STUDY DESIGN

Description of area

The freshwater wetland ecosystem under study is that of the Esteros del Ibera, in the Province of Corrientes, in NE Argentina. The region is located between latitudes 27º30' and 29º S, and longitudes 56º 25' and 58º W.

Wetlands are broadly defined as a variety of shallow water bodies and high ground water environments that are characterized by permanent or temporary inundation or, in other words, a terrestrial ecosystem which hydraulic condition is that of water saturated soils with plants and animals adapted to life in such an environment (Lewis, W.M., 1995). From a hydrological point of view, the Ibera wetland is located in the Del Plata Basin, which covers some 3.5 million square kilometers within five countries of South America: Brazil, Paraguay, Bolivia, Uruguay and Argentina. The main watercourses are the Parana, Paraguay, Pilcomayo, Bermejo, and Uruguay rivers. Many hydroelectric dams have been built along these rivers, being the Parana River the one with the largest numbers of dams, basically due to its 4,000 Km. and an average flow of 19,000 m^3 s^{-1}. The climatic and geomorphologic features of this basin are ideal for the formation of large inland wetlands, among which can be found the Pantanal in Brazil, Ñeembucu in Paraguay and the Esteros del Ibera in Argentina

The Ibera wetland region in Argentina is one of the largest and last remaining wetland regions of its kind in Latin America. It is mainly known for its remoteness and isolation, and for the presence of several unique animal species. An extensive study of the Ibera macrosystem was carried on during the seventies by Instituto Nacional de Ciencias y Tecnicas Hidricas (INCyTH) and Instituto Correntino del Agua (ICA) and was published in 1981.

Morphology

The Ibera is a great depression located over ancient beds of the Parana River. The system rests on top of more than fifty meters of permeable sediments, mainly deposited fluvial sand taking the form of a pool of superficial storage of pluvial water. These sediments rest over a bed of basalt. The ancient islands emerge as longitudinal hills or *"lomadas"* with a physiognomy of savanna. An outstanding longitudinal hill separates Ibera into to subsystems of distinct dynamical characteristics. The system shows a diversity of deposited materials, removed and deposited again by complex physical and chemical factors that changed both spatially and temporally. In general, sandy materials are dominant at the bottom of extended bodies of water and as elongated elevations. These sandy materials develop over an average depth of 50m and belong to the Ituzaingo formation that rests over the impermeable formation of Fray Bentos.

The catchment area has been estimated in 13,700 Km^2. It has a triangular shape some 250 Km long and between 20 and 140 Km wide. Roads and human settlements are to be found only on the surrounding areas, not within the wetlands. The isolation and the inaccessibility of the region have, up to now, helped its preservation.

Nowadays, 90% of its area is covered by permanent or temporary floods, depending on the balance of atmospheric input and output, the surface runoff, the underground water balance, as well as on the previous storage level. The weedlands (*malezal*) and marshlands (*esteros*) cover some 80% of the water surface. The deeper wetlands are for the most part covered by aquatic vegetation forming characteristic "*embalsados*" or dammedlands– floating vegetation islands as much as 4m. thick (Neiff, 1981).

The Eastern subsystem is characterized by a sheet-flow dynamics and a deeper topographic profile. The open, vegetation free areas, delimited by floating "*embalsados*", generate lagoons which are, in some cases, interconnected by deep channels, and which follow the trace of the paleolithic-river bed of the Parana. The Western subsystem shows a more rugged topography with marked lines of drainage that converge towards the Medina lagoon at the SW end of the system. Both the central longitudinal hill that separates the two subsystems, and the longitudinal hill that separates the Ibera from the Batel-Batelito system to the West, permit the transfer of groundwater between the systems. At surface level, both hills hold pseudokarstic lagoons (INCyTH-ICA, 1981a).

The Ibera system is a great "natural reservoir" in which the only superficial input is precipitation. The main output is given both by evaporation and evapotranspiration, and by the superficial discharge through the Corriente River, at the Southern limits of the system. The long response delay of the system is due to its morphology, the soil types, and the presence of vegetation that conditions the flow. The water flows very slowly over a general slope of 1:10,000, from de NE to the SW. In general terms, as a consequence of the strong relationship between morphological, hydrological, climatic, and pedological (edafological) factors, the macrosystem may have a regulatory mechanism that corresponds to an ultrastabilized system that has a long response time and a tendency to reach a dynamic equilibrium with the environment (INCyTH-ICA, 1981a).

Vegetation

The behavior of the system is strongly conditioned by vegetation. The lagoons and the permanent channels are the only free water areas. The main lagoons have been measured and studied since 1910, as reflected in remarkable reports published in the Annals of the Sociedad Cientifica Argentina (1910-1914). Their boundaries have not changed substantially with time, even though the variations in water levels have been important. The reason for them remaining unchanged may be given by the fact that the borders are dammedlands (*embalsados*) rather than firm soil.

The dammedlands are formed by accumulation of interweaving aquatic plants that create floating platforms strong enough as to allow the growth of other plants and trees over them. These floating islands are generally 1 to 3 m. thick and can go up or down with the fluctuations of water level. They are the ideal habitat for birds and for large vertebrates, which have adapted to live on them, such as capybara (*Hydrochaeris hydrochaeris*), black caiman (*Caiman yacare*) and marsh deer (*Blastocerus dichotomus*). The relationship between the geomorphology and the dammedlands, and the reasons for floating vegetation not invading the lagoons and natural channels are not well understood yet.

Observed changes

This special system has recently suffered an important change in the average water level that is affecting the native populations of plants and animals, as well as the neighboring human activities. The hydrometric scale located in the Ibera Lagoon is the only station located inside the borders of the system that has been measuring water levels since its installation in 1968. The records show a very important and rapid increase in water levels over the period of few months between 1989 and 1990. These levels have been maintained until today, bringing the relative mean level from 1.24 m (62.29m a.s.l.) over the period 1970-1988, to 2.06 m (63.11m a.s.l.) over the period 1991-2000, as shown in Figure 43. Considering the topography and the characteristics of the system, such a change in the average water levels (0.82m) can be translated into a total increase in storage within the system of approximately 11,000 hm^3.

The observable consequences of this increase are significant loses in productive lands located besides the Western and Northern borders of the system. Within the system, there is an increase in the flux and the dragging of sediments, as well as changes in vegetation dynamics and habitat quality. It is difficult to assess the degrees of impact that these changes on environmental conditions may have on the persistence of native species, both plants and animals. On the one hand, the Ibera system has been able to maintain its equilibrium through hydro-biological regulation mechanisms favored by the hydraulic characteristics of the "*embalsados*" and the morphology of the submersed soils. On the other hand, geosystems such as the Ibera show a long response delay. Both features put together allow us to assume that the consequences of this sharp increase in water levels are not yet fully manifested by the ecosystem.

As a matter of fact, the Del Plata Basin, as a whole, has suffered changes due to both natural and anthropic processes. The natural causes for changes in the basin have been studied at basin level. Global climatic change since 1970 and the addition of climate variability, namely El Niño Southern Oscillation (ENSO) events have been considered as the main culprits. The consequences are the increase of rainfall and runoff, leading to a water excess in the area. The IPCC (1997) reports on these changes. It is generally agreed that the stage and extent of large reservoirs and lakes may serve as useful indicators of climate change, as they have a tendency to filter out short-term variability and respond to long-term change in the hydrological cycle (Kelly et al., 1994). In the case of the Esteros del Ibera, given the vastness and inaccessibility of the region, it seems very natural to turn to remote sensing as a tool for detection of changes. Nevertheless, it is difficult to use satellite images in a direct way for the determination of monthly or seasonal variations between flooded versus dry areas within the system because of particular characteristics of this system.

The anthropic changes introduced into the system are mainly the construction of more than forty dams on the rivers making the Del Plata Basin. Only a few Km. North of the Esteros del Ibera system, and separated by a thin saddle (*albardon*) of sand and clay sediments, sits the Yacyreta dam, on the Parana River.

There is a growing scientific agreement that environmental issues are closely interlinked, meaning that the development of any ecosystem requires an integrated approach, very particularly when aiming at its sustainability. Since climate a crucial factor in biodiversity issues, therefore, the sustainable management of wetlands can no longer be achieved without taking climate change into account. Increasing temperatures and changes in precipitation, and evapotranspiration are the main variables of climate change that will affect wetland distribution and function (Bergkamp & Orlando, 2000).

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