	INS	B	
Thamnophilus caerulescens Vieillot, 1816	Batará Variable	X			LC		B	INS	F	
Taraba major (Vieillot, 1816)	Batará Mayor	X	X		LC		B	INS	B	
Conopophaga lineata (Wied, 1831)	Jejenero Rojizo	X		AM	LC		M	INS	F	
Family Dendrocolaptidae Gray, 1840										
Sittasomus griseicapillus (Vieillot, 1818)	Trepatroncos Oliváceo	X			LC		M	INS	F	
Campylorhamphus trochilirostris (Lichtenstein, 1820)	Picoguadaña Piquirrojo	X			LC		M	INS	B	
Lepidocolaptes angustirostris (Vieillot, 1818)	Trepatroncos Chico	X	X		LC		B	INS	B	
Xiphocolaptes major (Vieillot, 1818)	Trepatroncos Colorado	X	X		LC	CH	M	INS	F	
Family Furnariidae Gray, 1840										
Furnarius rufus (Gmelin, 1788)	Hornero Común	X	X		LC		B	INS	C	
Phacellodomus rufifrons (Wied, 1821)	Espinero Común	X	X		LC		B	INS	B	
Schoeniophylax phryganophilus (Vieillot, 1817)	Pijuí Chotoy	X	X		LC		B	INS	B	
Synallaxis frontalis Pelzeln, 1859	Pijuí Frentigrís	X			LC		B	INS	B	
Family Tityridae Gray, 1840										
Tityra cayana (Linnaeus, 1766)	Titira Colinegro	X			LC		M	ONI	F	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Pachyramphus polychopterus (Vieillot, 1818)	Anambé Aliblanco	X	X		LC		B	INS	F	
Pachyramphus validus (Lichtenstein, 1823)	Anambé grande	X	X		LC		M	INS	F	
Family Rhynchocyclidae Berlepsch, 1907										
Mionectes rufiventris Cabanis, 1846	Mosquero Ladrillito	X		AM	LC		M	INS	F	
Todirostrum cinereum (Linnaeus, 1766)	Titirijí Común	X			LC		B	INS	B	
Hemitriccus margaritaceiventer (d'Orbigny & Lafresnaye, 1837)	Titirijí Perlado	X	X		LC		M	INS	B	
Family Tyrannidae Vigors, 1825										
Camptostoma obsoletum (Temminck, 1824)	Mosquerito Silbón	X	X		LC		B	INS	B	
Elaenia chiriquensis Lawrence, 1865	Fiofío Belicoso	X	X		LC		B	INS	B	
Suiriri suiriri (Vieillot, 1818)	Fiofío Suirirí		X		LC		M	INS	B	
Myiopagis caniceps (Swainson, 1835)	Fiofío Gris	X			LC		M	INS	B	
Myiopagis viridicata (Vieillot, 1817)	Fiofío Verdoso	X	X		LC		B	INS	B	
Phaeomyias murina (Spix, 1825)	Piojito Pardo	X			LC		B	INS	B	
Attila phoenicurus Pelzeln, 1868	Atila Cabecigrís	X		AM	LC		A	INS	F	
Legatus leucophaius (Vieillot, 1818)	Mosquero Pirata	X	X		LC		B	INS	F	
Myiarchus ferox (Gmelin, 1789)	Copetón Feroz	X	X		LC		B	INS	C	
Myiarchus tyrannulus (Statius Muller, 1776)	Copetón Tiranillo	X	X		LC		M	INS	F	
Sirystes sibilator (Vieillot, 1818)	Mosquero Silbador	X			LC		M	INS	B	
Casiornis rufus (Vieillot, 1816)	Burlisto Castaño	X			LC		M	INS	B	
Pitangus sulphuratus (Linnaeus, 1766)	Bienteveo Común	X	X		LC		B	INS	B	
Machetornis rixosa (Vieillot, 1819)	Picabuey	X			LC		B	INS	C	
Myiodynastes maculatus (Statius Muller, 1776)	Bienteveo Rayado	X	X		LC		B	INS	F	
Megarynchus pitangua (Linnaeus, 1766)	Bienteveo Pitanguá	X			LC		B	INS	B	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Tyrannus melancholicus Vieillot, 1819	Tirano Melancólico	X	X		LC		B	INS	B	
Tyrannus savana Vieillot, 1808	Tijereta Sabanera	X	X		LC		B	INS	C	
Griseotyrannus aurantioatrocristatus (d'Orbigny & Lafresnaye, 1837)	Tuquito Gris	X			LC		B	INS	C	
Empidonomus varius (Vieillot, 1818)	Tuquito Rayado		X		LC		B	INS	B	
Myiophobus fasciatus (Statius Muller, 1776)	Mosquero Estriado	X	X		LC		B	INS	B	
Sublegatus modestus (Wied, 1831)	Mosquero Matorralero Sureño	X	X		LC		M	INS	F	
Cnemotriccus fuscatus (Wied, 1831)	Mosquero Parduzco	X			LC		B	INS	F	
Lathrotriccus euleri (Cabanis, 1868)	Mosquero de Euler	X			LC		M	INS	F	
Xolmis cinereus (Vieillot, 1816)	Monjita Gris	X			LC		M	INS	C	
Xolmis velatus (Lichtenstein, 1823)	Monjita Velada	X	X		LC		M	INS	C	
Xolmis irupero (Vieillot, 1823)	Monjita Blanca	X			LC		B	INS	C	
Family Vireonidae Swainson, 1837										
Cyclarhis gujanensis (Gmelin, 1789)	Vireón Cejirrufo		X		LC		B	INS	F	
Hylophilus poicilotis Temminck, 1822	Verdillo Coronado		X	AM	LC		M	INS	F	
Vireo chivi (Vieillot, 1817)	Vireo Chiví	X	X		LC		B	INS	F	
Family Corvidae Leach, 1820										
Cyanocorax cyanomelas (Vieillot, 1818)	Chara Morada	X	X		LC		B	ONI	F	
*Cyanocorax cristatellus (Temminck, 1823)**	Chara Crestada	X	X	AM	LC		M	ONI	B	
Cyanocorax chrysops (Vieillot, 1818)	Chara Moñuda	X			LC		B	ONI	B	
Family Hirundinidae Rafinesque, 1815										
Progne tapera (Vieillot, 1817)	Golondrina Parda	X	X		LC		B	INS	C	
Family Troglodytidae Swainson, 1831										

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Campylorhynchus turdinus (Wied, 1831)	Cucarachero Turdino	X	X		LC		B	INS	B	
Cantorchilus guarayanus (d'Orbigny & Lafresnaye, 1837)	Cucarachero del Guarayos	X	X		LC		B	INS	B	
Family Polioptilidae Baird, 1858										
Polioptila dumicola (Vieillot, 1817)	Perlita Azul	X	X		LC		M	INS	F	
Family Turdidae Rafinesque, 1815										
Turdus leucomelas Vieillot, 1818	Zorzal Sabiá	X	X		LC		B	ONI	B	
Turdus rufiventris Vieillot, 1818	Zorzal Colorado	X			LC		B	ONI	B	
Turdus amaurochalinus Cabanis, 1850	Zorzal Chalchalero	X			LC		B	ONI	B	
Family Mimidae Bonaparte, 1853										
Mimus saturninus (Lichtenstein, 1823)	Sinsonte Calandria		X		LC		B	ONI	C	
Family Passerellidae Cabanis & Heine, 1850										
Zonotrichia capensis (Statius Muller, 1776)	Chingolo Común	X			LC		B	GRAN	C	
Ammodramus humeralis (Bosc, 1792)	Chingolo Pajonalero	X	X		LC		B	GRAN	C	
Family Parulidae Wetmore, Friedmann, Lincoln, Miller, Peters, van Rossem, Van Tyne & Zimmer 1947										
Setophaga pitiayumi (Vieillot, 1817)	Parula Pitiayumí	X			LC		M	INS	B	
Basileuterus culicivorus (Deppe, 1830)	Reinita Coronidorada	X			LC		M	INS	B	
Myiothlypis flaveola Baird, 1865	Reinita Amarillenta	X			LC		M	INS	B	
Family Icteridae Vigors, 1825										
Procacicus solitarius (Vieillot, 1816)	Cacique Solitario	X			LC		B	ONI	F	
Cacicus chrysopterus (Vigors, 1825)	Cacique Aliamarillo	X	X		LC		B	INS	B	

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Cacicus haemorrhous (Linnaeus, 1766)	Cacique Lomirrojo	X			LC		B	ONI	B	
Icterus pyrrhopterus (Vieillot, 1819)	Turpial Variable	X	X		LC		M	ONI	B	
Gnorimopsar chopi (Vieillot, 1819)	Chopí	X			LC		B	ONI	C	
Agelaioides badius (Vieillot, 1819)	Tordo Músico		X		LC		M	INS	C	
Molothrus oryzivorus (Gmelin, 1788)	Tordo Gigante	X			LC		B	ONI	C	
Molothrus bonariensis (Gmelin, 1789)	Tordo Renegrido	X			LC		B	ONI	C	
Sturnella superciliaris (Bonaparte, 1850)	Charrancito Amazónico		X		LC		B	INS	C	
Family Thraupidae Cabanis, 1847										
Paroaria coronata (Miller, 1776)	Cardenilla Crestada	X	X		LC		B	GRAN	B	
Paroaria capitata (d'Orbigny & Lafresnaye, 1837)	Cardenilla Piquigualda	X			LC		B	INS	B	
Tangara sayaca (Linnaeus, 1766)	Tangara Sayaca	X	X		LC		B	FRU	B	
Nemosia pileata (Boddaert, 1783)	Tangara Encapuchada		X		LC		B	FRU	F	
Conirostrum speciosum (Temminck, 1824)	Conirrostro Culirrufo	X	X		LC		B	INS	B	
Sicalis flaveola (Linnaeus, 1766)	Dorado	X	X		LC		B	GRAN	C	
Volatinia jacarina (Linnaeus, 1766)	Semillero Volatinero		X		LC		B	GRAN	C	
Coryphospingus cucullatus (Statius Muller, 1776)	Soldadito Crestirrojo	X	X		LC		B	INS	C	
Tachyphonus rufus (Boddaert, 1783)	Tangara Negra	X	X		LC		B	FRU	B	
Coereba flaveola (Linnaeus, 1758)	Platanero		X		LC		B	ONI	B	
Sporophila caerulescens (Vieillot, 1823)	Semillero Corbatita	X			LC		B	GRAN	C	
Sporophila angolensis (Linnaeus, 1766)	Semillero Curió		X		LC		B	GRAN	C	
Saltatricula atricollis (Vieillot, 1817)	Pepitero Gorjinegro	X	X		LC		M	GRAN	B	
Saltator coerulescens Vieillot, 1817	Pepitero Grisáceo	X			LC		B	ONI	C	
Family Fringillidae Leach, 1820										

Taxon	Popular Name in Paraguay	Register		Categories of Threat		End	Sens.	Guild	Habitat	Migr.
		DIA	ADA	PY (2019)	IUCN (2020)					
Euphonia chlorotica (Linnaeus, 1766)	Eufonia Golipúrpura	X	X		LC		B	FRU	B	

Categories of Threat PY 2019 - Resolution 254/2019 of the Ministry of Environment and Sustainable Development of Paraguay IUCN 2020 - The IUCN Red List of Threatened Species, version 2020.1. Legend: AM - threatened with extinction; NT - near threatened; LC - of little concern; Endemism (End.) - CH - Chaco; EX - exotic species. Sensitivity (Sen.): B - low; M - medium; A - high. Guilda: CAR - carnivore; DET - detritivore; FRU - frugivore; GR - granivore; INS - insetivore; MAL - malacophageal; NEC - nectarivore; NECR - nerophageal; ONI - omnivore; PISC - piscivore. Habitat: A - wet environments; B - fragmentary edge; C - fields and open areas; F - forest. Migration (Migr.): VN - northern traveller.

Photographic record

Figure 316 to Figure 369 shows the photographic record of some species diagnosed in the DIA and DAA of the PARACEL pulp mill.

Figure 324 – Amazona Frentiazul (*Amazona aestiva*).

Figure 325 – Pato Brasileño (*Amazoneta brasiliensis*).

Figure 326 – Cotara Ipacaá (*Aramides ypecaha*).

Figure 327 – Aratinga Ñanday (*Aratinga nenday*).

Figure 328 – Garza Cuca (*Ardea cocoi*).

Figure 329 – Correlimos Batitú (*Bartramia longicauda*).

Figure 330 – Cacique Aliamarillo (*Cacicus chrysopterus*).

Figure 331 – Cacique Lomirrojo (*Cacicus haemorrhous*).

Figure 332 – Picamaderos Barbinegro (*Campephilus melanoleucos*).

Figure 333 – Carancho meridional (*Caracara plancus*).

Figure 334 – Martín Pescador Verde (*Chloroceryle americana*).

Figure 335 – Milano Picogarfio (*Chondrohierax uncinatus*).

Figure 336 – Tortolita Azulada (*Claravis pretiosa*).

Figure 337 – Chara Morada (*Cyanocorax cyanomelas*).

Figure 338 – Suirirí Piquirrojo (*Dendrocygna autumnalis*).

Figure 339 – Hornero Común (*Furnarius rufus*).

Figure 340 – Busardo Sabanero (*Heterospizias meridionalis*).

Figure 341 – Zafiro Bronceado (*Hylocharis chrysura*).

Figure 342 – Jacana Suramericana (*Jacana jacana*).

Figure 343 – Mosquero Pirata (*Legatus leucophaius*).

Figure 344 – Trepatroncos Chico (*Lepidocolaptes angustirostris*).

Figure 345 – Sinsonte Calandria (*Mimus saturninus*).

Figure 346 – Bienteveo Rayado (*Myiodynastes maculatus*).

Figure 347 – Cormorán Biguá (*Nannopterum brasilianus*).

Figure 348 – Buco Durmilí (*Nystalus striatipectus*).

Figure 349 – Chachalaca Charata (*Ortalis canicollis*).

Figure 350 – Anambé grande (*Pachyramphus validus*).

Figure 351 – Paloma Colorada (*Patagioenas cayennensis*).

Figure 352 – Espinero Común (*Phacellodomus rufifrons*).

Figure 353 – Nido de *Phimosus infuscatus*

Figure 354 – Espátula Rosada (*Platalea ajaja*).

Figure 355 – Chorlito Dorado Americano (*Pluvialis dominica*).

Figure 356 – Cacique Solitario (*Procacicus solitarius*).

Figure 357 – Aratinga Ojiblanca (*Psittacara leucophthalmus*).

Figure 358 – Mosquero Silbador (*Sirystes sibilator*).

Figure 359 – Batará Variable (*Thamnophilus caerulescens*).

Figure 360 – Aratinga Cabeciazul (*Thectocercus acuticaudatus*).

Figure 361 – Bandurria Común (*Theristicus caudatus*).

Figure 362 – Titira Colinegro (*Tityra cayana*).

Figure 363 – Trogón Curucuí (*Trogon curucui*).

Figure 364 – Monjita Blanca (*Xolmis irupero*).

Figure 365 – Trepatroncos Colorado (*Xiphocolaptes major*).

Figure 366 – Tordo Músico (*Agelaioides badius*).

Figure 367 – Garcita Verdosa (*Butorides striata*).

Figure 368 – Halcón Murcielaguero (*Falco rufigularis*).

Figure 369 – Cernícalo Americano (*Falco sparverius*).

Figure 370 – Pirincho (*Guira guira*).

Figure 371 – Cardenilla Crestada (*Paroaria coronata*).

Figure 372 – Carpintero Verdiamarillo (*Piculus chrysochloros*).

Figure 373 – Lechuzón de Anteojos (*Pulsatrix perspicillata*).

Figure 374 – Tucán Toco (*Ramphastos toco*).

Figure 375 – Ñandú Común (*Rhea americana*).

Figure 376 – Fiofío Suirirí (*Suiriri suiriri*).

Figure 377 – Paloma Picazuró (*Patagioenas picazuro*).

Final consideration about birdlife

The present diagnosis of the bird community in the areas of influence of the pulp mill was carried out in October 2019 (dry season) and March 2020 (rainy season), registering 181 species of birds distributed in 49 families and 24 orders. In the DIA 161 species were recorded, with a Shannon index that shows a high diversity for the area (H'= 4.33). In the DAA 106 species were recorded, with a diversity of H'= 3.80. The distribution of abundance among the species in the study areas corroborates the predictions for the neotropical regions, being relatively homogeneous, especially if we consider the Pielou Equivalence Index obtained for the DIA and the DAA from the PARACEL pulp mill (J'= 0, 85 and J'= 0, 81, respectively).

In general, it can be said that a large part of the diagnosed birdlife is considered synanthropic and not very sensitive to changes in the environment, with only three highly sensitive species being recorded during the present diagnosis: Pteroglossus castanotis, Piculus chrysochloros, Attila phoenicurus, the latter being considered rare in Paraguay. With respect to migratory birds, two long-distance migratory species have been recorded: Pluvialis dominica and Attila phoenicurus. Both species breed in tundra areas in the northern hemisphere, moving to their wintering grounds in southern South America.

The endemic birds of the Chaco, with a predominant phytophysiology in the areas of influence of the PARACEL pulp mill, were represented by two species during the study: Chachalaca Charata (Ortalis canicollis) and Trepatroncos Colorado (Xiphocolaptes major). Finally, as regards the endangered birds found in the sampled areas, seven species are included in the national (Resolution n. 254/2019) and/or global (IUCN, 2020) list: Greater Rhea or American Rhea, Pyrrhura deville), Conopophaga lineata, Mionectes rufiventris, Attila phoenicurus, Hylophilus poicilotis and CrCyanocorax cristatellus. Among the species mentioned, Conophophaga lineata and Mionectes rufiventris must be highlighted because they are underwood forest foragers and therefore dependent on the integrity of the forest.

9.2.2.5.2.3 Herpetofauna

Richness

During the two campaigns, 37 species of herpetofauna were recorded in the DAA (Area Directly Affected) and in the DIA (Direct Influence Area) (Figure 370), being 28 amphibians and nine reptiles. A total of 34 species were recorded in the DIA and 33 species in the ADA. Amphibians belong to the Order Anura and are divided into five families: Bufonidae (3 spp.), Hylidae (13 spp.), Leiuperidae (3 spp.), Leptodactylidae (8 spp.) and Microhylidae (1 sp.). The reptiles belong to three orders: Testudinae, represented by the family Testudinidae (1 spp.); Order Crocodilya, represented by the family Alligatoridae (1 spp.); Order Squamata, represented by five families: Teidae (1 spp.), Colubridae (1 spp.), Elapidae (1 spp.) Viperidae (1 spp.) and Dipsadidae (3 spp.). Among the species recorded during the study, none of them is considered endemic to the Chaco.

Most of the species recorded were in both the Direct and Indirect Areas of Influence. However, some species were unique to DIA at certain points: *Pithecopus azurea*, *Elachistocleis bicolor*, *Leptodeira annulata* e *Mussurana bicolor*. Reagrding DAA, following species exclusive registers: *Salvator merianae*, *Chironius quadricarinatus* e *Pseuduboa nigra.*

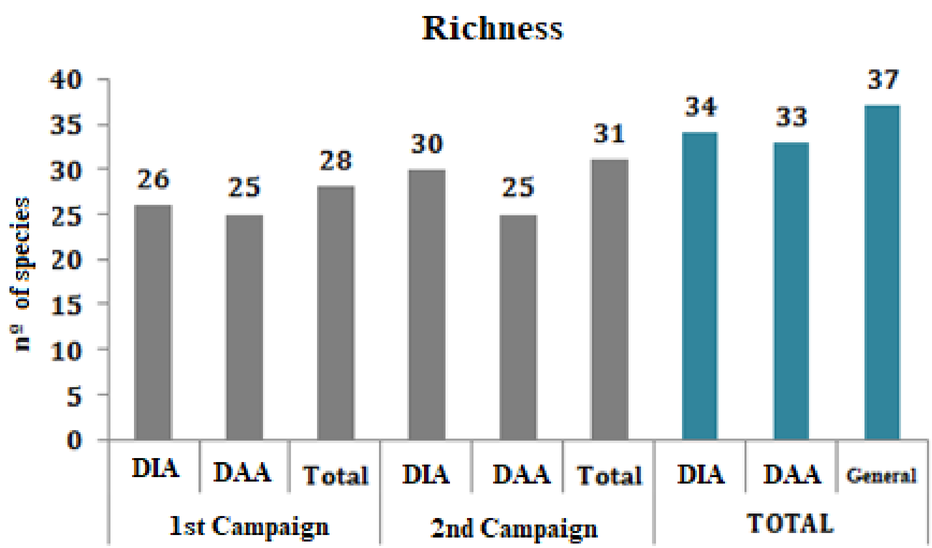

Figure 378 – Species richness of the herpetofauna recorded during the first and second sampling campaigns. SD - Secondary data.

Abundance

A total of 2015 individuals have been recorded for both the DAA and the DIA, with 1968 individuals for amphibians and 48 for reptiles. The most representative species of amphibians in terms of number of individuals were: *Leptodactylus podicipinus* (n= 260), *Leptodactylus latrans* (n= 204), *Leptodactylus fuscus* (n= 190), with 13,21%, 10,35% and 9,65%, respectively, of the total number of individuals sampled. The *Physalaemus biligonigerus* (n= 5) and *Elachistocleis bicolor* (n= 1), were the amphibians considered rare for the sample, with only 0.25% and 0.05%, respectively.

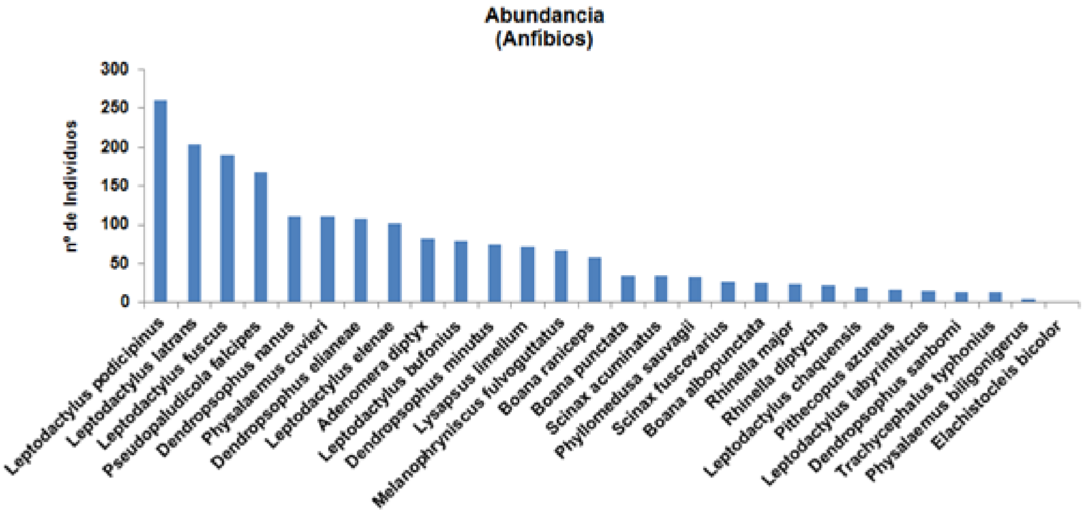

Figure 379 – Abundance of amphibian species recorded during the first and second sampling campaigns.

Among the reptiles, the most representative species were: *Bothrops diporus* (n=22) with 45,83% and *Caiman yacare* (n= 12) with 25%, the remaining reptiles had been represented with only three, two or one sample by specie, representing approximately 6,25%, 4,15% and 2,10% respectively.

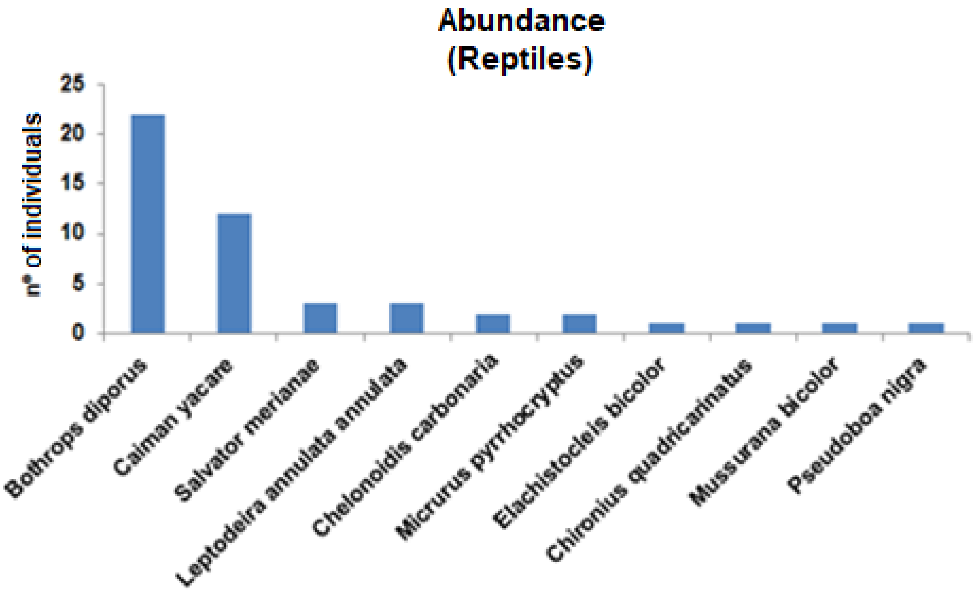

Figure 380 - Abundance of reptile species recorded during the first and second sampling campaigns.

Sample efficiency curve

The sample efficiency curve will then be presented, taking into account the data collected in both campaigns, using both methods (active search + point sampling), for both reptiles and amphibians. Since the number of amphibians recorded is much higher than that of reptiles, the two groups will be evaluated together.

It can be seen that the curve is still rising and has not reached the asymptote, indicating that new records can be made. The richness estimator (Jackknife 1) indicated that a total of 41 species could be observed (only four more species than those observed) (Figure 373). The Chao1 estimator indicated a number close to Jackknife 1, indicating 39 ± 2.0 species. Therefore, although the herpetofauna was very well sampled and represented in both campaigns, it is expected that, with further campaigns and sampling efforts, other representatives of the herpetofauna will be found, for both the DAA and the DIA.

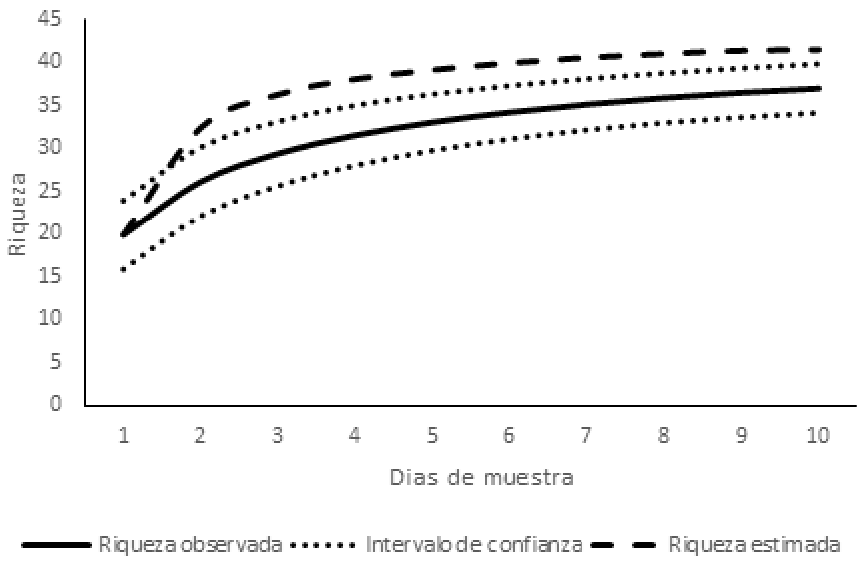

Figure 381 – Efficiency curve of the species sample and estimated richness (Jackknife 1) of the herpetofauna, based on 1000 randomized.

Diversity index

Taking into account the total data recorded in this campaign, the calculated Shannon diversity index was 3.03 and the equitability index was 0.8329, which indicates that the abundance of individuals is satisfactorily well distributed among the species, showing a low dominance (D'= 0.0633). The areas obtained a very similar richness, having a slight superiority for the direct influence area in the second campaign, 30 species and 26 species for the first campaign, the directly affected area obtained a richness of 25 species in both campaigns. The number of individuals recorded for all the areas combined was 2015.

Table 31 – Indexes obtained for registered herpetofauna during the first and second sampling campaigns.

	1st Campaign		2nd Campaign		TOTAL		
	DIA	ADA	DIA	ADA	DIA	ADA	General
Richness	26	25	30	25	34	33	37
Abundance	632	486	478	419	1113	909	2015
Dominance	0,07945	0,07567	0,07087	0,0959	0,06508	0,06783	0,0633
Diversity (Shannon)	2,729	2,79	2,928	2,721	2,983	2,98	3,03
Equitability	0,8376	0,8668	0,8608	0,8452	0,8391	0,8522	0,8329

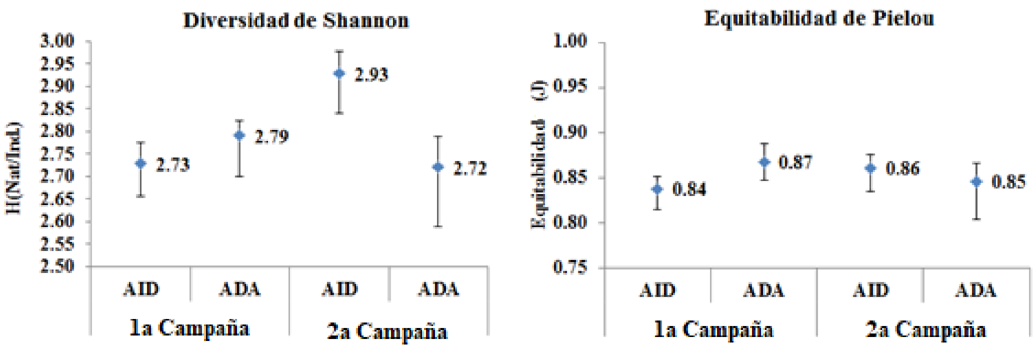

Figure 382 – Diversity and Equitability of the herpetofauna recorded during the first and second sampling campaigns.

Ecological Categories

Bioindicator species

Some species can be considered as bio-indicators of environmental quality, particularly with regard to their feeding habits or habitats. Among the amphibians, the painted toad, Melanophryniscus fulvoguttatus, stands out. This species occurs in eight departments of Paraguay, with diurnal and terrestrial habits. It is found in flooded areas and on the edges of water bodies in the regions of the Cerrado, the Atlantic Forest and the Chaco. The frogs Pithecopus azureus and Phyllomedusa sauvagii, have a nocturnal and arboreal habit and have a unique characteristic in their reproduction, in which they deposit their eggs in leaves on the water and in the future the tadpoles fall into the water by "dripping", that is to say, it is extremely dependent on vegetation around the water body.

In addition to being targeted for animal trafficking, to be used as a pet. For reptiles, the C. yacaré stands out as a great predator and has a great need to consume fish, birds, small mammals and even invertebrates. In the case of the snakes, the Micrurus pyrrhocryptus stands out, a species of discreet habits, mainly fossorial, that feeds mainly on other snakes, which makes it extremely indicative of the quality of the environment, since the environment must be balanced to have the capacity to sustain such a sensitive species with such a specific feeding habit.

Rare species

Some species were considered rare at diagnosis. Among the amphibians, the following should be highlighted: *Elachistocleis bicolor* where it obtained only one record in the two campaigns combined and was considered the rarest species for diagnosis among amphibians. Subsequently, *Physalaemus biligonigerus* was also considered rare with only five records in the second campaign. Amphibians: *T. tiphonius, D. sanborni and L. labyrinthicus* obtained an average of only 14 individuals and were also considered rare for the study. Among reptiles, it is common to obtain few records, as life history, food and population density may already justify the low records of the group. However, the few records of the following species stand out: *Pseudoboa nigra, Mussurana bicolor, Chironius quadricarinatus* e *Micrurus pyrrhocryptus*, which only got one record.

Endangered, endemic or exotic species

Although no species is considered endemic, three of them have some degree of threat or poor data. The toad *Rhinella diptycha* and *Dendropsophus elianae* are in danger of extinction, according to the list of animals threatened according to Resolution 433/2019, meanwhile that *Pithecopus azureus* was found as DD – Deficient Data, in accordance with International Union for Conservation of Nature Red List of Threatened Species (IUCN, 2020). It is not listed, but is highly threatened due to its commercial value, most notably *C. carbonaria*, a species widely used as food by hunters and widely used in wildlife trafficking, which is sold not only in Paraguay but all over the world.

The table bellow lists the herpetofauna species recorded during the first and second sampling campaigns, followed by the categories of threat and information on habitat preference, period of activity, abundance, song site, habitat and endemism.

Table 32 – List of herpetofauna species recorded during the first and second sampling campaigns in October/2019 and March/2020 respectively.

Taxon	Popular Name in Paraguay	Area of register		Threat categories		Habitat	Period of Activity	Abundance	Singing site	Habit	End.
		AID	ADA	PY (2019)	IUCN (2020)						
Order Anura		-	-								
Family Bufonidae		-	-								
Melanophryniscus fulvoguttatus (Mertens, 1937)	Sapito punteado (Toky to syry)	35	32		LC	AB	D	R	BL		MA
Rhinella major (Muller & Helmich, 1936)	Sapito mayor (Kururu'i)	16	8		-	AB/F	N	F	BL/RR	T	
Rhinella diptycha (Cope, 1862)	Cururú	15	8	EN	LC	AB/F	N	F	BL/RR	T	
Family Hylidae		-	-								
Dendropsophus elianeae (Napoli & Caramaschi, 2000)	Rana (Ju'i)	68	40	EN	LC	AB	N	F	BL	Ar	
Dendropsophus minutus (Peters, 1872)	Ranita amarilla comun	42	32		LC	AB	N	F	BL	Ar	
Dendropsophus nanus (Boulenger, 1889)	Ranita enana	67	44		LC	AB	N	F	BL	Ar	
Dendropsophus sanborni (Schmidt, 1944)	Ranita enana	4	10		LC	AB	N	F	BL	AR	
Boana albopunctata (Spix, 1824)	Ranita punteada	11	15		LC	AB	N	F	BL	Ar	
Boana punctata (Schneider, 1799)	Rana punteada	4	31		LC	AB	N	PF	BL/RR	AR	
Boana raniceps (Cope, 1862)	Rana arborea meridional	22	36		LC	AB	N	F	BL	Ar	
Pithecopus azureus (Cope, 1862)	Ranita mono chaqueña	16	-		DD	AB	N	PF	BL	Ar	
Phyllomedusa sauvagii (Boulenger, 1882)	Rana monito (Ju'i)	15	18		LC	AB	N	PF	BL	Ar	
Lysapsus limellum (Cope, 1862)	Ranita (Ju'i)	60	11		LC	AB	N	F	BL	Ar	
Scinax acuminatus (Cope, 1862)	Ranita (Ju'i)	16	18		LC	AB	N	PF	BL	Ar	MA
Scinax fuscovarius (A. Lutz, 1925)	Ranita (Ju'i)	12	15		LC	AB/F	N	F	BL	Ar	
Trachycephalus typhonius (Linnaeus, 1758)	Rana lechosa (Ju'i nekere)	6	7		-	AB/F	N	F	BL	AR	
Family Leiuperidae		-	-								
Physalaemus biligonigerus (Cope, 1861 "1860")	Rana llorona	3	2		LC	AB	N	PF	BL	Ar	

Taxon	Popular Name in Paraguay	Area of register		Threat categories		Habitat	Period of Activity	Abundance	Singing site	Habit	End.
		AID	ADA	PY (2019)	IUCN (2020)						
Physalaemus cuvieri (Fitzinger, 1826)	Rana perro	44	66		LC	AB	N	F	BL	T	
Pseudopaludicola falcipes (Hensel, 1867)	Ranita de Hensel o macaquito	113	54		LC	AB	D/N	F	BL	C	MA
Family Leptodactylidae		-	-								
Adenomera diptyx (Boettger, 1885)	Rana (Ju'i)	64	18		LC	AB	N	PF	BL	Ar	
Leptodactylus bufonius (Boulenger, 1894)	Rana hornera o rana ocico de pala	51	28		LC	AB	N	PF	BL	Ar	
Leptodactylus chaquensis (Cei, 1950)	Rana chaqueña o rana criolla	13	7		LC	AB	N	F	BL	C	
Leptodactylus elenae (Heyer, 1978)	Rana marmolada de labio blanco	36	65		LC	AB	N	F	BL	C	
Leptodactylus fuscus (Schneider, 1799)	Rana silbadora	112	78		LC	AB	N	F	BL	T	
Leptodactylus labyrinthicus (Spix, 1824)	Sapo toro laberintico	6	9		LC	AB	N	F	BL	T	
Leptodactylus latrans (Steffen, 1815) Leptodactylus ocellatus	Rana criolla	111	93		LC	AB/F	N	F	BL	T	
Leptodactylus podicipinus (Cope, 1862)	Rana de vientre moteado	122	138		LC	AB	N	F	BL	T	
Family Microhylidae		-	-								
Elachistocleis bicolor (Valenciennes in Guérin-Menéville, 1838)	Ranita aceituna o panza amarilla	1	-		LC	AB	N	F	BL	GT	
Order Testudines		-	-								
Family Testudinidae		-	-								
Chelonoidis carbonaria (Spix, 1824)	Tortuga terrestre	1	1			AB/F	D	R	NC	T	
Order Crocodilya		-	-								
Family Alligatoridae		-	-								
Caiman yacare (Daudin, 1802)	Jakare negro o jakare hú	3	9		LC	AB	D/N	F	NC	T/ Aq	
Order Squamata		-	-								
Family Teiidae		-	-								

Taxon	Popular Name in Paraguay	Area of register		Threat categories		Habitat	Period of Activity	Abundance	Singing site	Habit	End.
		AID	ADA	PY (2019)	IUCN (2020)						
Salvator merianae (Duméril & Bibron, 1839)	Lagarto overo	-	3		LC	AB/F	D	F	NC	T	
Family Colubridae		-	-								
Chironius quadricarinatus (Boie, 1827)	Mbói ysypo	-	1			AB/F	D	PF	NC	T/ Ar	
Family Elapidae		-	-								
Micrurus pyrrhocryptus (Cope, 1862)	Coral chaqueña	1	1		LC	AB/F	N	R	NC	T	
Family Viperidae		-	-								
Bothrops diporus (Cope, 1862)	Yarará chica	12	10		LC	AB/F	N	F	NC	T	
Family Dipsadidae		-	-								
Leptodeira annulata annulata (Linnaeus, 1758)	Falsa mapanare / Ojo de gato	3	-		LC	AB/F	D/N	F	-o-	AR /T	
Mussurana bicolor (Peracca, 1904)	Mussurana bicolor	1	-		LC	AB/F	N	PF	NC	T	
Pseudoboa nigra (Duméril, Bibron & Duméril, 1854)	Mussurana	-	1		LC	AB/F	N	F	-o-	T	

Legend: Threat Categories: PY – Paraguay 2019; **IUCN (2019)** – Lista Roja IUCN de Species Amenazadas de Extinción (versión 2019.2). **LC** – Least Concern; **DD** – Poor data. **Habitat: AB** – open area; **AF** – area forestal; **AB/F** – area open or forested (generalist). **Activity: D-** diurnal; **N** – nocturne. **Abundance: F** – frequent; **PF** – low frequent; **R** – rare. **Sítios de canto: BM** – bromélia; **BL** – lagoon edge; **CM** – piso del bosque; **RR-** remanso del río; **NC** – no canta. **Habit: Ar** – arbóreo; **C** – criptozóico; **T** – terrestre; **Aq** – aquatic. **End: Endemism:** Ch – Chaco

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Photo Report

Figure 383 – *Melanophryniscus fulvoguttatus*

Figure 384 – *Rhinella major*

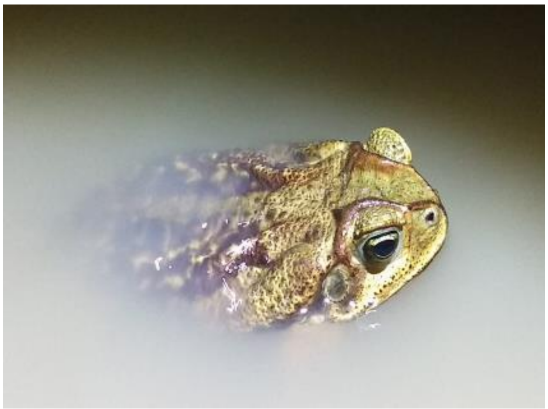


Figure 385 – *Rhinella diptycha*

Figure 386 – *Dendropsophus minutus*

Figure 387 – *Dendropsophus sanborni*

Figure 388 – *Boana albopunctata*

Figure 389 – *Boana punctata*

Figure 390 – *Pithecopus azurea*)

Figure 391 – *Phyllomedusa sauvagii*

Figure 392 – *Lysapsus limellum*

Figure 393 – *Scinax acuminatus*

Figure 394 – *Trachycephalus typhonius*

Figure 395 – *Physalaemus biligonigerus*

Figure 396 – *Leptodactylus bufonius*

Figure 397 – *Leptodactylus elenae*

Figure 398 – *Leptodactylus fuscus*

Figure 399 – *Leptodactylus latrans*

Figure 400 – *Elachistocleis bicolor*

Figure 401 – *Chelonoidis carbonaria*

Figure 402 – *Caiman yacare*

Figure 403 – *Chironius quadricarinatus*

Figure 404 – *Micrurus pyrrhocryptus*

Figure 405 – *Bothrops diporus*

Figure 406 – *Leptodeira annulata*

Figure 407 – *Mussurana bicolor*

Figure 408 – *Pseudoboa nigra*

Final considerations about herpetofauna

During the two campaigns, 37 species of herpetofauna were recorded in the DAA (Directly Affected Area) and the DIA (Area of Direct Influence), which are 28 anuria amphibians and nine reptiles. A total of 34 species were recorded in the DIA and 33 species in the ADA. Amphibians belong to the Order Anura and are divided into five families: Bufonidae (3 spp.), Hylidae (13 spp.), Leiuperidae (3 spp.), Leptodactylidae (8 spp.) and Microhylidae (1 sp.). The reptiles belong to three orders: Testudinae, represented by the family Testudinidae (1 spp.); Order Crocodilya, represented by the family Alligatoridae (1 spp.); Order Squamata, represented by five families: Teidae (1 spp.), Colubridae (1 spp.), Elapidae (1 spp.) Viperidae (1 spp.) and Dipsadidae (3 spp.).

Although the two campaigns took place at different times of the year (drought and rain), which would technically make two campaigns with a good sample sufficiency, the unfavorable weather for the rain campaign was certainly not enough for the campaign. With many dry lakes and the absence of rain, species that should be in the breeding period showed little or no vocal activity during the occasional sampling in the lakes. These data are corroborated by the similarity and superiority in the species record of the first campaign (dry), with a total of 28 species (1124 individuals) and 31 species (891 individuals) in the second campaign. Certainly, with new campaigns and sampling new species would be found (as also indicated in the indices and the rarefaction curve) and a better representation of the local herpetofauna could be obtained.

Three species have some degree of threat or poor data. The toad (Rhinella diptycha) and the *Dendropsophus elianae* are endangered, according to the Resolution 433/2019 (list of threatened animals), while *Pithecopus azureus* is listed as DD – Deficient Data, according to the International Union for Conservation of Nature - Red List of Threatened Species (IUCN, 2020).

9.2.2.5.2.4 Ichthyofauna

Richness

Fifty-eight species were identified belonging to 17 families of 4 orders in which Characiformes had the highest number of species representatives (32), followed by Siluriforms with 19 species. (**Figure 401**)

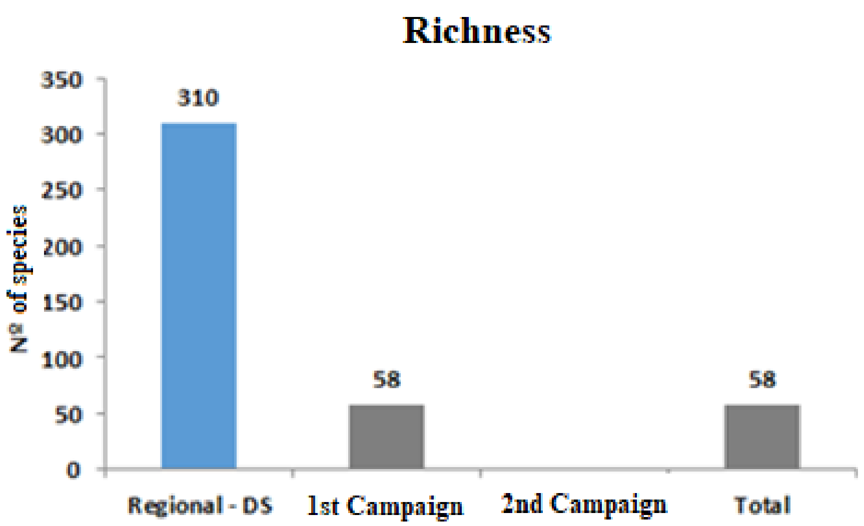


Figure 409 – Fish species richness recorded during the first monitoring campaign.

The occurrence behavior of diversity for the Neotropical drains is of greater richness and absolute number of species of the Characiform Orders followed by the Siluriforms, as has been pointed out since Lowe-McConnell (1999) (cf. also Beaumord, 1991).

The Characiform Order are present in all domains, both in lotic and lentic environments, being one of the largest groups of freshwater fish. Its success is related to the wide distribution and variability of feeding habits observed also in the great ecological and morphological diversification of the group (Moreira, 2007). A greater representativeness of the Characiformes Order is expected, so this group will be dominant among freshwater sources present in South America (Britski et al., 2007).

Of all the species found in the area sampled in this campaign, the Characiformes were the largest representative **Figure 402**, as well as the Characidae family, the largest family of this Order and which had the highest number of species captured (Lowe-mcconnell, 1999).

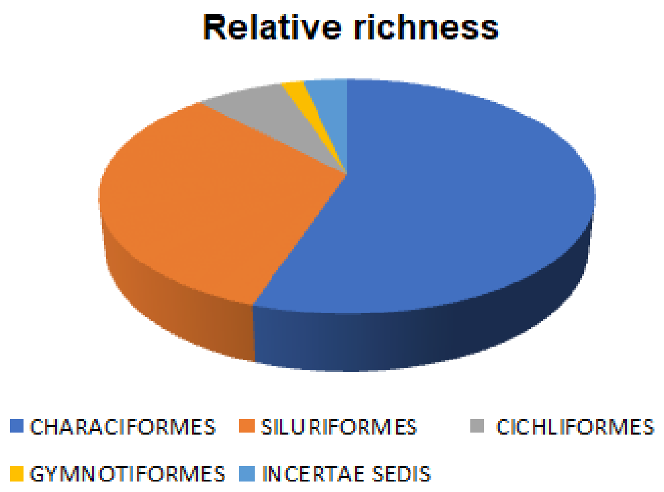


Figure 410 – Relative order richness of ichthyofauna recorded during the first sampling campaign.

Abundance

The quantitative analysis of ichthyofauna is presented by the results of numerical abundance (number of individuals) and relative abundance (%), as shown in Table bellow. A total of 443 individuals were caught during the campaign, with *Bryconamericus exodon* being the most abundant, with 55 individuals, representing 12.4% of the total fish caught, followed by *Aphyocharax anisitsi*, with 46 individuals, corresponding to 10.4%.

Table 33 – Results of relative abundance of ichthyofauna registered during the first sampling campaign.

Taxon	1st day	2nd day	3rd day	4th day	Total	Relative %
Abramites hypselonotus (Günther 1868)			1		1	0.2%
Acestrorhynchus pantaneiro Menezes 1992			1		1	0,2%
Apareiodon affinis (Steindachner 1879)	4		2		6	1,4%
Aphyocharax anisitsi Eigenmann & Kennedy 1903	6		39	1	46	10,4%
Astyanax lacustris (Lütken 1875)			3		3	0,7%
Astyanax sp.			1		1	0,2%
Bryconamericus exodon Eigenmann 1907	55				55	12,4%
Bujurquina vittata (Heckel 1840)			1		1	0,2%
Characidium laterale (Boulenger, 1895)	2				2	0,5%
Creagrutus meridionalis Vari & Harold 2001	1				1	0,2%
Crenicichla semifasciata (Heckel 1840)			1		1	0,2%
Crenicichla vittata Heckel 1840	2		3	1	6	1,4%
Curimatella dorsalis (Eigenmann & Eigenmann 1889)			2		2	0,5%
Eigenmannia trilineata López & Castello 1966			1		1	0,2%

Taxon	1st day	2nd day	3rd day	4th day	Total	Relative %
Galeocharax humeralis (Valenciennes 1834)	5		1	4	10	2,3%
Gasteropelecus sternicla (Linnaeus 1758)			1		1	0,2%
Gymnogeophagus balzanii (Perugia 1891)			1		1	0,2%
Hemiodus cf. *orthonops* Eigenmann & Kennedy 1903	6		2		8	1,8%
Hoplias malabaricus (Bloch 1794)			2	2	4	0,9%
Hypoptopoma inexspectatum (Holmberg 1893)	5		9		14	3,2%
Hypostomus cf. *boulengeri* (Eigenmann & Kennedy 1903)				1	1	0,2%
Hypostomus cf. *latifrons* Weber 1986	5		8	2	15	3,4%
Hypostomus sp1.	14		25		39	8,8%
Hypostomus sp2.	1		4		5	1,1%
Hypostomus sp3.			1		1	0,2%
Iheringichthys labrosus (Lütken 1874)		5	1	1	7	1,6%
Leporinus friderici (Bloch 1794)				1	1	0,2%
Leporinus striatus Kner 1858	1				1	0,2%
Loricaria sp.		3		2	5	1,1%
Loricariichthys platymetopon Isbrücker & Nijssen 1979		1			1	0,2%
Moenkhausia intermedia (Eigenmann 1908)			24	6	30	6,8%
Moenkhausia dichroura (Kner 1858)	2				2	0,5%
Myloplus levis (Eigenmann & McAtee 1907)			1		1	0,2%
Odontostilbe pequira (Steindachner 1882)	28		1	1	30	6,8%
Otocinclus vittatus Regan 1904	1		13		14	3,2%
Oxydoras kneri Bleeker 1862		1	2		3	0,7%
Phenacogaster jancupa Malabarba & Lucena 1995	2		2		4	0,9%
Pimelodella cf. *megalura* Miranda Ribeiro 1918	1				1	0,2%
Pimelodella gracilis (Valenciennes 1835)	4				4	0,9%
Plagioscion squamosissimus (Heckel 1840)				1	1	0,2%
Plagioscion ternetzi Boulenger 1895		1			1	0,2%
Psectrogaster curviventris Eigenmann & Kennedy 1903		1		6	7	1,6%
Pterygoplichthys ambrosettii (Holmberg 1893)		1			1	0,2%
Pygocentrus nattereri Kner 1858		1		1	2	0,5%
Pyxiloricaria menezesi Isbrücker & Nijssen 1984		1		5	6	1,4%
Rineloricaria cf. *parva* (Boulenger 1895)			2		2	0,5%
Roeboides affinis (Günther 1868)		6		1	7	1,6%
Roeboides cf. *microlepis* (Reinhardt 1851)				1	1	0,2%
Schizodon borellii (Boulenger 1900)			1		1	0,2%
Serrasalmus maculatus Kner 1858			2	1	3	0,7%
Spatuloricaria evansii (Boulenger 1892)			1	9	10	2,3%
Steindachnerina brevipinna (Eigenmann & Eigenmann 1889)			1		1	0,2%
Sturisoma barbatum (Kner 1853)		2		7	9	2,0%
Tetragonopterus argenteus Cuvier 1816	2			1	3	0,7%
Thoracocharax stellatus (Kner 1858)	16				16	3,6%
Trachydoras paraguayensis (Eigenmann & Ward 1907)		12		20	32	7,2%
Triportheus nematurus (Kner 1858)		3		2	5	1,1%

Taxon	1st day	2nd day	3rd day	4th day	Total	Relative %
Triportheus pantanensis Malabarba 2004			5		5	1,1%
Total	**163**	**38**	**165**	**77**	**443**	**100,0%**

Sample efficiency curve

The scarcity curve was developed by extrapolating data on the number of species and the number of individuals, to analyze the sampling effort of the collection campaign. Through the graph with the richness and abundance data it is possible to observe that the number of species increases as more individuals are captured. In this first campaign a total of 443 individuals were captured. Possibly, with the increase of the capture of individuals, new species can be captured (**Figure 403**).

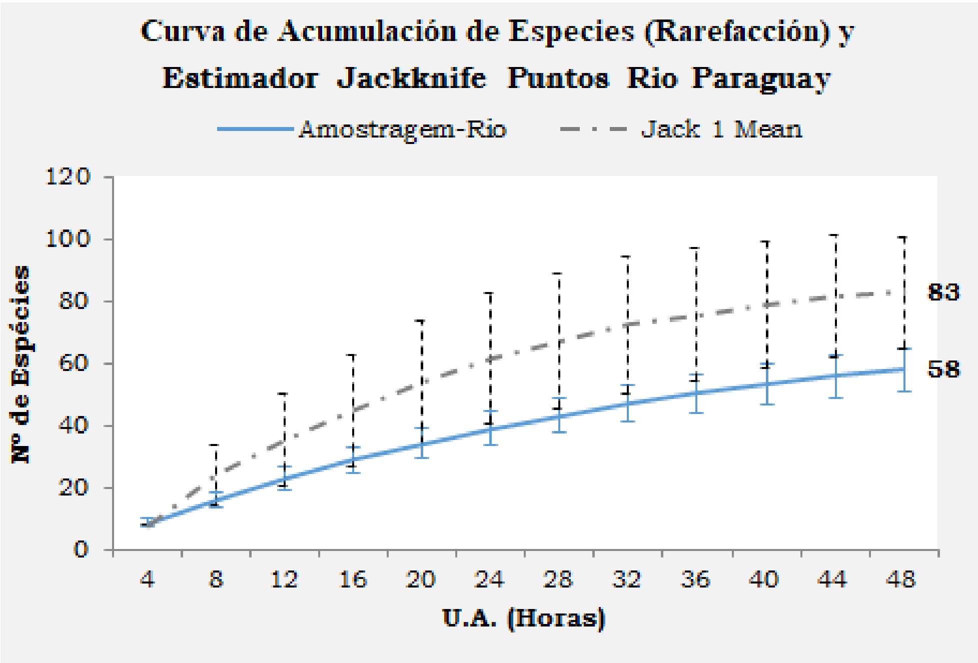


Figure 411 – Rarefaction curve of ichthyofauna species recorded during the first sampling campaign.

As shown in the graph, the Jackknife 1 richness estimator indicates a potential richness of 83 species, compared to 58 identified in the first collection campaign, showing an increasing trend. Thus, with the continuity of the studies, the number of species recorded tends to increase. This occurs because tropical communities tend to be formed by many individuals of few species (common species) and few individuals of many species (rare species). Therefore, the probability of capturing rare species tends to increase with greater sampling effort.

Diversity index

The Shannon H diversity index (3.3) indicates that there is great local diversity. Community equitability (0.81) is also expressed by the low dominance index (0.057), where the two estimators range from 0 to 1.

With these results, it can be deduced that the set of fish in the region of the collection is diverse and with notable abundance.

Table 34 – List of ichthyofauna species recorded during the first sampling campaign in March/2020.

Taxon	Popular Name in Paraguay	General	Day 1	Day 2	Day 3	Day 4	Guild	Status	Status fishbase	Categories of Threat	
										IUCN (2018)	PY
CHARACIFORMES											
Family Acestrorhynchidae											
Acestrorhynchus pantaneiro Menezes, 1992	Pira jagua	1			1		GEN/CA	AUT/NA	Native	Not valued	NC
Family Anostomidae											
Abramites hypselonotus (Günther, 1868)	Jiki	1			1		GEN/HE		Native	NA	NC
Leporinus friderici (Bloch, 1794)	Boga	1				1	GEN/HE-CA	AUT/NA	Native	NA	NC
Leporinus striatus (Kner, 1858)	Boguita rayada	1	1				GEN/HE-CA	AUT/NA	Native	NA	NC
Schizodon borellii (Boulenger, 1900)	Boga fina	1			1		HE	AUT/NA	Native	NA	NC
Family Characidae											
Astyanax lacustris (Lütken, 1875)	Mojarra	3			3		GEN/ON	AUT/NA	Native	NA	NC
Astyanax sp.	-	1			1		GEN/ON	AUT/NA	Native	NA	
Moenkhausia dichroura (Kner, 1858)	Mojarra	2	2				ON		Native	NA	NC
Moenkhausia intermedia Eigenmann, 1908	Mojarra cola de tijera	30			24	6	ON		Native	NA	NC
SubFamily Aphyocharacinae											
Aphyocharax anisitsi (Eigenmann & Kennedy, 1903)	Tetra de atletas rojas	46	6		39	1	GEN/ON	ALO/NA	Native	NA	NC
SubFamily Characinae											
Galeocharax humeralis (Valenciennes, 1834)	Dientudo	10	5	0	1	4	CA		Native	NA	NC
Phenacogaster tegatus (Eigenmann, 1911)	-	4	2		2		CA		Native	NA	NC
Roeboides cf. *affinis* (Guenther, 1868)	Dientudo jorobado	7		6		1	CA			NA	NC
Roeboides cf. *microlepis* (Reinhardt, 1851)	Dientudo	1				1	CA		Native	NA	NC

Taxon	Popular Name in Paraguay	General	Day 1	Day 2	Day 3	Day 4	Guild	Status	Status fishbase	Categories of Threat	
										IUCN (2018)	PY
SubFamily Cheirodontinae											
Odontostilbe pequira (Steindachner, 1882)	Pequira	30	28		1	1	GEN/ON	AUT/NA	Native	NA	NC
SubFamily Stevardiinae											
Bryconamericus exodon Eigenmann, 1907	Mojarra, Piky	55	55				IN		Native	NA	NC
Creagrutus paraguayensis Mahnert & Géry, 1988	-	1	1				ON		Native	NA	NC
SubFamily Tetragonopterinae											
Tetragonopterus argenteus Cuvier, 1816	Relojito	3	2			1	ON		Native	NA	NC
Family Crenuchidae											
Characidium laterale (Boulenger, 1895)	-	2	2				IN	AUT/NA	Native	NA	NC
Family Curimatidae											
Curimatella dorsalis (Eigenmann & Eigenmann, 1889)	Sabalito, blanquillo, boguita	2			2		Detr		Native	NA	NC
Psectrogaster curviventris Eigenmann & Kennedy, 1903	Sabalito, llorona, blanquillo, gritón	7		1		6	Dent		Native	NA	NC
Steindachnerina brevipinna (Eigenmann & Eigenmann, 1889)	Sabalito, blanquillo, huevada	1			1		Dent		Native	NA	NC
Family Erythrinidae											
Hoplias malabaricus (Bloch, 1794)	Tararira tarey'i	4			2	2	GEN/CA	AUT/NA	Native	NA	NC
Family Gasteropelecidae											
Gasteropelecus sternicla (Linnaeus, 1758)	Pez hacha común	1			1		Ins/Inv		.	NA	NC
Thoracocharax stellatus (Kner, 1858)	Pechito, chirola, medallita, pez volador	16	16				Ins/Inv		Native	NA	NC
Family Hemiodontidae											
Hemiodus cf. *orthonops* Eigenmann & Kennedy, 1903	Sardina de río	8	6		2		ON		Native	NA	NC
Family Parodontidae											

Taxon	Popular Name in Paraguay	General	Day 1	Day 2	Day 3	Day 4	Guild	Status	Status fishbase	Categories of Threat	
										IUCN (2018)	PY
Apareiodon affinis (Steindachner, 1879)	Virolito	6	4		2		ON	Nativo	Native	NA	NC
Family Serrasalmidae											
Myloplus levis (Eigenmann & McAtee, 1907)	Palometa	1			1		HE		Native	NA	NC
Pygocentrus nattereri Kner, 1858	Piraña roja, piraña mora, palometa	2		1		1	CA		Native	NA	NC
Serrasalmus maculatus Kner, 1858	Piraña, pirái	3			2	1	CA		Native	NA	NC
Family Triportheidae											
Triportheus nematurus (Kner, 1858)	Golondrina, machete, pirá güirá, chape	5		3		2	Ins/Inv		Native	NA	NC
Triportheus pantanensis Malabarba, 2004	Golondrina	5			5		Ins/Inv		Native	NE	NC
Order Gymnotiformes											
Family Sternopygidae											
Eigenmannia trilineata (López & Castello, 1966)	Banderita	1			1		GEN/IS-CA	AUT/NA	Native	NA	NC
Order Siluriformes											
Family Doradidae											
Oxydoras kneri Bleeker, 1862	Armado chancho	3		1	2		ON		Native	NA	NC
Trachydoras paraguayensis (Eigenmann & Ward, 1907)	Armado	32		12		20	ON		Native	NA	NC
Family Heptapteridae											
Pimelodella cf. *megalura* Miranda Ribeiro, 1918	Mandi´i	1	1				INS/INV		Native	NA	NC
Pimelodella gracilis (Valenciennes, 1835)	Bragecito, bagre cantor	4	4				ON		Native	NA	NC
Family Loricariidae											
SubFamily Hypostominae											
Hypoptopoma inexspectatum (Holmberg, 1893)	Limpiafondos, vieja del agua, vieja	14	5		9		Detri		Native	NA	NC

Taxon	Popular Name in Paraguay	General	Day 1	Day 2	Day 3	Day 4	Guild	Status	Status fishbase	Categories of Threat	
										IUCN (2018)	PY
Hypostomus cf. *boulengeri* (Eigenmann & Kennedy, 1903)	Vieja de agua	1				1	Detri		Native	NA	NC
Hypostomus cf. *latifrons* Weber, 1986	Vieja de agua	15	5		8	2	Detri		NE	NA	NC
Hypostomus sp1.	Vieja de agua	1			1		Detri		.		
Hypostomus sp2.	Vieja de agua	39	14		25		Detri		.		
Hypostomus sp2.	Vieja de agua	5	1		4		Detri		.		
Pterygoplichthys ambrosettii (Holmberg, 1893)	Vieja de agua	1		1			DETR	ALO/NA	Native	NA	NC
SubFamily Hypoptopomatinae											
Otocinclus vittatus Regan, 1904	Limpiavidrios	14	1		13		HER		Native	NA	NC
SubFamily Loricariinae											
Loricaria sp.	Cascarudo	5		3		2			.		
Loricariichthys platymetopon Isbruecker & Nijssen, 1979	Vieja de agua	1		1			DETR		Native	NA	NC
Pyxiloricaria menezesi Isbrücker & Nijssen, 1984	Vieja de agua	6		1		5	DETR		NE	NA	NC
Rineloricaria cf. *parva* (Boulenger, 1895)	Vieja del agua, viejita cola de látigo	2			2		DETR		Native	NA	NC
Spatuloricaria evansii (Boulenger, 1892)	Vieja	10			1	9	DETR		NE	NA	NC
Sturisoma barbatum (Kner, 1853)	Vieja de agua	9		2		7	DETR		NE	NA	NC
Family Pimelodidae											
Iheringichthys labrosus (Luetken, 1874)	Bagre picudo, bagre trompudo	7		5	1	1	ON		Native	NA	NC
Order CICHLIFORMES											
Family Ciclidae											
Bujurquina vittata (Heckel, 1840)	Acara, takype	1			1		ON		Native	NA	NC
Crenicichla semifasciata (Heckel, 1840)	Chanchita	1			1		CA		Native	NA	NC
Crenicichla vittata Heckel, 1840	Cabeza Amarga Colorado	6	2		3	1	CA		Native	NA	NC

Taxon	Popular Name in Paraguay	General	Day 1	Day 2	Day 3	Day 4	Guild	Status	Status fishbase	Categories of Threat	
										IUCN (2018)	PY
Gymnogeophagus balzanii (Perugia, 1891)	Chanchita	1			1		ON		Native	NA	NC
INCERTAE SEDIS											
Plagioscion squamosissimus (Heckel, 1840)	Corvina de río, pescada da Piauí	1				1	CA		Native	NA	NC
Plagioscion ternetzi Boulenger, 1895	Corvina de río	1		1			CA		Native	NA	NC

Legend: Food guild (detritivores (DETR); generalists (GEN); insetivores (INS); invertivores (INV); herbivores (HE); omnivores (ON) and piscivores (PISC); Status according to fishbase (native/non-native); Threat categories according to IUCN Not Evaluated (NA), PY Nothing appears (NC).

Ecological Categories

Food Guilds

The following characteristics were selected for the food guilds (detritivores; generalists; insectivores; invertors; herbivores; omnivores and piscivores). Invertivorous fish are likely to be favored by the increased availability of food, as flooding favors the abundance of benthic invertebrates (Neckles et al., 1990; Aspin et al., 2018). Similarly, omnivorous fish, being generalists, may be favored by the overall increase in resource availability provided by more intense flooding, as fish have more access to floodplain compartments and allochthonous resources (Junk et al., 1997; Balcombe et al., 2005; Quirino et al., 2018; Castello et al., 2019; Liu et al., 2019). Herbivorous fish can be favored in long-lasting droughts, as flooding fragments and reduces the appearance of macrophyte and biomass shoals (Bulla et al., 2011; Schneider et al., 2018), so in periods of drought these shoals tend to be more durable, favoring feeding. For fishermen's associations, during droughts the isolation and confinement of fish in floodplain enclosures (Rodríguez and Lewis; 1997; Thomaz et al., 2007; Pusey et al., 2016), can benefit from greater success in the predatory activities of fish species.

In tropical regions, generalist and/or opportunist species predominate, promoted by the wide and variable supply of resources (Lowe McConnell 1999, Araújo-Lima et al 1995). According to Schoener (1971) generalist species are those that have a wide spectrum of food and/or a high variation of food. Already opportunistic species feed on rare sources of their diet or use abundant and unusual food sources (Gerking 1994). As an example of this behavior, omnivorous fish also combine intake of plant and animal elements. Plant items do not require as much effort to obtain as animal items, but they have a high energy value (Montgomery & Targett, 1992). And studies of the ecomorphology of the species Pimelodus and Rhamdia are examples of omnivores that feed at great depths and have a nocturnal habit (Lolis & Andrian 1996, Souza & Barella 2009).

Species of economic interest

Larger fishes are of great economic and sporting interest such as the *Prochilodus lineatus*, *Salminus brasiliensis*, *Pseudoplatystoma corruscans*, *Pseudoplatystoma reticulatum*, *Piaractus mesopotamicus*, *Leporinus friderici* and *Brycon hilarii* are some of the most notable species of Pantanal ichthyofauna. This is due, in part, to the large size of these species, which are valuable for both amateur and professional fishing (Catella, 2004).

Poorly documented but no less important, small fish species up to 15 cm in length are essential for feeding because they are links in the food chain or directly make up the food preference of larger species, without which many large species could not exist. Small fish are organisms whose biological richness has not yet been adequately assessed (Sabino and Prado, 2006).

Bioindicators species

Fish are good bioindicators of environmental water quality, due to aspects of clustering, such as the inclusion of different groups of different trophic levels (Flores and MAlabarba, 2007). Knowledge of biodiversity, especially of fish, due to the various positions this group occupies in a food chain, and knowledge of how spatial and temporal variation behaviours work, is a great biological tool to evaluate the quality of the environment (Teixeira et al., 2005). Species such as Astyanax, Hyphessobrycon and

Piabina, are generally considered to be environmental bioindicators (Bennemann et al. 2006).

Migratory species

Migratory fish species may be favored by longer flooding times, with increased water flow and connection of breeding areas. (Vasconcelos et al., 2014; Oliveira et al., 2015). Fish settle in certain environments due to a set of biotic and abiotic factors that occur at that time. Factors such as the availability of shelter, feeding and reproduction sites are essential for the establishment of these species (Bennemann; Shibatta; Garavello, 2000).

The *Leporinus friderici* migrates to adulthood. Most individuals of this species reside in rivers and large streams as adults and can occasionally be found in smaller streams in the juvenile stage (Pompeu & Godinho 2003). The flooding period is one of the determining factors in the recruitment of species, especially migratory ones (Gomes & Agostinho, 1997; Agostinho et al., 2004c). Populations may suffer declines due to the loss of essential habitats that are necessary to complete their life cycles (Agostinho et al., 1999; Ceregato & Petrere Jr., 2003).

Rare species

In the case of rare species, no cases were recorded in the first ichthyofauna campaign either.

Endangered, endemic or exotic species

Data generated during the international workshop on the assessment of fish extinction risk in the lower Plata river basin, held in 2008, assessed the conservation status of freshwater species present in Paraguay (Baigún et al., 2012), using the IUCN criteria (2010). Eleven species were assessed as threatened in the lower Plata river basin, four of which are found in Paraguay, as endangered species *Gymnogeophagus setequedas* (Malabarba and Pavanelli 1992), and *Hypostomus dlouhyi* (Weber 1985), in the vulnerable category *Ancistrus piriformis* (Muller 1989) and *Brycon orbignyanus* (Valenciennes, 1850) species with occurrence records for the Paraná river basin in Paraguay. Two species also cited as vulnerable and with possible presence in Paraguay are *Salminus hilarii* (Valenciennes 1850) and *Zungaro jahu* (Ihering 1898).

Of the species caught in the March 2020 campaign, none is included in the IUCN's list of endangered species (2018), or Paraguay's List of Endangered Fauna. Since exotic species cause significant impacts on regional fauna due to their rapid population explosion, they threaten native species, increasing environmental stress and competition (Augustine, 1993 and 1996; Buckup, 1998).

Plagioscion squamosissimus, found in the collection area is a species that was introduced in several basins, becoming abundant in several regions. The species adapts easily to various situations/environments due to its high plasticity, and therefore is present in several rivers. Young individuals feed essentially on insects and while adults feed on fish, a notable trophic ontogeny (Hahn and others 1997b; Hahn and others 1999).

Photographic report

Figure 412 – *Acestrorhynchus pantaneiro*

Figure 413 – *Gymnogeophagus balzanii*

Figure 414 – *Hypostomus cf. boulengeri*

Figure 415 – *Oxydoras kneri*

Figure 416 – *Myloplus levis*

Figure 417 – *Creagrutus meridionalis*

Figure 418 – *Loricaria sp.*

Figure 419 – *Pterygoplichthys ambrosettii*

Figure 420 – *Pygocentrus nattereri*

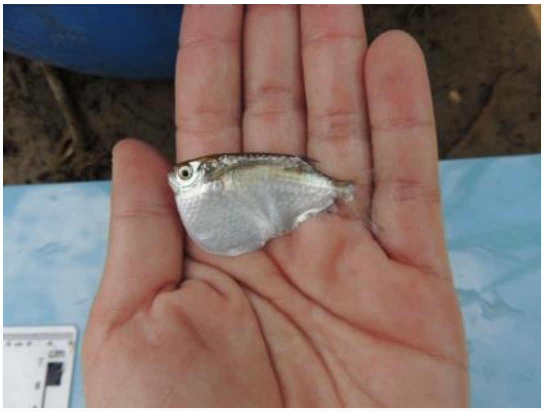


Figure 421 – *Thoracocharax stellatus*

Figure 422 – *Plagioscion squamosissimus*

Figure 423 – *Psectrogaster curviventris*

Final Considerations on Ichthyofauna

This ichthyofaunal study conducted in the area of influence of the PARACEL pulp mill shows that the richness and diversity of species is high, despite the advanced state of degradation of their biotypes and the constant impacts to which these populations are submitted, which demonstrates the need to implement conservation strategies, since the implementation of the PARACEL pulp mill in the area may cause another impact on the local ichthyofauna.

9.2.2.6 Aquatic Organisms (Phytoplankton, Zooplankton and Zoobenthos)

9.2.2.6.1 Regional Characterization (IIA)

The characterization of aquatic biota (phytoplankton and benthic invertebrates) in the Area of Indirect Influence - IIA of the PARACEL pulp mill was based on secondary data from the specialized literature, focusing on academic studies and publications provided by government agencies.

The mill's IIA is located in the Paraguay River basin, whose drainage area includes transboundary regions, receiving input from several tributaries, including the Verde River on the right bank, Aguaray Guazu, Manduvirá, Aquidabán and Ypané on the left bank. Among them, Aquidaban and Ypané are the main tributaries of the IIA. Details of the IIA's delimitation of the biotic environment are included in a separate chapter of this EIA. The general aspects of the aquatic communities assessed, and the results obtained in the secondary data study are discussed below.

A) <u>Phytoplankton</u>

General aspects

The phytoplankton community brings together microscopic organisms that live in the surface layers of the water, moving with the current. This community includes algae and cyanobacteria, primitive autotrophic beings formerly known as blue algae.

Phytoplankton performs photosynthesis and plays a role in the aquatic environment similar to that of plants in the terrestrial environment. Algae and cyanobacteria assimilate the mineral nutrients available in the water, especially nitrogen and phosphorus, tending to develop more in lentic environments, with high luminosity and enriched with mineral salts.

The predominance of certain groups of phytoplankton is the result of the dynamics of the interactions between the physiological characteristics of the organisms and abiotic factors. In tropical regions, underwater radiation and the availability of mineral nutrients, mainly phosphorus and nitrogen, are of particular importance. These factors influence the productivity of phytoplankton organisms, with repercussions on the composition and abundance of other links in the aquatic food chain, such as zooplankton, benthic invertebrates and the fish community. Due to their short life cycle, phytoplankton organisms respond quickly to environmental changes, making them efficient indicators of water quality (REYNOLDS, 1997).

Results obtained

In September 1997, the Paraguay river basin, in the stretch between the Negro and Aquidabán rivers, was the object of the technical-scientific expedition called AquaRAP, coordinated by the conservationist entity CI (Conservation International). The results of the initiative, in which several researchers from different specialties participated, were published in a collection of chapters that summarize the increased knowledge of regional biodiversity. According to the authors, this region was selected because it is sparsely populated and under-researched, and has suffered relatively little anthropogenic disturbance (CHERNOFF, et al, 2001). Thirty-five stations were evaluated, 14 of which were distributed along the Paraguay River, including points upstream and in the IIA of the project in question. In this study, water quality, phytoplankton and benthic invertebrates were studied, among others.

According to the authors, the waters of the Paraguay River are generally slightly acidic (pH 6.0-6.5), with low oxygen levels (<6.0 mg/L), low electrical conductivity (60-100 µS/cm) and temperatures between 24-27° C. Preliminary analysis of phytoplankton indicated a wide diversity of this group, with the registration of species of *Chlorophyta*, *Euglenophyta*, *Chrysophyta*, *Bacillariophyta* and *Cyanophyta*. According to the authors, detailed identification at the specific level was in progress (CHERNOFF, et al, 2001), which made it impossible to compile a list of this work.

Santos (2016) carried out an extensive study of phytoplankton in the main watercourses of Paraguayan territory, including the points inserted in the IIA and in the bordering regions of this area, with emphasis on two of the main tributaries of the Paraguay River, the Aquidabán and Ypané Rivers, and two points of the Paraguay River.

Throughout the sampling network, 148 samples were collected between 2009 and 2012, resulting in the registration of 431 taxons, with the greatest richness attributed to the green *algae Chlorophyceae*, with 253 species, followed by the diatoms *Bacillariophyceae* (117) and *Cyanophyceae* (42).

In particular, points of interest on the Paraguay River were reported to be richer in Bacillariophyceae diatoms, including taxons of the genera Eunotia, Gomphonema, Rhopalodia and Surirella. This group is quite representative in continental aquatic ecosystems, both in terms of richness and abundance of algae species (HOEK et al. 1995).

The algae Zygnematophyceae and Euglenophyceae stood out secondarily for their greater diversity, bringing together taxons of the genera Staurastrum and Spirogyra (*zignemaficae*), Euglena and Phacus (*euglenophyceae*).

The group Cyanophyceae presented a low representativeness in terms of richness, registering only the species *Oscillatoria princeps*, which is a positive aspect, since cyanobacteria are capable of forming blooms with potential production of toxins. According to Sant'anna and others (2006), the same cyanobacteria can produce several cyanotoxins, as is the case with *Oscillatoria*.

The list of taxons registered in the Paraguay River and its tributaries is shown in the following table. It should be noted that the present study reviewed the phytoplankton taxonomic classification of the taxons presented in the Santos study (2016), using the global online database Algaebase (GUIRRY and GUIRRY, 2020).

Table 35 – Taxonomic composition of phytoplankton in the Paraguay River and tributaries

Taxonomic composition	Paraguay river*	Aquidabán river	Ypané river
Bacillariophyceae			
Cymbella cuspidata			X
Eunotia sp.	x		
Gomphonema af. *acutiusculum*	x		
Gomphonema af. *parvulum*		x	
Nitzschia levidensis			x
Rhopalodia parallela	x		
Surirella af. *arcta*	x		
Surirella sp.		x	

Taxonomic composition	Paraguay river*	Aquidabán river	Ypané river
Tabellaria fenestrata			x
Chlorophyceae			
Characium ornithocephalum var. *ornithocephalum*	x		
Trebouxiophyceae			
Oocystis solitaria	x		
Rhopalosolen cylindricus	x		
Zygnematophyceae			
Cosmarium pseudoconnatum var. *pseudoconnatum*			x
Gymnozyga moniliformis			x
Pleurotaenium ehrenbergii var. *elongatum*		x	
Staurastrum limneticum var. *cornutum*			x
Staurastrum minnesotense	x		
Spirogyra crassa	x		
Spirogyra cylindrica		x	
Spirogyra distenta	x		
Cyanophyceae			
Oscillatoria princeps	x		
Euglenophyceae			
Euglena oxyuris var. *minor*	x		
Euglena spirogyra	x		
Phacus longicauda	x		
Total de táxons	**14**	**4**	**6**

Source: Adapted from Santos (2016). * Coordinates of the points: Aquidaban river (S23 02,680 W57 00,698), Ypané (S23 25,438 W56 29,575 and S23 25,431 W56 29,602) and Paraguay (IIA: S23 27,362 W57 27,026 and downstream IIA - S26 51,298 W58 18,690).

Silva and others (2000) evaluated the phytoplankton community in the portion of the Upper Paraguay River, upstream of the limits of the Area of Indirect Influence, in Brazilian territory, in the city of Corumbá, with monthly collections made from January 1996 to February 1997, at a point on the Paraguay River, which made it possible to follow the spatial variation of this community in this watercourse.

According to the authors, algae belonging to the class Chlorophyceae predominated in number of taxons in the Paraguay River, followed by the Euglenophyceae. The highest phytoplankton densities occurred between February and April, with density fluctuations attributed to seasonal variations.

The algae of the class Cryptophyceae were numerically dominant, with the species Cryptomonas brasiliensis predominating. This group, according to Reynolds (1984), has a high metabolic activity and a high rate of production/biomass, which indicates a great adaptability and efficiency in the use of nutrients in extreme conditions of high luminosity, being considered opportunistic, developing mainly in adverse conditions to other species (KLAVENESS, 1988).

B) Benthic invertebrates

General aspects

In the ecological aspect of the aquatic environment, the benthic fauna, that is, the one that lives under or on top of the substrate, plays a preponderant role in the recycling of organic compounds, participating in the redistribution of the background material and contributing to the decomposition of potentially polluting substances. Benthic invertebrates can inhabit the coastal and deep water region, including mainly species of the groups Insecta (insects), Annelida (annelids), Nematoda (cylindrical worms), Crustacea (crustaceans) and Mollusca (bivalves and gastropods).

This community includes organisms of various trophic levels, from primary consumers to top predators, which also exhibit a wide variety of feeding habits, including collecting members (reservoir and filter consumers), scrapers, grinders, predators and parasites. This group of organisms represents an important link in the food web of aquatic systems, transferring energy from various trophic levels and feeding numerous species of fish and birds.

Benthic organisms are bio-indicators because they are abundant in all types of aquatic systems, have low mobility, and are selective in their habitat, reflecting more accurately possible imbalances, either through the introduction of polluting and contaminating compounds into water bodies, or through the physical alteration of the substrate caused, for example, by the transport of solids in the drainage area. The use of the benthic community also allows the temporary assessment of changes caused by disturbances in the aquatic environment, since, during its relatively long life cycle (from weeks to years), it responds continuously to variations in the environment, showing a wide variety of tolerance to pollution.

The distribution and abundance of benthic organisms are influenced by biogeographical aspects and characteristics of the environment, such as the type of sediment, organic matter content, depth, physical and chemical parameters of the water and the presence of macrophytes (CARVALHO & UIEDA, 2004). SMITH et al., 2003. VIDAL-ABARCA et al., 2004 apud ABÍLIO et al., 2007).

In this sense, some factors are important for the maintenance of benthic fauna diversity, highlighting the availability of oxygen, which tends to be limited in the deepest layers of aquatic ecosystems; the preservation of the substrate at the bottom, which corresponds to the place of fixation and refuge of most of these organisms; and the maintenance of riparian forests (protectors of water resources), which provide stability to the margins of watercourses and contribute to the introduction of food necessary for the survival of these beings.

Results obtained

Galeano Molinas (2018) conducted a survey of the benthic community in the Guasú stream region, located in an urban area of the Central Department of Paraguay, covering five sampling points, two of which were distributed on the Paraguay River and are limited to the project's IIA. In this study, samples were collected in two different periods (November 2017 and April 2018), covering the spring and autumn. In all campaigns, 254 individuals from the benthic community, members of the Insecta class, were recorded, distributed in six orders, of which Diptera was the most diverse, as shown in the table below.

The author concluded that only the families Chironomidae and Culicidae were recorded in both periods and were also more prominent in terms of abundance. Other families, such as Corixidae, Gerridae, Stratiomidae, Caenidae and Psychodidae, were also reported as indicators of water quality.

The application of the environmental indicator (BMWP Index - Biological Monitoring Working Group) indicated the critical water quality at the sampled sites. In addition, water samples were collected, and the Water Quality Index applied, according to the methodologies proposed by Brown (1970) and Lopez et al (2016), which showed water quality between Reasonable and Poor. The author pointed out that the association of these indicators showed that the low diversity of the benthic community in the points studied is due to anthropic changes (GALEANO MOLINAS, 2018), a condition that tends to affect benthic aquatic organisms, favoring the predominance of the taxons that are more resistant to environmental disturbances and changes.

The experiment called AquaRAP, carried out in September 1997, included studies of the benthic community in the Paraguay river basin, in the area between the Negro and Aquidabán rivers (CHERNOFF, et al., 2001). For the benthic community, 33 stations were evaluated, 14 of which were distributed along the Paraguay river, including points upstream and in the IIA of the PARACEL pulp mill.

In this study a total of 2,213 individuals from the benthic community were captured at the 33 sampling stations. Diptera larvae of the family Chironomidae and Oligochaeta ringidae were the dominant groups at 27 stations, representing respectively 52% and 35% of the organisms recorded. Other groups detected in smaller numbers are Odonata, Trichoptera, Ephemeroptera, Ceratopogonidae, Corixidae, Ostracoda, Bivalvia, Nematoda, Hirudinea, among others.

Among the larvae of Chironomidae, the most abundant were the taxons *Nimbocera paulensis, Polypedilum, Chironomus, Ablabesmyia, Goeldichironomus, Fissimentum desiccatum, Harnischia, Nilothauma, Parachironomus, Stenochironomus, Asheum, Coelotanypus* y *Djalmabatista.*

According to the authors, the diversity of benthic invertebrates can be considered high compared to other river basins in South America. Most recorded genres were considered typical of herbaceous swamps, lagoons, lakes and slower portions of streams and rivers. In sites rich in decomposing vegetation, the diversity of benthic organisms was lower, as was the case in some stations of the Paraguay River, where *Chironomus larvae* predominated, a typical group of habitats rich in decomposing organic matter, with low oxygen concentrations.

It should be noted that the work mentioned does not include a detailed list of all the taxons by environment monitored and sampled. However, Appendix 8 of the above-mentioned study (CHERNOFF, et al, 2001) presents the main taxon of the benthic community recorded in the sample as a whole. Thus, the list presented in the following table does not reflect all the data studied in the study, but it does provide a general overview of the benthic community living in the Paraguay river basin. In the preparation of this table, the taxonomic classification of benthic invertebrates was reviewed using the ITIS - Advanced Search and Report - Integrated Taxonomic System platform as a basis.

Table 36 – Taxonomic composition of benthic invertebrates in the Paraguay River and tributaries.

Taxonomic Composition	Paraguay river and tributaries	Arroyo Guasú and Paraguay river
	Chernoff, *et al.* (2001)	Galeano Molinas (2018)*
Phylum Annelida		
Class Clitellata		
SubClass Hirudinea	X	
SubClass Oligochaeta	X	
Phylum Arthropoda		
SubPhylum Crustacea		
Class Ostracoda	X	
Class Branchiopoda		
Order Laevicaudata	X	
SubPhylum Hexapoda		
Class Insecta		
Order Coleoptera	X	
Family Hydrophilidae		X
Order Diptera		
Family Ceratopogonidae	X	
Family Chaoboridae		
Chaoborus sp.	X	
Family Chironomidae		X
Subfamilia Chironominae		
Tribo Chironomini		
Asheum sp.	X	
Beardius sp.	X	
Chironomus sp.	X	
Cryptochironomus sp.	X	
Polypedilum sp.	X	
Tribo Tanytarsini		
Nimbocera sp.	X	
Subfamilia Tanypodinae		
Ablabesmyia sp.	X	
Family Tipulidae	X	
Family Culicidae		X
Family Muscidae		X
Family Psychodidae		X
Family Stratiomyidae		X
Order Ephemeroptera	X	
Family Caenidae		X
Order Hemiptera		
Family Corixidae	X	X
Family Gerridae		X
Order Odonata	X	
Order Trichoptera	X	
Order Lepidoptera		
Family Crambidae		X
Order Megaloptera		

Taxonomic Composition	Paraguay river and tributaries	Arroyo Guasú and Paraguay river
	Chernoff, *et al.* (2001)	**Galeano Molinas (2018)***
Family Sialidae		X
Phylum Mollusca		
Class Bivalvia	X	
Class Gastropoda	X	
Phylum Nematoda	X	
Phylum Platyhelminthes	X	
Total de táxons	**23**	**11**

Source: Adapted from Chernoff, et al (2001) and Galeano Molinas (2018) *Observation: Coordinates of the points of interest in the study by Galeano Molinas (2018): P03 25º24'18,34 "S e 57º34'18,92 "W e P04 - 25º24'36,50" S e 57º34'54,74 "W.

9.2.2.6.2 Local Characterization (DIA and ADA)

Methods

The Direct Influence Area (DIA) is located in the department of Concepción, covering the Paraguay River, about 10 km upstream from the urban center of Concepción. The area directly affected (ADA) of the project includes the proposed pulp mill on the left bank of the Paraguay River.

The assessment of aquatic biota (phytoplankton and benthic invertebrates), within the framework of the DIA and DAA of PARACEL pulp mill, was carried out on the basis of two sampling campaigns, conducted during the rainy season, the first on October 17, 2019, in the spring, and the second on March 5, 2020, in the summer.

The collection and analysis of aquatic biota was carried out by Econsult Environmental Studies. This laboratory is accredited according to ABNT NBR ISO/IEC 17025, by the General Accreditation Coordination - Cgcre of the National Institute of Metrology, Standardization and Industrial Quality - INMETRO, of Brazil.

Below is the characterization of the sampling and details of the procedures adopted in the area and laboratory, as well as the indicators adopted for the evaluation of the aquatic communities.

A. Monitoring network

For the evaluation of the phytoplankton and zoobenthos communities, two sampling points have been selected in the Paraguay River, located upstream and downstream from the future PARACEL pulp mill. The following table and figure show the location of the sampling points.

Based on the monitoring results, the inclusion of new points can be evaluated in the future.

Table 37 – Network for sampling aquatic biota in the Paraguay River and its tributary.

Point	Location	Geographical Coordinates (Time zone 21J)	
		North	East
P01	Paraguay River, upstream of the future PARACEL pulp mill	7.428.366	446.452
P02	Paraguay River, downstream from the future PARACEL pulp mill	7.424.505	449.700

Figure 424 – Sampling network of the aquatic biota in the Paraguay River and its tributary.

Source: Google Earth (2020).

B. Monitoring of Samples and Laboratory Analysis Procedures

The samples of the aquatic biota were made with the help of a boat. Before taking the samples, the following information was recorded about the river and its surroundings at each collection point, in order to help interpret the analytical results: identification of the point with the codes adopted by the project, geographic location with the GPS, date and time of collection, predominant weather condition during collection, occurrence of rain in the last 24 hours, approximate width of the water body and state of preservation of the forest protecting the waterway, and photographic record.

The field work also included direct measurements to determine the following variables: air temperature (thermometer), depth and transparency (Secchi's disc equipped with a tape measure and a depth meter) and current speed (flow meter).

The equipment used in the field was duly calibrated in the laboratory of the Brazilian Calibration Network (RBC, in Spanish and Portuguese) and verified with traceable parameters to ensure the accuracy and precision of the data obtained. Some of the field procedures are illustrated in the following figures. The chains of custody are shown in

Annex I. The procedures adopted in the area and in the laboratory for each of the aquatic communities assessed are detailed below.

Figure 425 – Measuring transparency with the Secchi disk.

Figure 426 – Measurement of depth.

<u>Phytoplankton</u>

The methodology used for phytoplankton collection and analysis was based on the Standard Methods for the Examination of Water and Wastewater, 23rd ed.

At each collection point, a quantitative sample of phytoplankton was taken from the surface by direct immersion in a stainless steel container, which was directed to a 250 mL cylinder. The qualitative phytoplankton sample was obtained by horizontal dragging, using a plankton net with a 20 µm mesh opening.

To preserve the qualitative samples, a solution of 2% formalin neutralized with sodium bicarbonate was applied. Lugol drops were added to the quantitative samples. The collection vials were homogenized, labeled and sent to the laboratory.

In the laboratory, taxonomic identification of the phytoplankton was based on the specific literature of each group of algae and cyanobacteria, such as Bicudo & Menezes (2006), Sant'Anna et al. (2012), Round & Crawford (1990), among others. The process of identification occurred whenever possible at the species level, from the analysis of the population, using a binocular microscope.

Quantification of phytoplankton followed the method of chambered sedimentation, described by Utermöhl (1958). The sedimentation time varied according to the concentration of material in the sample and the volume analysed. The count limit was established by listing 100 individuals of the most abundant taxon (LUND, 1958). Each cell, cenobium, colony or filament was considered as an individual.

The results of phytoplankton density were expressed in organisms per milliliter (org./ml). In addition, the cyanobacterial cell count was also considered, taking into account that this parameter is governed by Resolution n. 222/2002. The phytoplankton test reports are presented in Annex II. The figures below illustrate some of the procedures for the collection and analysis of phytoplankton.

Figure 427 – The 20 µm network for qualitative sampling.

Figure 428 – Horizontal phytoplankton dragging.

Figure 429 – Conservation of the quantitative phytoplankton sample.

Figure 430 – Phytoplankton sample conditioning.

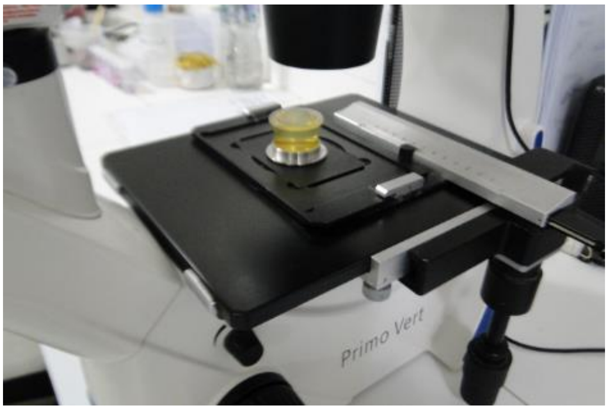


Figure 431 – Utermöhl camera sample.

Figure 432 – Identification and quantification of phytoplankton.

Benthic Invertebrates

The methodology used for the collection and analysis of benthic invertebrates was based on the Standard Methods for the Examination of Water and Wastewater, 23rd ed.

At each collection point, benthic invertebrate samples were taken in triplicate, using the Petersen bottom collector (Area = 0.058 m^2). The collected sediment was washed in the field with the help of 250 µm mesh sieves. The material retained in the mesh was conditioned and preserved in 70% alcohol, previously colored with 0.1% Rose Bengal. The collection vials were homogenized, labeled and sent to the laboratory.

In the laboratory, the organisms were examined in square Petri dishes with the help of a stereomicroscope. Subsequently, taxonomic identification was performed in the stereomicroscope, according to the group of benthic invertebrates detected in the sample, using the identification keys and descriptions available in the specialized literature, such as Trivinho-Strixino & Strixino (2011), Brinkhurst & Marchese (1989) and Simone (2006), Hamada, et al. Mugnai et al (2010), Latini et al (2016), Mansur et al (2012) and Santos (2018).

The qualitative analysis identified all invertebrate groups present in the samples. The density of the benthic community in each replicate (sample) was obtained using the following formula (WELCH, 1948):

$$N = \frac{X}{A \cdot S}$$

Where:

N= number of individuals /m^2
X= number of organisms counted in the sample.
A= sampler area (m^2)
S= launch/collection number

The density at each point was calculated by averaging the density of the three replicates, expressing the results in organisms per square meter (org./m^2).

Figure 433 – The Petersen dredger used to collect benthic invertebrates.

Figure 434 – The washing of the sediments on a sieve with an aperture of 250 µm.

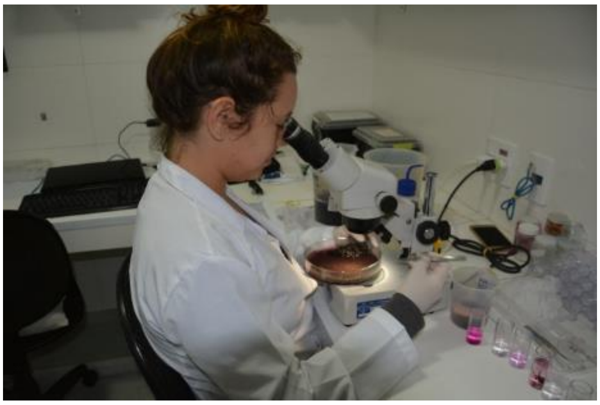


Figure 435 – Analysis of benthic organisms.

Figure 436 – Identification with the stereomicroscope.

C. Data analysis

The following indices were adopted in the evaluation of the results of the phytoplankton and benthic communities.

<u>**Qualitative Analysis**</u>

Taxonomic composition, taxonomic richness and relative richness

The taxonomic composition includes the characterization of the taxons present in the samples. Taxon richness is obtained by counting the number of taxons recorded at each point. For the richness, the integration of the data obtained in the quantitative sampling is also considered. Relative richness, expressed as a percentage, presents the proportion of the number of taxons in each group inventoried. In the richness analysis, each species, morphospecies and organism could not be identified at a specific level as a taxon.

Geographical Distribution and Frequency of Occurrence

The spatial distribution of the organisms in the sampling network was examined according to the presence or absence of a given taxon at the collection points.

Exotic, Threatened and Important Species

The presence of exotic species was assessed and the Paraguayan Biodiversity Conservation Action Plan (SEAM, 2016) and the International List of Threatened Species (IUCN, 2020) were consulted for the analysis of the occurrence of threatened taxons of the fauna.

Quantitative Analysis

Density and relative abundance of planktonic and benthic communities

The density represents the amount of organisms present in the samples per sampled volume. The relative abundance indicates the numerical proportion of each group or taxon present in the sample under consideration and is calculated by the following formula:

$$AR = n \cdot 100 / N$$

Where:

AR = relative abundance;
n = total number of organisms in the group or taxon;
N = total number of organisms in the sample.

Diversity indexes

The Shannon-Wiener diversity index relates the number of taxons and the distribution of abundance among different taxons in a specific sample and is calculated by the following formula:

$$H' = -\sum pi.\log_2 pi \qquad \text{y} \qquad pi = \frac{n}{N}$$

where:

H'= The Shannon-Wiener Diversity Index, in bit.ind^{-1};
pi= relative abundance;
n = number of individuals collected from each taxon;
N = total number of individuals collected in the sample.

The Equitability index refers to the distribution of individuals among species, being proportional to diversity and inversely proportional to dominance. The measure of equitability compares Shannon-Wiener diversity with the distribution of observed species. This index is obtained through the equation:

$$J = H' / H'_{max}$$

where:

J = Equitability
H' = Shannon-Wiener index
H' max = maximum diversity

Similarity Index

In the case of planktonic and benthic communities, the degree of similarity between the collection points was evaluated on the basis of the Bray-Curtis index. The similarity matrix was compared with a co-kinetic matrix in order to increase the reliability of the conclusions drawn from the interpretation of the dendrogram (KOPP et al., 2007). Values of 0.70 or more were adopted as a fidelity criterion (ROHLF, 1970).

Principal Component Analysis - PCA

Principal Component Analysis (PCA) was used to rank the physical and chemical parameters of water with phytoplankton density, considering the most representative taxons in terms of density. The benthic community was related to the sediment data. The physical-chemical data of water and sediments used in this analysis were obtained from the water quality diagnosis, based on the results of the first and second campaigns, presented in the chapter on physical environment diagnosis. For the correlation analyses, the PAST (Paleontological Statistics) version 2.17c (HAMMER et al., 2001).

Biological Monitoring Work Party Score System (BMWP index)

The assessment of the benthic community used the BMWP index, a metric that classifies invertebrate families into different groups, following a gradient of lower tolerance of organisms to organic contamination, regardless of the density found.

Each family corresponds to a score, which ranges from 10 to 1, with the highest values attributed to the families that are most sensitive to contamination. Since this index only requires identification at the family level, it is considered practical, easy to apply and useful for monitoring. The results obtained are added up and the final score acquired is classified into five classes, which correspond to the following categories: Excellent, Good, Fair, Bad and Poor.

9.2.2.6.3 Results obtained

The following is a description of the Paraguay River and the results of the aquatic communities, based on the data obtained in the two campaigns carried out during the rainy season, in October 2019, in the spring, and in March 2020, in the summer.

A. Characterization of Sampling Points

The following is a description of the sites sampled. The field records obtained are summarized in the table below. During both collections, the weather remained clear and rainy, with the occurrence of rain being recorded during the collection and in the previous 24 hours. The air temperature oscillated between 24.2ºC and 28.2ºC, both at point P01, in the first and second season, respectively.

Table 38 – Field records and *in-situ* monitoring on the Paraguay River

Field records	Paraguay river			
	P01		P02	
	1st C	2nd C	1st C	2nd C
Date of collection	17/10/2019	05/03/2020	17/10/2019	05/03/2020
Time of collection	16h00	09h00	14h50	09h55
Weather conditions in the campaign	Good	Good	Good	Good
Rain in the last 24 hours	No	No	No	No
Protective Forest	Partially Altered		Partially Altered	
Air temperature (ºC)	28,2	24,2	27,1	26,1
Approximate width (m)	1.500	1.400	950	900
Depth (m)	5,7	5,4	4,3	3,8
Transparency (m)	0,4	0,3	0,4	0,3
Current velocity (m/s)	0,4	0,3	0,4	0,2

The Paraguay River is a large watercourse and, in the DIA and ADA, it acts as a water boundary between the Departments of Presidente Hayes, on the right bank, and Concepción, on the left bank, observing the formation of meanders in this course. The nearest urban area (Concepción) is about 10 km downstream from point P02. In general, the riparian forest in the sampled sections is partially altered.

The width of this watercourse, in the sections evaluated, varied between 900 (P02) and 1,500 m (P01), with a depth of between 3.8 m and 5.7 m. Transparency was maintained at around 0.4 m in both collections. The current speed was high, reaching a maximum of 0.4 m/s, at both points, in the first campaign. The photographic record of the sampling points is as follows.

Figure 437 - Point P01: Paraguay river, upstream from PARACEL pulp mill, in campaign 1.

Figure 438 – Point P01: Paraguay river, upstream from PARACEL pulp mill, in campaign 2.

Figure 439 – Point P02: Paraguay river, downstream from PARACEL pulp mill, in campaign 1.

Figure 440 – Ponto P02: Paraguay river, downstream from PARACEL pulp mill, in campaign 2.

B. Phytoplankton

<u>Qualitative Analysis</u>

Taxonomic composition, taxonomic richness and relative richness

The consolidated results of the two sampling campaigns, conducted in October 2019, during the dry season, and March 2020, during the rainy season, showed the presence of 71 phytoplankton taxons in the Paraguay River, belonging to 11 taxonomic classes: Bacillariophyceae (20), Cyanophyceae (14), Chlorophyceae (12), Euglenophyceae (7) Conjugatophyceae (6), Coscinodiscophyceae (5), Mediophyceae (2), Cryptophyceae (2), Dinophyceae (1), Chrysophyceae (1) and Trebouxiophyceae (1).

The phytoplankton community recorded in this watercourse was predominantly formed by diatoms of bacillariumphyceae (class Bacillariophyceae), accounting for 28.2% of the total richness of the taxon, followed by cyanobacteria (class Cyanophyceae), with 19.7% of the total diversity sampled, as shown in the figure below.

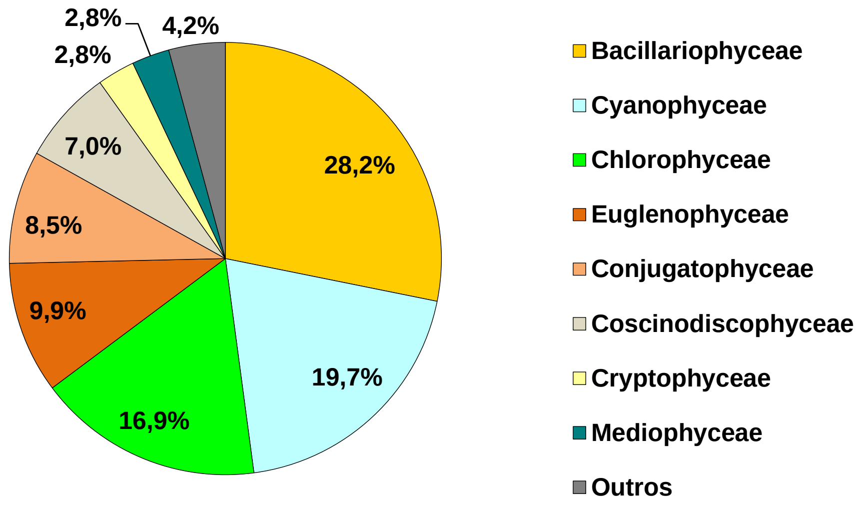


Figure 441 – Phytoplankton richness by taxonomic group in the Paraguay river - 1st C (October/2019) and 2nd C (Mar/20).

Obs: The group "Others" comprises the classes Chrysophyceae, Dinophyceae and Trebouxiophyceae.

The class Bacillariophyceae belongs to the group of diatoms, together with the Coscinodiscophyceae and Mediophyceae, which individually contributed 7% and 2.8% of the collected taxon, respectively, with diatoms accounting for 38% of the richness.

Diatoms add species that have a high rate of sedimentation in the aquatic environment, due to the composition of their cell wall, which is constituted by silica. As mentioned, this group is quite representative in inland aquatic ecosystems, both in terms of richness and abundance of algae species (HOEK et al. 1995).

In the Paraguay River, bacillaryophytes were represented by specimens of the genres *Achnanthes*, *Amphipleura*, *Amphora*, *Cymbella*, *Diadesmis*, *Eunotia*, *Fragilaria*, *Gyrosigma*, *Navicula*, *Nitzschia*, *Pinnularia*, *Stauroneis*, *Surirella*, *Synedra*, *Tabellaria y Ulnaria*, and an unidentified organism of the *Naviculaceae* family at the gender level. The class *Conscinodiscophyceae* brought together the genre *Aulacoseira* and *Melosira* and the class *Mediophyceae* taxon of the genre *Cyclotella* and *Thalassiosira*.

Cyanobacteria (class *Cyanophyceae*), the second most special taxonomic group (19.7%), include species that have efficient survival strategies due to their ecological and physiological characteristics (PAERL, 1988). Among the key factors for their reproductive success and development is the stability of the water column due to the presence of gaseous vacuoles (aerotopes) in several species, which allows the cells to regulate their fluctuation in response to the availability of light and nutrients (KLEMER & KONOPKA, 1989).

Some species in this group have the ability to assimilate nitrogen gas directly from the atmosphere, which is an advantage in environments with lower availability of nitrogen compounds. Among the competitive advantages of cyanobacteria, the lower herbivore pressure of zooplankton can also be mentioned (OLIVER & GANF, 2000). In this class, some specimens are recognized for their ability to produce toxins, which can cause interference in water quality and aquatic environment, especially when they form blossoms, as has been mentioned. However, it should be noted that the density of this class was inexpressive in the sample mesh, as detailed in the subtopic of quantitative analysis.

Chlorophyceae was the third class with the highest number of taxons (16.9%) in the Paraguay River, with the presence of eight genera, of which Monoraphidium with four species, followed by Desmodesmus and Pediastrum, with two taxons each.

This group includes green algae, cosmopolitan organisms that present an immense morphological variety. Most of them are typical of fresh water and may have planktonic and benthic habits, growing in environments of broad-spectrum salinity and eutrophication. According to Henry (1999), chlorophylls are one of the most ecologically important groups in inland aquatic ecosystems.

Euglenophyceae (*euglenophyceae*), responsible for 9.9% of the taxons sampled, were the fourth richest group, with specimens of the genera *Euglena*, *Lepocinclis*, *Phacus*, *Strombomonas y Trachelomonas* presents in Paraguay river.

This class comprises unicellular and filamentous animals, predominantly inhabitants of continental water systems. In general, these organisms tend to excel in waters rich in organic substances, due to the excessive development of aquatic macrophytes or the release of untreated effluent, especially in low-current environments with availability of nitrogen compounds. The possibility of moving through the flow is also an adaptation of this group in environments with high turbidity, which allows them to use the nutrients accumulated in deeper layers and then return to the euphotic region (BRANCO, 1986).

Conjugate algae (conjugatophyceae) were represented by taxon of the genera *Cosmarium, Closterium, Closteriopsis, Gonatozygon and Haplotaenium*, which account for 8.5% of the total taxon sampled, making up an extremely diverse group that is practically exclusive to these environments (GUIRY, 2013). This class includes a large number of species typical of oligotrophic aquatic systems, but there are representatives related to eutrophic systems, both in the planktonic and the peripheral communities (COESEL, 1982 apud MELO & SOUZA, 2009; SILVA, 1999).

The other classes recorded in the Paraguay River, including Cryptophyceae, Chrysophyceae, Dinophyceae e Trebouxiophyceae, had a smaller relative share in phytoplankton richness, which individually represented values equal to or less than 2.8% of the total taxons collected.

The analysis of richness by point points to similarities between the sampling points, considering the two campaigns carried out, with a minimum of 30 taxons at point P02, in the Paraguay river, downstream of the future PARACEL pulp mill, and a maximum of 33, in the upstream segment, in both collections, as shown in the figure below. As for the distribution of taxonomic groups among the qualitative samples of the two segments sampled in the Paraguay river, there was a greater participation of *bacillariumphytic diatoms*, followed by cyanobacteria.

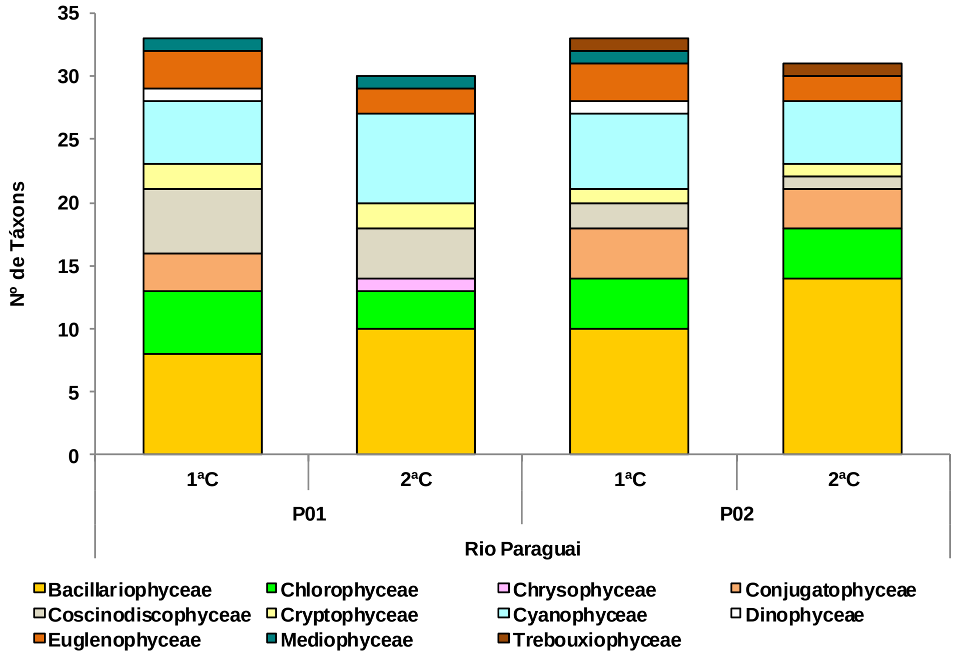


Figure 442 – Phytoplankton richness by sampling point in the Paraguay River - 1st C (Oct/2019) and 2nd C (Mar/20).

Spatial distribution and frequency of occurrence

The following table shows the spatial distribution and frequency of phytoplankton emergence in the first (October/2019) and second campaigns (March/2020).

Among the 71 inventoried taxons, the diatoms Diadesmis sp., Gyrosigma sp., Nitzschia sp., Aulacoseira granulata, a cyanobacteria Phormidium sp. and an unidentified taxon at genus level of the class Cryptophyceae occurred at all collection points in both seasons (100% frequency), being considered very frequent, according to the classification of Souza et al. (2009).

Another 31 taxons were classified as frequent (occurrence between 50% and 80%), seven of which occurred in 75% of the samples, corresponding to the diatoms Eunotia sp., Surirella sp, Ulnaria ulna e Melosira varians, the chlorophyll Monoraphidium arcuatum, the conjugate algae Gonatozygon sp. and the euglenophyceae Strombomonas sp. The others (34 taxons) were limited to one point (25%).

Among the taxons that stood out in terms of frequency, examples of the genera Nitzschia, Eunotia and Surirella were also found in the survey carried out by Santos (2016), in the main waterways of Paraguayan territory. The following is a photographic record of two phytoplankton specimens recorded in the Paraguay River.

Figure 443 – Chlorophycea - *Monoraphidium contortum.*

Source: Econsult (2020).

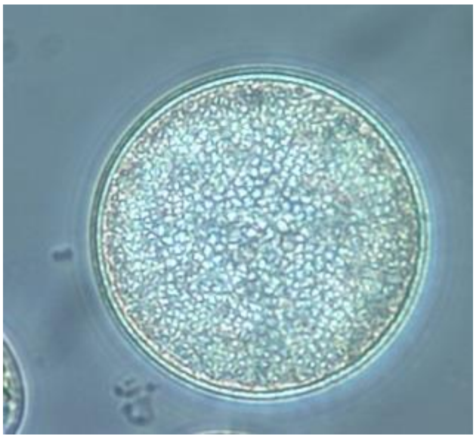


Figure 444 – Mediophyceae *Thalassiosira* sp.

Table 39 – Spatial distribution and frequency of phytoplankton emergence in the Paraguay River - 1st C (Oct/2019) and 2nd C (Mar/20).

Taxonomic Composition	Paraguay river				Occurrence	Frequency of Occurrence
	P01		P02			
	1st C	2nd C	1st C	2nd C		
Bacillariophyceae						
Achnanthes sp.					1	25
Amphipleura sp.					1	25
Amphora sp.					1	25
Cymbella sp.					2	50
Diadesmis sp.					4	100
Eunotia sp.					3	75
Fragilaria sp.					2	50
Gyrosigma sp.					4	100
Naviculaceae					2	50
Navicula sp.					1	25
Nitzschia sp.					4	100
Pinnularia sp.					2	50
Stauroneis sp.					2	50
Surirella tenera					2	50
Surirella sp.					3	75
Synedra goulardii					2	50
Synedra sp.					1	25
Tabellaria sp.					1	25
Ulnaria acus					1	25
Ulnaria ulna					3	75
Subtotal	**8**	**10**	**10**	**14**		
Chlorophyceae						
Chlamydomonas sp.					1	25
Desmodesmus armatus					1	25
Desmodesmus sp.					2	50
Eutetramorus sp.					1	25
Monactinus simplex					1	25
Monoraphidium arcuatum					3	75
Monoraphidium contortum					1	25
Monoraphidium irregulare					1	25
Monoraphidium griffithii					1	25
Pediastrum duplex					2	50
Pediastrum duplex var. *duplex*					1	25
Scenedesmus acuminatus					1	25
Subtotal	**5**	**4**	**3**	**4**		
Chrysophyceae						
Dinobryon sp.					1	25
Subtotal	**-**	**-**	**1**	**-**		
Conjugatophyceae						
Cosmarium sp.					1	25

Taxonomic Composition	Paraguay river				Occurrence	Frequency of Occurrence
	P01		P02			
	1st C	2nd C	1st C	2nd C		
Closterium setaceum					2	50
Closterium sp.					2	50
Closteriopsis sp.					1	25
Gonatozygon sp.					3	75
Haplotaenium sp.					1	25
Subtotal	**3**	**4**	**-**	**3**		
Coscinodiscophyceae						
Aulacoseira ambigua					2	50
Aulacoseira granulata var. *angustissima*					1	25
Aulacoseira granulate					4	100
Aulacoseira sp.					2	50
Melosira varians					3	75
Subtotal	**5**	**2**	**4**	**1**		
Cryptophyceae						
Cryptophyceae					4	100
Cryptomonas sp.					2	50
Subtotal	**2**	**1**	**2**	**1**		
Cyanophyceae						
Aphanocapsa sp.					2	50
Geitlerinema sp.					2	50
Komvophoron schmidlei					1	25
Merismopedia sp.					1	25
Merismopedia glauca					1	25
Microcystis sp.					2	50
Oscillatoria sp.					1	25
Phormidium aerugineo-caeruleum					1	25
Phormidium tergestinum					2	50
Phormidium sp.					4	100
Planktolyngbya sp.					2	50
Planktothrix sp.					2	50
Pseudanabaena sp.					1	25
Synechococcales					1	25
Subtotal	**5**	**6**	**7**	**5**		
Dinophyceae						
Peridinium sp.					2	50
Subtotal	**1**	**1**	**-**	**0**		
Euglenophyceae						
Euglena sp.					1	25
Lepocinclis acus					1	25
Lepocinclis sp.					1	25
Phacus longicauda var. tortus					1	25
Strombomonas sp.					3	75
Trachelomonas volvocina					2	50

Taxonomic Composition	Paraguay river				Occurrence	Frequency of Occurrence
	P01		P02			
	1st C	2nd C	1st C	2nd C		
Trachelomonas volvocinopsis					1	25
Subtotal	**3**	**3**	**2**	**2**		
Mediophyceae						
Cyclotella sp.					1	25
Thalassiosira sp.					2	50
Subtotal	**1**	**1**	**1**	**0**		
Trebouxiophyceae						
Dictyosphaerium sp.					2	50
Subtotal	**-**	**1**	**-**	**1**		
Total por Punto	**33**	**33**	**30**	**31**		
Total en la Campaña	**71**					

Indicator species

Among the species registered in the Paraguay River, algae of the genus Trachelomonas, such as T.volvocinopsis, have a shell formed almost exclusively of iron hydroxide and manganese, being an indicator of the precipitation of these elements in aquatic systems (BRANCO, 1986).

Monoraphidium algae are considered resistant to organic and chemical pollution (SLADECEK, 1973), presenting species related to water bodies with different trophic levels.

Quantitative Analysis

Density and Relative abundance

The quantitative analysis of phytoplankton in the Paraguay River included the results of density (org/mL) and relative abundance (%) of the taxonomic classes. Phytoplankton density in aquatic ecosystems is the result of the dynamics of interactions between physiological characteristics of organisms and abiotic factors, which influence the primary productivity of phytoplankton, with reflection on the composition and abundance of zooplankton and benthic beings.

In the Paraguay River, phytoplankton density significantly varied between campaigns, being higher in the first campaign (spring), carried out in October 2019, in both points monitored, reaching 813 org./mL at point P01 and 752 org./mL at point P02.

In the second campaign, conducted in March 2020, in the summer, the phytoplankton density was lower, with values of 19 org/mL at point P01 and 11 org/mL at point P02.

The low density results of the March 2020 campaign were maintained at the same level as those proposed by Silva et al. (2000), in the portion of the Upper Paraguay river during the flooding season (48 org/mL), which the authors indicated as the lowest density among the samples taken, which was attributed to the dilution effect of the flooding cycle.

Densities in the October 2019 campaign in the Paraguay River were around the order of magnitude reported by Domitrovic (2002) in Upper Paraguay, which recorded lower phytoplankton density values in winter, averaging between 731 and 878 org/mL. However, it should be noted that the studies mentioned presented a much greater sampling effort than this diagnosis.

In terms of abundance, algae of the class Cryptophyceae were exceptional, mainly in the first season, contributing with 746 org./mL at point P01 and 666 org./mL at point P02, attributed to Cryptomonas sp and an unidentified taxon. Silva et al. (2000) also reported a predominance of Cryptophyceae in the Paraguay River, as detailed in the IIA.

As mentioned, algae Cryptophyceae are considered opportunistic in quantity when densities of other algae decrease (KLAVENESS, 1988). They have low light tolerance and are generally found in rivers and small lakes (ISAKSSON, 1998). Studies by Oliveira and Calheiros (2000) associated the dominance of Cryptophyceae with adverse conditions for the development of other groups.

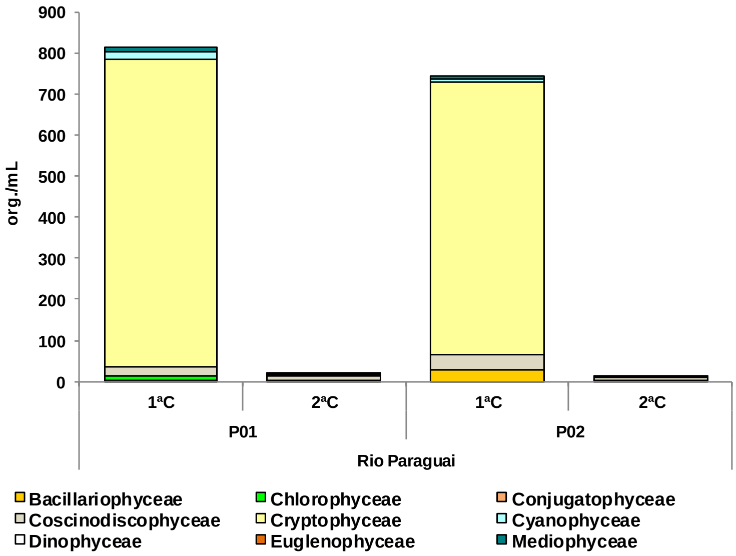


Figure 445 – Phytoplankton density in the Paraguay river – 1stC (Oct/19) and 2ndC (Mar/20).

In summary, the most abundant group in the first campaign in the two points analysed was Cryptophyceae, with a relative abundance of 92% at point P01 and 90% at point P02. In the second campaign (March 2020), the diatoms of Coscinodiscophyceae were more numerically representative, reaching 53% and 64%, at points P01 and P02, with emphasis on the species Aulacoseira granulata. The others had a low representativeness in terms of abundance, as shown in the following figure.

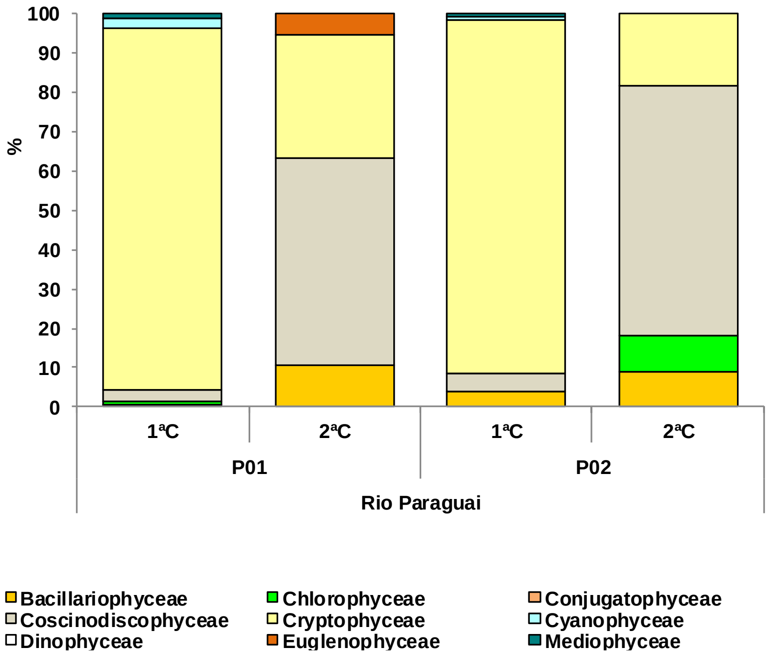


Figure 446 – Relative abundance of phytoplankton in Paraguay river – 1stC (Oct/19) and 2ndC (Mar/20).

As mentioned, the phytoplankton analysis also included cyanobacterial cell counts. In the Paraguay river, in both collections and at both points, the densities of this group were low, reaching maximum values in the first campaign, with a maximum of 264 cells per mL (P01), as shown in the following figure.

Article 11 of SEAM Resolution n. 222/02, based on WHO guidelines (World Health Organization - 1999), suggests rigorous surveillance of lakes when cyanobacterial cell densities reach 100,000 cells/mL. Although the Paraguay River is a lotic environment, it should be noted that the values recorded in the two campaigns are much lower than those foreseen in this resolution. This result is a positive aspect, considering that this group has taxons producing cyanotoxin, which can cause damage to aquatic biota and water quality, especially that intended for human supply, when present in large quantities.

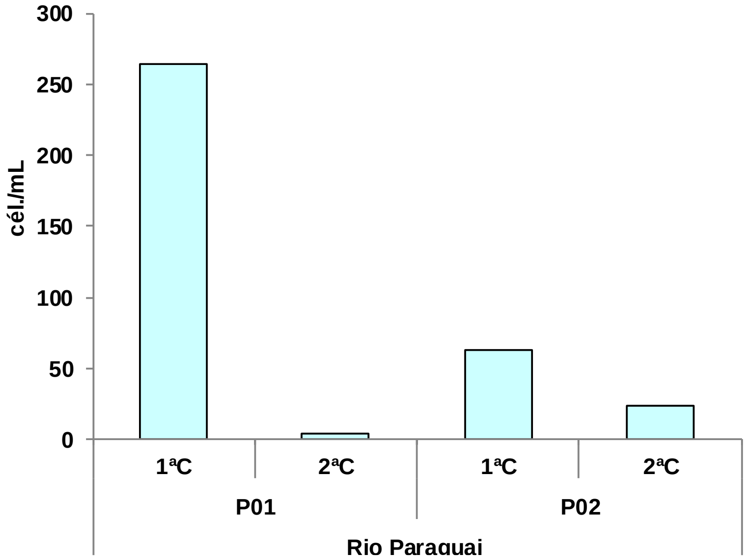


Figure 447 – Density of cyanobacteria in the Paraguay River – 1stC (Oct/19) and 2ndC (Mar/20).

Table 40 – Density and relative abundance of phytoplankton in the Paraguay River - 1stC (Oct/19) and 2ndC (Mar/20).

Taxonomic Composition	Paraguay river							
	P01				P02			
	1stC		2ndC		1stC		2ndC	
	org./mL	%	org./mL	%	org./mL	%	org./mL	%
Bacillariophyceae								
Achnanthes sp.	-	-	-	-	-	-	<1	-
Amphora sp.	-	-	-	-	4	0,54	-	-
Cymbella sp.	-	-	<1	-	-	-	<1	-
Eunotia sp.	4	0,49	-	-	-	-	<1	-
Naviculaceae	-	-	1	5	-	-	<1	-
Navicula sp.	-	-	-	-	-	-	<1	-
Nitzschia sp.	-	-	1	5	24	3,23	1	9
Surirella sp.	-	-	<1	-	-	-	-	-
Synedra goulardii	-	-	<1	-	-	-	<1	-
Synedra sp.	-	-	-	-	-	-	<1	-
Subtotal	**4**	**0,49**	**2**	**11**	**28**	**3,77**	**1**	**9**
Chlorophyceae								
Desmodesmus sp.	-	-	-	-	-	-	<1	-
Monoraphidium arcuatum	4	0,49	<1	-	-	-	1	9
Monoraphidium contortum	4	0,49	-	-	-	-	-	-
Monoraphidium irregulare	-	-	<1	-	-	-	-	-
Subtotal	**8**	**0,98**	**-**	**-**	**-**	**-**	**1**	**9**
Conjugatophyceae								
Closteriopsis sp.	-	-	<1	-	-	-	-	-

Taxonomic Composition	Paraguay river							
	P01				P02			
	1stC		2ndC		1stC		2ndC	
	org./mL	%	org./mL	%	org./mL	%	org./mL	%
Subtotal	**-**	**-**	**0**	**-**	**-**	**-**	**-**	
Coscinodiscophyceae								
Aulacoseira ambigua	-	-	-	-	24	3,23	-	-
Aulacoseira granulata var. *angustissima*	7	0,86	-	-	-	-	-	-
Aulacoseira granulata	-	-	10	53	-	-	7	64
Aulacoseira sp.	18	2,21	-	-	12	1,62	-	-
Subtotal	**25**	**3,08**	**10**	**53**	**36**	**4,85**	**7**	**64**
Cryptophyceae								
Cryptophyceae	616	75,77	6	32	556	74,93	2	18
Cryptomonas sp.	130	15,99	-	-	110	14,82	-	-
Subtotal	**746**	**91,76**	**6**	**32**	**666**	**89,76**	**2**	**18**
Cyanophyceae								
Aphanocapsa sp.	-	-	-	-	-	-	<1	-
Geitlerinema sp.	-	-	<1	-	-	-	-	-
Komvophoron schmidlei	-		-	-	4	0,54	-	-
Phormidium sp.	4	0,49	-	-	-	-	<1	-
Planktolyngbya sp.	11	1,35	-	-	4	0,54	-	-
Synechococcales	4	0,49	-		-	-	-	-
Subtotal	**19**	**2,34**	**0**	**-**	**8**	**1,08**	**0**	**-**
Dinophyceae								
Peridinium sp.	-	-	<1	-	-	-	-	-
Subtotal	**-**	**-**	**0**	**-**	**-**	**-**	**-**	
Euglenophyceae								
Trachelomonas volvocina	-	-	1	5	-	-	<1	-
Subtotal	**-**	**-**	**1**	**5**	**-**	**-**	**0**	**-**
Mediophyceae								
Cyclotella sp.	-	-	-	-	4	0,54	-	-
Thalassiosira sp.	11	1,35	<1	-	-	-	-	-
Subtotal	**11**	**1,35**	**-**	**-**	**4**	**0,54**	**-**	**-**
Total	**813**	**100**	**19**	**100**	**742**	**100**	**11**	**100**

Diversity and Equitability index

The figure below presents the results of the phytoplankton community diversity and equity indices sampled in the October 2019 and March 2020 campaigns.

In the first campaign, phytoplankton diversity in the Paraguay River ranged from 1.26 bits.ind-1 at point P01 to 1.29 bits.ind-1 at point P02. In the second campaign, an increase in diversity was observed, with 3.06 bits.ind-1 at point P01 and 3.47 bits.ind-1 at point P02.

The lower value of diversity in the first campaign is a consequence of the high relative abundance of Cryptophyceae. A similar behavior was observed in terms of equity, whose values remained low (<0.5), in the first campaign, with an increase in the second collection (>0.8), reflecting the better distribution of the taxons in the samples.

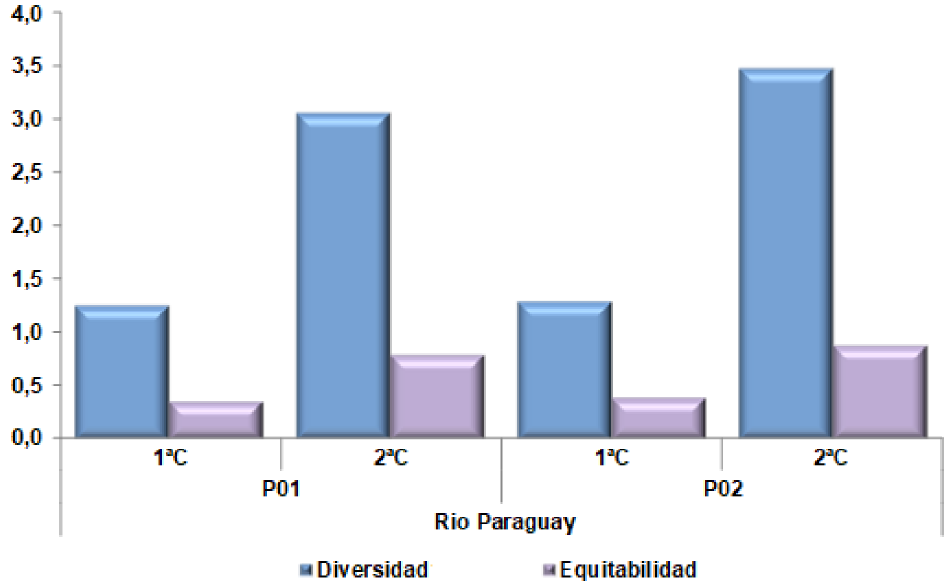


Figure 448 – Phytoplankton diversity and equity indices in the Paraguay river - 1stC (Oct/19) and 2ndC (Mar/20).

Similarity index

The evaluation of the similarity of the phytoplankton community, sampled in the two campaigns carried out in the Paraguay River, was based on the Bray-Curtis similarity index.

The results of this indicator indicate a high level of similarity between the points and the campaigns, and that the segregation of the samples into two main groups was influenced according to the sampling campaign, with the highest similarity between points P01 and P02, in the first campaign, with a similarity of approximately 85%. In the second cluster, which gathered the points P01 and P02 from the March 2020 collection, the similarity was approximately 60%. These clusters are a consequence of similar density behaviours in the same campaign, with a high cryptophysical density in the first campaign and a higher abundance of diatoms in the second one.

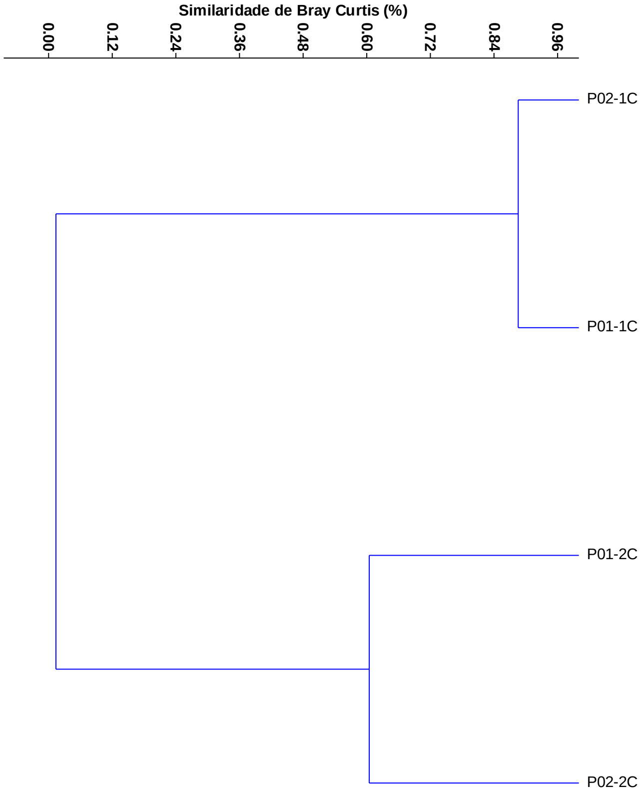


Figure 449 – Phytoplankton similarity in Paraguay River - 1st C (Oct/19) and 2ndC (Mar/20).

Coefficient = 0,999.

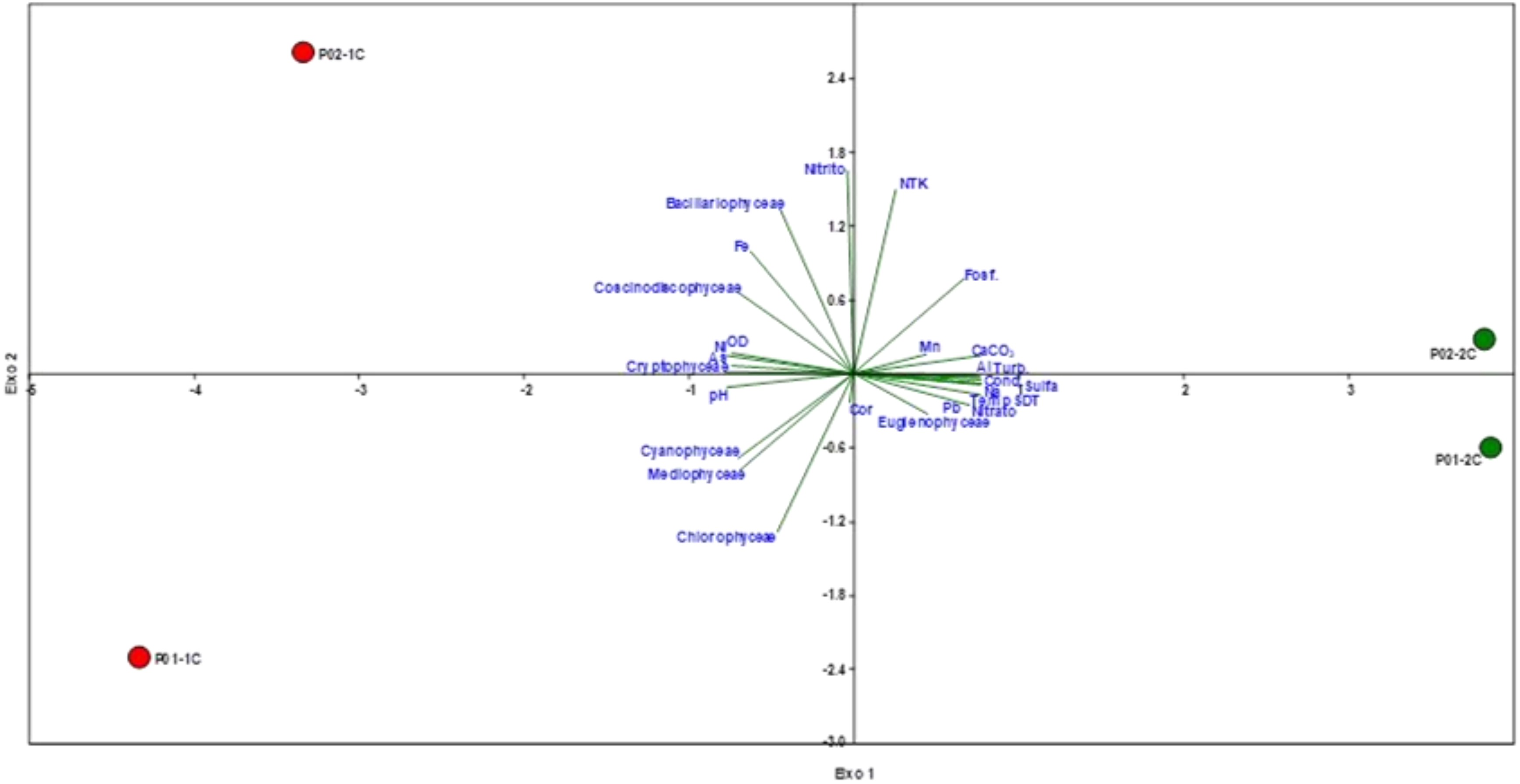
Principal Component Analysis (PCA)

The results of the ordering of the sample points according to the densities of the phytoplankton communities and the abiotic variables of the quality of the surface waters (PCA) in the first two campaigns carried out in October 2019 and March 2020, respectively, showed that the 1 and 2 represented 88.7% of the variability of the data, with the first being responsible for 73.2% and the second for 15.5%.

The first component showed a strong positive correlation mainly with abiotic variables, such as water conductivity and temperature, and a negative correlation mainly with cryptophytic algae density. The latter correlation is mainly responsible for the horizontal differentiation of the points, where the points referred to the first campaign, characterized by the high density of these algae, are on the left and the points referred to the second campaign are on the right (Figure 442).

The second main component was mainly correlated with the concentration of nitrites in surface waters. In general, nitrite levels were in compliance with the legal standard (SEAM Resolution n. 222/02) in the Paraguay river during the sampling campaigns. However, high concentrations of phosphorus were detected in this watercourse, with extrapolation of the legal norm, in the sampling. In general, the nutrients cited did not have a strong relationship with the results of phytoplankton.

Figure 450 – Principal Component Analysis (PCA) of the phytoplankton community and abiotic variables in the Paraguay River - 1stC (Oct/19) and 2ndC (Mar/20).



Legend: Al - Dissolved Aluminum As - Total Arsenic, Pb - Total Lead, Ni - Total Nickel, Fe- Dissolved Iron and Mn - Total Manganese. CaCO3 - Total Hardness. Total Kjeldahl Nitrogen - NTK. Dissolved Oxygen = OD. Fosf= Total Phosphorus. SDT - Total Dissolved Solids. Cond- Conductivity. Turb = Turbidity.

C. Benthic Community

Qualitative Analysis

Taxonomic Composition, Taxon Richness and Relative Richness

In the diagnosis of benthic invertebrates, carried out in October 2019 and March 2020, samples were taken from a total of 11 taxons, belonging to the following taxonomic groups: phylum Annelida - class Clitellata (2 taxons), phylum Arthropoda - sub-phylum Hexapoda (7 taxons), phylum Mollusca (1 taxon) and phylum Nematoda (1 taxon).

The main representatives of benthic invertebrates were the immature forms of aquatic insects (class Insecta), which accounted for 63.6% of the total taxons inventoried for this group of organisms.

The second most relevant group in terms of richness were the annelids, represented by the Oligochaeta and Hirudinea subclasses, which together constituted 18.2% of the richness of the community. A smaller proportion of molluscs and nematode worms were obtained, each with 9.1% of the taxon identified in the sampling network. The following figure shows the relative richness of this community by taxonomic group.

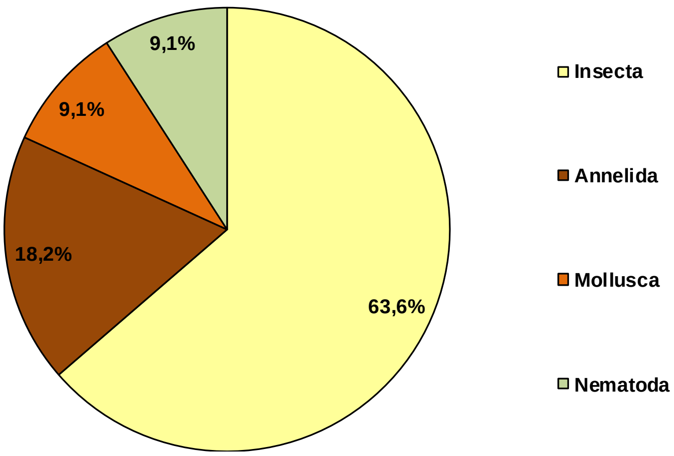


Figure 451 – Relative richness of benthic invertebrates in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

The insects were represented by the order Diptera (Diptera), including the families Ceratopogonidae and Chironomidae, among which the latter showed greater taxonomic richness, with six taxons.

Popularly known as flies and mosquitoes, diptera constitute an important part of the benthic fauna of lentic and lotic aquatic environments, and can even appear in brackish waters (COSTA et al., 2003). Adults of this order lay eggs on the surface of the water or in substrates and give rise to a high number of larvae which generally colonise sandy and muddy sediments, as well as aquatic vegetation. These organisms spend part of their life or their entire cycle associated with the bottom substrate and for some of them the larval stage is longer than the adult stage.

Larvae of the family Chironomidae (chironomidae) are generally omnivorous opportunists, feeding on algae, small animals and waste, and playing an important role in the decomposition of organic matter. Some of them are equipped with special organs, such as external gills, and manage to survive in polluted waters and in environments with low concentrations of dissolved oxygen (ROSSARO, 1991 apud OLIVEIRA, 2005). According to Coffman and Ferrington (1996), the family Chironomidae is the most taxonomically rich group, being the most distributed and often the most abundant aquatic insects in inland water ecosystems.

The family Ceratopogonidae, recorded only at point P02 downstream of the PARACEL pulp mill, is characterized by larvae with a predatory habit, which feed on microorganisms. At this stage of development, some representatives are tolerant to anthropic disturbances, which correspond to bioindicators of water quality (CALLISTO et al. 2001). In adults, there are taxon that can act as vectors of nematoids, protozoa and pathogens that affect human health.

Among annelids, the Oligochaeta subclass (oligophytes) and the Hirudinea subclass (hirudians) each had a single taxon, and the only recorded individual of the Hirudinea subclass belonged to the family Glossiphoniidae.

In general, oligochaetes can be used as indicators of pollution in the aquatic environment, as they are commonly found in environments rich in organic substances and with low concentrations of dissolved oxygen, which characterizes a competitive advantage over other species in the community (DORNFELD et al., 2006).

Hirudines are common in calm waters or low flow bodies of water, live preferably on the margins, attached to substrates (logs, rocks, etc.) and, like trace elements, withstand conditions of low oxygen concentration and live in places with high organic matter content (ROLDÁN, 1992 apud PARESCHI, 2008).

The representatives of phylum Mollusc (molluscs) were only recorded at point P02, in the two sampling campaigns. All individuals sampled belonged to the species Limnoperna fortunei (class Bivalvia, family Mytilidae), an invasive alien species known by the popular name of golden mussel.

The phylum nematode (nematodes) was recorded only in the first season, at point P01. Most nematode species live freely and feed on sedimentary matter; many are detrital, others live in or on dead organisms or excrements, but several are parasites on a wide range of plant and animal hosts.

As shown in the following graph, insects prevail in the Paraguay River, with a lower participation, in qualitative terms, of the other groups. Both insects and oligochaetes were common to both sample points and to both campaigns. It can be seen that point P02 tends to be richer (maximum of six taxons) than point P01 (maximum of four taxons), and that the March 2020 campaign was slightly richer than that of October 2019 in the two sections evaluated in the Paraguay river.

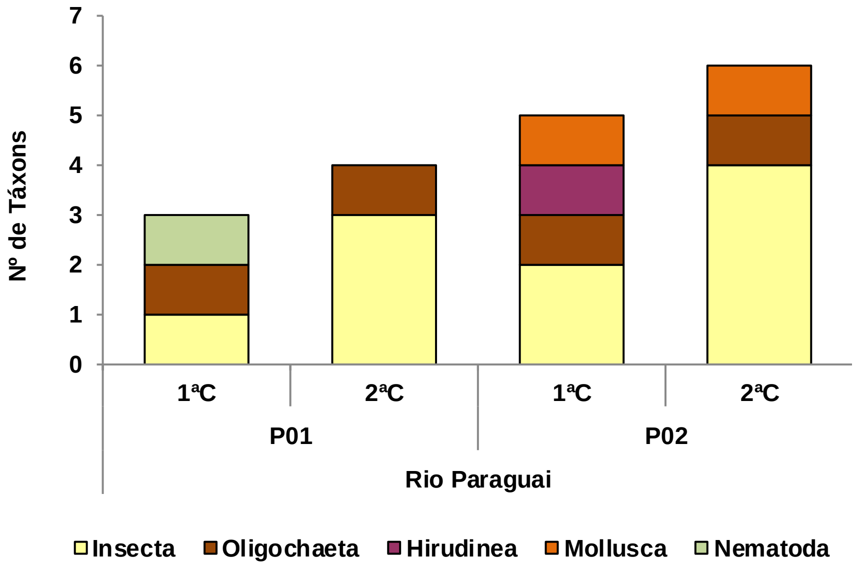


Figure 452 – Benthic invertebrate taxon richness by sampling point in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

In general, taxon richness was low in the sampled section. However, this low richness cannot be attributed to the low quality of the water, since it was detected in studies of well-oxygenated water quality (DO > 5.0 mg/L), with pH tending to neutral, low concentration of organic matter, expressed in terms of BOD (< 5.0 mg/L) and reduced rates of thermotolerant coliforms, complying with the standards determined by SEAM Resolution 222/2002 for class 2 waters, which increase is indicative of contamination by domestic wastewater. There was also no evidence of pesticide contamination in the waters or sediments of the Paraguay River.

In a specific study of the fauna of the chironomids of Upper Paraguay, Aburaya and Callil (2007) recorded 34 morphospecies of chironomids, distributed in three subfamilies and with high densities of the genus Polypedilum. According to the authors, the hydrological regime and flood dynamics are the main structuring factors of the benthic communities in this basin.

Analyzing the invertebrate fauna of the Paraguay River, in an extensive sampling network, Magalhães (2001) listed 13 species of crustaceans (Decapoda), five families of gastropods and three families of bivalves (Mollusca), and 34 families of insects, belonging to 10 orders. The author associated the greatest richness found with sites colonized by aquatic vegetation. It is important to note, however, that the studies mentioned above presented a much greater sampling effort than this, with a sample mesh of more than 50 collection points in one case and monthly collections throughout the hydrological cycle in the other.

Spatial Distribution and Frequency of Occurrence

The following table shows the spatial distribution and frequency of occurrence of benthic invertebrates recorded in the sediments of the sample points of the assessed water body.

The subclass Oligochaeta, as well as the family Chironomidae, was generally present in all samples, as is common in inland lotic environments. Among the family Chironomidae, representatives of the subfamily Chironominae were more frequent, being present at both sampling points, while the subfamilies Orthocladiinae and Tanypodinae had their records restricted to point P02 and point P01, respectively.

In a study conducted along the Paraguay River, Barbosa et al. (2001) recorded that the family Chironomidae was the most frequent and abundant representative of benthic fauna in the samples, representing about 52% of all fauna sampled, followed by the subclass Oligochaeta, which represented 35% of all fauna in the inventory.

The results obtained in the present study, although less rich than those recorded in the literature, corroborate those found by the other authors, which show communities structured mainly by the family Chironomidae and the subclass Oligochaeta. The following is a photographic record of some taxons registered in the Paraguay River.

Figure 453 – *Limnoperna fortunei*.

Figure 454 – *Chironomideae*.

Figure 455 – Diptera from the family *Ceratopogonidae*.

Figure 456 – Anelid *Oligochaeta*.

Source: Econsult (2020).

Table 41 – Spatial distribution and frequency of occurrence of benthic invertebrates in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

Taxonomic composition	Paraguay river				Ocurrence	Frequency of occurrence ficlo(%)
	P01		P02			
	1stC	2ndC	1stC	2nd C		
Phylum ANNELIDA						
Class Clitellata						
Subclass Hirudinea						
Order Rhynchobdellida						
Family Glossiphoniidae					1	25
Subclass Oligochaeta					4	100
Subtotal	**1**	**1**	**2**	**1**		

Taxonomic composition	Paraguay river				Ocurrence	Frequency of occurrence ficlo(%)
	P01		P02			
	1stC	2ndC	1stC	2nd C		
PhylumARTHROPODA						
Subphylum HEXAPODA						
Class Insecta						
Order Diptera						
Family Ceratopogonidae					2	50
Family Chironomidae					1	25
Sub-Family Chironominae					1	25
Tribo Chironomini						
Cryptochironomus					2	50
Polypedilum					2	50
Sub-Family Orthocladiinae						
Orthocladiinae N.I.					1	25
Sub-Family Tanypodinae						
Tanypodinae N.I.					1	25
Subtotal	**1**	**3**	**2**	**4**		
Phylum MOLLUSCA						
Clase Bivalvia						
Subclase Pteriomorphia						
Order Mytilida						
Family Mytilidae						
Limnoperna fortunei					2	50
Subtotal	**-**	**-**	**1**	**1**		
Phylum NEMATODA					1	25
Subtotal	**1**	**-**	**-**	**-**		
Total por Punto	**3**	**4**	**5**	**6**		
Total en la Campaña	**11**					

Exotic species

The presence of the bivalve mollusc known as the *Limnoperna fortunei*, an invasive species originating in Asia and accidentally introduced into South America by the ballast water of merchant ships, was recorded in the Paraguay River, downstream from the future PARACEL pulp mill (P02). In South America, this species has been causing economic losses, mainly in the hydroelectric and public supply sectors, due to the formation of incrustations in infrastructure equipment.

The incrustations formed by the golden mussel are voluminous, several individuals overlap adhering to the substrate and to each other, by the filaments they secrete, thus forming compact agglomerates (MANSUR et al., 2012).

According to Pestana and others (2010), the *Limnoperna fortunei* arrived in South America in 1991 and rapidly expanded its distribution, reaching the Paraguay River in 1997/98. The presence of the golden mussel in the sampled section indicates the susceptibility to invasion of this bivalve in the case of the installation of structures for capture in the river. In general, monitoring the distribution of this community is a measure that allows for the establishment of management and control strategies, if necessary.

Endangered Species

It should be noted that the benthic invertebrates of the Paraguay River recorded in October/2019 and March/2020 are common organisms, with a wide continental distribution, and are not included in the international list of threatened species (IUCN, 2020). According to the Action Plan for the Conservation of Biodiversity in Paraguay (SEAM, 2016), there is no list of threatened aquatic invertebrate species in Paraguay.

Indicator species

This study did not record insects of the orders Ephemeroptera, Plecoptera or Tricoptera, commonly used in monitoring programs as indicator organisms of good water quality due to their restricted environmental requirements. In general, the taxon sampled in these two campaigns are considered to have a wide range of tolerance to variations in their natural habitats and to loss of water quality.

<u>Quantitative analysis</u>

Density and relative abundance

In the quantitative evaluation of benthic invertebrates, in the campaigns carried out in October 2019 and March 2020, the density (org./m²) and relative abundance (%) of the organisms collected were considered, according to the results presented in the following table. The following figure shows the variation of the density parameter of all taxonomic groups, for each point and in each campaign.

In the Paraguay river, the highest densities of organisms were found at point P01, at the first station, with 2,884 org/m2, the great majority composed of larvae of the family Chironomidae (2,850 org/m2). Similarly, in the following season, this family was numerically dominant at this same site, with 115 org/m2 of a total of 166 org/m2.

Point P02, in turn, showed a community numerically dominated by the bivalve L. fortunei during the first season, when this species had a density of 672 org/m2, representing 74% of the organisms recorded in the samples. In the following season, in March 2020, the number of bivalves sampled was quite low, not exceeding 26 org/m2, and the community was again numerically dominated by the family Chironomidae.

These values of larval density of chironomids are not uncommon in the Paraguay River. Aburaya and Callil (2007) recorded frequent densities in the upper Paraguay River between 1,000 and 10,000 ind/m2, mainly for Polypedilum.

Table 42 – Density and relative abundance of benthic invertebrates per sampling point in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

Taxonomic composition	Paraguay river							
	P01				P02			
	1stC		2ndC		1stC		2ndC	
	org./m²	%	org./m²	%	org./m²	%	org./m²	%
Phylum ANNELIDA	-	-	-	-	-	-	-	-
Class Clitellata	-	-	-	-	-	-	-	-
Subclass Hirudinea	-	-	-	-	-	-	-	-
Order Rhynchobdellida	-	-	-	-	-	-	-	-
Family Glossiphoniidae	-	-	-	-	17	1,9	-	-
Subclass Oligochaeta	17	0,59	52	31	138	15,1	57	18,4
Subtotal	**17**	**0,59**	**52**	**31**	**155**	**17**	**57**	**18**
Phylum ARTHROPODA	-	-	-	-	-	-	-	-
Subfilo HEXAPODA	-	-	-	-	-	-	-	-
Class Insecta	-	-	-	-	-	-	-	-
Order Diptera	-	-	-	-	-	-	-	-
Family Ceratopogonidae	-	-	-	-	26	2,8	17	5,4
Family Chironomidae	-	-	-	-	61	6,6	-	-
Sub-Family Chironominae	2.850	98,82	-	-	-	-	-	-
Tribo Chironomini	-	-	-	-	-	-	-	-
Cryptochironomus	-	-	69	41,5	-	-	80	25,7
Polypedilum	-	-	29	17,3	-	-	98	31,3
Sub-Family Orthocladiinae	-	-	-	-	-	-	-	-
Orthocladiinae N.I.	-	-	-	-	-	-	35	11
Sub-Family Tanypodinae	-	-	-	-	-	-	-	-
Tanypodinae N.I.	-	-	17	10,2	-	-	-	-
Subtotal	**2.850**	**98,8**	**115**	**69**	**86**	**9**	**230**	**73**
Phylum MOLLUSCA	-	-	-	-	-	-	-	-
Class Bivalvia	-	-	-	-	-	-	-	-
Subclass Pteriomorphia	-	-	-	-	-	-	-	-
Order Mytilida	-	-	-	-	-	-	-	-
Family Mytilidae	-	-	-	-	-	-	-	-
Limnoperna fortunei	-	-	-	-	672	73,6	26	8,2
Subtotal	**-**	**-**	**-**	**-**	**672**	**74**	**26**	**8,2**
Phylum NEMATODA	17	0,59	-	-	-	-	-	-
Subtotal	**17**	**0,59**	**-**	**-**	**-**	**-**	**-**	**-**
Total	**2.884**	**100**	**166**	**100**	**913**	**100**	**312**	**100**

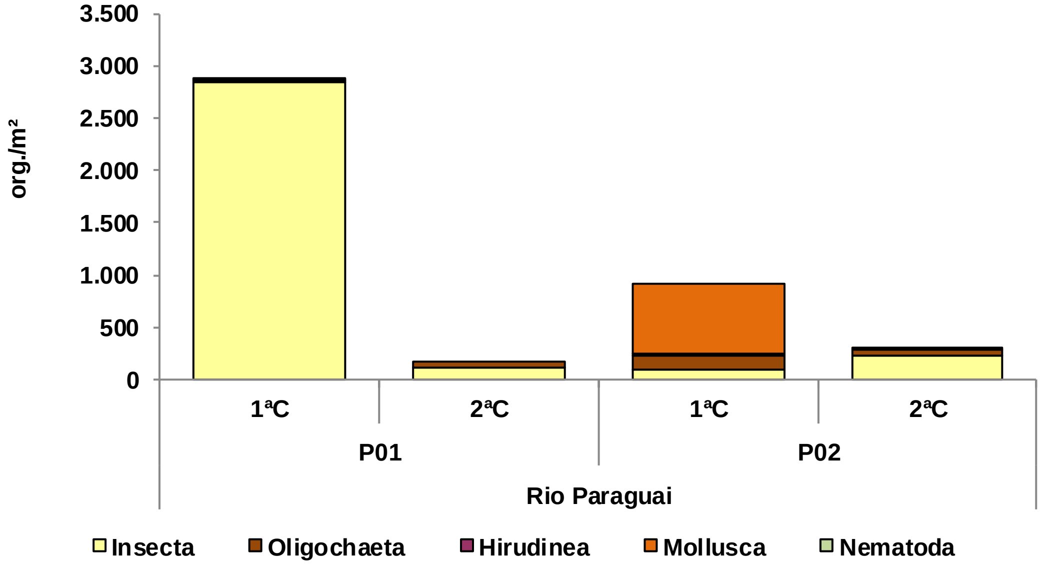


Figure 457 – Benthic invertebrate density per sampling point - 1stC (Oct/2019) and 2ndC (Mar/20).

The following figure shows the relative abundance of each taxonomic group at the sampling points during the two seasons. It is remarkable that insects have a numerical dominance above 70% in most of the samples, with the exception of point P02 in the first season, when there was dominance of the bivalve L. fortunei.

Oligochets maintained their relatively stable participation in most samples, except at P01 during the first campaign, when the high number of chironomids contributed to their percentage in the community being only around 1%. Both the Hirudinea subclass and the Nematoda phylum had low abundance in the samples. These results are consistent with the conclusions of Barbosa et al (2001), which determined that the family Chironomidae was numerically dominant in samples taken in 35 different locations between the regions of Alto and Bajo Paraguay and the tributaries of its basin.

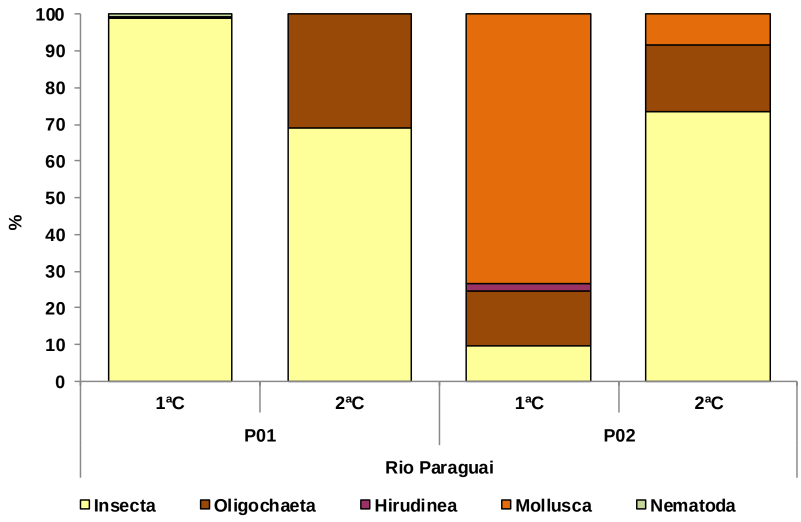


Figure 458 – Relative abundance of benthic invertebrates in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

Diversity and Equitability

In the Paraguay river, as shown in Figure 451, diversity and equitability were low at point P01 in the first season, which is due to the high abundance of the family Chironomidae relative to the other faunal groups sampled. In the other samples, the diversity presented higher values, which varied between 1.25 bits/ind-1 (P02, October/2019) and 2.35 bits/ind-1 (P02, March/2020).

Equitability, in turn, varied between 0.54 (P02, October/2019) and 0.91 (P01 and P02, March/2020). For the two sample points, diversity and equitability were higher in the second campaign than in the first.

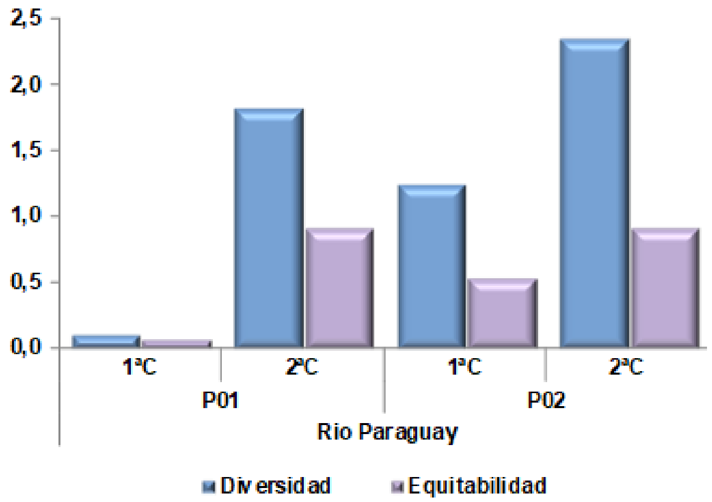


Figure 459 – Diversity and equitability of benthic invertebrates in the Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

Similarity index

The assessment of the similarity patterns of the zoobenthic community in the sample grid, taking into account the samples of October 2019 and March 2020, was based on the Bray-Curtis similarity index.

The results of this indicator point to the formation of a group formed by the samples collected in March 2020 (2nd campaign) and a greater differentiation between the samples collected in October 2019 (1st campaign). This result reflects the data recorded in the 1st campaign, when the high density of the family Chironomidae at point P01 and the high density of the bivalve L. fortunei at point P02 strongly distinguished these two sampling sites, while in the 2nd campaign the communities were much more similar at both points.

The similarity of the communities in relation to the collection period indicates that seasonality is a determining factor in their structuring. According to Bergier and Resende (2010), the dynamics of floods are especially determined by the rainy season, which, in the case of the central part of South America, where the Paraguay River basin is located, is concentrated from October to March and, depending on its distribution, intensity and duration, causes clear changes in the landscape. Several authors discuss the importance of the flood of the Paraguay River Basin in changes in water quality (CALHEIROS and FERREIRA, 1996), in the structure and distribution of plant species (DAMASCENO Jr. and others, 2005; SOUZA and others, 2011) and animals, including aquatic fauna (ALHO and SABINO, 2012).

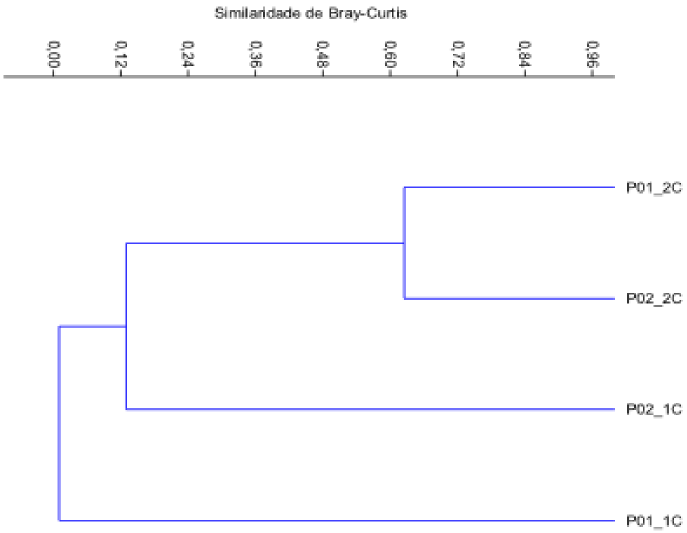


Figure 460 – Similarity of benthic invertebrates in Paraguay River - 1stC (Oct/2019) and 2ndC (Mar/20).

Coefficient = 0,9961,

BMWP Index

The result of the BMWP index for the section of the river Paraguay analysed is shown in the following figure, where the two sample points, in the two campaigns, were classified as poor quality, since the maximum value found was only 14 (P02, 1st campaign). Point P01 received in both campaigns a lower score than P02, which is consistent with the results recorded for richness, which was also lower in this place.

It should be considered that this index is not adapted to the watercourses of the large flood basins and that the water quality measured during the campaigns was good for most of the parameters measured. Therefore, the index may not reflect water quality itself.

In a comprehensive review of benthic invertebrate communities in the Paraguay River basin, Wantzen et al. In general, organisms capable of colonizing the Paraguay River on a large scale have short life cycles and strategic characteristics that allow them to quickly recolonize habitats that change from dry to flooded in a short period of time. According to the authors, as a reservoir basin, the Paraguay River tends to select filtering and collecting organisms from its substrate, such as bivalve molluscs, chironomideal larvae and oligo-lethal anelids. Therefore, it is considered that, despite the low richness and low BMWP, the communities recorded in this study are typical of the region in which they are inserted.

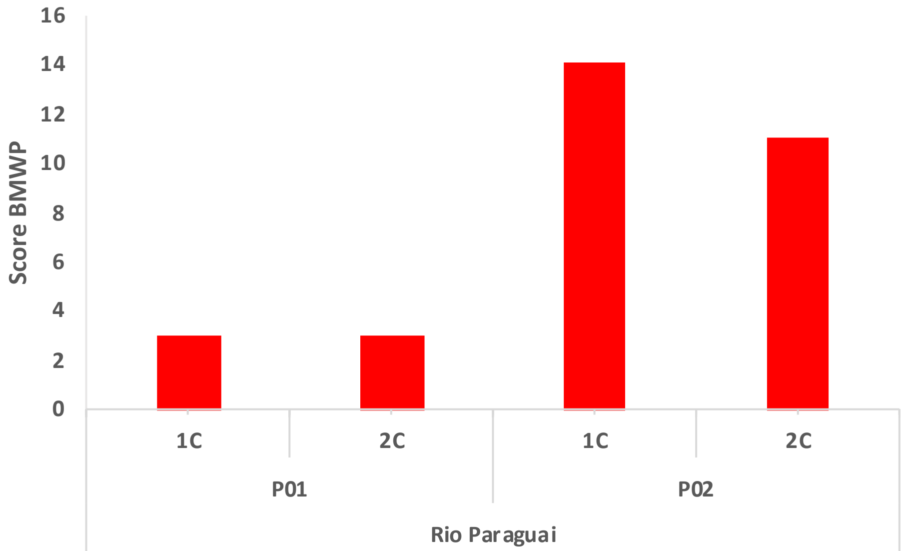


Figure 461 – BMWP Index in Paraguay River - 1stC (Oct/2019) and 2nd C (Mar/20).

Principal Component Analysis

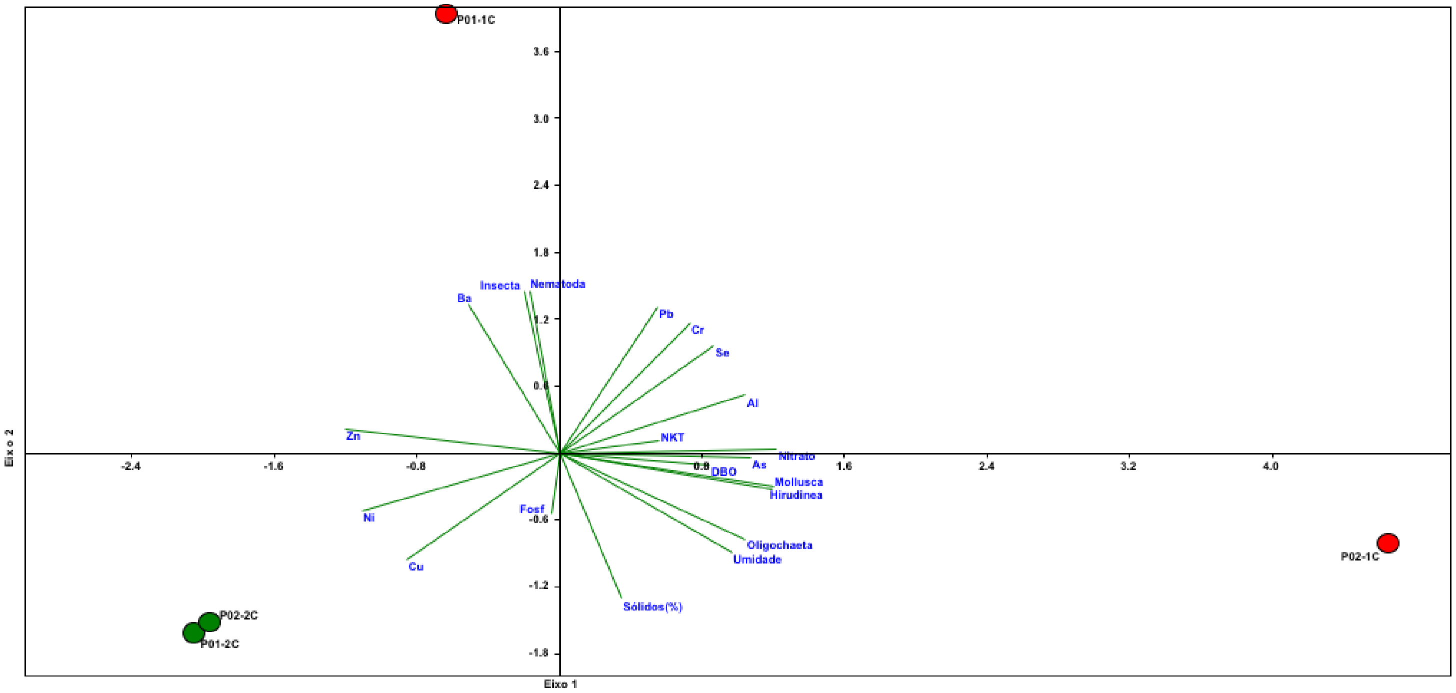
The PCA (Principal Component Analysis) analysis was conducted to investigate the relationships between the benthic invertebrate community and sediment characteristics, as shown in the figure below.

The first two axes of the PCA explain 85% of the data distribution. Axis 1 showed a positive correlation with nitrate, aluminum, arsenic, nickel, Oligochaeta, Hirudinea and Mollusca densities; and negative with variable nickel and zinc concentrations. The second axis showed a positive correlation with the concentrations of barium and lead and with the densities of Insecta and Nematoda; and negative with the percentage of solids.

Corroborating the results found in the similarity analysis, the PCA grouped the samples collected in the March 2020 campaign and showed that in the October 2019 campaign the results were differentiated between the sampling points.

Molluscs (bivalve L. fortunei) and annelids tended to present higher densities in environments whose sediments had the highest percentages of solids, higher BOD, as well as higher concentrations of nitrate and some metals, while insects (family Chironomidae) and nematodes (which only appeared at point P01 in the 1st campaign) presented the opposite trend. It should be pointed out that the PCA is an exploratory analysis and does not take the form of a hypothesis test, nor is it possible to establish a direct cause-and-effect relationship between such variables.

Figure 462 – Principal Component Analysis among Benthic Invertebrate Communities and Sediment Characteristics - 1stC (Oct/2019) and 2ndC (Mar/20).



Leyenda: Al - Aluminium, As - Arsenic, Pb - Plomo, Ni - Nickel, Cu-Copper, Zn= Zinc. Ba= Bario, Se = Selenium, Cr = Chromium, NKT = Total Kjeldahl Nitrogen.

Final considerations

The assessment of the phytoplankton community resulted in the registration of 71 taxons in the Paraguay River, taking into account the integrated data from the two campaigns held in October 2019 and March 2020, during the rainy season. The greatest richness was attributed to the diatoms Bacillariophyceae, followed by Cyanophyceae and Chlorophyceae, groups that are common components of plankton in continental aquatic ecosystems.

Among the taxons inventoried, bacillariophyceae diatoms Diadesmis sp., Gyrosigma sp. and Nitzschia sp., the conscinodiscophic diatom Aulacoseira granulata, the cyanobacterium Phormidium sp. and a taxon of the class Cryptophyceae occurred at all collection points in both campaigns, suggesting a greater adaptability of these taxons to local environmental conditions.

Quantitative analysis showed that phytoplankton density differed substantially between seasons, with the highest values associated with the October 2019 collection, mainly due to the contribution of Cryptophyceae, including algae Cryptomonas sp, considered opportunistic. In the second season (March 2020), the diatoms Coscinodiscophyceae were more numerically representative.

Cell densities of cyanobacteria were low in the two segments sampled in the Paraguay River, which is a positive aspect, considering that this group includes taxons that produce cyanobacteria, which can cause damage to aquatic biota and water quality when present in large quantities.

In the first season, phytoplankton diversity remained low, reflecting the high abundance of Cryptophyceae, and in the next collection there was an increase in this indicator. Bray Curtis' analysis showed a high level of similarity in the two points evaluated in the Paraguay river, in both collections.

The evaluation of benthic invertebrates, in the two campaigns in question, indicated the presence of 11 taxons, with the greatest richness attributed to immature forms of aquatic insects (class Insecta), with emphasis on diptera of the family Chironomidae.

The subclass Oligochaeta, as well as the family Chironomidae was present in all samples, a behavior considered common in continental lotic environments. Among the family Chironomidae, representatives of the subfamily Chironominae were more frequent, being present at both sampling points.

In general, the taxon sampled in these two campaigns are considered to have a wide range of tolerance to variations in their natural habitats and to decline in water quality. The presence of the Limnoperna fortunei, in the Paraguay river, downstream of the future PARACEL pulp mill (P02), should be highlighted as an invasive species, coming from Asia and accidentally introduced into South America by the ballast water of merchant ships.

In quantitative terms, the highest densities were obtained at point P01, in the first campaign, mainly due to the contribution of larvae from the family Chironomidae. At P02 the dominance of the bivalve L. fortunei was found in the first season and of Chironomidae in the later sampling.

Diversity and equitability in the Paraguay river were low at P01 in the first season, due to the high abundance of the family Chironomidae.

The similarity assessment pointed out similarities between the samples obtained in March 2020 (2nd season) and a greater differentiation between the samples obtained in October 2019 (1st season), reflecting the dominance behavior mentioned above.

In summary, in general, the benthic community found is in accordance with that already recorded by other authors in studies conducted in the region, with high frequency and abundance of the family Chironomidae and the Oligochaeta rings. The hydrodynamic regime and flood seem to be the main structuring factors of the community's environment, although there is not yet a complete hydrological cycle to confirm these behaviours.

9.2.3 Critical Habitat

Regarding the Critical Habitat concept as defined by International Finance Corporation (IFC) Performance Standard 6 (PS6) representing areas of high biodiversity value, identified based on five criteria addressing habitats of significant importance to (1) threatened species (EN, CR), (2) endemic species, (3) congregant and migratory species, (4) threatened or unique ecosystems, and (5) areas associated with key evolutionary processes, there are some located at the northwest and northeast of Paracel property. They are key areas for biodiversity defined by the Ibat tool, there are protected areas and there are key areas, considering these critical habitat areas with threatened and endemic species. All of Paracel's properties are in a critical habitat as defined by Performance Standard 6.

From the species sampled in the industry areas, five are listed in the lists of flora species in danger of extinction consulted (SEAM Resolution 524/2006 and SEAM Resolution 2,243/2006): the "jatai" (*Butia paraguayensis*),"grapia"*(Apuleia leiocarpa*), "algarrobo" (*Prosopis alba*), "preto carob" (*Prosopis nigra*) and the "guatambu" (*Balfourodendron riedelianum*) is endangered by IUCN 2021.

Threatened species are classified according to the global list (IUCN, 2020-1) and also the classification of Paraguay - Resolution 632/2017.

During the industry study 06 species were found to be listed by IUCN (2020-1) in the category of "Near Threatened" (NT), "Endangered" (EN), "Vulnerable" (VU) and "Threatened" (AM) and 03 in the list of Paraguay (Resolution 632/2017) according to the following table.

Table 43 – List of mammal species threatened with extinction.

Specie	Popular Name in Paraguay	Resolution 632/2017	IUCN (2017)
Cabassous chacoensis Wetzel, 1980	Armadillo chaqueño de cola desnuda		NT
Myrmecophaga tridactyla (Linnaeus, 1758)	oso hormiguero	AM	VU
Sylvilagus brasiliensis (Linnaeus, 1758)	tirica		EN
Leopardus tigrinus (Schreber, 1775)	tirica	AM	VU
Lontra longicaudis (Olfers, 1818)	nutria de río		NT
Tapirus terrestris (Linnaeus, 1758)	Tapir	AM	VU

Regarding mammals species of importance for conservation and of scientific interest on forestry component, we can highlight the records of *Panthera onca* (jaguar), Near Threatened (NT) internationally and Critically Endangered (CR) in Paraguay, as well as *Chrysocyon brachyurus* (maned wolf), NT under the IUCN and Vulnerable (VU) at the national level. Both species have been recorded indirectly based on the reliable testimonies from local people. Other records of interest include *Leopardus braccatus* (*gato del pajonal*), NT under the IUCN and Data Deficient (DD) at a national level; *Leopardus pardalis* (ocelot), NT in Paraguay; and *Myrmecophaga tridactyla* (giant anteater), *Tapirus terrestris* (tapir) and *Tayassu pecari* (white-lipped peccary), these last three being VU both at national and international levels. Among all the species recorded, eight fall under some category of national or international threat, two are considered DD (lacking data for evaluation) at the international level and one at the national level, while one species (*Sylvilagus brasiliensis*) is not evaluated due to recent changes in its taxonomy. Furthermore, 18 of the recorded species are found in one or another of the CITES appendices.

Among the threatened birds, the presence of two species of undergrowth foraging and, therefore, dependent on the integrity of the forest should be highlighted: *Conophophaga lineata* and *Mionectes rufiventris*. Habitat loss and fragmentation, associated with a decline in environmental quality, characterize the main causes of the threat to these species.

Six species were recorded on forestry component that fall under categories of threat at an international level (NT and VU), while six species were recorded that fall under categories of threat at a national level (Threatened and Endangered) (MADES Resolution No. 254/19, Rojas et al. 2020, IUCN 2021). There were several records of a single endemic species to the *Cerrado*, *Saltatricula atricollis* (*pepitero de corbata*), at CC and SA in all sampling sites. In spite of being considered an endemic, this species is expanding to the south due to the savannization of landscapes in the eastern region of the country (see ornithological annex). Also, the record of *Alipiopsitta xanthops* (loro cara amarilla) another endemic species, recently documented for the country and with few records (Alvarez et al. 2012), are among the eleven species endemic to the Cerrado which occur in Paraguay according to Silva (1997).

Although no herpetofauna species is considered endemic, three of them have some degree of threat or poor data. The toad *Rhinella diptycha* and *Dendropsophus elianae* are in danger of extinction, according to the list of animals threatened according to Resolution 433/2019, meanwhile that *Pithecopus azureus* was found as DD – Deficient Data, in accordance with International Union for Conservation of Nature Red List of Threatened Species (IUCN, 2020). It is not listed, but is highly threatened due to its commercial value, most notably *C. carbonaria*, a species widely used as food by hunters and widely used in wildlife trafficking, which is sold not only in Paraguay but all over the world.

In terms of conservation status, only *Rhinella scitula* and *Dendropsophus elianae* are included under some degree of threat in the forestry component, both at international and national levels. *Rhinella scitula* is a small terrestrial toad (34 -51 mm) endemic to the *Cerrado*; in Paraguay it is found exclusively within the Departments of Amambay, Concepción and San Pedro (Brusquetti et al. 2006, Smith et al. 2012, Sugai et al. 2014). *Dendropsophus elianae* (20 - 26 mm) is an endemic climbing frog of the *Cerrado* (Napoli & Caramaschi, 2000); it has few records in the country which all come from within the Departments of Amambay and Concepción.

Highlighting the key areas for biodiversity defined by the Ibat tool which shows that at the northwest and northeast of PARACEL properties there are protected areas and there are key areas, considering these critical habitat areas. All PARACEL's properties are in a critical habitat as defined by Performance Standard 6 (PS6). The same information can be seen at https://data.unep-wcmc.org/datasets/44 United Nations Council website.

To better understand the importance of a specific study and analysis, it is important to note what the WCMC (*UN Environment World Conservation Monitoring Centre* - Technical Briefing Note July, 2017) Areas are classified as "likely" or "potential" Critical Habitat depending on the resolution and reliability of the datasets and their matching the criteria of IFC Performance Standard 6 (PS6). The other areas were considered "unclassified" based on lack of data to assess the probability of critical habitat presence. On the detection layer they clarify that it is *intended only as part of a broader scope exercise to identify biodiversity values at a site* that can trigger a Critical Habitat. This can support and help lead these more detailed assessments, but it does not play an official role in the Critical Habitat classification. Given the limitations of the data, the interpretation of sites classified as Potential critical habitat or likely by the WCMC detection layer is carefully handled. This is because all global datasets can contain commission errors (indicating that a feature occurs when it does not) and omission errors (indicating that a feature does not occur when it occurs) and, always, areas classified as Probable or Potential Critical Habitat using that tool require field validation. Similarly, "unclassified" areas can include critical habitat for which there were simply no datasets to indicate presence.

For 60 years, World Wildlife Fund (WWF) has worked to help people and nature thrive. As the world’s leading conservation organization, WWF works in nearly 100 countries. At every level, it collaborates with people around the world to develop and deliver innovative solutions that protect communities, wildlife, and the places in which they live. According to WWF, Paraguay has got 5 different Terrestrial Ecoregions, as following map:

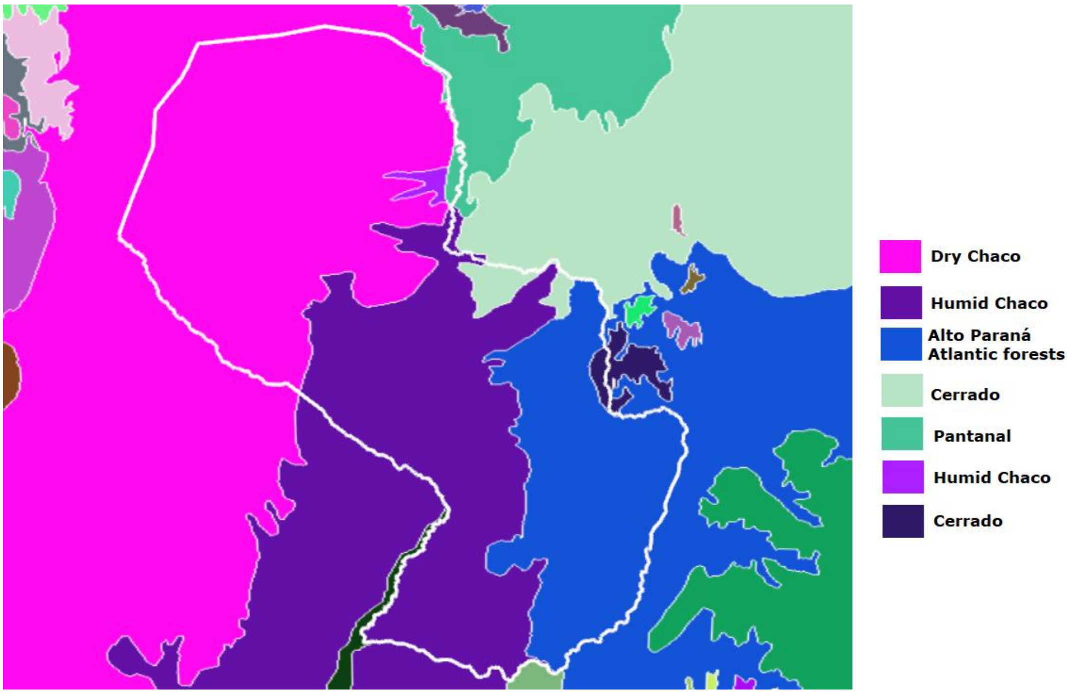


Figure 463 – Map of Paraguay Terrestrial Ecoregions. Source: WWF web site, 2021.

Terrestrial Ecoregions of the World (TEOW) is a biogeographic regionalization of the Earth's terrestrial biodiversity. Our biogeographic units are ecoregions, which are defined as relatively large units of land or water containing a distinct assemblage of natural communities sharing a large majority of species, dynamics, and environmental conditions. There are 867 terrestrial ecoregions, classified into 14 different biomes such as forests, grasslands, or deserts. Ecoregions represent the original distribution of distinct assemblages of species and communities. There are multiple uses for TEOW in our efforts to conserve biodiversity around the world.

The Paracel pulp property land contain a mosaic of land cover resulting from the juncture of three different biomes, mainly *Cerrado* and *Humid Chaco* with some influence of the *Atlantic Forest* biome. Therefore the area is considered is Humid Chaco is considered a Critical Habitat.

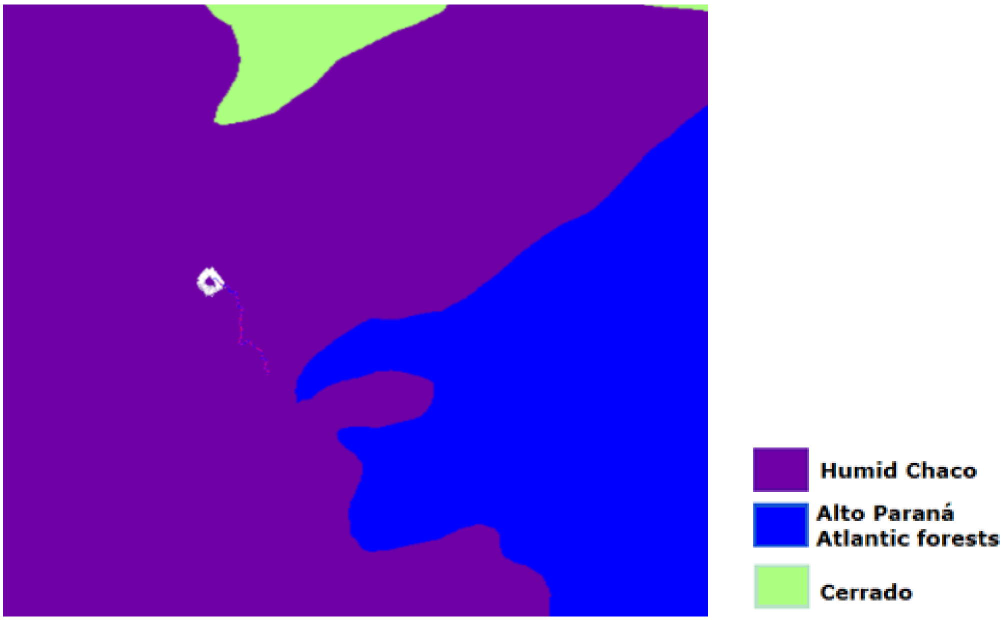


Figure 464 – Map of Paracel Pulp Property Area at Terrestrial Ecoregions. Source: WWF web site, 2021.

9.2.4 Protected Areas

Protected Wild Areas

The legal framework for natural resource conservation within protected areas in Paraguay was established by Law 352 on Protected Wildlife Areas ("Areas Silvestres Protegidas" - ASP in Spanish), approved in 1994, which created the National System of Protected Wildlife Areas of Paraguay (SINASIP) (Sienra et al., 2004).

In 2000, in response to a specific need to implement the subsystem of the private forest areas, three resolutions were enforced: Resolution 49, approving the methodology for the elaboration of Management Plans for Wildlife Areas protected by SINASIP;

Resolution n.73, authorizing the National Registry of Protected Wildlife Areas of Paraguay; and Resolution 79, establishing the procedure for the legal creation of private domain protected areas (Sienra et al., 2004).

That same year, Law 1561 created the National Environmental System and the Secretariat of State for the Environment (SEAM), entities whose function or objective is the formulation of policies, coordination, supervision and execution of environmental actions and plans, programs and projects within the framework of the National Development Plan and related to the preservation, conservation, recomposition and management of natural resources (Sienra et al., 2004). According to SINASIP, Paraguay's protected wildlife areas have three management categories:

Fully protection

National parks: Those natural areas with ecosystems that contain outstanding geomorphological features, as well as species representative of a natural region and that under protection are destined for research, education and tourism in nature.

Natural Monuments: Those areas that contain unique natural or cultural characteristics or features of outstanding cultural value and that under protection are intended for scientific research and recreation when conditions permit.

Flexible use

Wildlife Refuge: These are those preferably natural areas intended for the conservation of species and ecosystems through active management.

Protected landscapes: Those natural areas intended for the protection of land and water landscapes and recreation.

Reserves of Managed Resources: These are areas that make it possible to combine the conservation of biological diversity with the sustainable use of ecosystems and their components.

Biosphere Reserve: They are those areas that allow the constitution of a flexible use unit and allow the harmonious coexistence of different modalities of use and conservation, which include other categories of management inside its limits.

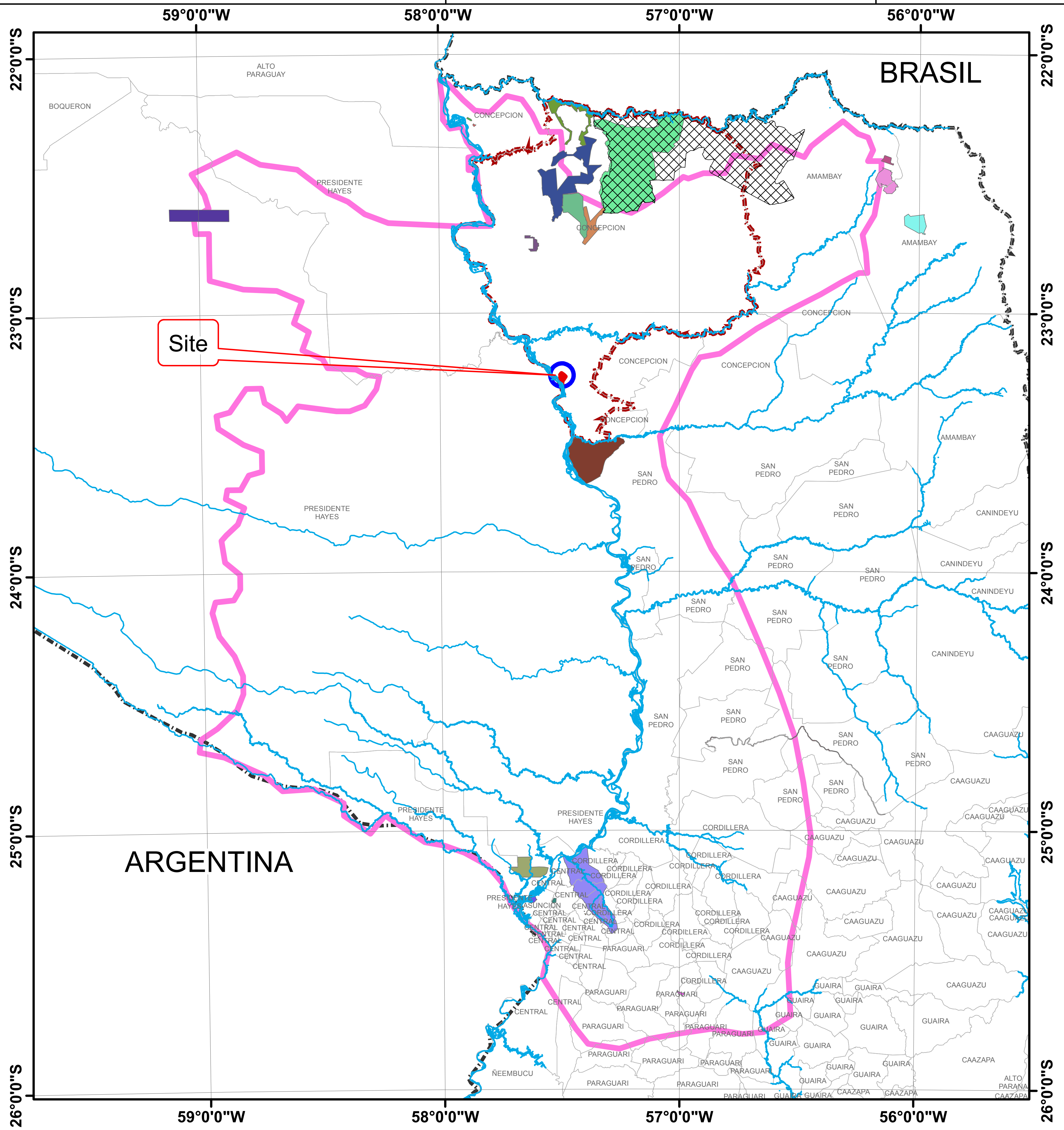
According to the Map of Protected Wildlife Areas in Paraguay (SINASIP/SEAM, 2007; DASP/DGPCB/SEAM, 2011) the country has 68 protected units, i.e. 27% of its territory is under some category of protection. In the department of Concepción, the protected areas are divided into the following categories:

Categories (SINASIP*)		**Law**	**Area (ha)**
National Parks	National Park Serranía de San Luís	Decree 20,712	103,018
	National Park Serranía de San Luís	Decree 17,740	10,273
Private natural reserves	Natural Reserve Cerrados del Tagatiya	Decree 7,791	5,700
	Natural Reserve Tagatiya mi	Decree 10,396	33,789
Biosphere Reserves	Biosphere Reserve of the Cerrado del Río Apa**	Decree 14e431	267,836

Source: * SINASIP: “Sistema Nacional de Áreas Silvestres Protegidas del Paraguay”, National System of Protected Wildlife Areas of Paraguay (2007); ** biosphere Reserve del Cerrado del Río Apa is inserted both in Departament of Concepción and Amambay (SEAM, DGECC, 2010).

In addition to the protected areas mentioned above in the study conducted by the World Database on Protected Areas (WDPA, 2017), the Department of Concepción has two other private natural reserves: Guayacán I, II and III and Arrecife. Although the department of Concepción has approximately 300,000 hectares of protected wildlife areas, both public and private, i.e. just over 15% of the total area of its territory, these are concentrated in the northern portion of the department as shown below, so there will be no interference in the protected areas due to the implementation of the PARACEL pulp mill.

Figure 465 – Map of Protected Areas.



Sistema de Coordenadas: SIRGAS 2000 - Geo
Proyección: UTM - Transversa de Mercator
Datum: SIRGAS 2000

FUENTE: Informe Nacional
"Áreas Silvestres Protegidas del Paraguay" - 2007

Subtitle

- DAA
- DIA
- IIA
- Concepción Paraguay_2002_municipios
- Paraguay_2002_rios_principales

Subtitle

UC's

- Arrecife
- Arroyo Blanco
- Banco San Miguel y Bahía de Asunción
- Bosque Yvyraty
- Caverna Kamba Hopo
- Cerrado del Río Apa
- Cerrados del Tagatiya
- Cerro Chorori
- Cerro Cora
- Cerro Koi
- Cerro Morado Caverna Ycua Pai
- Cuenca del Arroyo Tacuary Chopy Sayju
- Estero Milagro
- Estrella
- Guayacan I II III
- Humedales del Bajo Chaco
- Jukyty Guasú
- Lago Ypacarai
- Laguna Teniente Rojas Silva
- Paso Bravo
- Refugio Bilólogico Tati Yupi
- Serrania San Luis
- Tagatiya-mi
- Tapiracuai
- Tres Cerros-santa caverna-14 de Julio y Santa Caverna
- Zona Nacional de Reserva Cerro Lambare
- Ñu Guazu

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PARACEL PÖYRY

TÍTULO DEL MAPA: Protected Areas Map	
TÍTULO DEL PROYECTO: BIOTIC ENVIRONMENT - IIA	
PROCESO DE LICENCIA: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT	
TIPO DE LICENCIA: ENVIRONMENT PROCESS PERMIT	
UBICACIÓN: CONCEPCIÓN-PY	UGHRI: CIH8 Aquidaban y CIH18 Rio Pilcomayo

ESCALA:	REVISIÓN:	RESPONSABLE TÉCNICO:	CRBio Nº:
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Ramsar Convention

The Convention on Wetlands is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources. The Convention was adopted in the Iranian city of Ramsar in 1971 and entered into force in 1975. Since then, almost 90% of the UN member states, from all geographic regions of the world, have agreed to become "Contracting Parties", and it was ratified by Paraguay by Law 350/94 of February 2 (Dominguez, 2015).

This convention gives member countries the responsibility to develop and implement a plan to promote the conservation of wetlands included in the list of international importance and beyond the wise use of all wetlands in their territory. In this sense, it certifies the creation of nature reserves with the corresponding measures for their custody. In addition, the signatories are charged with promoting research and the exchange of data and publications related to wetlands and their fauna and flora (RAMSAR 2006 apud Domínguez, 2015).

Paraguay currently has 6 sites designated as Wetlands of International Importance (Ramsar sites), covering an area of 785,970 hectares (https://www.ramsar.org/wetland/paraguay):

Negro River (Ramsar nº. 729)

Located at 19°52'S and 58°34'W, on the border between Bolivia and Brazil, with a surface area of 370,000 ha it represents a river system of lakes and course located in an ecotone resulting from the confluence of three biogeographic provinces with a representative fauna.

Chaco Lodge Lagoon (Ramsar nº. 1330)

Located in Presidente Hayes, at 22°17'S and 59°18'W, it is a private reserve with 2,500 hectares of surface area. The Chaco Lodge is a salt water lake with marked level fluctuations, surrounded by xerophilic forests and bushes and halophilic vegetation, frequented by many species of birds.

Teniente Rojas Silva Lagoon (Ramsar nº. 1390)

Located in Boquerón at 22°38'S and 59°03'W, it is a private reserve with 8,470 ha of surface area. It occupies part of the basin of the South Yakaré stream in the Paraguayan Chaco, and this lake alternates between fresh and salt water conditions.

Tifunque (Ramsar nº. 730)

Located in Presidente Hayes, at coordinates 24°15'S and 59°30'W, it is a National Park with a surface area of 280,000 ha, which includes an alluvial plain along the Pilcomayo River, flooded most of the year and characterized by patches of forest, extensive grouped lakes and palm tree savannahs.

Estero Milagro (Ramsar nº. 731)

Located in San Pedro at 23°34'S and 57°22'W, it is a National Park with a surface area of 25,000 ha. The area is characterized by natural pastures, low forests, savannahs and gallery forests, swamps, small marshes and a great diversity of plant species. The site provides an important aquatic habitat for migratory birds and other animals associated with aquatic environments, as well as a habitat for the survival of several rare species and threatened plant species.

Ypoá Lake (Ramsar nº. 728)

Located in Paraguari, Ñeembucú, Central in the coordinates 26°30'S and 57°33'W, it is a National Park with 100.000 ha of surface. It is an area of extensive, shallow, grouped lakes (esterales) with mats of floating vegetation, some of which support small trees and fauna. The marshes are interspersed with wooded islands, savannas, rocky areas and streams. This site provides excellent habitat for wildlife and is one of the most important aquatic environments in Paraguay, important for several endangered species, migratory birds and five threatened plant species.

Although Paraguay has the six Wetlands of International Importance mentioned above, no Ramsar areas have been identified in the project's areas of influence.

Figure 466 – Map of Ramsar areas in Paraguay. Source: Ramsar Sites Information Service (Available at: https://rsis.ramsar.org/).

Priority Conservation Areas

According to MADES/DGPCB (2019), information from the studies: Priority Areas for Conservation in the Eastern Region of Paraguay by the Centro de Datos para la Conservación - CDC (1990) and the Project "Priority Areas for Conservation in Five Ecoregions of South America", Project GEF/1010-00-14, was used to define priority conservation sites.

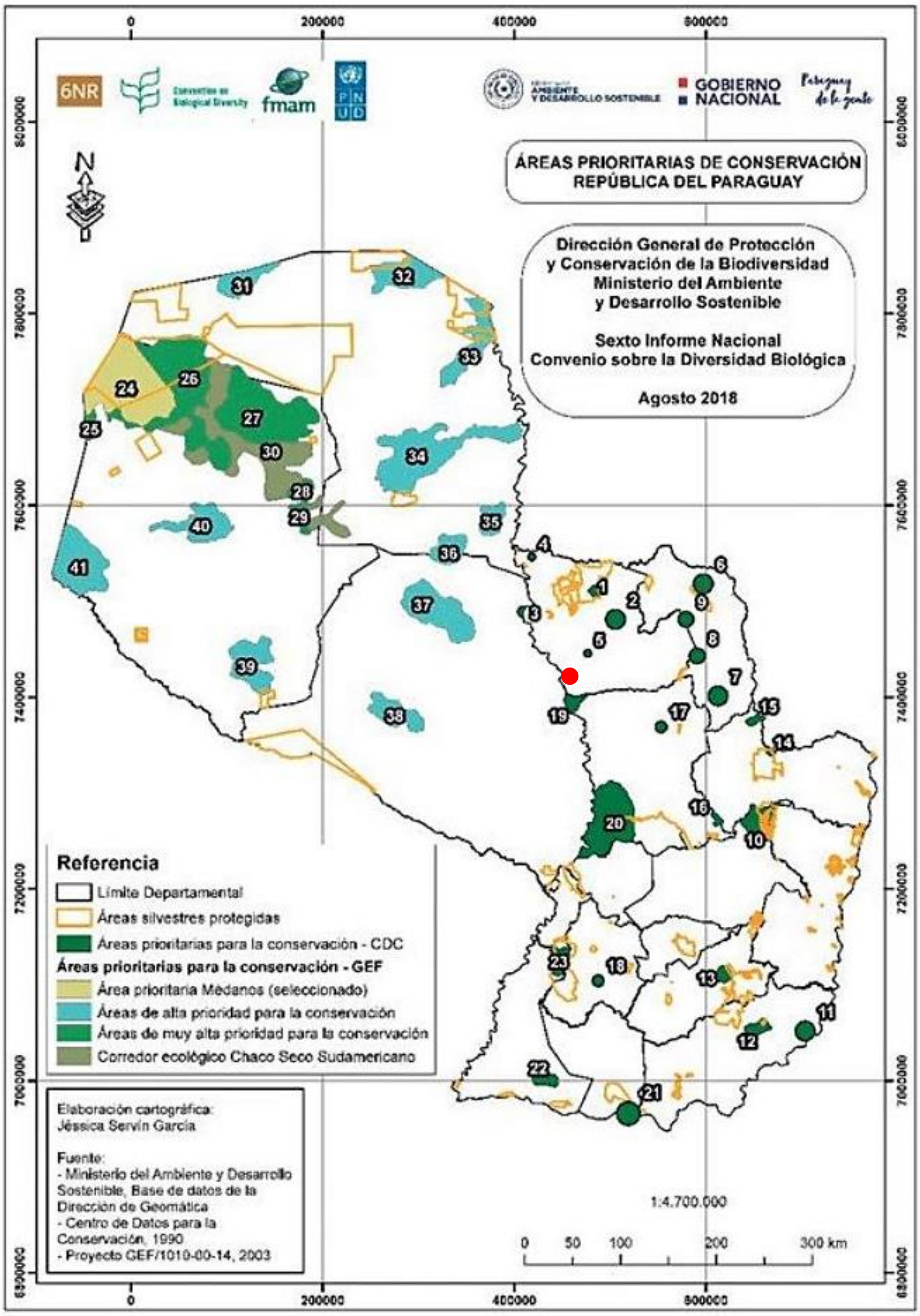

Figure 467 – Map of Priority Conservation Areas (2018). Source: MADES/DGPCB (2019). In red is the location of the PARACEL pulp mill.

Many of the priority areas for conservation identified in the above-mentioned studies overlap with existing protected wildlife areas - ASPs, however, in the eastern region 23 priority areas were identified that had the following characteristics: they were threatened, represented perhaps the last remaining characteristic in a virgin state of the representative ecosystems of each ecoregion, and needed more detailed scientific research. Of these 23 areas, the first five in order of priority are Mbaracayú, Bosque Arary, Cerro Guazú, Serranía San Luis and Serranía San Rafael.

In the western region, 18 priority areas were identified, which were subdivided into high and very high priority areas for conservation and two areas corresponding to the Médanos and the Chaco ecological corridor of South America. This classification took into account ecological and landscape criteria, combined with anthropogenic pressure factors and existing protected areas, and was carried out by means of a GAP analysis, which according to the CBD (Convention on Biological Diversity) is an evaluation of the degree to which a system of protected areas meets the protection objectives established by a nation or region to represent its biological diversity. High priority conservation areas have high diversity, endemism and globally important energy resources distributed over a large part of the proposed territory, as well as a high representation of highly threatened taxons and species.

The high conservation priority areas are important because of the concentration of threatened species according to IUCN, biological diversity, scenic beauty and the presence of migratory birds on Appendices I and II of the Convention on Migratory Species.

Although 41 priority conservation areas have been identified in Paraguay, these are not in the areas of influence of the PARACEL pulp mill.

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