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The Fluvial Forests as Indicators of the Flow and Permanence of Water

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Abstract

We evaluated the influence of the horizontal flows of the Paraná River on the composition and distribution of the floodplain landscape and we defined the ecohydrological signature of some species-index in the low Paraná River section, (27° 38' 04" S and 58° 50' 46" W). During the drought phase, the structure of the vegetation were characterizad using a Cottam & Curtis method. The trees were positioned in the topographic gradients during the flood phase, taking as reference the river water sheet in the nearest hydrometric gauge. To obtain the pulse attributes in different positions of the geomorphological gradient, PULSO software was used considering the daily water levels at Corrientes city between 1985 and 2015. Two main types of flooded forests were identified: pionner forest, dominated by one or two species (*Salix humboldtiana*, *Tessaria integrifolia*) in recent bars and islands, and pluri-specific flooded forests (*Albizia inundata*, *Cecropia pachystachya*, *Croton urucurana*, *Inga uruguensis*, *Ocotea diospyrifolia*, *Nectandra angustifolia* and *Peltophorum dubium*) occupying bars of the highest islands, with shorter flood phases, with trees are distributed in 2-3 strata in a closed canopy. Pulses were more frequent in pioneer forests than in multispecific forests. The ecohydrological signature allows the optimum condition and distribution limits of each species to be established. It is a tool to know the adjustment of biotic elements (populations) to the river variability regime. The procedure used can be used to anticipate the possible reorganization of the river plain landscape as a result of flow variations predicted by climate change models.

Keywords: hydrological regime, pulses, Paraná River, floodplains, ecohydrology, climatic change.

Introduction

Since the beginning of vegetation ecology, attention has been focused to know the number of species that inhabit a river and its basin. Few projects have been devoted to studying the causes of biodiversity in systems with a high fluctuation level. In this contribution we analyze an approach to link the vegetation composition as a consequence of the river regime on each site of the floodplain. Following the Pulse concepts (JUNK *et al.*, 1989, NEIFF, 1990, 1996) we attempt to know the relationship between the tree populations distribution and the pulse attributes. The vegetation, and especially the forests, are the most conspicuous structures and of greater permanence in the fluvial landscape. There is a clear asymmetry along the river between the floodplain vegetation and the adjacent phytogeographic territories to the Paraná River (CABRERA, 1976).

Objectives

To evaluate the influence of the horizontal flows of the Paraná River, on the composition and distribution of the fluvial forests.

To define the *ecohydrological* signature of some species of trees in the study area.

Materials and Methods

This study was carried out in the floodplain of the Paraná River, in Argentina, upstream of Paraná-Paraguay confluence (27°38' 04'' S and 58° 50' 46" W, Figure 1). During the drought phase (limnophase), we study the vegetation structure by the centered quadrants method (COTTAM; CURTIS, 1956). The trees were positioned during the flood phase (potamofase) in the topographic gradient taking as reference the river water sheet in the nearest hydrometric gauge (Neiff, 1986). PULSO software (NEIFF; NEIFF, 2003) was used to obtain the pulse attributes in different positions of the geomorphic gradient. Between 1985 and 2015, daily records the water level in Corrientes city was analyzed. More than a thousand points were measured to cover all possible sites where each of the nine indicator species considered is growing.

Results

According to our results, it is possible to differentiate two types of forests: the pioneer forests, dominated by *Salix humboldtiana* and / or *Tessaria integrifolia*, in low bars, between 45.71 and 48.01 m.a.s.l.. These forests constitute a habitat of very wide variability (water level, runoff velocity, erosion/ sedimentation and nutrient dynamic). The populations that live there can respond to disturbances. The germination phase are short and the vegetative growth is very fast. Plants invest a lot of energy in maintaining a long period of fertility to synchronize the production and release of fruits and seeds in a favorable hydrological phase. As a typical "*r*" strategists.

The other type of fluvial forests (mixed gallery forest), growth in the higher position of the topographical gradient, with almost 20 spp., represented by *Albizia inundata*, between 46.21 and 48.01 m.a.s.l.; *Cecropia pachystachya* (between 46.11 and 48.01 m.a.s.l.); *Croton urucurana* (between 46.21 and 48.01 m.a.s.l.), *Inga uruguensis* (between 47.71 and 48.01 m.a.s.l.); *Ocotea diospyrifolia* (between 46.21 and 48.01 m.a.s.l.); *Nectandra angustifolia* (between 46.21 and 48.01 m.a.s.l.) and *Peltophorum dubium* (between 46.21 and 47.01 m.a.s.l.). These forest occupy bars or marginal levees, where the flood phase is shorter, the sediments have more fine materials and the soil has more organic matter in surface. The trees are distributed in 2-3 strata with a continuous canopy. They produce an important interference in the flow during extraordinary floods (NEIFF *et al.,* 2006).

In the last twenty years, Paraná River had a irregular regime, with two extraordinary floods which exceed 8 m in Corrientes gauge (Figure 2). The pulses were more frequent in pioneer forests than the multiespecific forests (Table 1), that is to say, they are functionally connected to the river flow more times in the same time series.

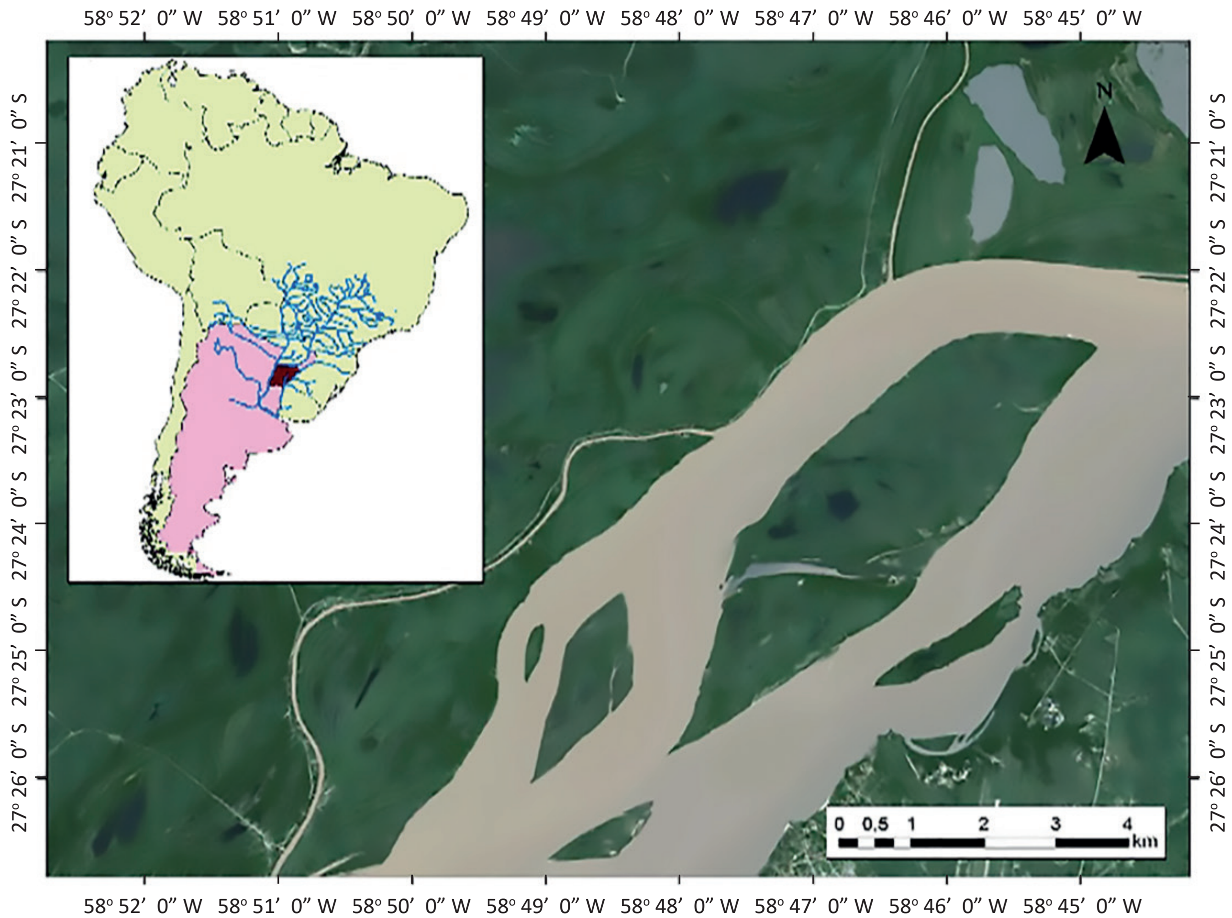

Figure 1 – Location of study area.

Table 1 – Pulse at tributes during 1985-2015.

Pulse attributes	Pioneer forests	Multiespecific forest
Overflow level (m.a.s.l.)	46.39 (4m)	48.39 (6 m)
Mean amplitude (days)	72.2	319.08
Mean intensity (m)	2.44	3.3
Pulse frequency	156	35
Mean water level (m)	3.95	3.95
Maximun mean (m)	6.41	1.18
Minimum mean (m)	2.14	0.71
Maximum tension	61.11	61.11
Minimum tension	65.44	65.44
Maximum (m)	8.64 (8 Jun. 1992)	
Minimum (m)	1.4 (30 Aug. 2001)	

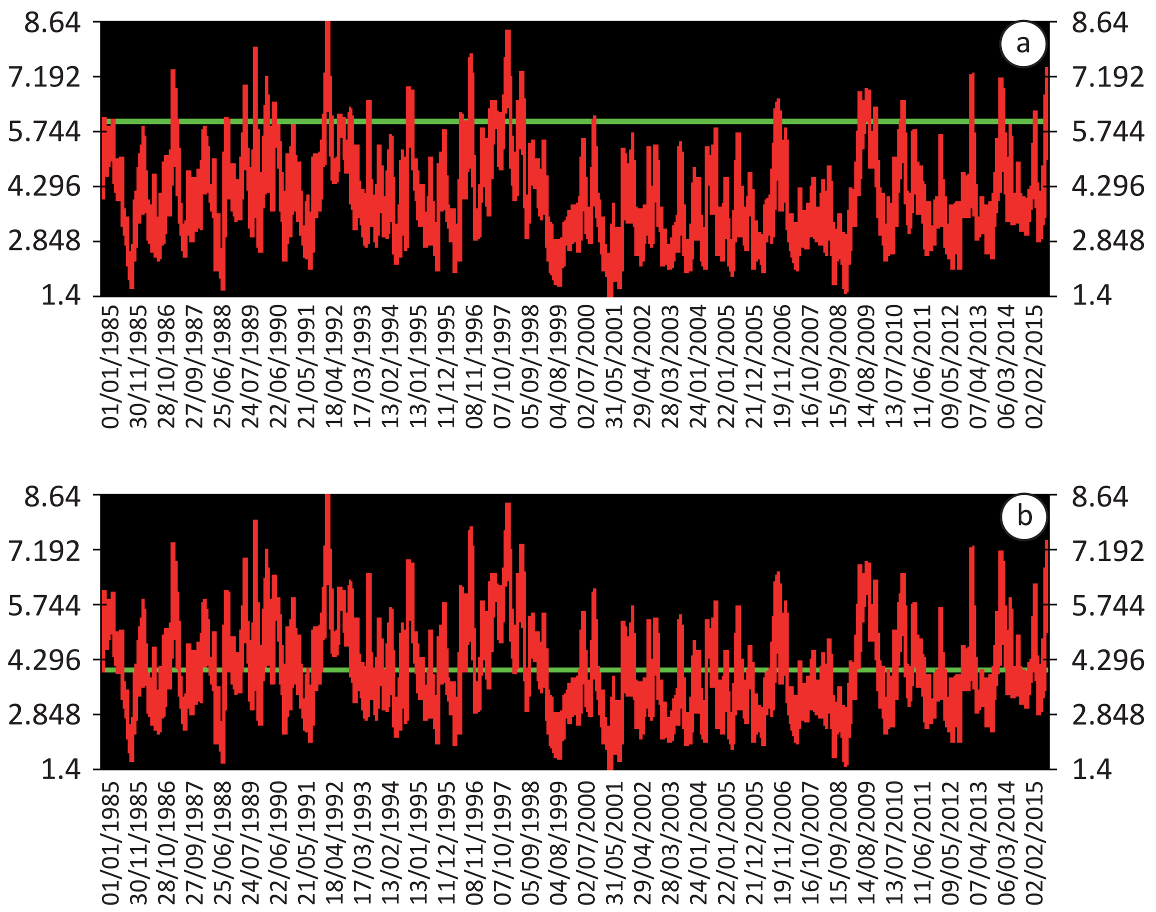

Figure 2 – Water level fluctuations of the Paraná River at Puerto Corrientes between 1985 and 2015. a. Overflow level of pioneer forests: 4 m; b. Overflow level of multiespecific forests: 6 m.

Conclusion

The multiespecific forests are located in the highest sites of the islands and the populations of the pioneer forests occupy the lowest sites of the topographic gradient. Knowledge of the distribution and abundance of organisms allows understanding the biotic complexity of the system, its temporal variability and the possibilities of organisms to colonize and maintain themselves in pulsatile environments of the rivers.

The species richness is conditioned by the frequency intensity, duration and timing of the hydrological phases. The current specific richness has a configuration that must be evaluated knowing the processes that regulate positively or negatively by the phases of the pulses. PULSE, can be seen as a tool to link the organization of biotic communities with the characteristics of the pulses (frequency, intensity, duration and seasonality). The analysis of periodic hydrological phenomena is a tool to understand why fluvial vegetation can be differentiated from the surrounding ecosystems, even from a satellite. Climatic changes that modify the hydrological dynamics influence the biodiversity of each site, by modifying the frequency, duration and seasonality of the flooded soil / dry soil phases of the site. These causes of biological settings on a site and in a basin require analysis at different scales: current evolutionary sucesionaly.

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