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Wetlands modification and wildlife habitat suitability: can capybaras survive in a matrix of poplar and willow afforestations?

Rubén D. QUINTANA [1,2] and Fabio A. KALESNIK[1]

Abstract: *WETLANDS MODIFICATION AND WILDLIFE HABITAT SUITABILITY: CAN CAPYBARAS SURVIVE IN A MATRIX OF POPLAR AND WILLOW AFFORESTATIONS?* .The lower delta of the Paraná River region has been highly modified since the beginning of the twentieth century, mainly due to forestry. In this paper we review the ways in which forestry has modified the lower delta landscape, resulting in changes in the hydrological regime, and we explain how the latter affects capybara conservation in terms of changes in habitat suitability. Forestry practices in the study region are of two types. The first involves afforestation with water management consisting of drainage canals to eliminate excess water and channel it rapidly to the main water courses. This has led to positive alterations to the islands' original landscape, improving habitat suitability for capybaras in terms of larger grazing areas, increased percentage of land-water interfaces and the presence of patches of freshwater marsh. The second consists of afforestation in which the plantation is totally surrounded by a dam to protect trees from floodwater. The complete drainage of the area behind the dam and systematic elimination of the original marshes drastically affect habitat suitability for capybara, basically due to the lack of water bodies. This indicates that successful compatible management of wildlife and traditional productive activities requires a clear idea of which landscape elements must be preserved or improved in order to guarantee habitat for any particular species.

Key words: *Hydrochaeris hydrochaeris*. forestry impact. hydrological alterations. Wetlands. Paraná River Delta.

Resumen: *WETLANDS MODIFICATION AND WILDLIFE HABITAT SUITABILITY: CAN CAPYBARAS SURVIVE IN A MATRIX OF POPLAR AND WILLOW AFFORESTATIONS?* El bajo delta del río Paraná constituye una región altamente modificada desde los comienzos del siglo XX debido, principalmente, a la actividad forestal. En este trabajo se describe de qué manera esta actividad ha modificado su paisaje, particularmente en el régimen hidrológico y se explica como estos cambios afectan la conservación del carpincho en términos de cambios en la aptitud de hábitat. En esta región se desarrollan dos tipo de prácticas forestales. La primera involucra un manejo del agua dentro de la forestación que consiste en la construcción de canales y zanjas de drenaje a fin de acelerar la salida de los excedentes hídricos hacia los cursos principales. Esto ha dado como resultado alteraciones positivas en el paisaje original de las islas incrementando la aptitud de hábitat para los carpinchos en términos del incremento de zonas de pastoreo y del porcentaje de interfases tierra-agua y el mantenimiento de parches de pajonales. La segunda consiste en forestaciones en las cuales las plantaciones se encuentran totalmente rodeadas por un dique protector de las inundaciones. En este caso, el drenaje completo del área interior de los diques y la eliminación de los pajonales originales afectan drásticamente la aptitud de hábitat para este roedor, debido particularmente a la pérdida de los cursos de agua dentro de la plantación. Esto indica que para que un manejo conjunto de especies de fauna silvestre y actividades productivas tradicionales se requiere tener en claro que elementos del paisaje deben ser preservados o mejorados a fin de garantizar la permanencia de las condiciones de hábitat para una especie en particular.

Palabras claves: *Hydrochaeris hydrochaeris*. impacto forestal. alteraciones hidrológicas. Humedales. Delta del Río Paraná.

[1] Grupo de Investigaciones en Ecología de Humedales (GIEH), Laboratorio de Ecología Regional, Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.
[2] CONICET. Running Head: Can capybaras survive in poplar and willow afforestations?
Correspondence: Rubén Darío Quintana Tel: +54 11 4576 3349 Fax: +54 11 4576 3384
e-mail: rubenq@ege.fcen.uba.ar

Introduction

Wetland ecosystems are considered among the most productive and highly biodiverse ecosystems on Earth (Mitsch & Gosselink 1986), providing critical habitat for many animal and plant species (Bedford *et al.* 2001). Some of the greatest threats to wetland biodiversity are the result of conflicting land uses (Brinson & Malvárez 2002) involving important processes of transformation and exploitation (Pearce & Turner 1990). The latter modify the original landscapes as well as the plant and animal assemblages of wetlands (Roggeri 1995).

The lower delta of the Paraná River is one of the most important wetland areas of Argentina. We deemed this wetland worthy of special attention for its ecological and biogeographical characteristics, unique in South America. Despite profound transformations due to human activities, it still preserves an important biological heritage, including both species that are threatened nationally and internationally (e.g. marsh deer -*Blastoceros dichotomus*- and river otter -*Lontra longicaudis*-) and species particularly important in commercial terms and a vital resource for local communities (e.g., coypu -*Myocastor coypus*- and capybara -*Hydrochaeris hydrochaeris*-. This is one of the reasons for which, in November 2000, an important area of the lower delta was included in the Unesco´s worldwide network of Biosphere Reserves, thus determining the actual establishment or the "Delta del Paraná" Biosphere Reserve (Kandus *et al.* 2006). This reserve protects not only wildlife but also freshwater marshes, ceibo (*Erithrina crista-galli*) forests and relicts of the original riparian forest which are insert in a matrix composed mainly by poplar (*Populus* spp.) and willow (*Salix* spp.) afforestations and patches of secondary forests.

Furthermore, it is a very important natural area for various peripheral cities, particularly Buenos Aires, whose location makes it subject to pressures such as large infrastructure construction and changes to productive modalities that have a detrimental effect on hydrological dynamics and, therefore, on ecological characteristics.

This paper reviews how forestry activities have modified the islands' original landscapes of the lower delta of the Paraná River and takes the capybara as an example of an amphibious species sensitive to changes in the hydrological conditions of its habitat in order to discuss how different forestry landuse modalities may affect its conservation, especially as regards alterations to the hydrological regime. We point out that some forestry systems are better able to maintain the hydrological dynamics of this delta whereas others, given the magnitude of the changes they cause, lead to the loss of original wetland characteristics, with the resulting detrimental effect on capybara.

The capybara

The capybara (*Hydrochaeris hydrochaeris*), the largest living rodent in the world, is typical of South American tropical and subtropical wetlands (Ojasti 1973). Adapted to an amphibious life, it is invariably associated with aquatic habitats, where it is better able to fulfill its physiological functions such as thermoregulation and mating. Being an excellent swimmer, it also uses water bodies as refuges and escape routes from predators. Exclusively herbivorous, it grazes close to water (Herrera & Macdonald 1989; Quintana 2002). Consequently, water availability, grazing and terrestrial resting areas determine the extent of suitable habitats (Ojasti 1973; Herrera & Macdonald 1989).

The lower delta of the Paraná river

The Paraná River delta lies at the end of the Del Plata Basin, Argentina, over an area of 17,000 km^2 (Malvárez 1999). The lower delta, the southernmost sector, accounts for around 320,000 hectares (Fig.1a). Its islands are surrounded by a higher perimeter or levee whose original riparian forest (Burkart 1957) has been replaced by afforestations. The central area covers about 80% of the island's total surface area and consists of freshwater marshes and ceibo forests, the only significant surviving natural plant communities in the area (Kandus 1997). In biogeographical terms, the region is considered to be a subtropical intrusion into a temperate region, which has led to the co-existence of species from both areas, creating a differentiated and peculiar profile (Quintana *et al.* 2002).

The complex hydrological regime is characterized by periodic flooding of the Paraná and Uruguay rivers and moon and eolic tides of De La Plata River, sometimes so intense and lasting that it has serious consequences for both biota and local people (Kandus *et al.* 2006).

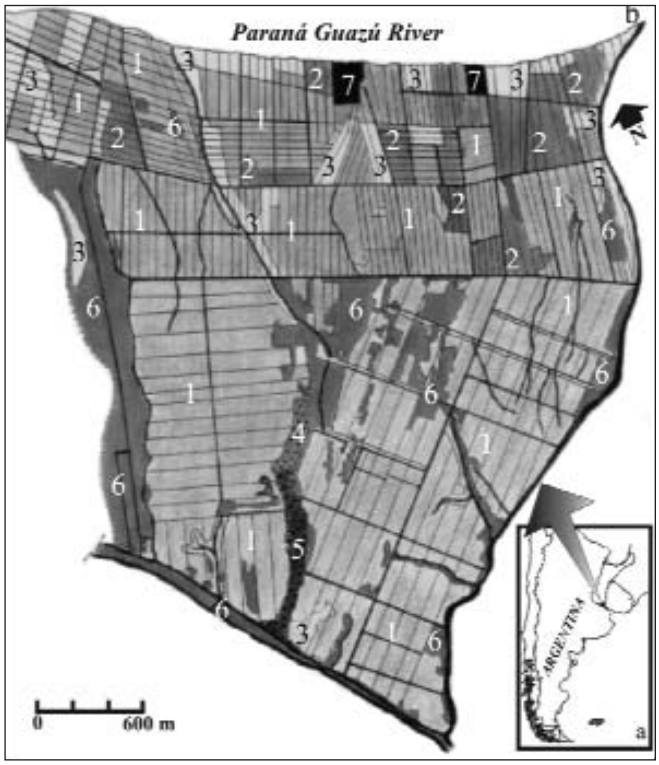

Figure 1: a) Study area in the Lower Delta of the Paraná River, Buenos Aires, Argentina. **b)** Habitat types present in an "open ditch" afforestation in the Lower Delta of the Paraná River ("Deltarbor" and "San Justo" forestry companies). **1)** Mature willow plantation; **2)** Young willow plantation; **3)** Poplar plantation; **4)** Mature forest of "black acacia" (*Gleditsia triacanthos*); **5)** Young forest of "black acacia"; **6)** Freshwater marsh; **7)** Surrounding human dwellings; ( ) Levees + channels; ( ) Ditche. (Source: aerial photographs, scale 1:20.000)

Alterations to the lower delta landscape due to forestry

Since the turn of the twentieth century, the natural landscape of the lower delta has undergone dramatic alterations due to human activities. Forestry with poplars (*Populus* spp.) and willows (*Salix* spp.) is now the main economic activity, involving roughly 20% of the region (Kandus 1997) and causing profound alterations to the original landscape. The original riparian forest been replaced and large areas of freshwater marshland have been drained and forested. Such alterations have led to the current cultural landscape with a mix of new artificial habitat-types with marshes and ceibo forest patches (Quintana 2005). An example of this is the land belonging to the forestry companies "Deltarbor" and "San Justo" (Fig. 1b). In this type of afforestation, so-called "open ditch", water management typically consists of drainage canals to eliminate excess water and channel it rapidly to the main water courses. Forestry patches predominate over 67% of the surface area, mainly mature willows (52%), the only relics of natural vegetation being isolated patches of freshwater *Scirpus giganteus* marsh (17% of total area; Table I). Forestry has also created lineal habitats or water lines consisting of ditches and channels and earthworks (man-made levees) in an intricate crisscross network. The landscape also includes two distinctive patches resulting from the dispersal of the exotic black acacia (*Gleditsia triacanthos*) (Quintana *et al.* 2005).

Family	Plant species	f (%)
Amaranthaceae	*Althernantera philoxeroides*	0.38
Poaceae	*Axonopus affinis**	6.09
Cyperaceae	*Carex riparia*	48.21
Poaceae	*Cynodon dactylon**	15.04
Cyperaceae	*Cyperus sp.*	0.21
Pontederiaceae	*Eichhornia crassipes*	0.04
Cyperaceae	*Eleocharis* spp.	0.96
Equisetaceae	*Equisetum* sp.	0.42
Juncaceae	*Juncus* spp.	0.29
Poaceae	*Lolium multiflorum**	0.54
Poaceae	*Panicum grumosum*	11.62
Poaceae	*Panicum sabulorum*	0.17
Poaceae	*Paspalum* spp.**	3.88
Poaceae	*Paspalum quadrifarium*	0.58
Fabaceae	*Trifolium repens**	0.17
Alismataceae	*Sagittaria montevidensis*	0.50
Salvineaceae	*Salvinia rotundifolia*	0.13
Poaceae	*Stipa hyalina**	0.04
Poaceae	*Zizaniopsis bonariensis*	2.21
Poaceae	Other Poaceae	2.34
Cyperaceae	Other Cyperaceae	4.75
	Malvaceae	0.83
	Dicotyledonous	0.83

Table I: Botanical composition of the capybara diet and annual percentual contribution of each food item for the Lower Delta of the Paraná River (Modify from Quintana et al. 1994). (*) Species only found in modified habitat types. (**) Genera *Paspalum* includes species found in modified and natural habitat types.

Thus, this far more complex landscape with its diversity of patches and their space-time relationships has resulted in a dynamic ecological mosaic in which the dense network of ditches and channels results in high landscape connectivity.

Landscape modification and its effects on capybara habitat

Cordero and Ojasti (1981) found that both capybara social behavior and family group concentration along the water courses reveal a far-from-random pattern of distribution. Thus, the type and space distribution of the water bodies determines the distribution of capybara populations. In this context, and on a landscape scale, "open ditch" forestry appears to have had a positive effect on habitat suitability for capybara because the resulting reticulate pattern not only creates more land-water interfaces (Quintana 1996) but also facilitates the matter, energy and species fluxes (Forman & Godron 1986) (Fig. 2). The intricate network of ditches and forestry channels has apparently benefited capybara as the low-predator-risk water corridors facilitate their access to the different type of patches.

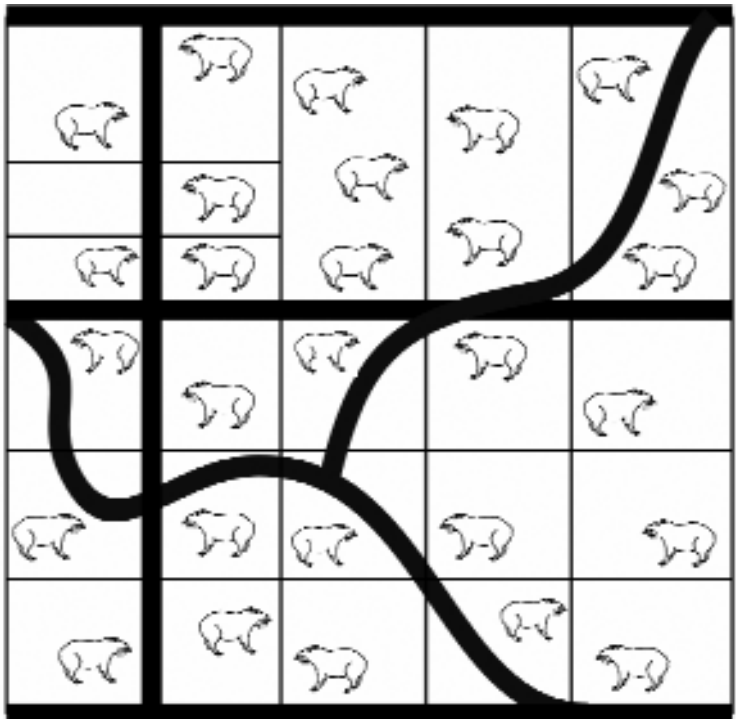

Figure 2: Sketch of potential distribution of capybaras in an "open ditch" afforestation. The diagram shows the aquatic network including both natural and man-made (channels) and natural (streams) water courses.

The other type of lineal habitats consists of levees running alongside the channels which are mostly used to move agricultural machinery within the forestry plantations. They provide capybara with rich grazing and sheltered resting areas (Quintana *et al.* 1994; Quintana 1996; Quintana *et al.* 2005). The establishment of new plant species and wider dispersal of native species in the latter as well as in other forestry habitats are reflected in their diet throughout the year. In particular, *Carex riparia*, the staple food of capybara in this area (Table I), is very abundant in habitats resulting from forestry activity (Quintana *et al.* 2005). *Cynodon dactylon*, *Panicum grumosum*, *Paspalum* spp., *Axonopus* affinis and *Lolium multiflorum* (Table I) are also consumed; they have become more common in the area thanks to the construction of levees, which are relatively higher and unaffected by periodic flooding, thereby allowing colonization by species with lower tolerance to flood conditions.

All these environmental features determine the usually presence of this rodent in "open ditch" afforestations. Our field observations show abundant capybaras´ tracks in many of the different habitat types (Table II).

Habitat type	FO (%)
YPP	0.0
MPP	2.0
ALE	87.0
YBA	0.0
MBA	3.0
YWP	66.0
MWP	7.7
FWM	85.0

Table II: Frequency of occurrence (FO) of capybara´s tracks observed in the different habitat types of an "open ditch" afforestation in the Lower Delta of the Paraná River ("Deltarbor" and "San Justo" forestry companies). YPP: Young Poplar plantation; MPP: Mature poplar plantation; ALE: Artificial levees; YBA: Young forest of "black acacia" (*Gleditsia triacanthos*); MB : Mature forest of "black acacia"; YWP: Young willow plantation; MWP: Mature willow plantation; FWM: Freshwater marsh.

The lower delta contains another type of afforestation in which the plantation is totally surrounded by a dam ("polder afforestation") to protect trees from floodwater. The area behind the dam is completely drained and the original marshes systematically eliminated, making the habitat much less suitable for capybara due to lack of water courses and freshwater marsh patches (Quintana 1996). Previous surveys on this type of afforestation have shown an absence of tracks indicating capybara activity, unlike in "open ditch" afforestations (Bó 1995).

In conclusion, "open ditch" afforestation has introduced what could be regarded as positive alterations to the islands' original landscape. Now, this forestry landscape has a high level of connectivity for such amphibian rodent and the aquatic network faci-

litates the access of capybara to the foraging, resting and shelter areas (Figs. 1b and 2). They improve habitat suitability for capybaras in terms of larger and better grazing areas, increased percentage of land-water interfaces and the presence of freshwater marsh patches for shelter. Other wildlife species have also been adapted to the ecological conditions of this type of afforestation. For instance, river otter uses actively water channels (García Cabrera 2006) and dusky-legged guan (*Penelope obscura*), a big frugivorous game bird, eats mainly fruits and leaves from alien plant species such as *Ligustrum lucidum*, *L. sinence*, and *Morus* spp., among others, and it is found mainly in patches of mature afforestations and secondary forests located along the rivers (Malzof *et al.* 2006).

However, when forestry activities are carried out behind dams, they drastically reduce habitat suitability for capybara and other typical wetland species in comparison with that of the original landscape basically due to the lack of water bodies. Thus, once forestry exceeds a certain threshold in terms of intensity or impact on original landscape structure, it may become incompatible with the very existence of capybara. Therefore, successful compatible management of wildlife and productive activities requires a clear idea of which landscape elements must be preserved or improved in order to guarantee the necessary habitats for a particular species. It must also take into account, above all, the accumulative impacts that such activities may have on the region as they become more widespread.

Finally, the fact that many wildlife species find open-ditch afforestations as a suitable habitat could be of relevance for wildlife management and forestry planning in the Biosphere Reserve and for the formulation of conservation policies for threatened species.

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Habitat suitability index models: black bear, upper great lakes region. Fish.and Wildlife Service U.S. Department of the Interior. Model evaluation form. Habitat models are designed for a wide variety of planning applica-tions where habitat information is an important consideration in the decision process.Â We also would appreciate information on model testing, modification, and application, as well as copies of modified models or test results. Please return this form to: Habitat Evaluation Procedures Group U.S. Fish and Wildlife Service 2627 Redwing Road, Creekside One Fort Collins, CO 80526-2899 Thank you for your assistance. Practice Wetland Wildlife Habitat Management Shallow Water Development and Management. Wetland Restoration. Wetland Creation.Â Habitat structure in restored wetlands appears to be a primary element that determines bird use of individual wetland sites. Density of waterfowl breed-ing pairs was lower in borrow ponds constructed along a highway in North Dakota than in natural basins of similar size (Rossiter and Crawford 1981, 1986). This was attributed to lack of a shallow water area and emergent wetland vegetation in borrow area wetlands. During drought conditions, Ruwaldt et al. As I have mentioned many times, the world has been engaged in a silent war waged by the global elite fought with quiet weapons since 1954. The COVID-19 scamdemic is the culmination of the eliteâ€™s 63 year plan to reduce the world population to 500,000,000. We are in the â€˜end phaseâ€™ of their clandestine depopulation agenda that is hidden in plain sight for all to see, read and hear. The elite talk about it and they write about it. These facts cannot be denied. Wildlifeâ€“habitat relationships models include spatially explicit models that â€œkeep track of the exact locations of plants and animalsâ€ or â€œhave a structure that specifies the location of each object of interest.â€ Application of spatially explicit habitat models has been facilitated by readily available aerial and satellite imagery, global positioning systems (GPS), increasingly comprehensive field inventories, and geographic information systems (GIS).Â Although the species can be found in a variety of forest types, it generally prefers a sufficient area of older forests across a landscape for foraging and roosting activities, and in some areas prefers landscapes with gentle slopes (Everett et al. 1997, Gaines et al. 2010). In order to survive in the hostile Amazon rainforest that is full of deadly predators and tough conditions, capybaras â€“ the worldâ€™s largest rodents (around 35â€“66 kg) â€“ have developed more specialized adaptations than any other rodent. First and foremost, capybaras are good swimmers, given that theyâ€™re physically well-adapted to a semi-aquatic lifestyle, particularly with their webbed feet that help them maneuver in the water or in muddy grounds, as well as their superior leg powers that enable them to swim with ease.Â Of course, thatâ€™s not enough in most cases: not all capybaras can make it to safety in time, because some can be killedâ€¦Â It is usually associated with living in wooded savanna habitat, but it is also commonly found in tropical rainforest areas too.