CHAPTER 18

THE UPPER PARANÁ RIVER AND ITS FLOODPLAIN: MAIN CHARACTERISTICS AND PERSPECTIVES FOR MANAGEMENT AND CONSERVATION

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Abstract

In this chapter, we broadly described the floodplain, including geomorphological features, species richness, abiotic and functional aspects, regional and local impacts and finally, we concluded making suggestions to direct research and management of the area to guide its conservation. The last undammed stretch of the Paraná River and its remaining floodplain has two distinct surfaces: the Low Terrace and the Fluvial Plain. These create great habitat diversity in flooded areas where are included active and semi-active channels, lagoons, and elongated lowlands associated with paleochannels, and lowlands associated with the flood basin. Surveys conducted in the Upper Paraná River floodplain system since 1986, registered 2920 taxa of terrestrial and aquatic organisms. In the region, the flood pulse is still the main forcing function that regulates functioning and communities' composition and structure. Main sources of impact on the area are the current process of human occupation that has to be disrupted and dams operation upstream from the area that has to be rationalized. Important steps to disrupt human occupation were the creation of three conservation units in the region and recently its incorporation into the Atlantic Forest Biosphere Reserve. Also, it is needed intense enforcement and, mainly, a wide program of environmental education (already started) to alert people, locals and visitors, about the importance of the area, its preservation and the main regional and local sources of impacts. Alterations in the hydrological regime by operation of upstream dams (27 major dams) seem to be the most important source of impacts on the river-floodplain system, especially after the closure of the Porto Primavera Dam. Even so, the area still plays fundamental role in the maintenance of the regional biodiversity of terrestrial and aquatic organisms. It is suggested to use dam operation as a tool to benefit local and regional biodiversity, simulating floods that are beneficial for most of the organisms. However, all these actions should be discussed in a basin Committee. This Committee, with ample representation of stakeholders, should guide and prioritize actions to be taken in the floodplain.

Introduction

The Paraná River is formed by the junction of the rivers Grande and Paranaíba in south-central Brazil. It flows north-south, for about 4695 km and presents a watershed of somewhat 2.8 x 10^6 km^2, draining most of the south-central South America

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(18° to 34° S; 45° to 68° W) from the Andes to the Serra do Mar near the Atlantic Ocean, emptying in the La Plata River in Argentina. The first third part of this basin is named Upper Paraná River and most of it runs inside the Brazilian territory. This stretch has an area of 891,000 km^2 covering about 10.5% of Brazil and it is occupied by 35% of the Brazilian population. More than 50 million people live in the region, corresponding to 57 inhabitants per square kilometer. It also presents the most important industrial centers and harbors intensive agriculture.

However, the most common human interference on the region is the construction of dams that altered its landscape. Dams are found in most of the major tributaries (such as the Grande, Paranaíba, Tietê and Paranapanema rivers) and the Paraná River channel itself, totaling at least 130 major reservoirs (dams higher than 10 m). Of this total, 27 reservoirs have areas greater than 100 km^2 (see Chapter 3). Four reservoirs are in the Paraná River itself, and they present areas ranging from 544 (Jupiá Reservoir) to 2250 km^2 (Porto Primavera Reservoir).

The Upper Paraná River originally presented an extensive floodplain on its west side, with 480 km long and more than 20 km wide, being the main undammed portion of the Upper Paraná River inside the Brazilian territory. However, in 1998, the Porto Primavera Dam (located in the middle of the dam-free stretch) was concluded and it formed the Porto Primavera Reservoir, which reduced the floodplain to a stretch of 230 km between the Porto Primavera Dam and the beginning of the Itaipu Reservoir.

Despite the intense regulation upstream, the flood regime is still predictable in some areas where undammed tributaries empty, mainly on the west side. Thus the flood pulse is still the main forcing function that regulates the functioning and the communities' composition and structure of the Upper Paraná River and its floodplain (Agostinho *et al.* 2000; Agostinho *et al.* in press). But recently, with the conclusion of the Porto Primavera Dam, there are some indications that the functioning of the floodplain is changing. Because the area is one of the few representative river-floodplain systems in the Upper Paraná basin, there were created three conservation units, aiming biodiversity protection. They are the Protect Area of Islands and "Várzeas" of the Paraná River ("Area de Proteção de Ilhas e Várzeas do Rio Paraná"; 1,000,310 ha), the Ilha Grande National Park ("Parque Nacional de Ilha Grande"; 78,000 ha) and the Ivinheima River State Park ("Parque Estadual do Rio Ivinheima"; 70,000 ha). Recently the whole area was incorporated into the Atlantic Forest Biosphere Reserve ("Reserva da Biosfera da Mata Atlântica") by MAB/ Unesco. The area is also a study site of the Brazilian "Long Term Ecological Research" program (Site 6), supported by the National Council for Development of Science and Technology (CNPq) – Fig. 1.

In this chapter, we summarize major information presented along the other chapters. First, we broadly describe the main characteristics of the floodplain, considering it as a landscape, including geomorphological features, species richness, abiotic and functional aspects. Latter we identify potential risks to its maintenance. After we focus on regional and local impacts on the area and finally, we make some suggestions that would serve as base to direct research and management of the area to guide its conservation.

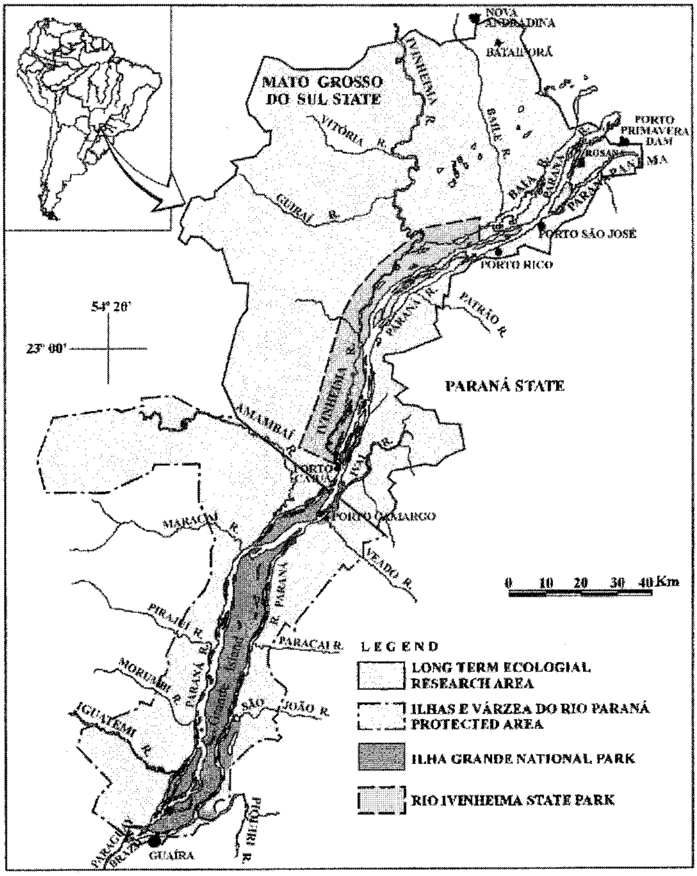

Fig. 1 The Upper Paraná River floodplain showing the area of Long Term Ecological Research and the conservation units of the region (Agostinho *et al.* in press).

Components of the Landscape

1) Physical features

The Upper Paraná River runs north-south/southwest (1800 km), draining areas with tropical and subtropical climates. Mean monthly temperatures are above 15°C and precipitations above 1500 mm year^{-1} are registered (IBGE 1990). Climate is characterized by a dry winter and a wet summer.

A detailed description of the physical aspects of the Upper Paraná River and its floodplain is given in Chapter 1. The remaining part of the Paraná River Plain has two distinct surfaces: the Low Terrace and the Fluvial Plain. The Low Terrace is an erosional landform carved out in the Middle Terrace during the excavation of the fluvial plain, and abandoned by channel migration. Its surface is characteristically marked by a large group of relict channels. The Fluvial Plain is present along the entire Paraná River Plain, and contains the floodplain and very low terraces. The high areas are represented by natural levees, crevasse splay fans, and paleobar landforms, which are subject to inundation by floods at intervals longer than three years (very low terraces). Flood basins that are inundated annually occupy an intermediate level. The low part includes the flooded areas and the channel sandbars.

A great habitat diversity is found in the flooded areas where are included active and semi-active channels, lagoons, and elongated lowlands associated with paleochannels, and lowlands associated with the flood basin. In nearly every flood period, water enters these areas from the Paraná River, from tributaries or from groundwater, inducing a highly seasonal pattern to these habitats. They are very important to help the high species diversity, especially during low water periods, when they remain as refuges for several aquatic organisms.

All tributaries of the right bank flow into a complex of secondary channels formed by the Baía River, the Curutuba Channel, and the lower course of the Ivinheima River. These channels form a continuous complex, more or less parallel to the Paraná River, connected to it at several points. In the Porto Rico region, close to most of the investigated sites in this book, the plain occurs mainly on the right bank, where it occupies a 3 to 7 km wide strip, but also appears as islands up to 2 km wide (see Chapter 1).

One of the most preserved areas in the Upper Paraná River floodplain is located close to the mouths of the Ivinheima River, where the Ivinheima State Park was created (Fig.1). This river runs perpendicularly to the Paraná River until entering the plain. Along its course it is connected to the Paraná River at three places.

Based on sedimentary facies analysis, paleopedology and palynological studies it was shown that four climatic events were observed in the area in the last 40,000 years: two dry and two wet climates. Formation of the present oxbow lakes and marshes on the floodplain from abandoned channels, formation of the present island system and mobilization of the bed load with large bedforms occurred from 1500 years to the present. During this period of time, the climate remained close the present wet conditions (see Chapter 2).

Data obtained in the last 30 years show that the differences between high and low water periods reach, on average, 2.5 m (Agostinho *et al.* 2000; see also chapters 3 and 4).

2) Species richness

Detailed information about the structure of different communities are described in chapters 5 to 17. Most of the studies in the Upper Paraná River and its floodplain were dealt with terrestrial vegetation and aquatic communities. Data for terrestrial vertebrates surveys used to characterize the area were obtained by previous studies in the upstream portion of the site, in the area now flooded by the Porto Primavera Reservoir (Mussara 1994). Given the continuity between that and the studied area, it is supposed that the same species are found in the area object of this book.

Considering the surveys carried out since 1986, together with the surveys carried out by Mussara (1994), about 2920 taxa were already registered in the Upper Paraná River floodplain system (Fig. 2). Most of the investigations in this stretch was carried out in few environments until 1999. During this period, ca. 2159 taxa of terrestrial vegetation and aquatic organisms were registered. The incompleteness of such surveys are easily shown by the increase in spatial sampling effort, during the beginning of the Long Term Ecological Research program, when 36 stations, among lagoons, channels, backwaters and the main channel of the Paraná, Baía and Ivinheima rivers were sampled. One unique survey carried out in 2000, in the new sites, increased the number of taxa registered in 11.4% (to 2406 taxa) (Agostinho *et al.* in press). Such results show clearly that the number of species recorded in this last undammed stretch of the Paraná River is still far from the real value.

According to Agostinho *et al.* (in press), the importance of the area for biodiversity conservation is also indicated by comparisons of the number of species recorded in the river-floodplain with the numbers presented by the Ministério do Meio Ambiente (2002) for the Atlantic Forest domain, where it is included. This biome covers about 136,000,000 ha of the Brazilian territory, extending from the Northeast to the extreme South of Brazil. Although the studied region has an area of only 526,000 ha (ca. 0.4% of the biome area), it contains about 50% of fish species, 35% of birds, 24% of mammals, 6% of amphibians and 4% of terrestrial plants recorded at the Atlantic Forest biome.

In addition to this high species diversity, this area has been considered very important for conservation of threatened species in Brazil, as for example migratory fish (see Chapter 10) and large terrestrial vertebrates, like the marsh deer *Blastocerus dichotomus*, which used to be found in large populations in the area flooded by Porto Primavera Reservoir (Pinder 1996). Recent evaluation and identification of priority areas for conservation, done by the Environmental Ministry of

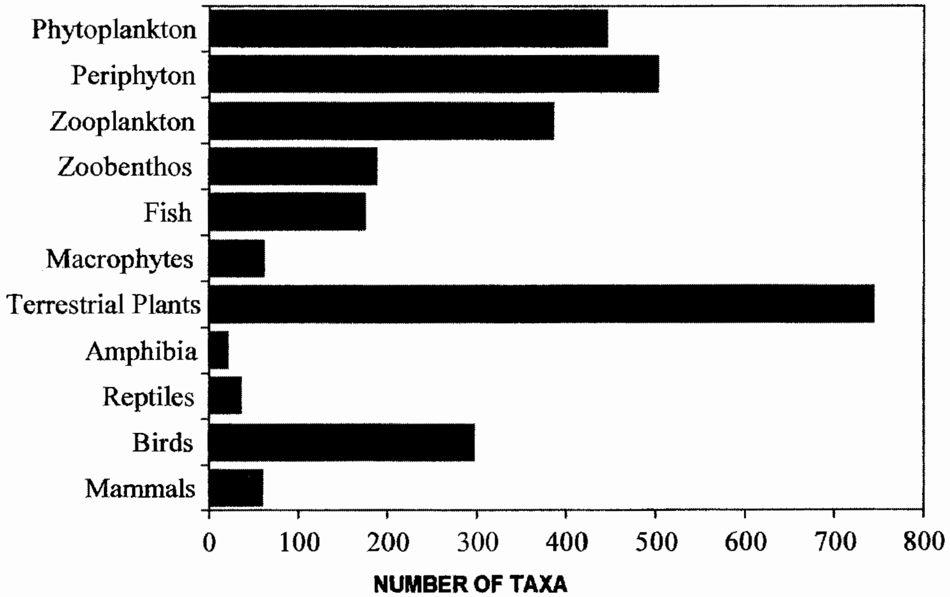

Fig. 2 Number of taxa identified in the area of Long Term Ecological Research (Upper Paraná River floodplain) during the period of 1986 to 2000. For most of the groups, surveys are still incomplete (Agostinho *et al.* in press).

Brazil, pointed out this stretch of the Upper Paraná River basin as an area of extreme biological importance for fish, amphibian, reptilian, bird and mammal (Ministério do Meio Ambiente 2002).

3) Abiotic and functional characteristics

Abiotic characteristics vary widely temporally and spatially in waterbodies of the floodplain and in the river channels (see Chapter 4). The flood pulse strongly influences biogeochemical cycles in the floodplain. Connectivity prompted by the pulse regulates the exchange of water among floodplain waterbodies and rivers.

Different river dynamics and connections of floodplain waterbodies with different rivers increase at a large scale habitat heterogeneity in the river-floodplain system. Then, depending on what river they are close and the distance from it (what determines the degree of connectivity), floodplain components differ among them along a seasonal cycle and they may also present different chemical features and communities structure. For instance, lagoons connected to the Ivinheima River usually present greater concentration of phosphate than the ones connected to the Paraná (see Chapter 4). Moreover, the undammed Ivinheima River transports greater loads of solids and nutrients than the Paraná. Also, flooding is important because it promotes an increase in nutrient inputs from decomposition of detritus accumulated during low water periods (see Chapter 15). Therefore, these events are important to maintain high productivity of aquatic communities over time.

It has been shown that, in general, great floods tend in homogenizing the system, leading the limnological characteristics of the waterbodies to become more similar during the high water periods (see Chapter 4). During low water periods, local forcing functions (e.g., wind, inflow of small tributaries and local rains) are important determinants of the waterbodies characteristics. The lower connectivity among water habitats together with the more pronounced effect of local forcing functions lead to great heterogeneity during low water periods. Such high habitat diversity may be considered an important feature in the whole system, explaining, partially, the great diversity found. On the other hand, higher connectivity observed during high waters allows several species to disperse in the floodplain, making their local extinction less probable. This appears to be very important for rare species.

Temporal and spatial variation of the abiotic factors are more conspicuous in temporary lagoons. During low water, remaining lagoons are shallow (less than 0.5 m deep) and usually fragmented. The highest beta diversity of aquatic macrophytes are found in this group of lagoons (see Chapter 15), what may be accounted for by their high variability in physical and chemical characteristics.

The Baía River is a typical semi-lotic environment, with intermediate limnological conditions between the Paraná River and lagoons. The Ivinheima River differs from the others mainly due to phosphorus concentrations, that are on average, twice than the ones registered in the Paraná River (28 to 132 $\mu g.l^{-1}$) (see Chapter 4). Therefore, the Ivinheima River is an important source of phosphorus for floodplain waterbodies. On the other hand, the Paraná River water is poor in phosphorus. This river has low phosphorus concentrations when compared with other South-American rivers (Agostinho *et al.* 1995), but this situation became worse after Porto Primavera Dam closure, which decreased even more its phosphorus loads (see

Chapter 4). This phosphorus impoverishment may be directly associated to the reservoir cascade located upstream and this is one of the most typical characteristics of the Paraná River.

The low phosphorus concentrations indicate that it is one of the limiting nutrients for aquatic primary productivity. Decreasing loads of phosphorus carried by the Paraná River may have serious consequences to the primary productivity of the floodplain, although such effects are still difficult to be assessed. Phytoplankton productivity in lagoons is usually higher during the low water periods as indicated by the greater metabolism, chlorophyll-*a* (up to 70 $\mu g.l^{-1}$) concentrations, and phytoplankton densities (see chapters 4 and 5). This increase is a result of a combination of factors associated with lagoons depth (characteristically shallow in this phase), nutrient inputs from sediment (wind action) and diel mixing of the water column.

Primary productivity of aquatic plants also responds to the water cycle. The few information available for this community indicate that the biomass of the three main species did not respond similarly to water fluctuation. Floating emergent *Eichhornia azurea* presented higher growth during low water whereas the emergent *Polygonum* sp. grew according to water levels increases. *Salvinia auriculata* did no show any pattern (Bini 1996, see also Chapter 15).

Detritus (from aquatic and amphibian vegetation) are important food resource in the floodplain. Several detritivores and bottom feeding fishes present high biomasses in the area. Several rotifers, such as *Lecane*, and chironomids are also common in the floodplain and feed on detritus and bacteria (see chapters 7 and 9). Among fishes *Prochilodus lineatus* is the most important detritivore (see chapters 10 and 11).

Effect of the flood regime on food availability and shelter to avoid predation make the floodplain ideal to initial development of fishes. Seasonal variations in water level are the main factor that controls fish spawning and recruitment success. This may be established not only by the high synchronism between floods and main events of the reproductive cycle (see Chapter 10), but also by the relationship between recruitment success and the time, duration and amplitude of floods (Gomes & Agostinho 1997; Agostinho *et al.* 2000). These relationships are more evident for long distance migratory species (usually large fishes; maximum standard length greater than 40 cm) that present seasonal and total spawning, small eggs and high fecundity (see Chapter 12). This group constitutes near 19% of the regional species richness and 21% of the total catch numerically (Agostinho *et al.* 2003). Migratory fishes depend on large stretches of free-flowing river and are the most affected by the series of dams built in the area (Agostinho *et al.* 2000).

The description of the functioning of the Upper Paraná River floodplain presented in the preceding pages, broadly follow the flood pulse concept (*sensu* Junk *et al.* 1989; Neiff 1990). Apparently, after the closure of the Porto Primavera Dam (in 1998), located just upstream from the studied area, effects of dams appear to be strong and there are some indications that the system is functioning differently. That functioning appears to be within the concepts of serial discontinuity (Ward & Stanforf 1995), oligotrophication (Ney 1996) and the cascading reservoir continuum (Barbosa *et al.* 1999). But these alterations will be treated here as impacts (see next topic).

Regional and local impacts

Misuses of the landscape and resources associated to energy demands have submitted the Upper Paraná River basin and its floodplain to severe disturbances, which affected the ecosystem regionally and/or locally. The area is intensively used for agriculture, ranching (mainly cattle) and there are large urban and industrial centers. In São Paulo State, where cities are more populous, urban demand of water is greater than 87 $m^3.s^{-1}$, with 50% returning to rivers. Only 8% of these receive adequate treatment before re-entering rivers. Estimated demand of water for 2300 industries out of 4300 registered by the "Departamento Nacional de Águas e Energia Elétrica" (National Department of Water and Electricity) is 113 $m^3.s^{-1}$, of which 68% return to rivers (São Paulo 1990).

Water demand for irrigation is also high, but there is no information available. The ever increasing demand for water, intense use of chemicals, inadequate soil management, removal of riparian vegetation and poor quality of the water that return to rivers are worsening the situation (Agostinho *et al.* in press). In the Tietê River basin (a tributary on the east side of the Paraná River), that drains great cities like São Paulo, impacts due to inadequate use of water reached alarming proportions. Water in a large stretch of this river is inappropriate for consumption and costs for treatment are high. However, water quality improves toward its mouth in the Paraná River channel, after it passes over seven large reservoirs (Esteves 1983; Agostinho *et al.* 1995; Barbosa *et al.* 1999).

The floodplain area described in this book have been used for many purposes which impacted its functioning, among them are those related to ranching, cropping rice, *Pfaffia* extraction, sand extraction and navigation. Floodplain areas have been extensively used for ranching during low water periods (dry season). Some islands (there are more than 300 in the area) are occupied by ranching during droughts, when farmers find difficulties to feed cattle in other pastures. Although specific data on impacts from this activity are scarse, it is expected that stepping compacts soil, produces marginal erosion and destroys saplings and herbaceous vegetation. Preliminary experiments carried out in one island showed evidence that prevention of grazing can result in increased species richness, at least in the short term period (Milne *et al.* in press). Impacts are even worse after burnings made to accelerate growth of grasses and herbaceous vegetation. Impact of deforestation, in general associated to ranching, was quantified for the Porto Rico Island, with an area of 100 ha. Aerial images show, for this island, that 92% were covered by forests in 1952, 42% in 1965, 23% in 1970, 17% in 1980 and only 6% in 1996 (see Chapter 17). Although it was not quantified, it seems that other islands in the region were also fast deforested in recent decades. However, five years (after the creation of three conservation units in this region) were enough to visualize some restoration of the vegetation, even considering that the units were not completely installed.

Collectors of *Pfaffia* (a plant exported to the cosmetic industry) commonly burn the floodplain to easily find such plant (this species is the first to sprout after burning). Another important source of impacts is dredging and, sometimes, use of biocides in rice agriculture onto the floodplain. Plain areas are incorporated to agriculture (that increased in the region until recently), subtracting nursery areas for fish, leading to negative impacts upon fish populations and fishery stocks.

There are projects for navigation planned for the Paraná basin and they will increase traffic of barges to transport harvest of grains from west Paraná State and south Mato Grosso do Sul State to Santos Harbor (State of São Paulo). Nowadays, most of the barges start journey in the Itaipu Reservoir, navigate upriver, passing trough locks in the dams located in the Paraná and the Tietê rivers. Bank erosion and pollution are probable impacts caused by this activity (Agostinho *et al.* in press).

Introduced species is an emergent complicated issue in the region. Nowadays, two bivalve species originally from Asia, became very abundant in the Upper Paraná River, especially in the floodplain and reservoirs (see Chapter 8). The fast proliferation of *Corbicula fluminea*, the first dispersed in the floodplain, was associated to the disappearance of native bivalves from the samples. The other invasive bivalve, the golden mussel *Limnoperna fortunae*, arrived firstly in Argentina (ballast water, in 1991) and dispersed upstream in the basin. Impacts of its introduction are under study, but its effects on economic activities is well known elsewhere. Some allochthonous fish, especially from the Amazon basin, were introduced in the basin some decades ago (see Chapter 10). Their populations are also increasing in the area, taking advantage from the water regulation by upstream dams. Recently, fish stocking is becoming more and more accepted as an alternative tool to enhance sport fishery, resulted from lobby of sport associations and governments. Absence of appropriated protocols and failures to control stocking make this actions risky, with great potential to be a threat for the tremendous high regional biodiversity.

Alterations in the hydrological regime by operation of upstream dams seem to be the most important source of impacts on the river-floodplain system studied. Among them, nutrient and solid retention, allied to others resulted from the re-distribution of water discharge along the year (increase during the dry season and reduction during the wet season) affect chemical, physical and biological components of the system (see chapters 3 and 4). These perturbations, which can be categorized as "downstream impacts of reservoirs chain" falls into the concepts mentioned before (serial discontinuity, oligotrophication and reservoir cascading). They interfere directly or indirectly upon habitat structure, communities functioning and composition, and they also reduce floodable areas.

The control of the flood regime in the Upper Paraná River by upstream dams was more effective after the closure of the Porto Primavera Dam. It (i) affected riparian vegetation by bank erosion, modified sedimentation process and changed the regular recharge of the aquifer, with reflex on dispersion, germination and development of seeds; (ii) altered aquatic vegetation structure, with intense proliferation of submerged plants due the increase of water transparency and water level stabilization (see Chapter 15); (iii) influenced the composition and dominance in plankton and macro invertebrate communities by the effects that connectivity and water chemistry have on their distribution and abundance (see chapters 7 and 8). For fish, reduction of connectivity is especially deleterious due to the fact that it directly influences spawning and, if fish reproduce, it affects the access of larvae to lagoons (nursery areas). As demonstrated in chapters 12 and 13, in the Upper Paraná River floodplain, the flood regime is essential to the maintenance of migratory fishes. Data on young-of-the-year show that absence of flood has negative effects on any reproductive strategy (see Chapter 10). High water transparency increases eggs and larvae mortality by visual predators. Fish recruitment is specially favored by longer floods, with duration greater than 75 days and water level higher than 3.5 m, measured in Porto São José hydrological station. However, species react differently to the flooding in relation to spawning (sedentary species does not depend on floods).

Dam operation to attend peaks of energy demands is another source of impacts because it promotes daily water level fluctuations up to a meter, isolating lagoons and contributing to their premature desiccation. In addition, abrupt reduction in water level increases bank erosion. Rapid movements of ground water and consequent removal of particles, produce holes in the banks, as consequence of the strong hydraulic gradient in ground water during the abrupt falling of the water level of the Parana River (piping effects), that started after the closure of Porto Primavera (see Chapter 3). On the other hand, sudden water level decreases affect biotic components of the system, like those verified for the periphyton that have conspicuous losses by biofilm removal (see Chapter 6).

All the above mentioned mechanisms somehow affect the biota. Then, river regulation may reduce levels of biodiversity, directly or indirectly. In fact, it was verified alteration in composition of fish communities, especially in relation to species that depend on flood to spawn and use the area as nursery. For example, since the year 2000, juvenile of migratory fish species are absent in the area (Petry *et al.* 2003; Agostinho *et al.* in press), in contrast with their huge abundances registered in past years, such in 1992 and 1993 (Agostinho *et al.* 2000; Agostinho *et al.* 2001) (for more details, see Chapter 10). In addition, plankton may have the same fate, because its species richness apogee was observed during high water levels (see chapters 5 and 7). Thus, reducing the connectivity may also be deleterious for zooplankton communities, whose whole scale (gamma) diversity seems to depend on water exchanges among habitats and between the littoral and pelagic zones (see Chapter 7).

Another issue to be considered is the fish ladder constructed at Porto Primavera Dam. Monitoring of that ladder has demonstrated its efficacy in transposing fish. However, the importance of the transposition to fish conservation was not monitored and is controversial. Thus, the little stretch of running water upstream from Porto Primavera Reservoir and the barrier that the reservoir is for larvae drifting indicate that fish that ascend the ladder do not return and so their descendents. Then, it is possible that the ladder is impacting migratory fish population of the floodplain located downstream.

Despite of all these impacts on the Upper Paraná River floodplain, mainly induced by regulation of water discharge by dams upstream, this stretch presents high habitat heterogeneity, and therefore, still plays fundamental role in the maintenance of the regional biodiversity of terrestrial and aquatic organisms.

Final considerations and perspectives for management

The state of preservation of the Upper Paraná River basin is spatially heterogeneous, with most of the area slightly modified and some still not modified. Areas near urban centers are altered whereas those far present pristine conditions, such as the area near the mouth of the Ivinheima River. State agencies are discussing with researchers and other governmental agencies schemes for a sustainable development of the floodplain, with purpose to maintain its integrity. Two main issues that emerged from these discussions will be considered here (i) the current process of human occupation in the region that has to be disrupted and (ii) the rationalization of dams operation upstream from the area.

In relation to the first, removal of trees (riparian vegetation) located on some islands, levees and east bank of the Paraná River is common (see chapters 16 and 17). Most of these areas are used for ranching and subsistence agriculture (corn, bean and rice). Areas that are seasonally flooded are covered by bushes and grasses, during the dry season, they are used for agriculture and ranching. These activities and some others developed in the area are conflicting with ongoing environmental legislation. Then, prosecutors of the region are pressuring farmers to remove cattle from islands, prohibiting the extraction of *Pfaffia* (both of them use fire), imposing restriction on sand mining and requesting impact studies related to the increasing navigation. However, nothing has been done to stop varzea draining in some parts inside the area of restrictive use (APA – Environmental Protected Area) with propose to crop rice, that is also forbidden. The same attention has been devoted to fish stocking. The latter find obstacles to be controlled because of people's common sense that it is a proper action and regional politician interests, because stocking may guarantee votes.

Important steps to disrupt human occupation were the restriction resulted from the creation of three conservation units in the region and recently, the incorporation of the floodplain area into the Atlantic Forest Biosphere Reserve. Even considering the improvement registered after the creation of these units, specific studies, intense enforcement and, mainly, a wide program of environmental education to alert people, locals and visitors, about the importance of the area, its preservation and main regional and local sources of impacts are urgently requested. Preliminary actions to achieve this purpose already began with the Long Term Ecological Research Program. Researchers and graduate students involved in this Program are training teachers and students of public high and elementary schools located within the area.

The artificial control of floods by dams upstream (controlling discharge) has a great potential to simulate the natural flood regime in the studied stretch of the Paraná River basin. Porto Primavera Reservoir (area of 2250 km^2) has possibility to increase two meters the current maximum level to help in this task, besides some level manipulation during the operation. But operation of dams in the Paraná River basin is controlled by the National System Operator (ONS). Dam operation has some flexibility, but there are some pitfalls like political will to consider biodiversity and absence of precise data on specific responses of the biota to flood attributes. Then, more detailed studies are necessary in order to determine biological requirements of threatened species and to identify the minimum level, duration and timing of floods necessary to organisms life cycles. It is also important to better aware local population about the importance of the flood in preserving floodplain biodiversity. In doing so, it is expected some reflex on politicians that will have to re-evaluate their position in relation to the issue.

Among the information needed to spread to people of the region, we can point out the strong influence of the flood regime on (i) erosion and sedimentation processes – chapters 1 and 3; (ii) the direct exchange of nutrients and pulses of them from the decomposition of inundated floodplain vegetation – Chapter 4; (iii) primary productivity – chapters 4 and 5; (iv) biophysical responses of macrophytes – Chapter 15; (v) several taxa of invertebrate – chapters 7, 8 and 9; and (vi) fish – chapters 10, 11, 12 and 13, specially migratory. This group is more conspicuous in the biota because of their direct importance as local income and food, and it must be emphasized that they depend on the flood to reproduce and reach nursery areas. In the floodplain, some large sized migratory species are still captured (e.g. *Pseudoplatystoma corruscans* – may reach up to 150 cm; *Salminus maxillosus* – up to 100 cm). Also, the fishery in the Itaipu Reservoir, located downstream the floodplain, is twice more profitable than in any other reservoir of the Upper Paraná River basin, and some large migratory species are still landed in those fisheries. Pristine regions, such as the Ivinheima, is important as spawning grounds for fish (see Chapter 13).

Therefore, it is concluded that the maintenance of the biodiversity of the last undammed segment of the Paraná River in Brazil depends on the integrity of the land – inland water ecotone represented by the floodplain that should be necessarily linked to dam operation. Then, regulation of flow by upstream dams has modified the structure and functioning of the Upper Paraná River floodplain and negatively impacted the biota. However, the results of this regulation on the hydrograph of the floodplain are still predictable. Consequently, the management of the quality and specially the quantity of water passing trough the dams to maintain hydrological cycle close to the natural regime has great potential to reduce impacts on all organisms that inhabit the flood plain, especially fish.

Efficacy of flow management requires detailed information on its effect onto the floodplain functioning and assemblage responses that would allow determining flood attributes advantageous to organisms. Then, even knowing that dam operation has some flexibility, these informations are still not available and dam operation usually serves only the interest of power companies.

Apparently a broader discussion is necessary to guide and prioritize actions to be taken in the region, and this should be done by a basin Committee. This Committee has to have ample stakeholders representation and deliberative power on water use, including the construction of new dams and operation of the already built. It should be implemented urgently to guarantee the sustainable development of the last stretch of the Paraná River inside the Brazilian territory with running waters.

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