Chapter 8
Islands of Forests Among Savannas: Key Elements for Conservation and Production in the Paraguayan Humid Chaco

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Abstract This chapter provides information on islands of forests immersed in flood-prone savannah-dominated landscapes for biodiversity conservation and productive activities. Our study area in the Paraguayan Chaco is in a region dedicated to low intensity cattle rearing, with native grasslands as forage within a mosaic of natural plant formations. The region is highly diverse due to the variety of plant formations and the great amount of wild fauna. We present results of research projects conducted by the American Chaco Research Center, a Paraguayan research initiative. These results suggest that extensive or semi-extensive ecosystem-based livestock production could be an opportunity to maintain ecosystem services, including biodiversity, in the region via a production system that is highly compatible with the conservation of forest species. Adverse environmental conditions for production (such as floods from rain and periodic floods of the Paraguay River) underscore the importance of maintaining the regulating functions of natural ecosystems, which leads to an opportunity for the conservation of threatened biodiversity. The mosaic of forest islands, flood-prone palm savannas, and wetlands is fundamental for water quality and hydrological regulation as it reduces the intensity of the effects of flooding on neighboring areas, as well as for carbon sequestration. Inclusion of live fencing and the maintenance of continuous areas of intact or lightly disturbed vegetation can increase habitat connectivity, provide a barrier to manage fires, and serve as a refuge for animals when fires occur. These native ecosystems are at high risk of disappearing due to the intensification of agriculture and livestock production, as well as the expansion of urban areas, so strategies for their conservation, including tailor-made incentives are needed.

Keywords Biodiversity conservation · Ecosystem services · Floodable forest · Habitat connectivity · Livestock farming · Wildlife

8.1 Introduction

8.1.1 Forests as Islands Immersed in Flood-Prone Savannas

This chapter describes the relevance of forest islands as part of a mosaic of savannas, palm groves and wetlands (an image of the study area is shown in Fig. 8.1). The presence of any of these formations is determined mainly by the geomorphology of its terrain. The landscape includes plains and depressions where water settles for different periods of time according to weather conditions (Mereles et al. 2020a). Wetlands occupy the lowest areas, generally with permanent waters where species linked to water develop with different life forms: floating, submerged (free or not) and rooted in the mud of the bottom. Some of the plant species recorded in the wetlands of the study area are *Cyperus giganteus, Typha domingensis* and *Sagittaria montevidensis*, with *Cyperus giganteus* being the most abundant and frequent (Macedo 2018). Palm groves are monotypical formations that can flood frequently.

Fig. 8.1 Image of the study site in the Humid Chaco ecoregion. Dense forest island immersed in extensive savannas. (Photo: Gianfranco Mancusi)

The characteristic species is the native palm locally known as Karanday (*Copernicia alba*), accompanied by a rich herbaceous stratum, whose density varies according to the presence of water (Mereles and Rodas 2014; Mereles et al. 2013).

The landscape consists of dense forest islands immersed in savannas, palm groves and wetlands, resulting in different forest types: Dense Subtropical Forest, which occurs naturally on islands associated with palm groves in the floodplain of the Paraguay River (Pérez de Molas 2015); Dense Mesoxerophytic Forest, with Red Quebracho (*Schinopsis balansae*) being the dominant tree species (Mereles et al. 2020a); and Riparian Forest, which develops adjacent to the riverbeds forming strips 50–100 meters wide (Maturo et al. 2005; Peña-Chocarro et al. 2006). Main arboreal tree species found in the area are shown in Table 8.1.

This chapter is based on field studies that were conducted in rangelands located on the right bank of the Paraguay River (Fig. 8.2), where average rainfall is 1200 mm/year and the average temperature is 24 °C (Mereles et al. 2013). During some years, with the occurrence of the El Niño phenomenon, intense rainfall causes generalized flooding. In other years, drought is accentuated and prolonged (Ginzburg and Adámoli 2006; Junk et al. 2013). The study site itself has experienced both of these extremes (most recently in 2015 and 2019): over half of its surface area remained flooded during one part of the year and then suffered an extreme drought in the same year. The pulsing water-level in the rainy season and the pronounced dry and wet periods create an aquatic-terrestrial transition zone where important ecological processes occur (Mereles et al. 2020b). Most of the studies were conducted in nearby ranches, which are located within the Key Biodiversity Area 22 La Rafaela (Cartes and Clay 2009), and which have been identified as potential birding tour areas (Mamede et al. 2019) and as important corridors for connectivity of the Great American Chaco (Mereles et al. 2020b).

Table 8.1 Forest types and tree species recorded in dense forest islands of the study area

Forest type	Tree species	Source
Dense subtropical forest	*Peltophorum dubium, Enterolobium contortisiliquum, Ficus enormis, Ocotea diospyrifolia, Sapium haematospermum, Gleditzia amorphoides, Guazuma ulmifolia, Chloroleucon tenuiflorum, Handroanthus heptaphyllus, Syagrus romanzoffiana, Copernicia alba.*	El Raiss (2014)
Dense mesoxerophytic forest	*Schinopsis balansae, Rollinia emarginata, Aspidosperma quebracho blanco, Forsteronia sp., Tabernaemontana catharinensis, Syagrus romanzoffiana, Acrocomia aculeata, Copernicia alba, Tabebuia nodosa, Handroanthus heptaphyllus, Tabebuia aurea, Cordia americana, Carica papaya, Cecropia pachystachya, Celtis sp., Terminalia triflora, Sapium longifolium, Gleditsia amorphoides, Parapiptadenia rigida, Albizia niopoides, Enterolobium contortosiliquum, Prosopis affinis, Inga uraguensis, Peltophorum dubium, Copaifera langsdorfii, Pterogyne nitens, Vitex megapotamica, Ocotea diospyrifolia, Trichilia catigua, Trichilia pallida, Maclura tinctoria, Sorocea sprucei, Psidium guajava, Myrcianthes pungens, Genipa americana, Calycophyllum multiflorum, Zanthoxylum petiolare, Zanthoxylum riedelianum, Casearia sylvestris, Diplokeleba floribunda, Sapindus saponaria, Chrysophyllum marginatum, Guazuma ulmifolia, Seguieria paraguayensis, Ruprechtia laxiflora, Phyllostylon rhamnoides.*	Lubián (2014)
Riparian forest	*Ocotea diospyrifolia, Lonchocarpus sp., Terminalia triflora, Celtis sp., Peltophorum dubium, Nectandra angustifolia, Copernicia alba, Guazuma ulmifolia, Zanthoxylum petiolare, Machaonia spinosa, Xylosma venosa, Inga uraguensis,Vitex sp., Genipa americana, Pouteria glomerata, Albizia inundata, Chrysophyllum gonogocarpum, Zigia sp., Vitex megapotamica, Chrysophyllum marginatum, Enterolobium contortisiliquum, Sorocea sprucei, Myrsine sp.*	Macedo (2018)

The chapter begins with a description of the study site explaining why these forests exist as islands immersed in flood-prone savannas. The next part focuses on ecosystem services such as carbon sequestration and water quality and describes the native fauna housed within the forest islands and surroundings. In the following sections, we present information about the role that these biodiversity islands play in functional connectivity and as fire-breaks in the savanna. Finally, we emphasize the benefits of forest islands to cattle ranching in native grasslands and the challenges for their conservation.

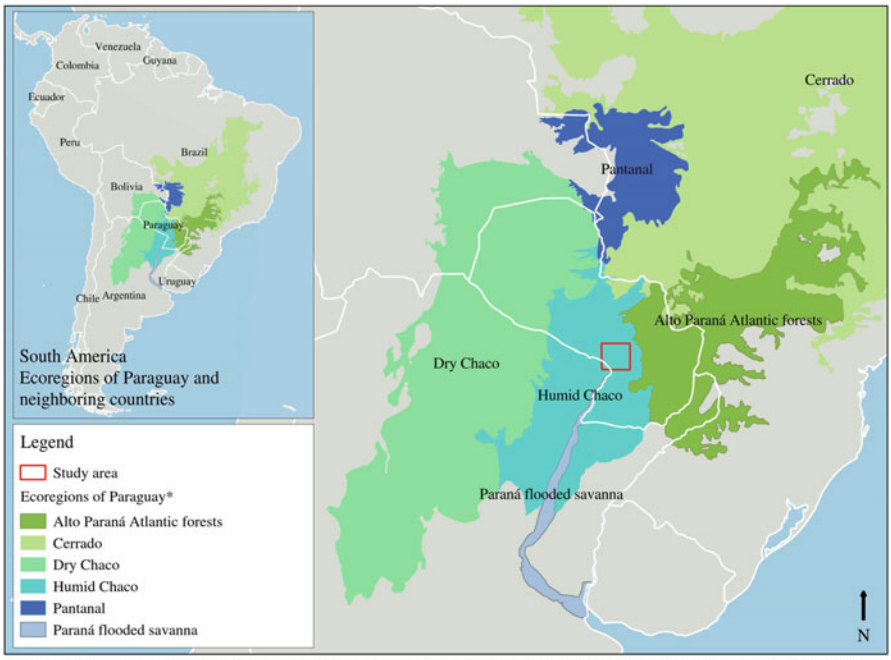

Fig. 8.2 Study site in the Humid Chaco ecoregion. Landscape is dominated by naturally occurring savannas, palm groves, wetlands and dense forests

8.2 Ecosystem Services Evaluated in the Study Site

8.2.1 Carbon Sequestration and Water Quality

Measurements of carbon storage were made in the dense forest islands, in the surrounding savannas and palm groves, and in the wetland soils. Lubián (2014) determined 254 tons of CO_2e/ha in the forest and 24.5 tons of CO_2e/ha in the palm groves and grasslands. Another evaluation focusing on the forest islands (Boródn 2015) calculated 175.8 tons CO_2e/ha (following IPCC 2005 report) and 291 tons CO_2e/ha (following Sato et al. 2014 equation) for the aboveground biomass, and 103.9 tons/ha for forest carbon soil. For wetland soil, Brun (2013) reported average values of 3.15 tons of CO_2/ha.

Wetlands are among the most productive primary ecosystems on the planet, depending on the hydrological regime, i.e., how often they are flooded and how long they remain flooded (Kandus et al. 2010). Water originates in the lowest areas, between savannas, marshlands and swamps with high productivity of the herbaceous stratum (Benzaquen et al. 2017). The herbaceous cover of the wetlands decreases water speed and facilitates the sedimentation and retention of suspended materials, thus improving water quality (Kandus et al. 2010). Wetlands of the study area were

of 'good' qualitative conservation status according to the ECELS index[1] evaluated by Ferreira (2018) and Brun (2013). In addition, exploratory analysis of water quality (including pH, Electrical Conductivity, Suspended Solids, Nitrate, Total Phosphorus, Total Nitrogen, Chloride, Sulphate, Biochemical Oxygen Demand, Chemical Oxygen Demand, Coliforms and water temperature) found no relevant pollution in wetlands and rivers of the study area, except for specific sites where the flow decreased in the dry season (Chaparro 2014, PINV 15-143 2018).

In addition to maintaining water quality, the mosaic of forest islands, flood-prone palm savannas and wetlands is fundamental for hydrological regulation as it reduces the intensity of the effects of flooding on neighboring areas. Although these ecosystems do not prevent flooding, they reduce the river's flood peaks, retain excess runoff after rainfall and release it slowly afterwards, and encourage aquifer recharge (Kandus et al. 2010).

8.2.2 Wildlife Housed in the Forest Islands and Surroundings

The study of amphibians, reptiles, mammals, and birds was carried out inside of the different forest islands (FI) and surrounding savannas (S), palm groves (PG) and wetlands (W) through different sampling methods.

Amphibian surveys were made using three different sampling techniques, as these vary in their effectiveness depending on intrinsic species characteristics (Ali et al. 2018). The three sampling methods used from August 2017 to June 2018 were visual encounter surveys (Crump and Scott 1994), pitfall traps with drift fences (Corn 1994) and PVC pipes of 40 mm of diameter as refuge for tree frog species (Boughton et al. 2000).

All together we registered 2449 individuals corresponding to 29 species included in the families: Bufonidae, Hylidae, Leptodactylidae, Phyllomedusidae, Microhylidae and Odontophrynidae, which represent 48% of all the species registered in the Humid Chaco ecoregion (Brusquetti and Lavilla 2006; Frost 2020). Some of these species are shown in Fig. 8.3. Regarding their conservation status, all species found are categorized as Least Concern (LC) at international (IUCN 2019) and national levels (Motte et al. 2019), except for the Rio Grande Dwarf Frog (*Physalaemus riograndensis*) (Motte et al. 2019). This species is considered to be in the data deficient category (DD) at the national level due to its scarce records (Table 8.2), which are mostly from the southern region of the country (Brusquetti and Lavilla 2006; Motte et al. 2019; Frost 2020). In addition, we obtained the first departmental record for the White spotted Humming frog (*Chiasmocleis albopunctata*),

[1] ECELS (Estado de Conservación de Ecosistemas Lénticos Someros Index) is a methodological tool used to determine the ecological status of wetlands, which was developed by Agencia Catalana del Agua (ACA 2004).

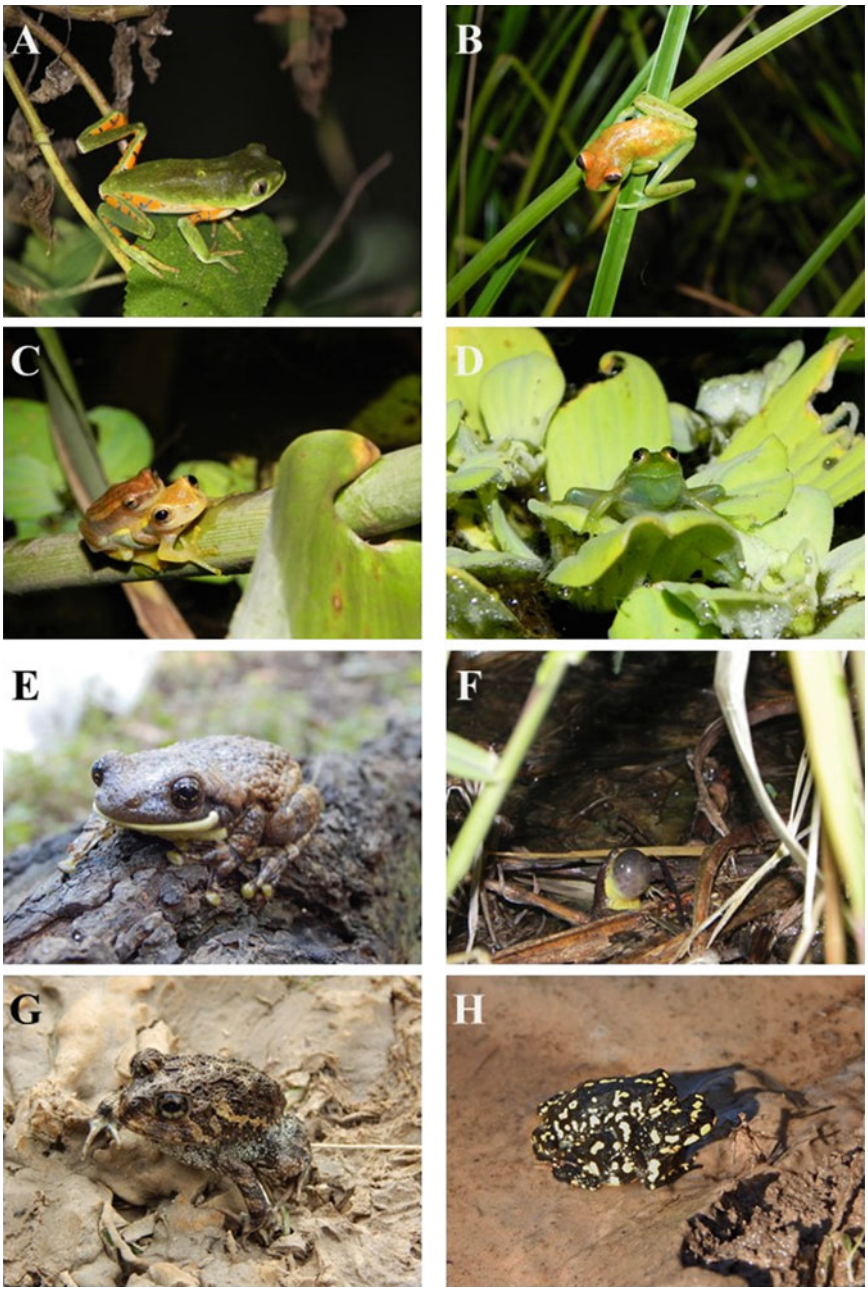

Fig. 8.3 Amphibian species registered at the study area. A. Monkey frog (*Pithecopus azureus*). B. Polka-dot Tree Frog (*Boana punctata*). C. Male (on the top) and female of Dwarf tree-frog (*Dendropsophus nanus*). D. Uruguay Arlequin Frog (*Lysapsus limellum*). E. White lipped-tree frog (*Trachycephalus typhonius*). F. Two colored Oval frogs (*Elachistocleis bicolor*). G. Common

a rare species mainly due to its fossorial habits,[2] size and mimetic coloration. Only one individual was registered during the study time frame through the pitfall trap method. Nevertheless, the record is interesting since it extends the distribution range of the species 57 km northwest from the nearest locality at the Surubi'i Urbanization, Central Department (Aquino et al. 2004; Brusquetti and Netto 2008).

Through pitfall traps, visual encounter surveys and camera traps, we registered a total of 12 reptile species including snakes, lizards of the families Tupinambidae and Teiidae, and the Jacare caiman (*Caiman yacare*). Individuals of Jacare caiman were actively searched for at night, and we found them mostly isolated and using different water body types, including cattle ponds. When isolated sections of the wetlands were searched, we found juvenile aggregations along with adults, which indicates a preference in habitat use and reproductive success. Further research will improve our knowledge about the species habitat use, reproductive sites and its estimated density in the area, which harbors great potential for reproduction and conservation of Jacare caiman. Another great lizard found was the Black-and-white Tegu (*Salvator merianae*), which was recorded frequently with camera traps.

Fifteen mammal species were registered using camera traps that were placed in different types of environments in the area for three years. We obtained records of species categorized as vulnerable at the national level (APM and SEAM 2017), mainly as a consequence of fragmentation and habitat conversion associated with agricultural and livestock activities, illegal hunting, and road run overs, among others (Table 8.2). We found the Giant anteater (*Myrmecophaga tridactyla*) and even the Maned wolf (*Chrysocyon brachyurus*), which is typically an elusive species (Mujica 2014). Furthermore, we obtained records of Puma (*Puma concolor*) through camera traps. Although this species is categorized as least concern (APM and SEAM 2017), it still has conservation problems and its populations are decreasing (Nielsen et al. 2015). The Azara's night monkey (*Aotus azarae*), the Black and Gold howler monkey (*Alouatta caraya*) and the four-eyed gray opossum (*Philander opossum*) were also registered through night sightings. Presence of Jaguar (*Panthera onca*) was confirmed with camera traps on November 2020, after this chapter closed edition. Some of the registered mammal species are shown in Fig. 8.4.

The Humid Chaco harbors more than 430 species of birds, which represents ~60% of the avifauna of Paraguay (Del Castillo 2019). Specifically, in the Key Biodiversity Area 22 La Rafaela and nearby ranches, numerous census and surveys have been carried out by several ornithologists and researchers throughout the last decades. We compiled records obtained during the 2000–2020 period from available

Fig. 8.3 (continued) Lesser Escuerzo (*Odontoprhynus americanus*). H. Klappenbachmmmmms Red-bellied Toad (*Melanophryniscus klappenbachi*) in amplexus. (Photographs: A - D, F: A. Caballero-Gini. E, G, H: M. Ferreira)

[2] Species that are adapted to digging and living in burrows.

Table 8.2 Fauna species of national and global conservation concern, with details of habitat and breeding status

Class	Common name	Scientific name	Habitat and ecology	Conservation status Paraguay	Conservation status IUCN	Breeding status
Amphibia	Rio Grande dwarf frog	*Physalaemus riograndensis*	S	DD	LC	–
Birds	Greater Rhea	*Rhea americana*	FI, S, PG	–	NT	BR
	Bare-faced curassow	*Crax fasciolata*	FI	Threatened	VU	BR
	Turquoise-fronted parrot	*Amazona aestiva*	FI, S, PG	–	NT	BR
	Bearded Tachuri	*Polystictus pectoralis*	S, PG	Threatened	NT	BR
	Sharp-tailed tyrant	*Culicivora caudacuta*	S	Endangered	VU	BR
	Dinellimmmmms Doradito	*Pseudocolopteryx dinelliana*	W	–	NT	AM
	Strange-tailed tyrant	*Alectrurus risora*	S	Endangered	VU	BR
	Dark-throated seedeater	*Sporophila ruficollis*	S	–	NT	BN, AM
	Rufous-rumped seedeater	*Sporophila hypochroma*	S	–	NT	BN, AM
Mammalia	Giant anteater	*Myrmecophaga tridactyla*	FI, W	Threatened	VU	–
	Maned wolf	*Chrysocyon brachyurus*	S, PG	Threatened	NT	–
	Neotropical otter	*Lontra longicaudis*	W	Least concern	NT	–
	Azarammmmms agouti	*Dasyprocta azarae*	FI	Least concern	DD	–

Habitat and ecology: S, Savannas; FI, Forest islands; PG, Palm groves; W, Wetlands
Conservation status Paraguay (APM and SEAM 2017; MADES 2019; Motte et al. 2019): Threatened, "*Amenazada de extinción*"; Endangered, "*En peligro de extinción*"; DD, Data Deficient
Conservation status IUCN (IUCN 2019): LC, Least Concern; NT, Near Threatened; VU, Vulnerable; DD, Data Deficient
Breeding status (Guyra Paraguay 2004): BR, Breeding permanent resident; BN, Breeding resident but northern austral migrant; AM, Austral migrant

Fig. 8.4 Mammals registered in the Humid Chaco (Paraguay) through camera traps and visual encounters. A. Giant anteater (*Myrmecophaga tridactyla*) carrying its cub. B. Gray Brocket (*Mazama gouazoubira*). C. Puma (*Puma concolor*). D. Lesser Capybara (*Hydrochoerus hydrochaeris)*. E. Collared peccary (*Pecari tajacu*). F. Neotropical otter (*Lontra longicaudis*). G. South American Coati (*Nasua nasua*). H. Gold howler monkey (*Alouatta caraya*). (Photographs: A - G: camera traps installed during 2017 to 2018. H: K. Musalem)

data in the eBird online platform (eBird 2020a, b), Guyra Paraguay's Biodiversity Database (www.guyra.org.py) and personal checklists, obtaining a total of 249 species included in 51 families, which represents 35% of the species of Paraguay and 58% of the species registered at the Humid Chaco ecoregion.

Habitat preferences of these species, based on our records in the area, have been identified for four main ecosystems: forest islands (FI), savannas (S), palm groves (PG) and wetlands (W). A total of 125 species (51% of the total species of the area) use FI as one of their habitats, and 82 species (33%) depend mainly on this habitat.

Nine bird species are globally threatened or near threatened (IUCN 2019), four of which are also nationally threatened or endangered (MADES 2019). Bare-faced curassow (*Crax fasciolata*), Sharp-tailed tyrant (*Culicivora caudacuta*) and Strange-tailed tyrant (*Alectrurus risora*) are categorized as Vulnerable (IUCN 2019), and the former depends strictly on forest island habitats in the area (Table 8.2). At the national level, the Bare-faced curassow and the Bearded tachuri (*Polystictus pectoralis*) are categorized as Threatened species, while the Sharp-tailed and Strange-tailed tyrant are Endangered species. Moreover, four species are endemic of the Chaco (Guyra Paraguay 2004): Chaco chachalaca (*Ortalis canicollis*), Cream-backed woodpecker (*Campephilus leucopogon*), Dinelli's doradito (*Pseudocolapterix dinelliana*) and Black-capped warbling-finch (*Microspingus melanoleucus*). Forty-one species are migratory. Six of those are austral migrants, found mainly during austral winter. Twenty-two are northern austral migrants, which breed in Paraguay but are less abundant or absent during the winter. Seven are southern austral migrants, breeding also in Paraguay, but increasing in numbers during the winter. Some bird species observed in the study area are shown in Fig. 8.5.

8.3 Role of Biodiversity Islands in Functional Connectivity at Local and Regional Levels

At a regional level, a recent study identified our study area as part of priority biological corridors relevant for connectivity of the Great American Chaco, an ecoregion that extends through Paraguay, Argentina and Bolivia (Mereles et al. 2020b). The study highlights the importance of biological corridors to maintain a long-term vision of biodiversity, which maintains the connection between key areas for conservation. Loss of continuous areas can lead to changes in the structure and function of the remaining fragments (Lindenmayer and Fischer 2006). One of the problems caused by habitat reduction and fragmentation is a contraction in population size, along with increases in inbreeding and the consequent decrease of genetic diversity (Shaffer 1990).

Although there is considerable uncertainty regarding how fast species respond to habitat loss, and how time-delayed responses vary in space (Semper-Pascual et al. 2018), we found evidence linked to population reduction sizes and fragmentation of

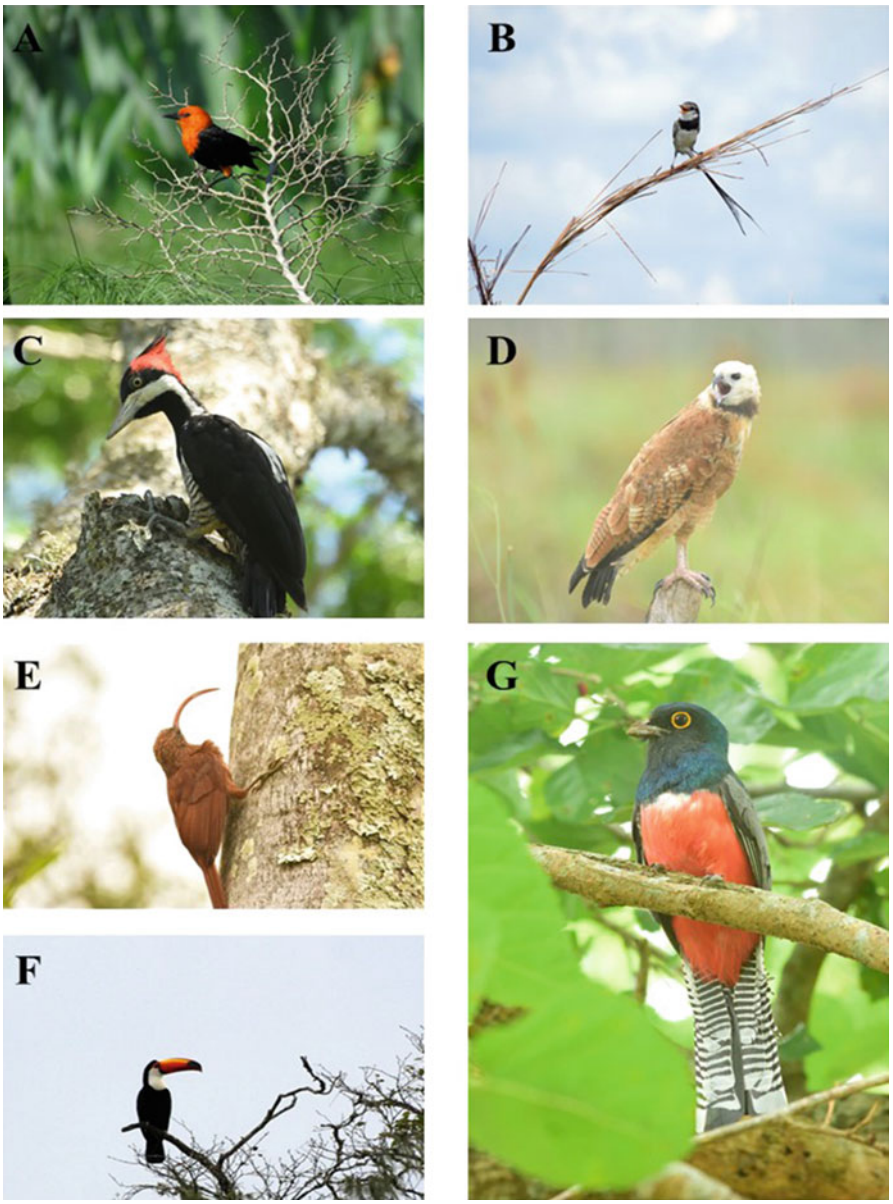

Fig. 8.5 Birds registered in the Humid Chaco, Paraguay. A. Scarlet-headed Blackbird (*Amblyramphus holosericeus*). B. Strange-tailed Tyrant (*Alectrurus risora*). C. Crimson-crested Woodpecker (*Campephilus melanoleucos*). D. Black-collared Hawk (*Busarellus nigricollis*). E. Red-billed Scythebill (*Campylorhamphus trochilirostris*). F. Toco toucan (*Ramphastos toco*). G. Blue-crowned Trogon (*Trogon curucui*). (Photographs: A - B: N. Cantero. C - E, G: A. Esquivel. F: A. Merenciano)

habitat at Chaco and other regions (e.g., Gómez Fernández et al. 2016; Crooks et al. 2017; Zastavniouk et al. 2017; Pereyra et al. 2019). For example, according to Rodrigues et al. (2008), the main causes of decline of the Giant anteater populations are the reduction, deterioration and fragmentation of habitats. Habitat loss may lead to a decrease in population size and isolation among remnant populations. In this sense, Collevatti et al. (2007) warned that the population of *Myrmecophaga tridactyla* in Emas National Park (Brazil) has a low level of genetic diversity and a high level of inbreeding.

The Paraguayan Chaco is undoubtedly highly diverse due to the variety of plant formations and the great amount of wild fauna that remains (Mereles et al. 2020b). At a local level, the Humid Chaco ecoregion borders the Dry Chaco and the Pantanal to the North, and the Cerrado and the Alto Paraná Atlantic Forest to the Southeast (Rumbo 2010), therefore, the conservation of native ecosystems could benefit the fauna exchange with the other four ecoregions present in Paraguay. In both Humid Chaco and Pantanal ecoregions, the wooded formations of *Schinopsis balansae*, an emblematic tree species with a high content of natural tannins, are also found. These vegetation types constitute one of the most diverse ecotonal formations in the Great Chaco, where plant species converge from the Atlantic Forest, the Cerrado, the Amazon and the Dry Chaco, among others (Mereles et al. 2020b).

In the study site, El Raiss (2014) examined the functional connectivity of forest islands for the Black-and-gold Howler Monkey (*Alouatta caraya*) within the native silvopastoral system (i.e., the cow-calf system where animals graze on savannas and are interspersed with mixed native forests). The author's findings show an Equivalent Connected Area (ECA) of 79%, indicating a good connectivity condition of forest islands in the landscape. The author also points out that 10 to 15% removal of forest islets would drastically affect this connectivity due to this species' dependence on forest islets. Thus, the study concluded that the current production system is highly compatible with the conservation of this species.

In addition, the inclusion of live fencing, which is not a common practice in the region, can increase habitat connectivity. The maintenance of continuous areas of intact or lightly disturbed vegetation is a priority issue to consider in conservation policies.

8.4 Forest Islands as Fire-Breaks in the Savanna

Fires are a normal and frequent event that occur in flooded savannas around the world (Whelan 2006). For example, in South Africa, fire is considered a natural factor in the development and maintenance of the vegetation of the Kruger National Park (Govender et al. 2012). At the regional scale, Silveira et al. (1999) recommend a fire management program to minimize the danger of uncontrolled fires, using controlled burns on a rotational basis in different sections of the Emas National Park in Brazil. The program was also meant to improve the availability of food for herbivores and control the spread of alien grass species.

In addition to flooding, fire is a main agent of disturbance in the Chaco. According to Morello et al. (2009), floods put pressure on ecosystems with equal intensity as the fires. Fire is an ecological component in the vegetation distribution of the Humid Chaco, due to the high productivity of the herbaceous stratum during the wet season and the insufficient number of herbivores to assimilate all the production (Herrera et al. 2003). Fire consumes plant production that is not consumed by herbivores and other foraging species (such as ants) and re-opens space for growth. Extensive fires are provoked by natural causes such as electric storms or by anthropogenic burning during the management of pastures and forests (Ginzburg and Adámoli 2006; Benzaquen et al. 2017). In almost all of the world's natural savannas, the frequency of spontaneous fires is increased by human action and its effects can influence the existing balance in the natural vegetation (Whelan 2006).

Fire is used as a management tool in livestock production in savannas. After burning, the herbaceous stratum reaches a higher concentration of nitrogen and protein in the regrowth (Ginzburg and Adámoli 2006), and lignified grasses are eliminated, thereby stimulating the growth of native grasses, which are more palatable for cattle (López-Hernández and Hernández Valencia 2009). Inadequate fire management during pasture burning and the lack of regulation of the livestock load (such as intensity and frequency of grazing), lead to significant incidence of forest fires (Galindo et al. 2009). Inappropriate fire regimes threaten biodiversity conservation because high-intensity fires kill plants and animals and change the landscape for years, decades, or even centuries in some natural communities (Whelan 2006). Therefore, the conservation of forest islands in landscapes such as the Humid Chaco is of utmost importance as a barrier to manage fires that may get out of control. The islands of vegetation serve as a refuge for animals when fires occur (Silveira et al. 1999). In addition to the maintenance of forest islands immersed in savannas, controlled grazing is also proposed as a fire prevention measure (Ruiz-Mirazo et al. 2007).

8.5 Benefits of Forest Islands to Cattle Ranching in Native Grasslands

The farms located in the study area are usually dedicated to cattle raising, with a calving percentage[3] of 50% in cows and 80% in heifers, and weaned calves between six and eight months of age having a live weight of 130 to 150 kg. The stocking rate is 0.5 animal unit (of 400 kg) per ha, which is relatively low because it considers the possibility of flooding or drought, though it may increase during spring and summer in the crucial period of the birth of calves (Laino et al. 2017). Some ranches spare land purposely (as reserves, with no grazing animals) to avoid losing control of the

[3] Calving percentage (*porcentaje de parición*) is the percentage of females that give birth to calves from the total of cows/heifers serviced by bulls.

herd in difficult terrain or as a buffer area to avoid thefts, however no estimation is available of this practice.

Lubián (2014) determined the existence of a variety of native grasses that produce between 973 and 3612 kg of dry grass ha^{-1} $year^{-1}$ in the study site, the most palatable being Clavel grass (*Hemarthria altissima*) and *Kapií-pytá* (*Andropogon lateralis*). Extensive cattle production is based mainly on three factors: the natural supply of grasses for cattle feed, the availability of water and its accumulation in savannas, and the presence of dense forest islands immersed in savannas, palm groves and wetlands in the study area. The forest islands play a role in livestock breeding since they provide shelter for animals during floods and in extreme conditions of heat (up to 50 °C) in summer and cold (−3 °C) weather in winter. In addition, management of forests, with occasional extractions of wood for corrals, cattle ponds,[4] fences and bridges, allows savings of up to 40% of infrastructure costs in a productive unit. These savings would not be possible if forests were converted to exotic pastures (Laino et al. 2017).

The combination of these three factors - natural grasses, water and forest islands - has allowed extensive livestock farming in the context of climate change adaptation. At the same time, frequent floods and droughts lead the farmer to seek economic stability at the producer level due to low and unstable profits (Laino et al. 2017). At this intersection of climate adaptation and the consequent search for economic viability, land use change happens through the clearing of forests for planting exotic pastures of high yield, which maximizes economic production, but constitutes a risk for conservation in the region.

8.6 Challenges for Conservation of Forests Islands in the Chaco Region of Paraguay

Ecosystem degradation in the Chaco is occurring at the regional level (WWF 2016). From 2012 to 2018, a total of 2,925,030 ha experienced land use change in the South American Great Chaco, according to data from the land use change monitoring carried out by the NGO Guyra Paraguay. The work demonstrates the gradual degree of modification of the Great Chaco ecoregion, which until recently comprised one of the largest natural areas in the world (Guyra Paraguay 2018). These studies are almost entirely based on monitoring of deforestation of dense forests, but no studies focus on savannas or open landscapes. In particular, the farms included in this chapter are at higher risk of deforestation because of their proximity to urban areas and also due to illegal extraction of trees by intruders during high floods when farms can be accessed by boat.

The South American Great Chaco is not only being affected by a very intense process of deforestation, but is also suffering a loss of natural grasslands, both on

[4]These are "tajamares" or ponds that have been dug out for rain water collection.

higher land and in wetlands, with a rate of disappearance even higher than that of the forests (Bucher 2016). In most tropical and subtropical biomes, conservation strategies are mainly focused on the preservation of forests, but savanna ecoregions and open habitats deserve conservation attention as well (Grau et al. 2015). Many South American countries have no specific wetland management programs. In areas with low population density and without agro-industrial activities, wetlands are less impacted (Junk et al. 2013). The complex interactions between biophysical and socioeconomic processes that drive the trends of Chaco natural grasslands represent a major scientific challenge to preserve this shrinking environment and its valuable biodiversity (Grau et al. 2015).

Although many variables can affect the impact of livestock practices on ecosystems, low intensity cattle ranching, with low densities of cattle on native pastures (savannas) and conserved forest islands, could be beneficial for the survival of the wild fauna that still remains. The presence of cattle consuming the high herbaceous productivity could be a key factor in avoiding extensive fires. This in turn also contributes to maintaining wetlands and associated riparian forests in the region, which serve as natural refuges for wildlife.

The high relative abundance of aquatic animal species increases the conservation value of the Paraguayan Humid Chaco, even though there are no endemic fauna species (Mereles et al. 2013). Despite its high biodiversity, the Humid Chaco does not have enough protected areas (Caballero-Gini et al. 2020). Thus, cattle ranchers of the study area play an important role in the conservation of species at the local level, since its livestock activities allow the coexistence of wild native and domesticated exotic species.

The vast majority of wild protected areas of the Paraguayan Chaco are located in the Dry Chaco, Continental Sand Dunes and Cerrado (Mereles et al. 2020b), therefore it is crucial to highlight the importance of conserving the ecosystems of the Humid Chaco as well. In addition, as described, the ecosystems of the Humid Chaco are also important in flood mitigation, aquifer recharge and water quality improvement (Benzaquen et al. 2017). Future economic development, combining production with biodiversity conservation in a sustainable way, may be possible in the region (Mereles et al. 2020b).

This chapter has described general patterns of the richness of species of flora and fauna of the region. The aim is to highlight the value of these areas for conservation, despite being intended predominantly for economic productive activities. However, it is not clear yet if there is a deliberate intention of farmers to conserve certain natural elements, or if it is simply an unintended consequence of their management (or lack thereof). While this production-based conservation model may be interpreted as a low income generating activity by some (or perhaps even inefficient in economic terms), it may alternatively be interpreted as an opportunity for conservation motivated by non-economic reasons such as cultural, family ties, research, or appreciation of nature, or as a combination of both. Further research is needed to understand drivers for intensification and also motivations to preserve natural ecosystems in the area. However, the key message is that the type of management discussed here allows for conservation of natural elements that more intensive

economic activities may not allow. The chapter is not intended to present this production-conservation model as a substitute for the need to spare areas exclusively for biological conservation, but as a complement in the landscape.

The lack of a previous baseline of biodiversity present in the area before cattle ranching activities began (approximately 100 to 150 years ago), also limits our understanding of how cattle ranching activities have affected biodiversity in the past decades. Thus, this chapter provides only information of the current presence of fauna and flora under the existing management and makes no assumptions about the trends of the presence of the species. Comparisons through time, and especially with less intervened areas, are needed to understand the impact of the productive activity on biodiversity in the region over the long term.

8.7 Conclusion

Extensive or semi-extensive ecosystem-based livestock production could help to maintain ecosystem services in the region. The need to address adverse environmental conditions from the productive point of view, in this case floods from rain and periodic floods of the Paraguay River, could represent an opportunity for the conservation of threatened biodiversity. These native ecosystems are at high risk of disappearing due to the intensification of agriculture and livestock production, as well as the expansion of urban areas, and so strategies for their conservation, including tailored incentives, are needed.

Currently, an increase of higher yielding crops for the region are being proposed or piloted, and major roads and infrastructure are being planned or discussed locally for production of rice and other commodity crops. Dropping prices of meat in Paraguay and the poor recognition of these systems as a land sharing strategy, could in the future lead to other more profitable production systems, which could jeopardize relevant local ecosystem services such as wildlife, water quality, flood regulation, as well as global services such as carbon sequestration. Implementation of better management practices for cattle rearing, reducing taxes for sustainable farming, providing national and international incentives, increasing prices for meat produced under these environmentally friendly systems, and promoting ecotourism, among other strategies, are some of the possible solutions to promote conservation of the Humid Chaco forest islands, savannas and wetlands along with sustainable production.

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