

**Promoting Sustainability of Human
Livelihoods in the Ñeembucú Ecoregion, Paraguay**

by

Juan José Aveiro Talavera

A Thesis Submitted to the Faculty of Graduate Studies of
The University of Manitoba
in Partial fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY

Department of Environment and Geography

University of Manitoba

March 2010

Copyright © 2010 by Juan José Aveiro Talavera

**THE UNIVERSITY OF MANITOBA
FACULTY OF GRADUATE STUDIES

COPYRIGHT PERMISSION PAGE**

**PROMOTING SUSTAINABILITY OF HUMAN LIVELIHOODS
IN THE ÑEEMBUCÚ ECOREGION, PARAGUAY**

BY

Juan José Aveiro Talavera

**A Thesis Submitted to the Faculty of Graduate Studies of the University of
Manitoba in Partial Fulfillment of the Requirements of the Degree**

of

Doctor of Philosophy

Juan José Aveiro Talavera ©2010

**Permission has been granted to the Library of the University of Manitoba to lend
or sell copies of this thesis/practicum, to the National Library of Canada to
microfilm this thesis and to lend or sell copies of the film, and to University
Microfilms Inc. to publish an abstract of this thesis/practicum.**

**This reproduction or copy of this thesis has been made available by authority of
the copyright owner solely for the purpose of private study and research, and
may only be reproduced and copied as permitted by copyright laws or with
express written authorization from the copyright owner.**

“Life is a challenge, meet it! Life is a dream, realize it!
Life is a game, play it! Life is Love, enjoy it!”

Sri Sathya Sai Baba (Indian Spiritual leader)

Abstract

Paraguay has 35% of its territory covered by wetlands. One of the most important is the Ñeembucú wetland, situated mostly in the Department of Ñeembucú. Human activity in sectors such as agriculture, industry, transportation (roads), and energy (hydroelectric dams), exercise pressure on the environment and natural resources.

Wetland conservation in particular needs to be prioritized, and this cannot happen without the involvement of the local community (Local Residents or Campesinos and Ranchers), which currently does not take place. Consequently, implementation of an ecosystem management approach is crucial to maintaining social, economic, and environmental wellbeing.

The overall objective of this research project is to promote sustainability of human livelihoods in the Ñeembucú ecoregion, Paraguay, working in partnership with stakeholders in order to balance production with environmental priorities.

The principal findings of this research study are presented according to each specific objective it addressed.

(1) *Determine the socio-economic situation in the Ñeembucú.* Campesinos live in a very precarious situation.

(2) *Assess changes in areas of water bodies and other land cover.* Human activities such as drainage, burning and deforestation, are causing a change in the water distribution and the vegetation complexity of the area.

(3) *Identify general changes in wildlife abundance in the Ñeembucú region with particular emphasis on indicators of ecosystem health.* There is a decrease in the wildlife population in the Ñeembucú region.

(4) *Establish how these changes are associated with cattle and crop production in the San Juan del Ñeembucú District.* Ranchers were the main builders of channels and roads.

(5) *Identify and establish further socioeconomic initiatives with ranchers and farmers that balance production and environmental priorities.* There is a lack of networking and joint work among stakeholders.

(6) *Recommend approaches to enhance sustainability of the ecoregion.* The main

recommendations are:

- Develop an adaptive management plan
- Stimulate environmental education to create awareness
- Encourage public participation
- Create protected areas for wildlife
- Support research
- Motivate local tourism and create work alternatives
- Create a sustainable and regional water management plan for the Ñeembucú Department
- Offer government technical support to local producers

Acknowledgements

Committee

I wish to express my deepest appreciation to Dr Richard Baydack for his guidance, assistance and friendship during the whole process. I must express my gratitude to Dr. Stephane McLachlan for the help to elaborate the title, objectives, and for his healthy criticism. Appreciation is expressed to Dr. David Walker for his assistance to analyze the GIS (Geographic Information System) data. Thank you to Dr. Merlin Shoemith, Dr. Roderick Riewe and Dr. Dale Wrubleski for their valuable advise.

Funding

The fieldwork was supported by a Doctoral Research Award grant from the International Development Research Centre (IDRC).

Collaborators

Thanks to Lic. Oscar Rodas for his help analyzing the GIS data; Ing. Rafael Gonzalez for his help organizing the field work; and Dr. John Brierly for his valuable assistance in elaborating the survey questions.

Family

I want to thank my wife Luz María for all her support, love, and strength to finish this “endurance marathon” work. Many thanks to my children, Adriana, Juan María and Gabriela, for their love and understanding.

Table of Contents

Abstract		i
Acknowledgements		iii
Table of Contents		iv
List of Tables		vii
List of Figures		viii
Chapter 1	Introduction	1
1.1	Physical Geographic Considerations	1
1.2	Human Geographic Considerations	11
1.3	Problem Statement	12
1.4	General Goal and Specific Objectives	13
Chapter 2	Study Area	14
2.1	Introduction	14
2.2	Topography	17
2.3	Water Resources	17
2.4	Soil	19
2.5	Climate	19
2.6	Flora	23
2.7	Fauna	27
2.8	Threats	34
2.9	Summary	40
Chapter 3	Fundamentals for Assessing the Desirability of an Ecosystem Management Approach in a Developing Country: Paraguay	42
3.1	Introduction	42
3.2	Campesino	42
3.3	Traditional Knowledge	42
3.4	Local Knowledge	43
3.5	Complementing Scientific Knowledge with Traditional and Local Knowledge	44
3.6	Wetlands: Definition, Roles and Functions	46
	Flood Control	48
	Ground Replenishment	48
	Sediment and Nutrient Retention and Export	49
	Climate Change Mitigation	49
	Water Purification	50
	Wetland Products	50
	Recreation/Tourism	51

	Cultural Value	51
	Habitat	52
3.7	Geographic Information Systems and its Use in Ecosystem Management	52
3.8	Ecosystem Management	55
3.9	Challenges Faced by Local Residents and Government Policy Makers in Terms of Promoting the Conservation of Biological Diversity in Paraguay	61
3.10	Diversity and Uses of Medicinal Plants in Paraguay	63
3.11	Summary	64
Chapter 4	Socio-economic Situation in the Ñeembucú	66
4.1	Introduction	66
4.2	Material and Methods	69
4.3	Results	78
4.4	Discussion	87
4.5	Conclusions	90
Chapter 5	Changes in Areas of Water Bodies and Other Land Cover Types	93
5.1	Introduction	93
5.2	Material and Methods	94
5.3	Results	102
5.4	Discussion	113
5.5	Conclusions	118
Chapter 6	General Changes in Wildlife Abundance in the Ñeembucú Region with Particular Emphasis on Indicators of Ecosystem Health	121
6.1	Introduction	121
6.2	Material and Methods	125
6.3	Results	126
6.4	Discussion	131
6.5	Conclusions	133
Chapter 7	Changes Associated with Cattle and Crop Production in the San Juan del Ñeembucú District	136
7.1	Introduction	136
7.2	Material and Methods	139
7.3	Results	140
7.4	Discussion	149
7.5	Conclusions	151
Chapter 8	Socio-economic Initiatives for Ranchers and Farmers to Balance Production and Environmental Priorities	155
8.1	Introduction	155

8.2	Material and Methods	158
8.3	Results	159
8.4	Discussion	166
8.5	Conclusions	169
Chapter 9	Summary and Contribution to New Knowledge	172
9.1	General Conclusions	172
9.2	Beneficiaries of the Research	174
9.3	Potential Use of Results	175
References		185
Appendix I	Questionnaire for Local Residents	218
Appendix II	Questionnaire for Ranchers	227
Appendix III	Questionnaire for Environmental Professionals	234

List of Tables

Table 3.1	Main Differences between the Conventional and the Ecosystem Approach	58
Table 4.1	Household Utility Services (%)	82
Table 5.1	List of satellite images obtained for this study	97
Table 5.2	Topographic maps used for this study	98
Table 5.3	Change of the rainfall regime and area of water bodies in the last 5 Years in the San Juan del Ñeembucú District	102
Table 5.4	Major cover types, satellite image from 2004, District of San Juan del Ñeembucú	113
Table 7.1	Types of livestock in the study area for local residents (LR) and ranchers who participated in the survey	142
Table 7.2	Total number of cattle in Paraguay and in the Ñeembucú Department; and percentage of Ñeembucú bovine production representing to Paraguay	143
Table 7.3	Numbers of cattle and owners in the San Juan del Ñeembucú District	143
Table 7.4	Local residents products and percentage of people selling it in the study area	144
Table 7.5	Local residents problems and their incidence in the study area	144
Table 7.6	Ranchers problems and their incidence in the study area	144
Table 7.7	Owners with cattle breed types in Ñeembucú and in Paraguay	145
Table 8.1	Important tourism resources in the Ñeembucú Department	161
Table 8.2	Wildlife and flora protected areas of Paraguay	163

List of Figures

Figure 1.1	The South American continent with its major rivers: Orinoco, Amazon, Paraná, Paraguay and La Plata	2
Figure 1.2	Eleven major South American watersheds	3
Figure 1.3	Río de La Plata basin in the South American continent	4
Figure 1.4	Río de la Plata basin system with its major wetlands, Pantanal, Ñeembucú and Iberá. Major rivers, Paraná, Paraguay and Uruguay	6
Figure 1.5	Paraguay and its main rivers	7
Figure 1.6	Paraguay geographical regions: AC Alto Chaco, MG Matogrosense, BC Bajo Chaco, CC Campos Cerrados, CP Central Paraguay, ÑE Ñeembucú, AP Alto Paraná. The underlying shape represents the 17 Departments (Provinces) in which the country is divided	9
Figure 2.1	Paraguay political divisions into 17 Departments	15
Figure 2.2	The department of Ñeembucú and its 16 Districts	16
Figure 2.3	Principals wetlands in Paraguay	18
Figure 2.4	Surficial water (rivers, creeks and lakes) in the San Juan del Ñeembucú District	20
Figure 2.5	Tebicuary River forms the northern border of the San Juan del Ñeembucú District	21
Figure 2.6	Yacaré creek which forms the southern border of the San Juan del Ñeembucú District	21
Figure 2.7	Maká lake is one of the most important in size in the San Juan del Ñeembucú District	22
Figure 2.8	Taraguí marsh is one of the several marshes in the San Juan del Ñeembucú District	22
Figure 2.9	Mean annual temperature (⁰ C) in Paraguay	24
Figure 2.10	Mean annual precipitation (mm) in Paraguay	25
Figure 2.11	An example of the riparian forest vegetation found in the Tebicuary River	28
Figure 2.12	Palm Tree Savannas vegetation type found near the Yacaré Creek	28
Figure 2.13	Woodland island vegetation surrounded by marshes	29
Figure 2.14	Marsh vegetation: <i>Victoria cruziana</i>	29
Figure 2.15	Floating island vegetation	30
Figure 2.16	Karau, Limpkin (<i>Aramus guarauna</i>)	32
Figure 2.17	Ciervo de los Pantanos, Marsh deer, Guasú Pukú (<i>Blastocherus dichotomus</i>)	33
Figure 2.18	Carpincho, Capybara, Capií'yva (<i>Hydrochaeris</i> <i>hydrochaeris</i>) chosen as a bioindicator of ecosystem health for the Ñeembucú	33
Figure 2.19	Surubí (<i>Pseudoplatistoma</i> sp)	35
Figure 2.20	Route # 4 showing the dike effect, which is the accumulation of water on the left side of the picture and lack of water	

	(not shown) on the right side	36
Figure 2.21	An example of a drainage channel in the San Juan del Ñeembucú District	37
Figure 2.22	Fire disturbance. Burning of pastures for grazing management before the spring rains	40
Figure 4.1	Department of Ñeembucú political division into 16 Districts and the study area, San Juan del Ñeembucú	70
Figure 4.2	Mario Osmar Fernández, guide, translator and facilitator	73
Figure 4.3	Means of transportation, motorcycle	73
Figure 4.4	Project explanations before an interview	75
Figure 4.5	Present of yerba mate given to a participant after an interview	78
Figure 4.6	Age structure of survey respondents (household heads)	79
Figure 4.7	Types of transportation used by local residents in the San Juan del Ñeembucú District	80
Figure 4.8	Horse for transportation in the San Juan del Ñeembucú District	81
Figure 4.9	Bus: public transportation in the San Juan del Ñeembucú District	81
Figure 4.10	Kitchen where wood is used for fuel	83
Figure 4.11	Latrine used by local residents in the San Juan del Ñeembucú District	83
Figure 4.12	Well used by local residents in the San Juan del Ñeembucú District	84
Figure 4.13	Level of education for local residents in the San Juan del Ñeembucú District	84
Figure 4.14	Land tenure for local residents	85
Figure 4.15	Level of education for ranchers	85
Figure 5.1	Orthophotographs from 1994, District of San Juan del Ñeembucú	98
Figure 5.2	Satellite image from 2004 with landcover types identified	101
Figure 5.3	Grass re-growth after burning the fields	104
Figure 5.4	Caraguatá (<i>Bromelia serra</i>)	106
Figure 5.5	Binary images for water bodies, San Juan del Ñeembucú District, A-1987 and B-2004	108
Figure 5.6	Water area in hectares. San Juan del Ñeembucú District, 1975, 1987, 1997, and 2004	109
Figure 5.7	Average annual precipitations in four different decades, Pilar Station	109
Figure 5.8	Total annual precipitations from four different years, Pilar Station	110
Figure 5.9	Cumulative relative frequency of water patch sizes, in four different years, 1975, 1987, 1997, and 2004 representing the distribution of size of the water patches, San Juan del Ñeembucú District	112

Figure 5.10	Disturbances observed in the Satellite Imagery from 2004, District of San Juan del Ñeembucú	114
Figure 5.11	Drainage channel discharging water into Yacaré creek	114
Figure 5.12	Overgrazed pasture	115
Figure 6.1	Causes of a decrease in Capybara population as suggested by local residents	127
Figure 6.2	Capybara population trend as suggested by ranchers	128
Figure 7.1	Garden of a survey participant	138
Figure 7.2	Land use, District of San Juan del Ñeembucú in 1991	146
Figure 7.3	Indian hybrid cattle in the study area	146
Figure 8.1	Map of the Paraguayan IBAs. September 2005. IBA PY042 Redondo situated in the San Juan del Ñeembucú District. IBA areas are colored in gray	165
Figure 8.2	Grasslands areas of the southern cone of South America. Semi-arid Pampa (1), Humid Pampa (2), Uruguayan Savanna (3), Mesopotamic Savanna (4), and Southern Paraguayan Grasslands (5)	167

Chapter 1 Introduction

1.1 Physical Geographic Considerations

South America Context

South America is characterized by the existence of large wetland areas, generally situated in the drainage basins of large rivers (Neiff and Malvarez 2006).

This continent is, with few exceptions, a wet continent dominated by large rivers connected to large interfluvial wetlands. The Amazon, Orinoco; and Paraná, Paraguay and La Plata Rivers occupy 1st, 3rd and 10th positions in the worldwide ranking of river discharge (Figure 1.1) (Junk and Furch 1993, Neiff and Malvarez 2006).

In South America there are 11 major watersheds (Figure 1.2). These are among the most important in the world as is referenced in the water resources world map created by the World Resources Institute, the International Union for the Conservation of Nature and Natural Resources, the International Water Management Institute and the Ramsar Convention on Wetlands. One of the biggest basins in South America is formed by the Paraná and the Uruguay watersheds, and it is called Río de la Plata Basin (Figure 1.3). This basin drains approximately one-fifth of the South American continent. The La Plata River system is recognized around the world as having the highest numbers of endemic fishes (in the Paraguay River sub-basin), the highest numbers of endemic birds (in the Paraná River sub-basin), with 11 Ramsar sites (in the Paraguay River sub-basin) and the highest number of major dams (the Paraná River sub-basin) (La Plata River Basin 2005, The Annotated Ramsar List: Paraguay 2005).

Figure 1.1 The South American continent with its major rivers: Orinoco, Amazon, Paraná, Paraguay and La Plata.

Source: Perry-Castañeda Library Map Collection, www.lib.utexas.edu/maps/americas.html



Figure 1.2 Eleven major South American watersheds.

Source: *Water Resource Atlas* (World Resources Institute, International Union for the Conservation of Nature and Natural Resources, International Water Management Institute and the Ramsar Convention on Wetlands).

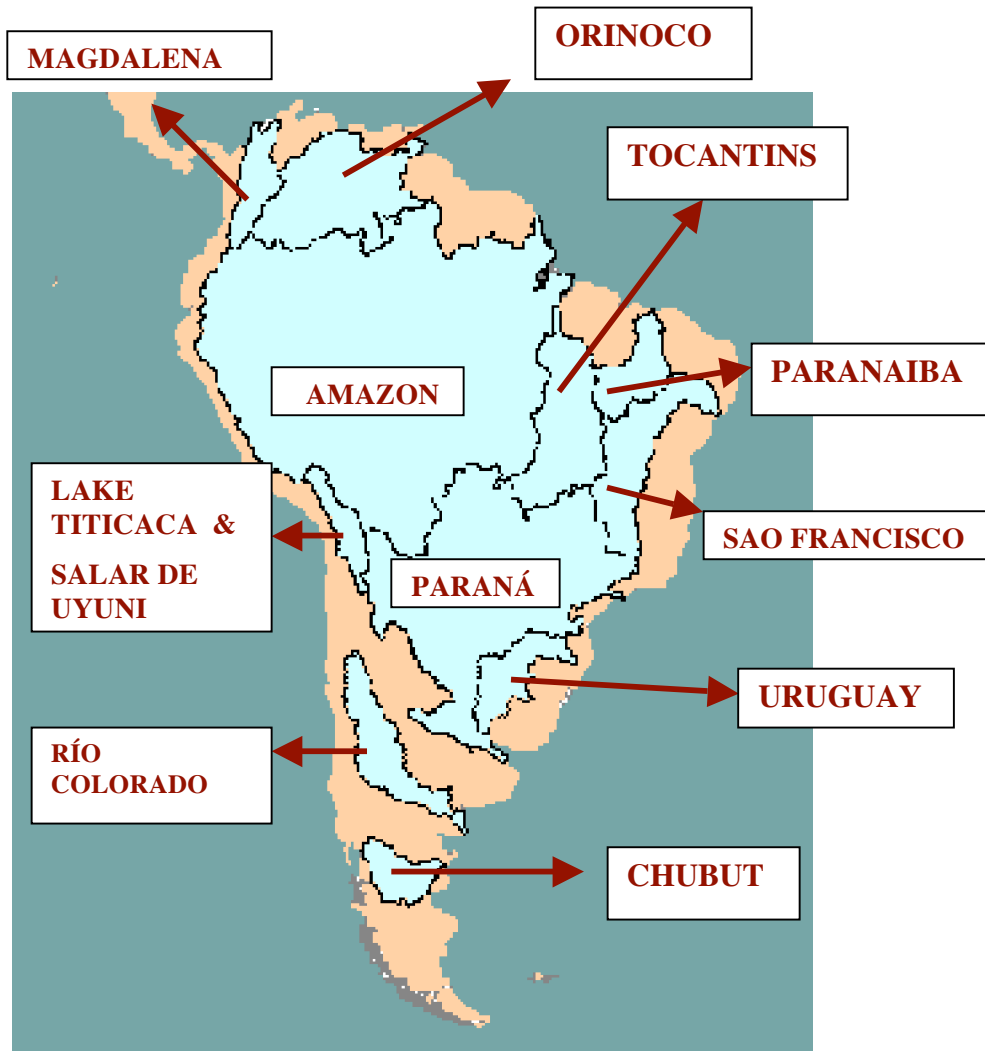


Figure 1.3 Río de La Plata basin in the South American continent.
Source: Oregon State University, Beccci Dale (cartographer).



The Río de la Plata Basin has major wetlands in this system such as: the Pantanal, Ñeembucú and Iberá (Figure 1.4) (Agua un Bien Común 2002).

Paraguayan Context

The Paraguay and Paraná rivers (Figure 1.4) are important migration flyways for shorebirds and other water birds in Paraguay. As well, the saline lagoons of the central Chaco and the Bahía de Asunción have been identified as key stopover sites for Nearctic shorebirds (Guyra Paraguay 2008).

Paraguay is a landlocked country and two-thirds of its borders are aquatic, formed by the Paraná, Paraguay, Pilcomayo, Apa and Negro Rivers, and the Estrella Stream. Associated with these rivers are numerous and extensive wetlands (30-40% of the country) (Figure 1.5). These wetlands are a meeting point for globally significant numbers of Nearctic migrants (primarily shorebirds), Austral migrants and resident species (Antas 1983, Hayes et al. 1990, Hayes and Fox 1991).

To date, 117 species of water birds have been recorded in Paraguay, of which 25 are Nearctic migrants (mostly shorebirds). Examples include: Pectoral Sandpiper (*Calidris melanotos*), Lesser Yellowlegs (*Tringa flavipes*) and Solitary Sandpiper (*Tringa solitaria*) (Lesterhuis et al. 2005).

One of the major wetlands in Paraguay is the Ñeembucú system, which occupies the southwestern corner of the east region in the Paraguayan territory. It includes the Departments of Ñeembucú and Misiones, and portions of Departments Central (southern), Paraguari (western), and Itapúa (western) (Hayes 1995).

Figure 1.4 Río de la Plata basin system with its major wetlands, Pantanal, Ñeembucú and Iberá. Major rivers, Paraná, Paraguay and Uruguay.
Source: Ecología y Sistemas Naturales con Enfoque en Sudamérica. Author: Joachim Puhe

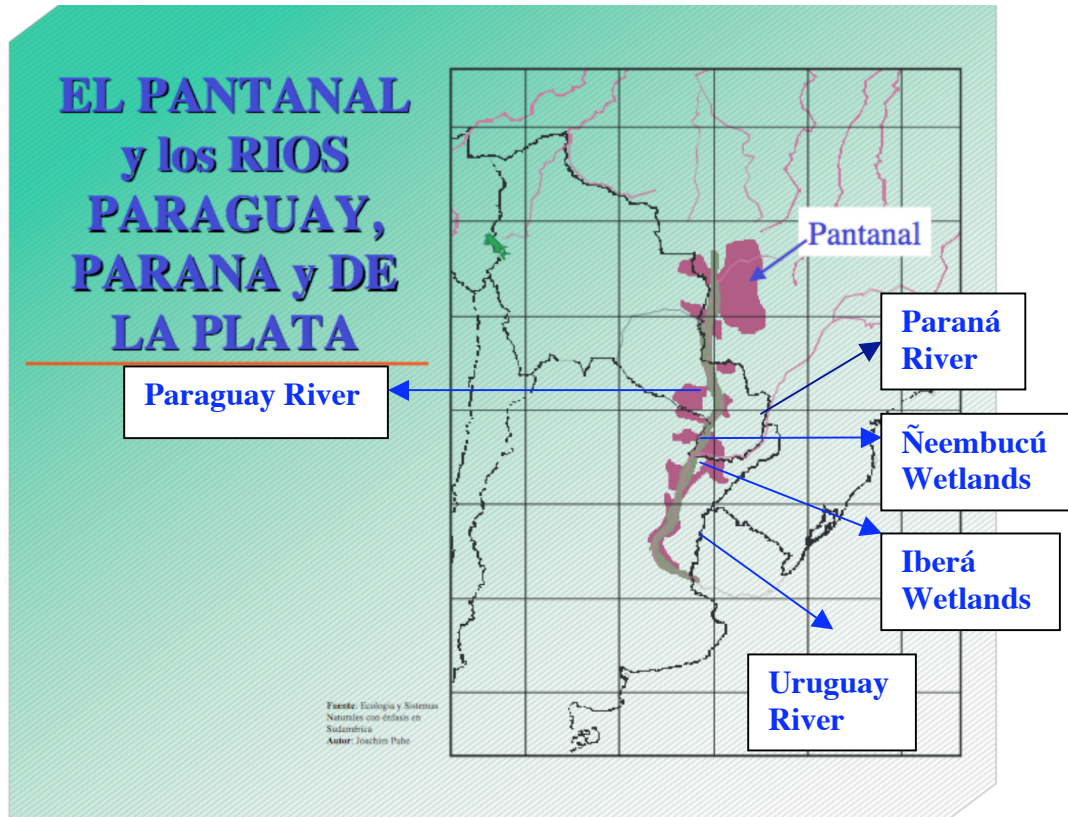


Figure 1.5 Paraguay and its main rivers.
Source: Encyclopædia Britannica, Inc., 1999.



Paraguay is subdivided based upon an ecological classification system into seven geographical regions (Figure 1.6) (Hayes 1995). One of these ecoregions is the Ñeembucú. Vast grasslands characterize this ecoregion as well as extensive, periodically inundated wetlands. Palm savannas, typical of the Chaco to the North, occur in some areas, and the landscape is dotted by small patches of low, sub-humid Chaco-like forest (8-15 m high) on slightly higher terrain. The region's terrain is generally flat and low in elevation and near the confluence of the Paraguay and Paraná rivers; its elevation is slightly less than 50 m above sea level (Hayes 1995, Estudios de Impacto Ambiental 1994).

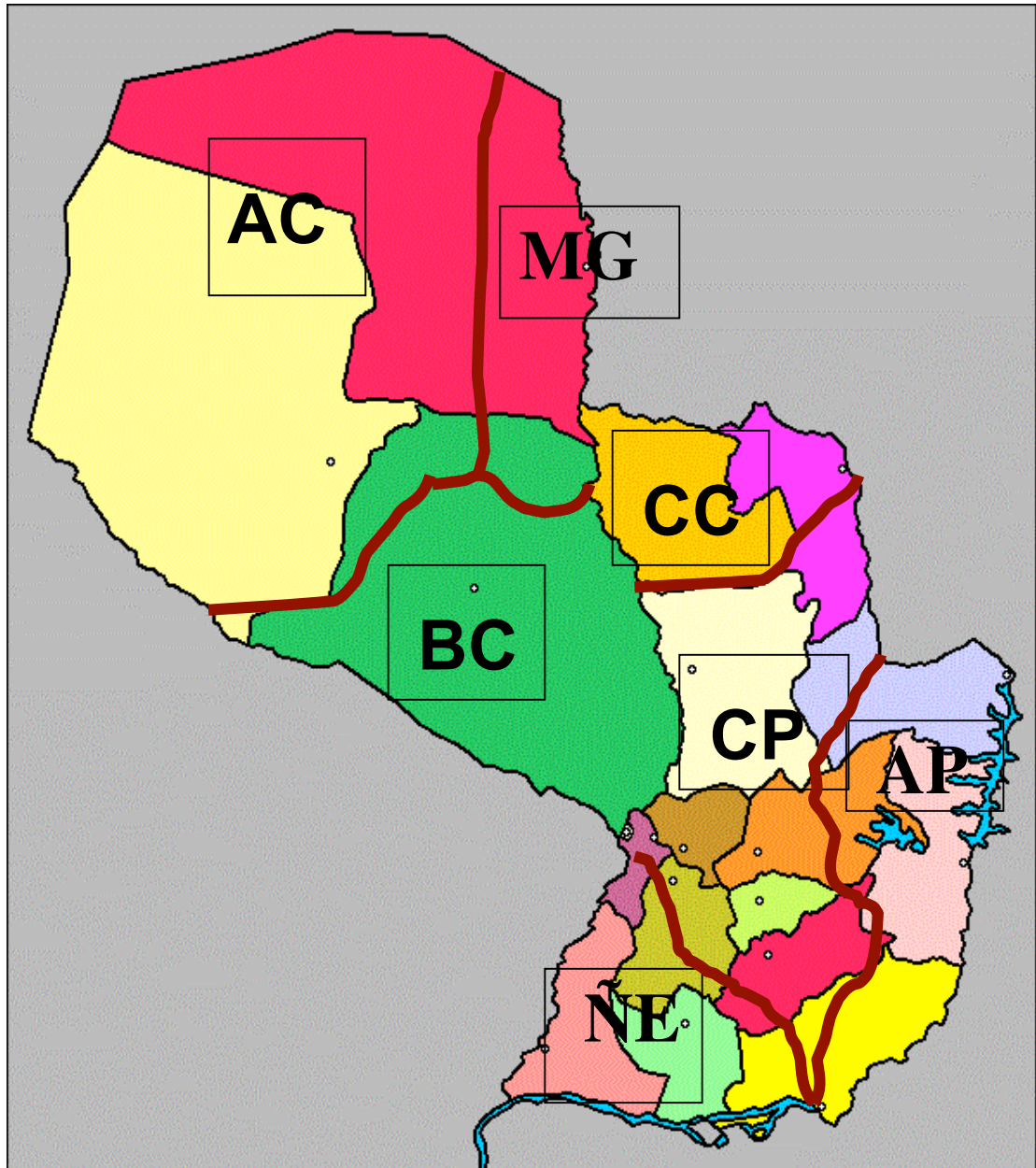
Natural Resources Use

Utilization of natural resources by humans is increasing in a geometric progression in Latin America, driven by population increase and rapid economic growth (Bucher et al. 1997). In fact, NAFTA (North America Free Trade Agreement) in North America and also MERCOSUR (Mercado Común del Sur, free trade agreement between Argentina, Brazil, Paraguay and Uruguay) in South America have exerted more pressure for even greater utilization of the natural resources in the region (Bucher et al. 1997).

During recent decades, the wetlands of South America have remained relatively pristine. Recent small-scale studies have shown, however, that those wetlands are disappearing at an alarming rate in some areas (Junk 2002). Long-term trends in wetland development vary from region to region according to the human demographic structure, economic development, and political system or leadership of each country. In this general framework, there are many human activities that affect

Figure 1.6 Paraguay geographical regions: AC Alto Chaco, MG Matogrosense, BC Bajo Chaco, CC Campos Cerrados, CP Central Paraguay, ÑE Ñeembucú, AP Alto Paraná. The underlying shape represents the 17 Departments (Provinces) in which the country is divided (Hayes 1995).

Source: Map from <http://www.luventicus.org/mapas/paraguay.html>



wetlands, such as fisheries, agriculture and ranching, modification of the hydrological regime, modification of the native flora and fauna, deterioration of water quality, climate change, recreation and tourism (Junk 2002).

In their migration, shorebirds use a succession of staging areas and a variety of habitats for resting and feeding such as wetland areas (Deinlein 2005). These wetland areas provide the food and resources needed at different times of the year for breeding, migration and survival (Donaldson et al. 2006). Today, many of these areas that have historically supported birds on their flights north and south of the Americas are reduced in size and the food supply has been degraded (Deinlein 2003).

Habitat loss in wintering grounds in Central and South America is affecting shorebird population size due to the fact that they are highly dependant on the resources found at the stopover areas. In many cases, bird conservation means protecting the places where birds nest and raise their young, spend their winters, and rest and rejuvenate during migration. For highly migratory species such as shorebirds, to attain population sustainability in the northern hemisphere will be impossible if effective conservation is not occurring in other parts of their range (Donaldson et al. 2006, O'Harra 2002).

The impacts of climate change are becoming apparent in changing temperatures and rainfall patterns around the world. Paraguay has had severe droughts in the past five years, which are affecting crop and cattle production, which are the cornerstones of the Paraguayan economy (Burgos et al. 2006). Wetlands play an important role in mitigating the effects of climate change; therefore, their conservation is crucial for the Paraguayan economy and the livelihood of the people

living in these areas (Estrategia Nacional y Plan de Acción para la Conservación de la Biodiversidad del Paraguay (ENPAB) 2003, Sudmeier-Rieux et al. 2006).

1.2 Human Geographic Considerations

Paraguay is divided politically into 17 Departments, including Ñeembucú. Ñeembucú has a low population density. Seventy percent of the Department's land area is flooded. Due to this topographic characteristic, the principal human productive activities are traditional livestock management and subsistence agriculture. In agriculture, people use high elevation lands for growing agricultural products that are used for subsistence and for trading. Corn, beans, and yucca are grown for subsistence, whereas cotton is commercialized (Proyecto de Desarrollo Rural 1992).

Ranchers in Paraguay rely on the environment entirely because all cattle are grass-fed. A rancher's main goal is to preserve the ecological balance of the area in order to have good beef production yet also earn the highest economic value for his livestock (Burgos et al. 2004).

Since the majority of the working force in this Department is situated in the primary sector, it is very important to maintain the sustainability of this ecoregion. This is because the habitants of this area depend on the environment for their livelihood (ENPAB 2003, Lesterhuis et al. 2005).

The conservation of wetland ecosystems in the Neotropics is a challenging task due to the ecological, geographical and socio-political complexity of these areas. These difficulties are compounded by an incomplete knowledge of system dynamics and the potential impacts that economic activities may have on wetland ecosystem functioning (Loiselle et al. 2004).

1.3 Problem Statement

The status of Paraguayan natural resources is threatened by diverse human activities such as: agriculture, industry, transportation (roads), energy (hydroelectric dams) and also from socio-demographic tendencies (Burgos et al. 2004, ENPAB 2003, Proyecto de Desarrollo Rural 1992, Salas-Dueñas et al. 2004).

This socio-demographic pressure over the environment occurs because three out of four people in the work force are in the primary sector (agriculture/livestock). This type of work depends heavily on the environment (Censo Nacional de Población y Viviendas 2002, Censo Agropecuario Nacional 1991, ENPAB 2003, Estudios de Impacto Ambiental 1994).

Consequently, in a Department such as Ñeembucú, working with sustainable restoration and preservation through partnerships, which pay attention to concepts of sustainable development, are critical. Thus, this study has investigated the need or desirability of using an ecosystem management approach for the Ñeembucú Department in order to better achieve sustainable development. As part of the investigation, the following were considered: environmental education, public participation, adaptive resource management, departmental and municipal policies, and creation of protected areas.

In addition, incorporating traditional and local knowledge as well as scientific knowledge are very important in order to determine if participatory adaptive management is possible. This approach should be used to promote community awareness and action on conservation and management of wetlands and wetland resources.

1.4 General Goal and Specific Objectives

The general goal for this study was to determine the desirability of using an ecosystem management approach to enhance sustainability in the Ñeembucú ecoregion, Paraguay.

The specific objectives of this study were to:

- Determine the socio-economic situation in the Ñeembucú.
- Assess changes in areas of water bodies and other land cover.
- Identify general changes in wildlife abundance in the Ñeembucú region with particular emphasis on indicators of ecosystem health.
- Establish how these changes are associated with cattle and crop production in the San Juan del Ñeembucú District.
- Identify and establish further socioeconomic initiatives with ranchers and farmers that balance production and environmental priorities.
- Recommend approaches to enhance sustainability of the ecoregion.

Chapter 2 Study Area

2.1 Introduction

Paraguay is a landlocked country situated in the center of the South American continent between meridians 54°19' and 62°38' west and parallels 18°18' and 27°30' south. The total area is 406,752 km² (Clay et al. 2008, Hayes 1995, Naumann and Coronel 2008). The word Paraguay is derived from the Guaraní language meaning “source of water” (Hayes 1995) or “river that goes towards the ocean” (Naumann and Coronel 2008).

The Paraguay River divides the country in two regions: the Oriental region to the east and the Occidental region or Chaco to the west. Paraguay is divided politically into 17 Departments and each one of them subdivided into Districts (Clay et al. 2008) (Figure 2.1). The Ñeembucú Department is situated in the southwest part of the country. It has an area of 12,147 km² and is geographically situated 26°35' – 27°20' latitude south and 56°35' – 58°40' longitude west. The Department is divided into 16 Districts (Figure 2.2) (Fogel 2000, Huespe et al. 1995).

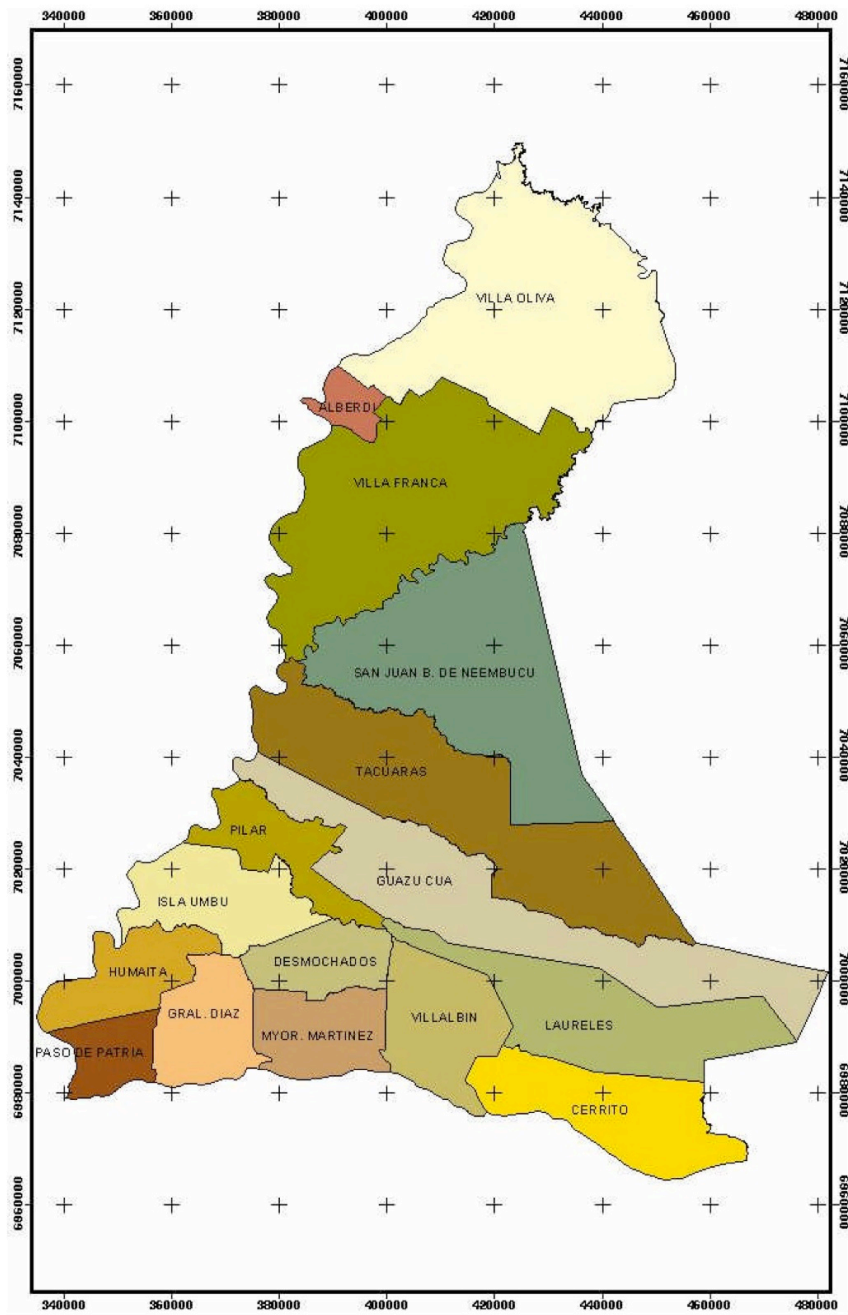
The Ñeembucú marsh system occupies most of this Department. This wetland system is one of the most important in Paraguay because of its size (800,000 hectares) and its richness in natural resources and biodiversity (Fogel 2000).

The District of San Juan del Ñeembucú was chosen to be the focus of my research project because it has very few environmental and socioeconomic projects and all the qualities mentioned above. Another important reason was that this District has two different types of environments, one influenced by a river (Tebicuary) and the rest influenced by wetlands. And finally the most important reason was that this District is a good example of the problems affecting the rest of the Department.

Figure 2.1 Paraguay political divisions into 17 Departments.
Source: Guyra Paraguay



Figure 2.2 The department of Ñeembucú and its 16 districts.
Source: Universidad Nacional de Pilar, September 2003.



The District of San Juan del Ñeembucú has an area of 141,294 hectares and a 2007 population estimate of 5,959 (Censo Nacional de Población y Viviendas 2002, Lombardi 2007). The town of San Juan del Ñeembucú (largest town in the District) was founded in 1817 (Riquelme 1974).

2.2 Topography

A flat and low terrain with a slope less than 1% characterizes the topographic profile of the Ñeembucú Department. It has small elevations to the south, which are called “albardones”, and which have a northwest – southeast orientation. There are many areas subject to flooding which originates from rain and water coming from the Paraná and Paraguay rivers (Fogel 2000, Huespe et al. 1995). According to Neiff (2004), this area has the Iberá - Ñeembucú wetlands model, which is: small lakes, surrounded by wetlands in sandy bars.

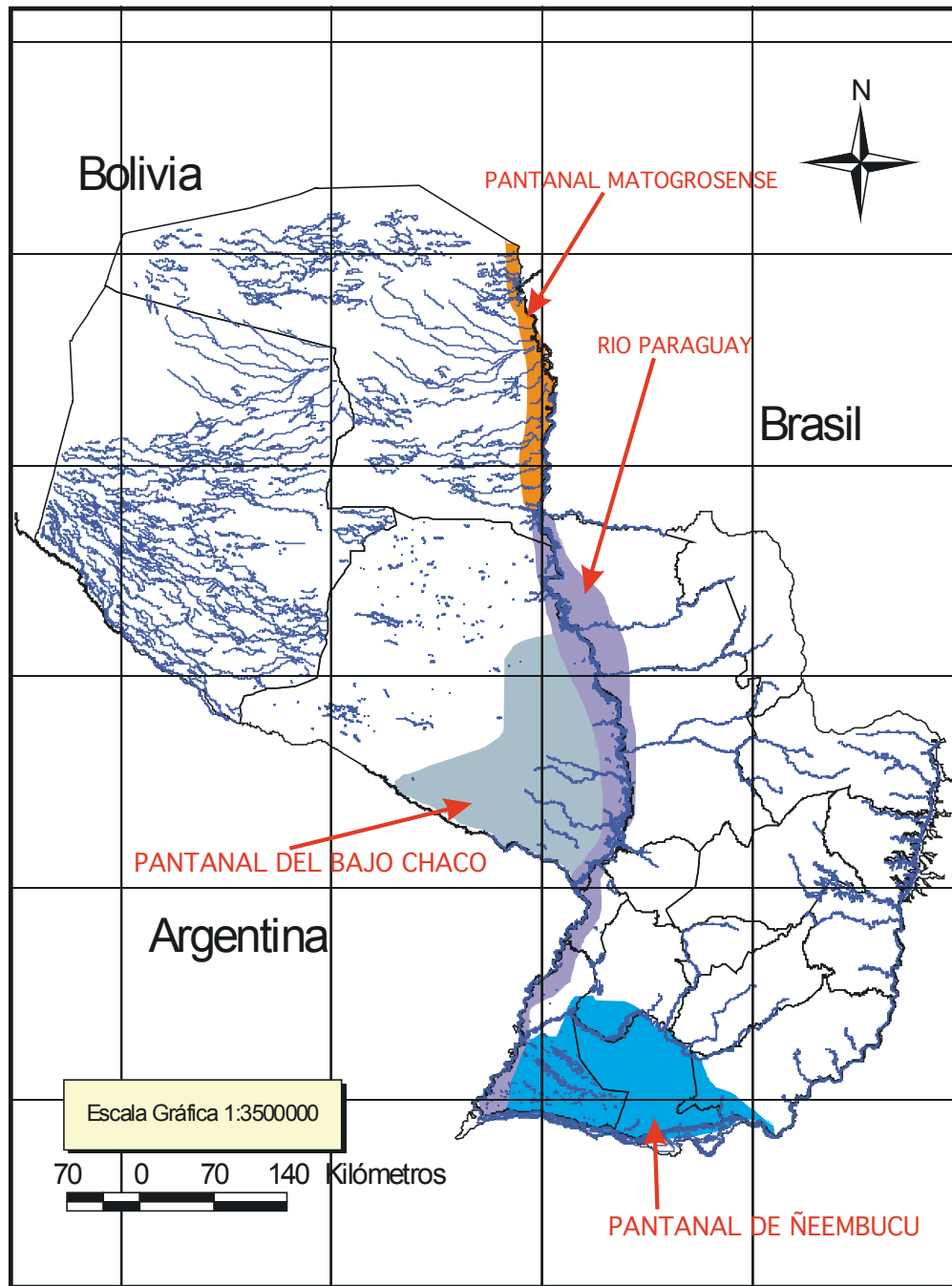
This wetland area originated from both geological and climatic factors. Tectonic movements, which occurred during the Tertiary Period, caused the Andean mountains to rise and resulted in a flat terrain that helped in the formation of wetland areas (Iriondo 2004, Neiff 2004).

2.3 Water Resources

More than 85% of the Department of Ñeembucú area is wetlands (Figure 2.3), which is part of the Paraguay-Paraná wetlands system, one of the biggest freshwater and biodiversity reserves in the world, extending into Argentina, Brazil, Bolivia, Paraguay, and Uruguay (Fogel 2000, Petean 2008).

The source of water in this Department comes from surficial water distributed in rivers, creeks, lakes and wetlands; water from rain (mean precipitation 1,350 mm); and ground water (Gonzalez 2006). In the District of San Juan del

Figure 2.3 Principal wetlands in Paraguay.
Source: Gonzalez 2006



Ñeembucú (Figure 2.4), there is one main river, the Tebicuary to the north (Figure 2.5), and one main creek, the Yacaré to the south (Figure 2.6). There is also a large system of lakes such as the Maká (Figure 2.7) and marshes such as the Taraguí (Figure 2.8), Cambá, Yacare-mi, Cecilio, Tayi care and Peguajho, covering the District (Fogel 2000).

All these sources of water are used as means of transportation, recreation, and for agricultural irrigation (Gonzalez 2006). The fact that most of the territory is covered by water creates what it is known as ‘la cultura del agua’ (‘culture of water’) (Fogel 2000).

2.4 Soil

Soils are comprised of 85% within the Alfisols group, 10% Entisols and 5% miscellaneous, using The Comprehensive Soil Classification System (CSCS) (Gonzalez 2006, Huespe 1995). Alfisols are soils of humid and sub-humid climates with a subsurface horizon of clay accumulation, and Entisols are mineral soils. The Alfisols and Entisols support forestry and cattle (Simonit et al. 2005, Strahler and Strahler 2005).

The soils are more or less acidic (pH 4.7 – 6.6). These soils are poor for agriculture due to the presence of sand, very little clay, low content of organic matter and low capacity to retain nutrients (Fogel 2000).

2.5 Climate

According to the Koeppen Climate Classification System, the entire Department of Ñeembucú falls in the cfa group of mesothermic classification. The letters ‘cfa’ stand for: c humid subtropical subgroup; f is for significant precipitation in all seasons; and a is for summer heat warmest month average temperature above

Figure 2.4 Surficial water (rivers, creeks and lakes) in the San Juan del Ñeembucú District.

Source: Dirección General de Encuestas Estadísticas y Censos, year 2002, Universidad Nacional de Pilar, Satellite Image Landsat ETM+, April 24 2002

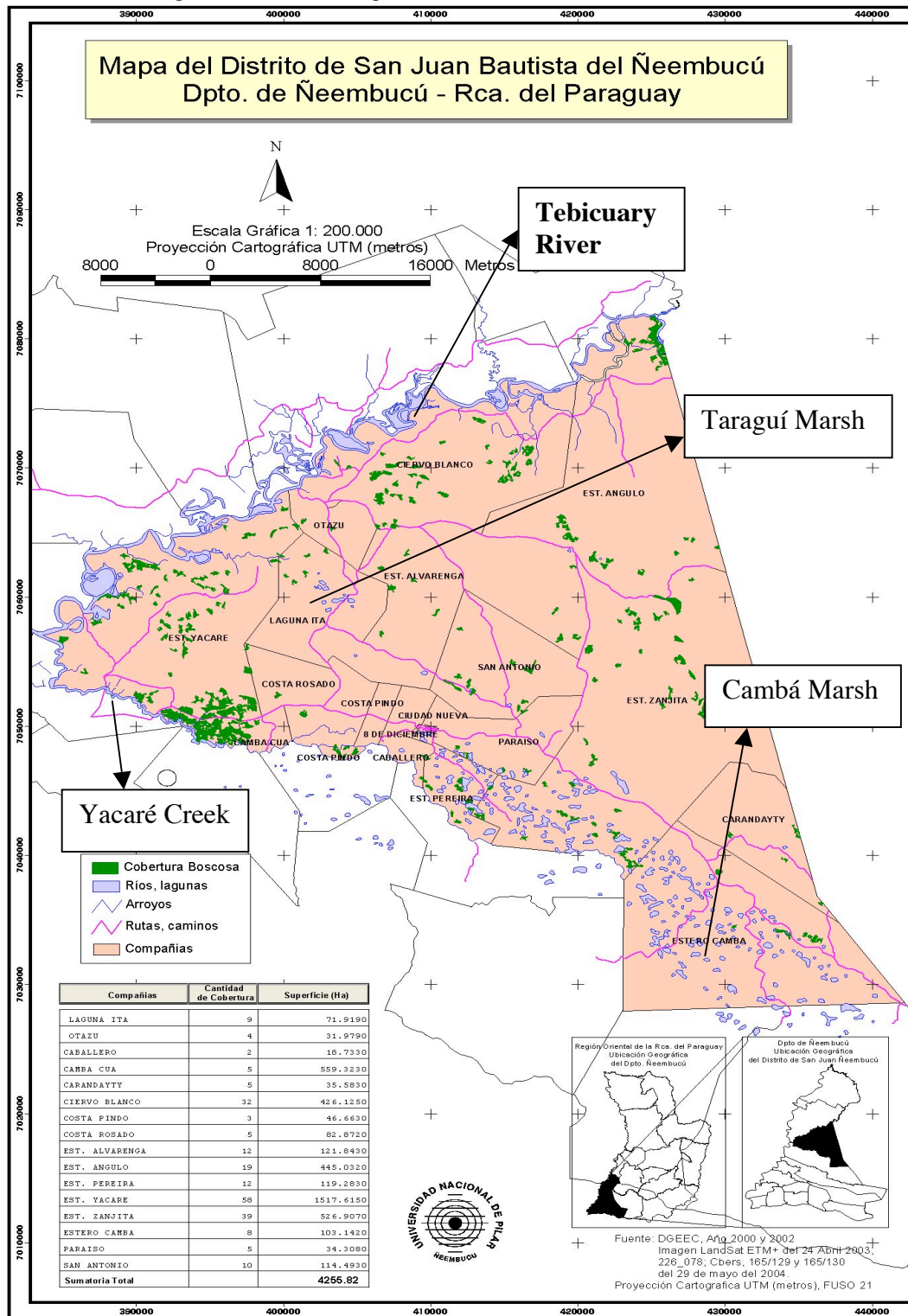


Figure 2.5 Tebicuary River forms the northern border of the San Juan del Ñeembucú district.



Figure 2.6 Yacaré creek which forms the southern border of the San Juan del Ñeembucú district.



Figure 2.7 Maká lake is one of the most important in size in the San Juan del Ñeembucú district.



Figure 2.8 Taragúí marsh is one of the several marshes in the San Juan del Ñeembucú district.



22⁰C (Clay et al. 2008, Huespe et al. 1995, Strahler and Strahler 2005).

The average temperature in the Department of Ñeembucú is 22⁰C with the coldest months of June, July and August occasionally reaching 0⁰C (Figure 2.9). Because winds are usually northeasterly or southeasterly, dramatic changes in temperature are common as warm or cold fronts pass through the area (Clay et al. 2008, Hayes 1995, Huespe et al. 1995).

The average rainfall is 1,400 - 1,500 millimeters, increasing toward the east and concentrated during the early summer months (November to January) (Figure 2.10) (Clay et al. 2008, Huespe et al. 1995).

2.6 Flora

The plants living in this area could be classified into three groups according to their type of habitat, and include aquatic or hydrophyte, marshy and terrestrial. Aquatic plants are those having their whole life cycle in water. The second group, the marshy plants, lives in inundated areas and have their rhizomes secured to the mud surface. Finally, terrestrial plants are those living on uplands, such as grasses, shrubs and trees (Perez de Molas 2003b).

The main vegetation formations in this District are: Riparian Forest, Palm Tree Savannas, Woodland Islands, Marshes and Floating Islands as classified by Mereles 2004a and Vogt and Mereles 2005.

The characterization of these vegetation formations is related to the characteristics of an aquatic environment, which is very predominant in this District. There are two main groups of vegetation complexes, classed as the aquatic environment and the inundated environment (Mereles 2004a, Vogt and Mereles 2005).

Figure 2.9 Mean annual temperature ($^{\circ}\text{C}$) in Paraguay.

Source: Dirección de Meteorología e Hidrología, www.meteorologia.gov.py

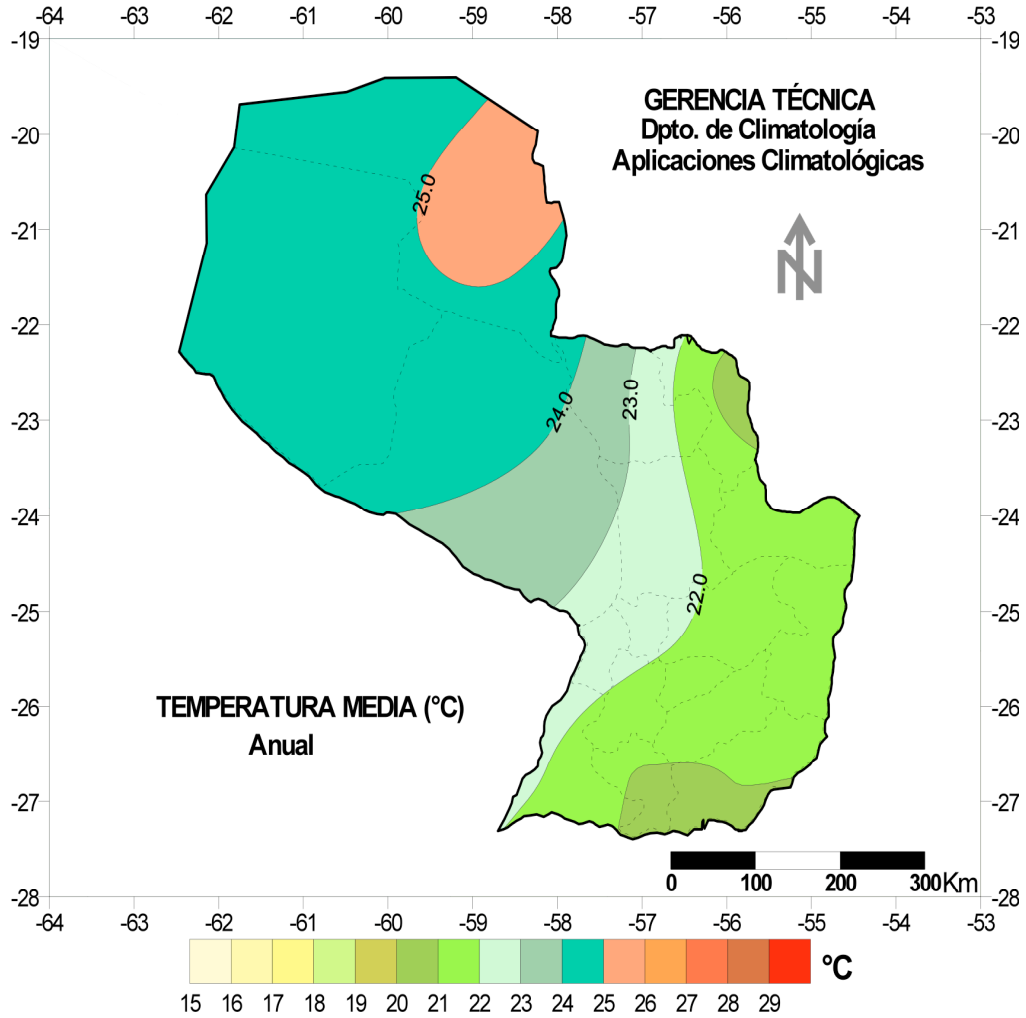
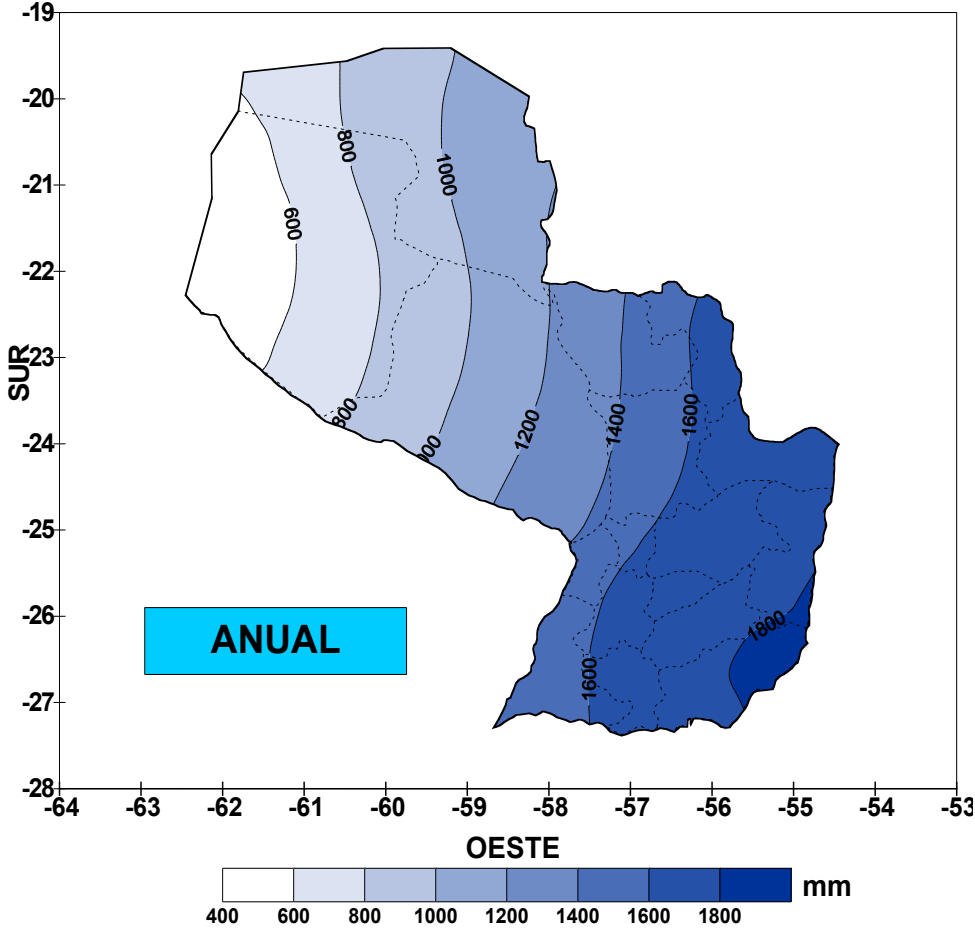


Figure 2.10 Mean annual precipitation (mm) in Paraguay.
Source: Dirección de Meteorología e Hidrología, www.meteorologia.gov.py



The aquatic environment consists of permanently flooded areas. In this group are the Marshes and the Floating Islands. The other group, the inundated environment, consists of areas flooded for variable periods of time. In this group are the Riparian Forest, Palm Tree Savannas, and Woodland Islands (Mereles 2004a, Vogt and Mereles 2005).

The Riparian Forest (Figure 2.11) is found adjacent to water bodies such as rivers, creeks and lakes. It has 2-4 vegetation layers, being approximately 6 meters height at the edge of the forest and approximately 20 meters height into the forest interior. The main trees that are found in this forest are Lapacho (*Tabebuia heptaphylla*) and Palo Blanco (*Calycophyllum multiflorum*), which grow on a sandy clay soil with considerable amount of organic matter (Fogel 2000, Gonzalez 2006, Perez de Molas 2003b, Vogt and Mereles 2005).

The Palm Tree Savannas vegetation type (Figure 2.12) is characterized by a large number of palm trees locally known as Karanday (*Copernicia alba*). This vegetation develops on a clay soil and constitutes remains of the vegetation type from the Occidental region or Chaco. This area gets inundated periodically and has rich hydrophyte vegetation such as the locally known water grass (*Elocharis elegant*) and the Mbery (*Canna glauca*) (Fogel 2000, Gonzalez 2006, Perez de Molas 2003a, Vogt and Mereles 2005).

The Woodland Islands vegetation type (Figure 2.13) is situated in higher areas, and received this name because of its shape resembling an island surrounded by water (wetlands). According to the plant species encountered, the woodland island vegetation could be classified as woodland island oriental and woodland island occidental. The woodland island oriental has vegetation species such as: Pindó

(*Arecastrum romanzoffiana*), Lapacho (*Tabebuia heptaphylla*) and Guayaybi (*Patagonula Americana*); and the woodland island occidental has vegetation species such as the Algarrobo (*Prosopis sp*) and the Quebracho Colorado (*Schinopsis balansae*) (Fogel 2000, Gonzalez 2006, Vogt and Mereles 2005).

The Marsh vegetation type has hydrophytic plants, deep water and soil with high organic matter content. Water comes from flooding of rivers and creeks. Species such as Yacaré Yrupé (*Victoria cruziana*) (Figure 2.14) and Camalotes (*Eichornia sp*) are found in this area (Fogel 2000, Gonzalez 2006, Perez de Molas 2003b, Vogt and Mereles 2005).

The Floating Island vegetation type (Figure 2.15) constitutes true floating islands with hydrophyte and marshy vegetation. The remains of these plants form an organic soil to which sediments transported by the wind are added. The main species are: Piri guazu (*Cyperus giganteus*) and Guajo (*Thalia sp*) among others (Fogel 2000, Gonzalez 2006, Vogt and Mereles 2005).

2.7 Fauna

The Ñeembucú Department has a high diversity of fauna with large numbers of birds, mammals, reptiles, amphibians and fish (Hayes 1995).

Paraguay has 685 species of birds of which 41% (279) are in the Ñeembucú Department (Pedrozo 2007).

Because of the prominence of water in this Department, there are many migratory and resident water birds (Gonzalez 2006, Pedrozo 2007). In Paraguay there are 130 species of migratory birds listed (Hayes 1995a) of which 22% are present in the Ñeembucú (Pedrozo 2007).

Figure 2.11 An example of the riparian forest vegetation found in the Tebicuary River.

Source: Lidia Pérez de Molas



Figure 2.12 Palm Tree Savannas vegetation type found near the Yacaré creek.



Figure 2.13 Woodland Islands vegetation surrounded by marshes.



Figure 2.14 Marsh vegetation: *Victoria cruziana*.



Figure 2.15 Floating island vegetation.



There are two main groups of migratory birds found in the country. The Austral migrants are those breeding in the Southern Hemisphere that regularly migrate northward during the nonbreeding season. In addition, the Nearctic migrants breed in North America and migrate southward during the nonbreeding season (Hayes 1995b).

The Nearctic migrants use the Paraguay River as a migration route. They enter the South American continent coming from the Caribbean and fly up to the Amazon River and its tributaries. Eventually, they reach the Pantanal and the Paraguay River reaching Paraguayan territory (Morales et al. 2006).

There are 39 species of Nearctic migrants listed in Paraguay. The most common Nearctic migrants in Paraguay are the aquatic nonpasserines, especially shorebirds.

Examples of these birds are Lesser Yellowlegs or Mbatuitui (*Tringa flavipes*); Solitary Sandpiper or Mbatui ño (*Tringa solitaria*); Pectoral Sandpiper or Playerito Pectoral (*Calidris melanotos*); and the Buff-Breasted Sandpiper or Playerito Canela (*Tryngites subruficollis*) (Hayes et al. 1990, Zarza and Morales 2006). Bertoni (1899) mentioned the Buff-Breasted Sandpiper in his descriptive catalog.

There are resident bird species that are economically important to the local people because they are a protein source. Examples of these species are: Jabiru, Tujujú (*Jabiru micteria*); Limpkin, Karau (*Aramus guarauna*) (Figure 2.16); and the Southern Screamer, Chajá (*Chauna torcuata*) (Pedrozo 2007).

Motte et al. (2004) cite 17 families of reptiles and five families of amphibians in the wetland environments of Paraguay. Reptile examples include the Paraguayan Caiman, Yacaré Hu (*Caiman yacaré*); the Broad-Nosed Caiman, Yacaré Overo (*Caiman latirostris*); the Boa Constrictor, Kuriyú (*Eunectes notaeus*) and the water turtles locally known as Karumbé (*Phrynops* sp). Amphibian families present in this area are the Bufoidae and the Hylidae (Gonzalez 2006, Motte et al. 2004, Pedrozo 2007).

There are 107 species of mammals in the Paraguayan wetlands and 19 of them are classified as threatened by the Ministry of Agriculture (Fauna amenazada del Paraguay 1998). Wetlands represent a refuge for a large number of mammals since the advance of mechanized agriculture has destroyed their habitat. This shows how important wetlands area for mammals in this country (Burgos 2004, Cartes 2004, Cartes 2006). The most emblematic mammals on the threatened list are: the Ciervo de los Pantanos or Marsh Deer or Guasú Pukú (*Blastocherus dichotomus*) (Figure 2.17)

Figure 2.16 Karau, Limpkin (*Aramus guarauna*).



and the Lobo de Crin or Maned Wolf or Aguará Guasú (*Chrysocyon brachyurus*). For the marsh deer, the Ñeembucú wetlands represents one of their few remaining habitats (Cartes 2006). Another mammal, the Carpincho or Capybara or Capií'yva (*Hydrochaeris hydrochaeris*) (Figure 2.18) is also used as a protein source (Cartes 2004, Neris et al. 2002). The Capybara was chosen as an indicator of ecosystem health for this study because it is found in areas with permanent water and its presence is characteristic of wetlands of this part of the world (Cartes 2004).

In this area, mammals are a source of protein as it was many years ago when aboriginals populated this region. The 'culture' of meat has given an important role to

the mammals in the Paraguayan socio-economy. Mammals are also used for medicinal purposes and for their hide (Burgos 2004, Cartes 2004).

Figure 2.17 Ciervo de los Pantanos, Marsh deer, Guasu Pukú (*Blastocheirus dichotomus*).



Figure 2.18 Carpincho, Capybara, Capii'yva (*Hydrochaeris hydrochaeris*) chosen as a bioindicator of ecosystem health for the Ñeembucú.

Source: Arne J. Lesterhuis



Hydrochaeris hydrochaeris
Arne J. Lesterhuis

Paraguayan wetlands are also very important for reproduction of most fresh water fishes. A 50% decrease in fishing on the Rio Paraná watershed has been attributed to wetland loss (Burgos 2004).

Examples of fish from lotic environments (river, creeks) are the Dorado (*Salminus maxillosus*) and Surubí (*Pseudoplatistoma* sp) (Figure 2.19) and from lentic environments (lakes, wetlands) the Bagres (*Pimelodidae*) and Tareyi (*Hoplias malabaricus*). The Surubí and Dorado are migratory fish and during migration may move into tributary rivers, lakes and wetlands for spawning. The young fish are able to grow here before returning to the river (Vera and Castillo 2006).

2.8 Threats

There are many threats to the Ñeembucú wetlands. The main ones are described below.

Construction of Roads

Some roads have been built in the area without an environmental impact assessment (Burgos 2004). This is the case of Route # 4, which creates a dike effect (Figure 2.20) due to the lack of sufficient culverts in a zone of difficult drainage because of its very flat terrain. The dike effect creates an accumulation of water on one side of the road and lack of water on the other side. Areas that were flooded for variable periods of time are now found with water most of the time or with no water at all. This dike effect is not only causing many trees to die but also interrupts several corridors for the local fauna and the inundation of grasslands used for ranching (Fogel 2000).

Construction of Hydroelectric Dams

In spite of its small size, Paraguay has two major hydroelectric dams. These two dams are located on the Paraná River. One of them, Itaipú, is considered the biggest in the world, generating 14.0 million kW of electricity. Both dams, Itaipú and Yacyretá brought economic development to Paraguay but at the same time direct and indirect environmental impacts to the area and to the country. The two dams, Itaipú and Yacyretá, inundated 135,000 and 100,000 hectares of land respectively. At the same time, these dams created major barriers for fish migration. Since these two dams are upstream of the Ñeembucú wetlands, they have caused environmental alteration to this region (Burgos 2004, Yanosky and Salas-Dueñas 2004). This is very important to consider because dams severely affect riverine wetlands, in both upstream and downstream directions (Brinson and Malvarez 2002).

Figure 2.19 Surubí (*Pseudoplatistoma* sp).



Drainage

Drainage (Figure 2.21) has been used in the area to recover land for more intensive agriculture and ranching. All of this was undertaken without an environmental impact assessment (Burgos 2004). In 1997, JICA (Japanese International Cooperation Agency) and the Paraguayan Government executed a project in the Ñeembucú Department called Dermasur. This project consisted of recovering land from 1983 flooding. Thirty kilometers of drainage channel systems were built for this purpose (Fogel 2000, Proyecto de Desarrollo Rural 1992). The

Figure 2.20 Route # 4 showing the dike effect, which is the accumulation of water on the left side of the picture and lack of water (not shown) to the right side.



negative effect of this project was that it was replicated in many areas of the Department without an objective environmental impact assessment. Machinery from the Dermasur project was also used to build roads, which resulted in more areas with dike effects, including privately owned land (Caballero and Gaona 2005).

Hidrovia

Hidrovia is another project threatening the Ñeembucú wetlands. This joint multicountry project between Argentina, Uruguay, Paraguay and Brazil, consists in dredging and canalizing the Paraguay and Paraná Rivers to create a 3,440 kilometer channel, at least three meters deep, so that large ships can navigate the interior of Argentina, Bolivia, Brazil, Paraguay and Uruguay. The Hidrovia will begin at

Figure 2.21 An example of a drainage channel in the San Juan del Ñeembucú district.



Puerto Caceres (Brazil) and end at Nueva Palmira (Uruguay) (Fogel 2000, Yanosky and Salas-Dueñas 2004).

Some detrimental effects are predicted. One of them is sediment suspension caused by dredging and navigation. These sediments may cause an obstruction of the natural drainage system of the wetlands and consequently alter the hydrologic system.

The decreasing of the water renewal in an inundated terrain will decrease the water quality and at the same time the nutrient contents. This situation could affect the local flora and fauna (Fogel 2000, Puhe 1997, Yanosky and Salas-Dueñas 2004). Another negative effect that this project will create is a downstream water flow increase in the Paraguay and Paraná Rivers, which will affect local riverine communities causing flooding of towns and properties (Puhe 1997). This flooding will also have a cultural impact because it will inundate archaeological and historic sites (Fogel 2000).

Fishing and Hunting

Hunting and fishing have increased but there is a lack of law enforcement from local authorities in the area (Burgos et al. 2004).

Deforestation

In 1945, the Oriental Region of the Paraguayan territory had 55% forest coverage. By 1997, only 17% of the forest cover remained. This deforestation has caused soil erosion and increased the negative effects of droughts and flooding, such as the 1983 flood in the Ñeembucú Department (Yanosky and Salas-Dueñas 2004).

An important threat to the local forest is the Pilar Textile Factory, which uses wood to fuel its steam engines. Angel Brusquetti (Agronomic Engineer, member of Moisés Bertoni environmental NGO and local hunter) mentioned in a recorded interview (July 30, 2007) that: “Pilar Textile Factory has been using wood since the 1930’s at a rate of 300 – 500 hectares per year. They have a reforestation program but it is not enough for its consumption”.

Agriculture and Ranching

Overgrazing caused by ranching and poor agricultural management is due to a lack of knowledge by the local producers and lack of technical support from

government officials (Burgos 2004). Ranching and agriculture have been the major activities impacting the environment in the area (Huespe et al. 1995).

Inadequate Policies for Natural Resources Conservation

Excessive concentration of land tenure, poor education, lack of public participation by local residents, lack of a land use plan and lack of laws tailored to the area are additional factors affecting local wetlands (Burgos 2004, Yanosky and Salas-Dueñas 2004).

Fire

Before the arrival of the first European settlers, the aboriginals in Paraguay used fire to hunt and farm. Aboriginal hunters used fire for hunting, especially during the winter when the pastures were dry. This type of hunting was used to hunt rodents and small animals; leaving a small “exit” where hunters waited and killed the animals running away from the fire. Later, the hunters would return to hunt deer, because these animals were attracted to the new pasture that resulted after the fire. For farming, aboriginals cut the trees and burned the fields. The ashes from the fire fertilized the fields. Some ethnic groups, such as the Avá, chose the jungle areas for their plantation sites where bamboo (*Merostachys clausenii* and *Chasquea ramosissima*) was abundant. Other plants did not grow in these sites and they had less work cutting trees (Métraux 1996, Miraglia 1975, Susnik 1982).

Currently, the majority of the fires occurring in Paraguay are from human activities such as agriculture and rangeland burning. Fire is used as a mechanism to reduce weeds and pests; and to promote new grass for cattle. Therefore, fire could be considered a disturbance since it is produced deliberately by man (Figure 2.22) (Neiff 2000).

Exotic plants

Exotic plants have been introduced into the Ñeembucú area. One example is the introduction of the eucalyptus (*eucalyptus* spp.). There are around 2,000 hectares of eucalyptus. There are some negative impacts when introducing eucalyptus in an area because it alters the soil structure and reduces other native

Figure 2.22 Fire disturbance. Burning of pastures for grazing management before the spring rains.



plants growth because its leaves and roots produce toxic substances such as phenols and alkaloids (Fogel 2000).

2.9 Summary

This chapter provides information about the study area and environment in order to understand the functional relationship of the ecosystem with the local people and producers.

Examples of this information are:

- **Location:** It is important to establish the geographical location of the study area in order to delineate the boundaries.
- **Topography and Soil:** These characteristics describe the ecosystem structure of the study area and at the same time, influence the human activities in the area.
- **Water Resources:** There is a functional relationship between water and people living in this area called “la cultura del agua” (the culture of water), which has a strong influence on everyday life.
- **Flora and Fauna:** This area has important biodiversity in flora and fauna, providing sources of protein and medicine (medicinal herbs) to local people.
- **Major Threats:** Major threats are the result of human intervention in this area, which affects the livelihoods of the local people and producers.

Chapter 3

Fundamentals for Assessing the Desirability of an Ecosystem Management Approach in a Developing Country: Paraguay

3.1 Introduction

The purpose of this chapter is to provide fundamental information on cultural issues, geographic characteristics, conservation issues, economic aspects and local governance issues for the study area. In this chapter, the influence that water has on the local people will also be described. The socio-economic structures and challenges that local people and Government face to protect the environment will also be discussed.

3.2 Campesinos

In order to clarify concepts and better understand Paraguayan culture, concepts such as “local residents” must be explained. Local residents are called Campesinos, and are defined as a person who works the land in order to produce food for their subsistence using help from family members. The Campesino’s economy has no wages and very little or no production surplus associated with it (Cuevas 2003).

3.3 Traditional Knowledge

There has been an increasing societal awareness of the importance of other knowledge systems; such as local and traditional knowledge, in describing resource uses. These types of knowledge are being used in resource dependent communities for the management of local resources and biodiversity (Turner et al. 2000, Berkes et al. 2000, Brook et al. 2006).

The term Traditional Knowledge (TK) is a knowledge system linked to tradition which is created, preserved and transmitted from generation to generation. This information is largely based on land use, environment, region, culture and

language (Gilligan et al. 2006, Huntington 1998). TK is also based on close observation of nature and refers to all types of knowledge related to the environment derived from the experience and traditions of a particular group of people (Pierotti and Wildcat 2000, Usher 2000). Traditional Knowledge is not restricted by genetics or by heritage to aboriginal persons (Usher 2000). According to Usher (2000), it has become a policy requirement in Canada to consider and incorporate Traditional Knowledge into environmental assessment and resource management.

In the past, Traditional Knowledge was an important form of resource management for North American aboriginal people. Some examples of this approach are that aboriginal social controls placed certain restraints on the fishing and hunting activities of the community in order to minimize concentrated efforts and to promote sustainability. By doing this, there was often a harvest surplus with the remainder given to the ones that most needed it (Gilligan et al. 2006). Traditional Knowledge has similarities to adaptive management with its emphasis on feedback learning and its treatment of uncertainty and unpredictability intrinsic to all ecosystems. Adaptive management could be seen as the scientific analogue of Traditional Knowledge because of its integration of uncertainty into management practices that confer resilience. Management practices based on TK may improve the process of designing alternative resource management systems (Berkes et al. 2000).

3.4 Local Knowledge

The term Local or Farm Knowledge is the knowledge generated through first-hand experience and the observations of the local environment by a specific group of people in a shorter period of time (Gilligan et al. 2006, Seixas 2002).

In aboriginal communities, Local Knowledge (LK) was obtained when children participated in harvesting and management of traditional foods. They observed and assisted their elders, parents and grandparents (Turner et al. 2000). In many parts of the world where there is a lack of scientific knowledge, local knowledge management models may substitute for scientific data. For example, in Brazil, knowledge from fishers provided detailed information on fish and other marine resources, including aspects of reproductive strategies such as location, timing and behavior. Local Knowledge is not a static set of information, it is constantly reshaped by users' own experiences; therefore, local knowledge can play an important role in designing, implementing and assessing adaptive management plans (Seixas 2002).

Local Knowledge can also be used for managing natural resources. For instance, local people in Kenya played a central role in the conservation of threatened wildlife and habitats in the Lower Tana River. This was accomplished by using their local knowledge in alternating fishing between lakes and the river through rotation (like in crops) based on seasons. This strategy enabled fish stocks to regenerate (Terer et al. 2004).

3.5 Complementing Scientific Knowledge with Traditional and Local Knowledge

Traditional and Local Knowledge can complement Scientific Knowledge in designing, implementing and assessing adaptive management plans because they adapt in response to crises (Seixas 2002).

Traditional and Local Knowledge can be integrated to Scientific Knowledge in order to have a better understanding of environmental topics. This knowledge can be used as the foundation for future decision-making (Gilligan et al. 2006). This

combination may build partnership and community consensus stimulating a dialogue between scientists and communities resulting in a synthesis of important values for natural resource management (Brook et al. 2006, Moller et al. 2004).

Science is excellent for collecting data in a relatively short period of time over a large area whereas Traditional Knowledge usually focuses on collecting data in a long time series basis, often in small areas. Combining Science and TK provides more complete information on time and space. Traditional Knowledge has a depth in experience in a local context and a window to cultural interpretations that may be unique. Therefore, these knowledge systems can be complementary in playing a positive role sustaining biodiversity and designing, implementing and assessing adaptive management plans (Becker and Ghimire 2003, Da Silva and Girard 2004, Moller et al. 2004, Seixas 2002).

As an example of this complementarity, Becker and Ghimire (2003) mentioned in their work in Ecuador that when scientists provided evidence about forest clearing reducing water supply to the community, local people modified land use patterns and set rules of use in the forest. Consequently, linking Traditional and Scientific Knowledge, has the potential to make a valuable contribution to communities and scientific research but at the same time requires considerable time and effort from all parties (Brook et al. 2006).

One of the downsides of the complementarity of Traditional and Local Knowledge is to identify a feasible way to document them (Huntington 1998). One of the methods is the semi-directive interview in which participants are guided in the discussion by the interviewer. This method is more a conversation than a question-and-answer session (Huntington 2000). The second method is a questionnaire.

Depending on the cultural context, this may be more comfortable for some respondents. Some questions can be left open-ended, giving the participant a chance to add detail. This format was the one used in the current study (Huntington 2000). The reason for using this approach was what Freire (1970) called “the culture of silence”. Freire describes “the culture of silence” as the result of oppression exerted on the people. In Paraguay, 34 years of dictatorship led to this condition and people opted not to talk much in order to “keep out of trouble”.

The analytical workshop is the other option to collect data and it consists of a workshop that brings together scientists and the holders of the information allowing both groups to better understand the other’s perspective and develop priorities for management (Huntington 2000).

3.6 Wetlands: definition, roles and functions

Wetlands have played an important role for humankind all through time. For example, the Nile, Tigris and Euphrates Rivers were the economic basis for the Egyptians and Sumerians 5,000 to 4,000 years ago (Junk 2002). Wetlands are among the most productive ecosystems on the planet (Stolk et al. 2006). In tropical countries, discussion of the value of the wetlands is still restricted to the use of resources for food production and of water resources for irrigation, and domestic and industrial use (Junk 2002).

Wetlands of international importance are recognized under the Ramsar convention. The Ramsar Convention is an inter-governmental conservation treaty, where a framework for international co-operation was provided for the conservation of wetland habitats to ensure their conservation and wise use. It is estimated, under the Ramsar Wetland Convention, that 33% of the world’s wetland are located in the

Neotropics (4.15 million square km²) (Kerry et al. 2000, van Dam et al. 2002). In South America, large wetlands cover an area of 1.0 million km² (Iriondo 2003, Junk 2002).

The Ramsar Convention definition for wetlands, widely used by local and regional researchers such as Burgos et al. (2004), Neiff (2004) and Puhe (1997), is as follows: “areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt including areas of marine water, the depth of which at low tide does not exceed 6 meters” (Wetland Values and Functions 2002).

The term wetland is not very precise. Wetlands are systems, which are not truly aquatic or terrestrial. It could be both at the same time or it could be terrestrial or aquatic depending on the season. This dynamism affects the flora and the fauna giving a habitat that differs from the aquatic and terrestrial (Stolk et al. 2006).

Wetlands are also characterized by flat areas in which the spatial and temporal occurrence of a variable cover of water during weeks to months produces important biogeochemical fluxes, and a biota whose structure and dynamics are well adapted to a wide range of water availability (Iriondo 2003).

Wetlands are valuable resources that supply many goods and services (or products, functions and attributes) to people. These functions are: flood control, groundwater replenishment, shoreline stabilization and storm protection, sediment and nutrient retention and export, climate change mitigation, water purification, wetland products, recreation/tourism, cultural value and habitat (Burgos et al. 2004, van Dam et al. 2002, Wetland Values and Functions 2002).

The description of each of the wetland functions is as follows:

Flood control

Wetlands play an important role in flood control. They can hold back heavy rainfalls, preventing possible flooding downstream by storing the water in the soil or retaining it in surface waters. Wetland vegetation also plays a role in slowing down the flow of floodwater (Bucher et al. 1997, Bullock and Acreman 2003, Fogel 2000, Wetland Values and Functions 2002).

For example, the Paraguayan wetlands are the major regulators of the regional climate of the Río de la Plata basin because they store most of the rainfall waters avoiding downstream flooding in the Argentinean and Paraguayan territory (Burgos et al. 2004). Flooding constitutes a major threat for the Ñeembucú ecoregion because it is situated at the confluence of two major rivers: Paraná and Paraguay. At this point, the Ñeembucú wetlands play an important role in flood control (Burgos et al. 2006).

Ground Water Replenishment

Strahler and Strahler (2005) define groundwater as subsurface water and aquifer as the layer, which holds groundwater. Groundwater is of crucial importance to billions of people in the world as their only source of drinking water. Many wetlands help recharge underground aquifers that store 97% of the world's unfrozen water. Other wetlands owe their existence to groundwater that has come to the surface as springs (Wetland Values and Functions 2002). In South America, one of the major aquifers in the world is the Guaraní Aquifer. Its expanse includes the territories of Argentina, Brazil, Paraguay and Uruguay. The Ñeembucú wetlands recharge the Guaraní Aquifer when the water table is low, but the aquifer will recharge the wetlands when the water table is high (Burgos et al. 2004, Burgos et al. 2006).

Sediment and Nutrient Retention and Export

Wetlands slow the passage of water and encourage the deposition of nutrients and sediments carried in water such as nitrogen and phosphorous. Nutrient retention in wetlands makes them among the most productive, rivaling even agricultural systems. This nutrient retention is completed by the growth of aquatic plants and by bacterial processes (Wetland Values and Functions 2002).

Inland floodplains and coastal deltas are the natural overflow areas that slow the velocity of the floodwaters, allowing nutrients and sediments to settle. The Ñeembucú wetlands are part of the Paraná Delta and have soils rich in organic matter (Burgos et al. 2004, Mereles 2004a, Wetland Values and Functions 2002).

Climate Change Mitigation

Climate change, defined in 1994 by the United Nations Convention on Climate Change, is a change in the climate attributed directly or indirectly to human activities, which alters the atmospheric composition with an increase of greenhouse gases and aerosols (Mendez et al. 2007). Carbon dioxide, methane and nitrous oxide are the most abundant anthropogenic greenhouse gases, and its primary source since the pre-industrial period results from the burning of fossil fuels. Increased greenhouse gasses contribute to a rise in temperature and a consequent change in precipitation patterns (Intergovernmental Panel on Climate Change 2007, Mendez et al. 2007).

In Paraguay, the main human activities and products causing an increase in greenhouse gases are: energy (production and use), industry (gases produced by the industries), agriculture and ranching. In these last two sectors, deforestation and pasture burning also occur. In 1945, the forest area in the east region of Paraguay was 55%, but by 1991 had been reduced to 15% (Mendez et al. 2007).

Wetlands have two major roles in mitigating effects of climate change. One is in the management of greenhouse gases, especially carbon dioxide. They act as significant carbon sinks storing as much as 40% of global terrestrial carbon. The other role is in buffering climate change impacts such as rising temperatures and changes in precipitation patterns. This was the case of “El Niño” (excessive rain, flooding) and “La Niña” (lack of rain, droughts) in the Ñeembucú wetlands during the years 2001 to 2005 (Burgos et al. 2004, Burgos et al. 2006, van Dam et al. 2002, Wetland Values and Functions 2002). During these years the Ñeembucú wetlands help counterbalance the negative effects of droughts by providing source of water.

Water Purification

Plants and soils in wetlands also play a significant role in purifying water, removing high levels of nitrogen and phosphorous and, in some cases, removing toxic chemicals. It can also be important in preventing high concentrations of these nutrients reaching groundwater supplies or other water sources that may be used for drinking water (Wetland Values and Functions 2002).

Aquatic plants such as the water hyacinth (*Eichornia crassipes*), native to South America and the Ñeembucú ecoregion (Mereles 2004a, Mereles 2004b), purify the water by absorbing and storing heavy metals in their tissues (Wetland Values and Functions 2002). These plants also serve as a substrate for microbial activity that removes nutrients such as nitrates, ammonia and phosphates (Bramwell and Prasad 1995).

Wetland Products

Wetlands such as the Ñeembucú provide humans with products such as fish, medicinal plants, fruits, ornamental plants, fiber, wood, water, forage plants and

others. For example caraguata'i or caraguatá del estero (*Eryngium elegans*) is used as a diuretic and the aguape'i or camalote (*Eichhornia crassipes*) as a cardiotonic.

Other plants are used as ornamental for aquariums such as the saeta de agua (*Sagittaria montevidensis*) and the helechito del agua (*Azolla filiculoides*). There are other aquatic plants, which are used as forage for animals such as the junquillo (*Eleocharis montana*) (Mereles 2004a, Mereles 2004b).

In the Ñeembucú wetlands, fish use these areas for spawning due to the slow flow of the water and the presence of water plants as habitat. This is the case with the fish, Dorado (*Salminus maxillosus*), with a strong link to this wetland area (Burgos et al. 2006, Fogel 2000).

Recreation/Tourism

The natural beauty as well as the diversity of animal and plant life in many wetlands makes them ideal locations for tourism. Recreational activities such as fishing, hunting, boating, and bird watching, involve millions of people who spend billions of dollars on these activities (Wetland Values and Functions 2002).

In economic terms, ecotourism is increasing in importance and may ultimately play an important role in the maintenance of tropical wetlands (Junk 2002). All of these activities can be implemented in the Ñeembucú wetlands due to its rich biodiversity, especially for bird watching (Burgos et al. 2006).

Cultural Value

Some wetlands have significant religious, historical, archeological or other cultural values for local communities, representing a part of a nation's heritage (Wetland Values and Functions 2002). The Ñeembucú wetlands have a rich history that must be strengthened because of its historic sites. Some of these historic sites are

battlegrounds of the Triple Alliance War fought against Argentina, Brazil and Uruguay from 1865 to 1870. There are also many churches that date back to the 1700s. Some areas have religious importance; this is the case of the spring called Ycuá Laurel, claimed to have miraculous healing properties (Burgos et al. 2004, Burgos et al. 2006, Fogel 2000, Miro 2004).

Habitat

Wetlands around the world hold a high biodiversity of species totaling around 40% of the world's species and 12% of all animal species (Wetland Values and Functions 2002). In Paraguay, wetlands are home to 107 species of mammals, of which 19 are considered threatened. Some examples are the Tapir (*Tapirus terrestris*) and Jaguar (*Panthera onca*) (Cartes 2004).

Wetlands also provide important habitat for birds. In Paraguay, 26% of the country's birds (179 species) are considered within the group of water birds, showing the importance that wetland habitat have for these species (Clay et al. 2004).

3.7 Geographic Information Systems and its Use in Ecosystem Management

There are many definitions for Geographic Information Systems or GIS. For the general public, GIS is: "a container of maps in digital form". For decision makers, community groups, and planners it is: "a computerized tool for solving geographic problems". For scientists and investigators it is: "a tool for revealing what is otherwise invisible in geographic information" (Longley et al. 2005).

Recent advances in remote sensing and the processing of remotely sensed data through GIS could help solve spatial problems, provided the capabilities of this technology are understood (Sample 1995). For this reason, researchers use this technology in order to retrieve data from large areas especially with the increasing

interest in landscape ecology and ecosystem management at a large scale (He et al. 1998).

Advances in technology such as GIS and RS (Remote Sensing) continue to facilitate the study of large, relatively unpopulated and inaccessible areas like wetlands and savannas in northern Australia. These technologies also provide valuable information for tropical environmental management information (Devonport and Bull 1999).

Managers need to know the status of natural resources, to monitor changes in these resources over time, and to predict and evaluate the impact of proposed courses of action. GIS provides the necessary framework to input, manipulate, analyze, and retrieve spatial data and related attributes of spatial features. GIS may also store data collected from a variety of sources and bring it together. Because of these features, GIS seems the most suitable tool to aid in the management of hydric resources (Calera et al. 1999, Devonport and Bull 1999).

The use of GIS can provide the efficient storage and retrieval of data with spatial characteristics that might otherwise be difficult to manipulate. The retrieval could be in the form of maps and reports that contain selected themes. These maps can be used as input data in models to examine forest landscape change over time (He et al. 1998). Change detection of wetland resources using satellite imagery over time is important because it ensures that wetland functions are maintained and also because wetland zones are very difficult to study due to very particular features such as heterogeneous and variable vegetation and water distribution (Canziani et al. 2003, Ozesmi and Bauer 2002). The application of different transformations to a temporal

sequence of images generates an advantageous method for problem detection through remote sensing (Canziani et al. 2003, Jepson 2005, and Ozesmi et al. 2002).

In the Neotropics, wetland conservation is a challenging goal due to the ecological, geographical, and socio-political complexity of these areas. There is a lack of knowledge of systems dynamics and the potential impacts that economic activities may have on wetland functioning (Loiselle et al. 2004). For this reason, to conserve wetland resources, it is important to inventory and monitor wetlands and their surroundings. For inventory and monitoring of wetlands, satellite remote sensing has many advantages. Satellite data has repeat coverage so that wetlands can be monitored seasonally or yearly. The satellite data are in a digital format and relatively easy to integrate into the GIS (Loiselle et al. 2004, Ozesmi and Bauer 2002).

There are many research studies where GIS was used as an important tool of spatial resolution for mathematical models applied to landscape dynamics for the conservation of vast wetlands in the La Plata Basin. They used it because it allowed them the possibility of studying the area in an integrated manner (Canziani et al. 2003).

In Paraguay, the use of GIS is relatively new, but increasing since 2000, due to different projects such as road construction, rice production, urban expansion and hydroelectric projects (Burgos 2006, Gonzalez et al. 2004).

As an example of GIS use in Paraguay, Burgos et al. (2006) used satellite images to create different theme maps. In research performed by Huang et al. (2007), the spatial extent of forest cover in 1989 and 2000 was mapped and the change between these years was documented for the entire country of Paraguay.

Technologies such as GIS combined with multidisciplinary study approaches can serve regional as well as local decision makers to make more informed decisions about territorial planning and wetland resource management (Loiselle et al. 2004). Management requires information to make decisions and GIS provides a framework for the collation and analysis of spatial data from different sources as well as information for input to management decision support systems (Devonport and Bull 1999).

3.8 Ecosystem Management

Meffe et al. (2002) define ecosystem as “a dynamic complex of plant, animal, fungal, and microorganism communities and their associated nonliving environment interacting as an ecological unit”. Ecosystem management could be defined as an approach to maintain or restore the composition, structure, and function of natural and modified ecosystems for the goal of long-term sustainability (Meffe et al. 2002).

This approach to land management has been supported by many scientists, managers, and others since the 1980s. At that time, managers could no longer discount the effects of humans in ecosystems (Grumbine 1994). Therefore, this approach integrated ecological, socioeconomic, and institutional perspectives (Meffe et al. 2002). Having said all this, we can assume that the main purpose of ecosystem management is understanding the ecological and socio-cultural processes, considering the people and their culture as dynamic agents and transformers of natural ecosystems (Andrade Perez 2008).

The main goals according to The Keystone National Policy Dialogue on Ecosystem Management (1996) and Shifley et al. (1997) for ecosystem management are:

- Maintain ecosystem integrity
- Sustain biodiversity and ecosystem processes at a regional scale
- Sustain vibrant, livable, and economically diverse human communities
- Incorporate distinct community and stakeholder values in the design and implementation of ecosystem management initiatives
- Integrate the ecological, economic, and social goals of stakeholders in an ecosystem.
- Employ adaptive management techniques.
- Address uncertainty and risk.

In order to have a better understanding of the ecosystem management concept we can use the comparison table used by Andrade Perez (2008) (Table 3.1). This table was introduced to point out the key differences between the conventional approach (CA) versus the ecosystem approach (EA) and these were: EA gives more emphasis to adaptive management not to conservation; EA incorporates other forms of knowledge such as traditional and local not only western knowledge; EA is based on people not only the environment; and finally, EA has a long-term vision not a short-term vision.

The ecosystem management approach follows the three-context model considering the ecological, socioeconomic, and institutional perspectives in the search for solutions (Meffe et al. 2002, Shepherd 2004). There are five basic steps in the ecosystem management approach used to implement this management system (Shepherd 2004, The Keystone National Policy Dialogue on Ecosystem Management 1996).

The first step is to map the ecosystem boundaries and determine the main stakeholders. This is done in order to determine the scale of the operation and to individualize the stakeholders who will manage the area. The area to be managed as an ecosystem should be large enough to encompass the complexities and linkages among the components and processes of the ecosystem and the solutions to the problems being addressed (Shepherd 2004, The Keystone National Policy Dialogue on Ecosystem Management 1996).

The second step is to describe the ecosystem structure with characteristics such as topography, weather, etc. In the third step the functional relationship of the ecosystem is described. In this step, it is important to address the relationship between climate, vegetation pattern and animal composition. This relationship is called internal. The external relationship will be the one relating the ecosystem being studied with other ecosystems (The Keystone National Policy Dialogue on Ecosystem Management 1996).

The fourth step sets society's goals and objectives. In this step the issues and problems will be identified. For this purpose, the stakeholder participation is crucial. Also, a time line for the project is set which in most programs reach 20 years (The Keystone National Policy Dialogue on Ecosystem Management 1996).

The fifth and last step is called implementation and evaluation. In this step the objectives are reached, the goals are achieved. For this matter, the information gained in data collection are used. The adaptive resource management over time is applied in this step and it involves long-term goals and manageable ways of reaching them (Shepherd 2004, The Keystone National Policy Dialogue on Ecosystem Management 1996).

Table 3.1 Main Differences between the Conventional and the Ecosystem Approach.
Source: Andrade Perez (2008)

Conventional Approach	Ecosystem Approach
Emphasis on conservation	Emphasis on adaptive management
Sectoral: management is focused on the extraction or use of a dominant good or service, in an isolated manner	Integral: takes into account all usable goods and services and optimizes the mixing of their benefits
Exclusively based on knowledge provided by western science	Involves other forms of knowledge including indigenous and local
Mainly environmentalist	Based on people, their society and their culture
Give priority to conservationist approaches to nature	Oriented to environmental and societal conservation
Top-down approach	Two-way approach, top-down and bottom-up
Short-term vision	Long-term vision
Give priority to production factors in an independent way	Considers goods and services as the product of a healthy ecosystem and not as ends in themselves

Meffe et al. (2002) define adaptive management as “the process of treating the work of managing natural resources as an experiment, making observations and recording them, so the manager can learn from the experience”. In other words, learn as you go.

The ecosystem management approach is emerging for the assessment and management of coastal waters around the globe utilizing modular strategies for linking science-based assessments of the changing states of large marine ecosystems to socioeconomic benefits expected from achieving long-term sustainability of their

resources. As an example, there is the Great Lakes approach, which led to agreements between the United States and Canada to follow longer-term pathways for sustainable use of ecological resources (Sherman and Duda 1999).

Another example would be Wear et al. (1996), who explained how ecosystem management was used as an organizing theme for land use and resource management in a Southern Appalachian watershed. This study indicated that public land management may have only limited influence on overall landscape pattern and that spatially targeted approaches on public and private lands may be more efficient than blanket regulation for achieving landscape-level goals.

Sparks (1995) documented the need to implement an ecosystem management approach for correct management of large rivers and their flood plains. This study concluded that allowing productive river-floodplain ecosystems to preserve species and produce fish and wildlife is probably cheaper and less problematic than building and operating hatcheries and zoological parks (Sparks 1995).

Focusing in South America, this continent presents some opportunities for the application of the ecosystem management approach. There are management experiences of protected areas lasting over 10 years. The Mata Atlantica project provides a valuable example of integrated planning applied in the region. There are also effective examples with participatory management experiences, mainly in the case of local communities with different types of players (Ripa de Marconi et al. 2001, Da Silva and Girard 2004).

Other projects in South America have shown the applicability of this approach. Azevedo-Ramos et al. (2006) integrated an ecosystem management approach with protected areas in the Brazilian Amazon. The results suggested that an

integrated network of protected areas among Amazon countries would be necessary to increase their efficiency in mammal conservation. Another important finding in this study was that the strengthening of the forest sector in Brazil as an economical alternative to ranching and agriculture becomes critical for the maintenance of large extents of forest.

The ecosystem management approach has also been used effectively in the Southern Cone (most southern tip of South America). An example for an ecosystem initiative in Paraguay is the connectivity strategy at Mbaracayú forest biosphere reserve (Salas-Dueñas and Garcia 2008). In this study, the social, environmental and economic aspects were included. The social component is represented by environmental awareness education and the creation and consolidation of a management committee in the local communities. The environmental component is represented by reforestation activities and building green corridors. In the economic aspect, communities are being favored by the creation of employment, such as reforestation. Therefore, this ecosystem project that was successfully applied has brought excellent environmental, social and economic results.

Some limitations for the implementation of ecosystem management are land boundaries, stakeholder illiteracy and the belief that participatory processes are very expensive (Andrade Perez 2008). Most developing countries will require assistance from the international community. However, it would be a tragic error to simply transfer temperate-region models and management methods to the tropics. Most of them are not suitable because they are cost intensive and do not fit the ecological and socio-economic requirements of developing countries. For these reasons, exchange of expertise is required (Junk 2002).

3.9 Challenges Faced by Local Residents and Government Policy Makers in Promoting the Conservation of Biological Diversity in Paraguay

Meffe et al. (2002) defines biodiversity as “the variety of life and its processes; also, the composition, structure, and function of life considered from genetic to landscape levels of organization”. Conservation of biological diversity is one objective of the ecosystem management approach (Baydack and Campa 1999).

There are several challenges that stakeholders, NGOs and government face in order to promote conservation of biological diversity in Paraguay. These are:

Weak Government Institutions

For the Paraguayan government, biodiversity conservation and sustainable use of natural resources are the two most important policies in writing. All of this is due to the intensive activities in farming, ranching, human engineering, deforestation and the contamination of water resources (Arce et al. 2005, Rios and Zardini 1989, Yanosky and Salas-Dueñas 2004). The Government however, in practice, is more concerned supporting agricultural and livestock production to improve the economy of the nation rather than investing resources into conserving biodiversity (Integrated Management and Conservation 2003).

But at the same time, the Paraguayan government has its own problems. The budget for the Secretariat of Environment (SEAM) is smaller than that of several NGOs. The General Directorate of Biodiversity Conservation and Protection of SEAM has minimal staff and a budget of less than US\$200,000 per year to manage the protected areas and undertake wildlife management and research. For example, the Defensores del Chaco National Park (720,000 hectares) currently has only three park guards for the entire area (Catterson and Fragano 2004). We may add to all this

that there are accusations for corruption and impunity against many of its institutions, creating a lack of trust in the government and its institutions (Proceso Río + 10 informe nacional Paraguay 2001).

Professional Training

There is a lack of trained specialists and skilled professionals. Sometimes, this situation prevents professionals from providing proper answers and solutions to environmental issues (Ripa de Marconi et al. 2001).

Policies

Another important challenge is that policies are erratic and long-term political and financial continuity are difficult because projects are planned to last only one government term (Ripa de Marconi et al. 2001).

Social factors

Complex social factors are important in Paraguayan culture and they operate in most of the country such as poverty, violence, absence of institutions; insecurity and injustice in land tenure limit the application of planning processes. At the same time, extreme poverty is increasing to high levels and especially in rural areas (Proceso Río + 10 informe nacional Paraguay 2001, Ripa de Marconi et al. 2001, Yanosky and Salas-Dueñas 2004).

Environment

Paraguay generates 100% of its electrical energy from hydropower creating pressure on the environment (Junk 2008). There is also a lack of economical sustainable production models. Economic development has to be sustainable and not inadequate for the environment. This is something yet to be seen in Paraguay (Ripa de Marconi et al. 2001). The reason behind this is that long-term political and

financial continuity are complicated because Government planning is designed to last a government term due to political partisanship; therefore, there is a need for long-term planning in order to achieve durable goals.

Community Participation

Lack of community participation is due to a deficient organizational structure of community groups (Proceso Río + 10 informe nacional Paraguay 2001). There is also little public environmental awareness at all levels of society and a lack of a credible participatory process (Integrated Management 2003, Ripa de Marconi et al. 2001).

Participation is a very important aspect to have in consideration since it is a cardinal piece for the application of the ecosystem management approach in the study area (Ripa de Marconi et al. 2001).

3.10 Diversity and Uses of Medicinal Plants in Paraguay

Humans have used medicinal plants since ancient times for healing purposes. In Paraguay, one of the biggest legacies left by the aboriginal people was their extensive knowledge in medicinal plants. This ethnic group called Guaraní contributed with their language to the botanic nomenclature of many plants. One of the most well known plants is the Yerba Mate (*Ilex paraguariensis*). The Yerba Mate is used to eliminate fatigue, and to stimulate mental and physical activity (Caceres and Machain 2001, Cataldo 1968). It is used in the national drink called mate (hot water infusion of leaves from Yerba Mate) or tereré (maceration of ground leaves from the same plant, with cold water) (Roguet 2009).

Paraguay has a strong cultural connection with medicinal plants. This makes Paraguay unique; a country that uses medicinal plants in a preventative way, on a

daily basis (Roguet 2009). This constitutes an immeasurable wealth for the Paraguayan people, which helps them cope with different health conditions. Knowledge of medicinal plants is an important part of the Paraguayan culture (Cataldo 1968) as shown during the interviews in the present research study.

Today, we can find around 700 genera and more than 40 botanical families of Guaraní origin (used by the Guaraní ethnic Group). Most of these medicinal plants come from Paraguayan forests, grasslands and wetlands (Caceres and Machain 2001).

To have a better understanding of a plant's use, they could be classified according to their pharmacological actions using the anatomic classification of the IMS (Intercontinental Marketing Service). This creates groups such as:

- Digestive tract and metabolism
- Heart, blood circulation
- Skin
- Urinary tract and reproductive organs
- Muscles and joints
- Nerves and pain
- Respiratory tract
- Infectious diseases

(Caceres and Machain 2001).

3.11 Summary

The purpose of this chapter was to provide fundamental information on important issues and variables in the study area.

Examples of this information are:

- Campesino concept: People working the land to produce for their own subsistence using the help of family members and having no wages or production surplus.
- Different types of knowledge found in the area: Sources of knowledge local people use to make a living in the study area.
- Topographic characteristic of the area: To understand the relationship between water and the local people and how they interact with it.
- Importance of the use of GIS in environmental projects: Important tool to monitor natural resource changes over time and to store data for decision makers.
- Ecosystem management: Important approach to manage natural resources and which incorporates people as a key component of the final solution.
- Challenges: Challenges to be considered during the planning process in order to promote biological diversity.
- Medicinal plants: There is a strong cultural connection with medicinal plants, which is a legacy from the aboriginal people.

Chapter 4 Socio-economic Situation in the Ñeembucú

4.1 Introduction

Many people in Paraguay have recognized the importance that local communities play in biodiversity conservation. One of the reasons for this is that local communities can provide local and traditional knowledge in regards to their environment, thereby integrating social and natural sciences to help solve information gaps in certain areas (Kerry et al. 2000, Pimbert and Pretty 1997, Pretty and Smith 2004).

Pretty and Smith (2004) stated that external agencies are increasingly recognizing that the protection of certain areas cannot be accomplished without the involvement of local people, and that Government and Non Governmental Agencies (NGOs) play an important role in bringing people together to form working groups to address environmental issues.

People working together in environmental projects are called stakeholders. Meffe et al. (2002) defines a stakeholder as “a person who wants to participate in a decision because the decision is important to his or her interests”. There are several types of stakeholders such as: private landowners; governmental organizations; local, state and federal government employees; nongovernmental organizations; tribal governments; businesses; commodity users; recreationists; international agencies and scientists (The Keystone National Policy Dialogue on Ecosystem Management 1996).

Not all stakeholders can or want to be involved to the same degree, thereby creating different groups of participants. The levels of involvement according to Pimbert and Pretty (1997) and Pretty and Smith (2004) are:

- Passive Participation: project organizers inform them of what is going to happen or has already happened.
- Participation by Consultation: people participate by answering questions and external agents collect information about their views.
- Bought Participation: people participate in return for food, cash or other incentives.
- Functional Participation: people participate by forming groups to meet goals
- Interactive Participation: people participate in joint analysis, development of action plans and formation of local groups
- Self-mobilization: people participate by taking initiatives independently and retain control over how resources are used.

In developing countries, poverty and biodiversity conservation are closely linked (Conserving Biodiversity, Improving Livelihoods 2007). This is because humans rely on the services provided by ecosystems such as food, clean water, disease regulation, climate regulation, spiritual fulfillment, and aesthetic enjoyment (Millenium Ecosystem Assessment 2005). The degradation of ecosystem services affects the local economic activity because one of the services provided by the ecosystem such as food production contributes to economic activity and employment (Millenium Ecosystem Assessment 2005). People living in rural areas often depend on biodiversity for food; therefore, conservation that excludes people could increase poverty and create conflict. On the other hand, working with people could create social capital, trust with local residents and decrease poverty (Conserving Biodiversity, Improving Livelihoods 2007, World Resources 2005).

In the Department of Ñeembucú, most of the local population exploits the ecosystem for its livelihood. The hunting, fishing and gathering culture and the exploitation of the natural resources are common practice in the whole area and these are cultural features derived from ancient civilizations that lived in this area (Fogel 2000, Gomez 2006). These ancient civilizations started with Paleo Indians (Pre-historic migrants), followed by the aboriginal groups of Kaingans (Guaicurú Family), the Mbya and later the Payaguas.

The Paleo Indians were prehistoric settlers with hunting and gatherer skills who arrived before the Christian era. Later, aboriginal groups of Kaingans (Guaicurú Family) arrived from the North (what is now known as Brazil). This group settled in the high areas (2000 B.C.) and survived by hunting, fishing, and gathering. Their knowledge of this ecoregion was transmitted from generation to generation (Fogel 2000, Gomez 2006).

The Mbya arrived in this region around the year 1 to 400 A.D. and assimilated the Kaingans and by doing this, they gained more knowledge. The Payaguas arrived, before the Spaniards, from the west of the Paraguayan territory. They incorporated the use of the “cachibeo” which is a canoe built from a single trunk of a tree. The local residents called esteranos, ribereños and campesinos acquired all the knowledge gained from these civilizations (Fogel 2000, Gomez 2006).

After the arrival of the Spanish, the Jesuits established large communal farms (1609 – 1767). After Paraguayan independence (1811), Dr. Rodríguez de Francia (Paraguayan Dictator) nationalized these lands and created successful communal farms. At the end of the Triple Alliance War (1870), political cronies and wealthy foreigners became the new owners of most of the land. This sequence of events

explains the current social structure in the Ñeembucú Department (Fogel 2000, Gomez 2006).

According to Gomez (2006) the traditional social structure in the Ñeembucú Department is as follows:

- Ranchers: those who own large amounts of land.
- Campesinos: those who own a small amount of land, few animals and a subsistence agriculture with some cash crops such as cotton, corn or yucca.
- Esteranos (people living on wetlands): those relying on the resources provided by wetlands; gatherers and hunters.
- Ribereños (people living beside the river): those who are fishers and hunters.

The people living in the Ñeembucú Department need to develop their natural resources sustainably because they are important to their livelihoods (Fogel 2000).

Wetland conservation in particular cannot happen without the involvement of the local community, which currently does not take place. Therefore, it is very important to develop a participatory process with the Campesinos, to enable them to participate in the decision making process in order to promote resource sustainability (Fogel 2000).

For all the reasons stated above, this chapter will focus on establishing the baseline socio-economic situation of the people living in this ecoregion in order to establish further socioeconomic initiatives to balance production and environmental priorities.

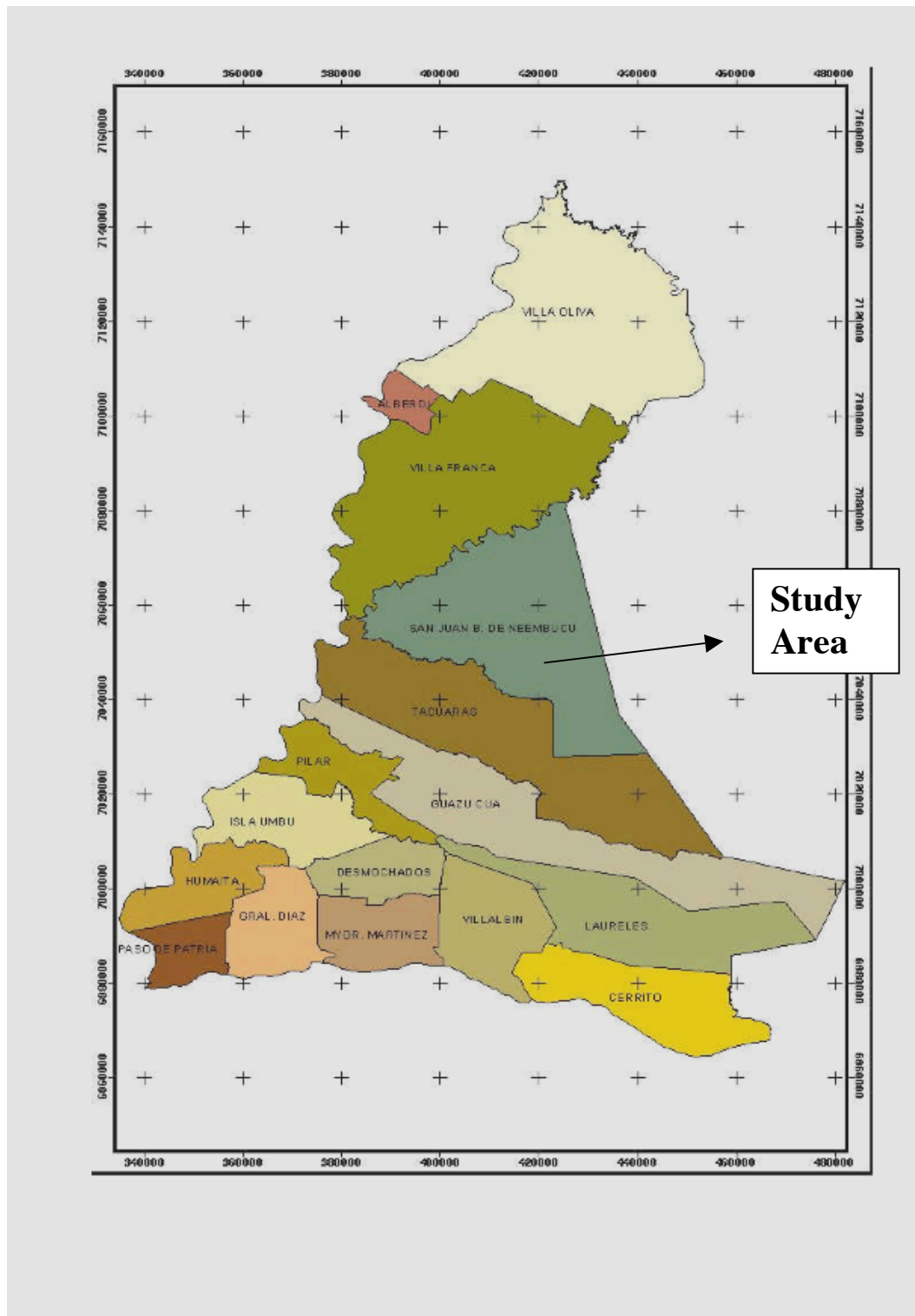
4.2 Materials and Methods

Study Area

The Department of Ñeembucú is divided into 16 Districts (Figure 4.1) and each District into Compañías. These political divisions were used to select a

Figure 4.1 Department of Ñeembucú political division into 16 Districts and the study area, San Juan del Ñeembucú.

Source: Universidad Nacional de Pilar, September 2003.



manageable area for this research study. The area chosen was the District of San Juan del Ñeembucú. For this area, I developed a strong collaboration with a local expert, Ag. Eng. Rafael Gonzalez Bordón, who has been an Instructor at the Universidad Nacional de Pilar for the past 15 years. This selection was based on the fact that few projects have been developed in this area, (there is a lack of available data) and that this area has an environment influenced by a river and by wetlands. In summary, this area could be used as a model for developing management strategies for the whole Department.

Two types of data collection were selected to gather socio-economic information: interviews and review of the available literature and reports.

Survey Instrument

As Fink (2003) describes: “a survey is a system for collecting information from or about people to describe, compare, or explain their knowledge, attitudes, and behavior”. This was the rationale behind the selection of interviews as an appropriate tool; I wanted to extract the knowledge of the local people, ranchers and environmental experts.

The survey instrument used for the local residents (Appendix 1) and ranchers (Appendix 2) was a questionnaire. It was developed with the assistance of Dr. John Brierley, (retired) Professor, Department of Environment and Geography, University of Manitoba. The questionnaire was divided into four sections, which were developed to answer my research objectives, and they were:

- Basic Information,
- Crops and Livestock,
- Environmental Situation,
- Personal Information.

Most of the questions were closed-ended. This was done because the Paraguayan Campesino have what is called “the culture of silence”. Paraguay was under a dictatorship for 34 years (1954-1989). The motto for people during those years was: “The less you talk the fewer problems you get into”. The closed-ended question style was chosen because I expected respondents would be unwilling to express themselves clearly due to the previous situation under which they had lived. This approach was supported by Fink (2003), who stated that not considering multicultural issues may result in a significant bias in data collection. The survey was conducted from August 7th to November 12th 2007.

The questionnaire was developed in English and later translated to Spanish and then to Guaraní. Guaraní is the aboriginal language spoken by the majority (92%) of the local residents, and Spanish is the second language. For this reason, a local guide was hired to help me with translation and guide me in the study area. Mario Osmar Fernández (Figure 4.2) was my guide and facilitator. He was born and raised in the area and was trusted by the people.

As a means of transportation, a motorcycle was used (Figure 4.3), which helped access all participants’ houses. After each interview, a GPS point was established and pictures were taken of the interviewed person and home. This was done in order to have visual record of the people interviewed and to set the GPS points into the GIS images. The two main reasons to take pictures of each person

Figure 4.2 Mario Osmar Fernandez, guide, translator and facilitator.



Figure 4.3 Means of transportation, motorcycle.



were: to show participants their importance in this study (locals feel recognized when their image has been documented); and to keep a visual file of the Campesinos and their houses types to show to non-paraguayans. The hand held GPS used was a Garmin GPS XL.

The total number of households in the San Juan del Ñeembucú District is 1,231 (Censo Nacional de Población y Viviendas 2002). A total of 70 interviews with local residents and 12 ranchers were conducted totaling 82 people surveyed, which constituted 7% of the households.

Each participant signed an informed consent form before taking part in the survey and received an explanation of the project (Figure 4.4). The person who officiated as guide/translator also signed a translator confidentiality agreement in order to assure that no information would be disclosed from the data collected in this survey.

The survey instrument used for the environmental professionals was an interview with 5 open-ended questions (Appendix 3). The whole interview was recorded and transcribed. A total of 11 professionals participated. Six were from NGOs, three government officials, one university instructor and one from the private sector.

Sampling

The sampling method used to select the local residents was random sampling from a District map. Random sampling gave me the opportunity to select a sample for study from the larger group (population) of the District. Each individual was chosen randomly and each member of the population had the possibility of being included in the sample, referred to as probability sampling. This technique was used in the study area due to the sparsely populated rural area (Fink 2003, Gregory 1978). In this study, the Campesinos were chosen and not the ribereños or the esteranos because of accessibility reasons and because Camapesinos had the upland and wetland experience.

Figure 4.4 Project explanations before an interview.



For sample selection, a table of random sampling numbers was used (Murdoch and Barnes 1998). Aerial sampling by random numbers requires that firstly the area under study should be “gridded” (Gregory 1978). Random numbers were plotted to a grid line on “gridded” paper. This gridded paper was superposed over the District map. All the points or coordinates provided by the random numbers were plotted to the map. The residence locations to be sampled were those nearest to the points marked on the map. I marked 120 residence locations in case some were abandoned or people did not want to participate in the survey.

The sampling method used for the ranchers and the environmental professionals was snowball sampling. The rationale behind this approach was that the number of participants in these two groups was small, there was no estimation of population size and they were difficult to locate. In this circumstance an identified member of each group were asked to identify other key members of the population. The first person was selected on the basis of criteria of importance to the study objectives (Dorma 2001, Fink 2003, Frank and Snijders 1994).

Ethics Approval

The University of Manitoba requires applications to be submitted to the Human Ethics Secretariat (HES) for referral to the Chair of the appropriate REB (Research Ethics Board) for surveys involving people. The reason for this was that in 1979, the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research published the Belmont Report. This report became the cornerstone for ethical research, including survey research, where three major principles must be considered including: respect for persons; beneficence, researchers must treat participants in an ethical manner and; fairly in their selection process (Fink 2003).

Three forms were submitted to the Board: Ethic Protocol Submission Form, Informed Consent Form and Human Subject Research. The approval certificate from the Joint-Faculty Research Ethics Board (JFREB) was dated May 5th, 2006 and had a one-year duration. A renewal request was submitted and approved for an extension until May 5th, 2008.

These forms stated that there would be feedback in Spanish given to the people that requested it. Each one of the people interviewed had the local contact phone number in order to get feedback upon request.

All the survey interview data were anonymous from the onset and will remain anonymous throughout the entirety of research development and completion. A number was assigned to each interview; therefore the interviewed family cannot be identified. Data were stored in a locked cabinet, accessible only by the involved researcher. All original written records were destroyed after being transcribed.

A present was provided to each survey participant in the form of a small package of Yerba Mate (*Ilex paraguariensis*) (Figure 4.5). This was in recognition of their time and contribution to the study. This present was considered to be appropriate because Paraguayans have a strong cultural connection with medicinal plants such as the Yerba Mate, which they drink daily, and it is considered the national drink.

A review of the available literature and reports was the other method used to gather information for this chapter. A public document was from a Paraguayan Government Institution. This publication was from:

- Censo Nacional de Población y Viviendas 2002 (2002 National Census of Population and Housing), Dirección General de Estadísticas, Encuestas y Censos (dgeec) (General Directorate of Statistics, Surveys and Censuses).

Data Analysis and Validity

The questionnaire was divided into four different sections or themes, including: basic information, crops and livestock, environmental situation, and personal information, and observation. A spreadsheet program was used in each section to group the results in order to create patterns and draw conclusions.

To validate the findings, three different strategies were used:

- Triangulation: used data from different sources such as field notes, transcribed interviews, reports and literature available to create justification for themes.
- Peer Debriefing: opinion from my guide who was born and raised in this District.

- Expert Opinion: personal communication from Ag. Eng. Rafael Gonzalez, an expert working in the area for the past 15 years at the Universidad Nacional de Pilar.

Figure 4.5 Present of Yerba Mate given to a participant after an interview.



4.3 Results

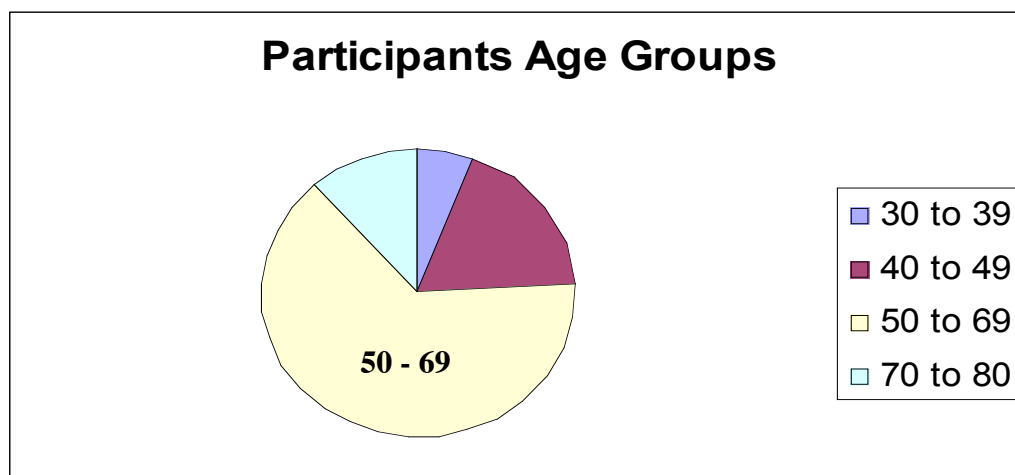
Local Residents or Campesinos

A total of 70 household heads participated in this survey. Of these, 69 were males and the mean age of the head of the household was 55.6 years (Figure 4.6). The majority (89%) of the households were married.

Almost half (34/70, 49%) of the household heads were sick last year, spending an average of 55.7 days without working. Most common diseases were high blood pressure, prostatitis and rheumatism. According to data supplied by Mr. Ivan Lombardi (Personal communication, Official Ministry of Health, Biostatistics

Department, August 23, 2007), there are only 13 health care workers in the San Juan del Ñeembucú District. This represents 1 health care worker for about 400 people.

Figure 4.6 Age structure of survey respondents (household heads).



The health care workers included: 1 nurse, 2 health technicians and 10 nurse technicians.

As a means of transportation (Figure 4.7), 40 (57%) used two means of transportation, including horses (mentioned by 40%) (Figure 4.8) and buses (mentioned by 34%) (Figure 4.9).

For communication, 73% (51) of the participants used cell phones and only 1 (1%) used a landline. The remaining did not have access to any type of communication.

For utility services (Table 4.1), wood was the primary (98%) fuel source for the kitchen (Figure 4.10), and 40% (28) used wood and propane. Most of the participants (64/71%) used a latrine (Figure 4.11) for their sanitary service. The

source for water in the majority (83%) of the participants was a well (Figure 4.12). Electrical service reached 92% (64) of the households.

Only two (3%) of the participants were illiterate. Most (80%) of the participants had an elementary education level (Figure 4.13) with an average of 4.7 years of instruction. Sixty-four participants (91%) were not exposed to any environmental education.

Figure 4.7 Types of transportation used by local residents in the San Juan del Ñeembucú district.

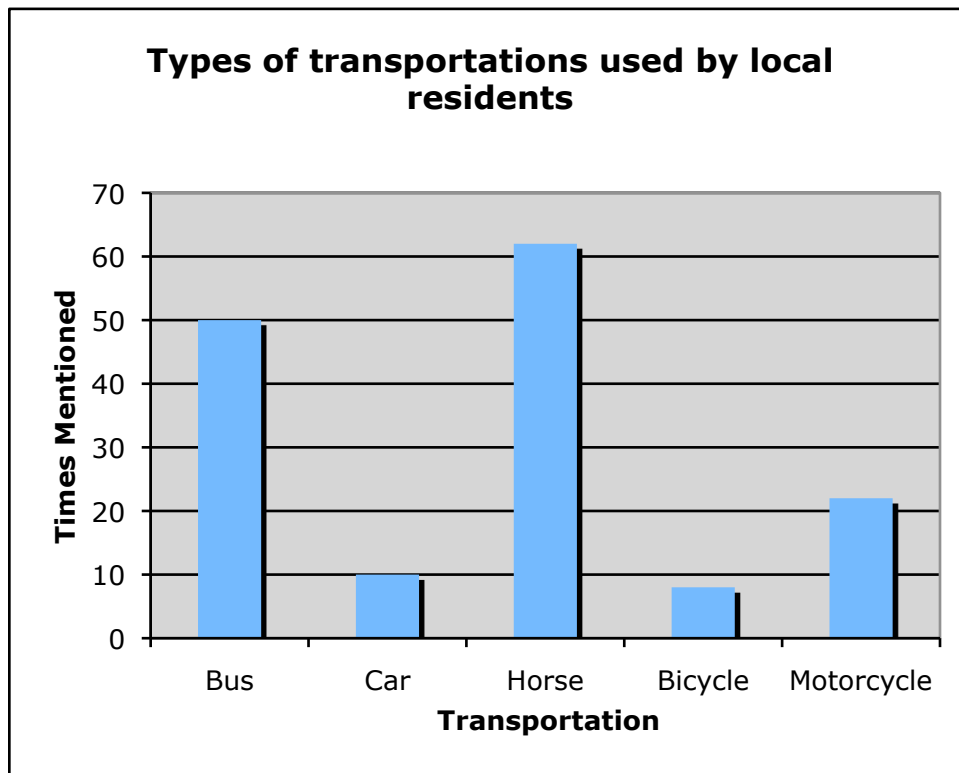


Figure 4.8 Horse for transportation in the San Juan del Ñeembucú district.



Figure 4.9 Bus: public transportation in the San Juan del Ñeembucú district.



Table 4.1 Local resident household utility services used in the in the San Juan del Ñeembucú district.

Houeshold Utility Services (%)	
1. Fuel to Cook	
Wood	99
Wood and Propane	40
Propane	2
2. Sanitary Service	
Latrine	76
Septic Tank	9
Latrine and Septic Tank	16
3. Water Source	
Well	83
Wetland	17
4. Electricity	
Electricity	92
No Electricity	8

The main occupations were agriculture (56%) and ranching (36%). More than two-thirds (73%) of the participants have land with title and only 14 (20%) were squatters (Figure 4.14). The mean size of landholdings was 36 hectares for people with title and 9.2 hectares for squatters.

Only 7% of the participants worked with other neighbors and from that percentage, only two worked in cooperative farming.

Ranchers

A total of 12 ranchers participated in this survey and all were males. The mean age of the ranchers (55.7) was similar to the Campesinos as well as their marital status (10 out of 12 were married).

There was a clear difference with the Campesinos in education level. Three out of twelve had high school education and seven out of twelve had university level education (Figure 4.15).

Figure 4.10 Kitchen where wood is used for fuel.



Figure 4.11 Latrine used by local residents in the San Juan del Ñeembucú district.



Figure 4.12 Well used by local residents in the San Juan del Ñeembucú district.



Figure 4.13 Level of education for local residents in the San Juan del Ñeembucú district.

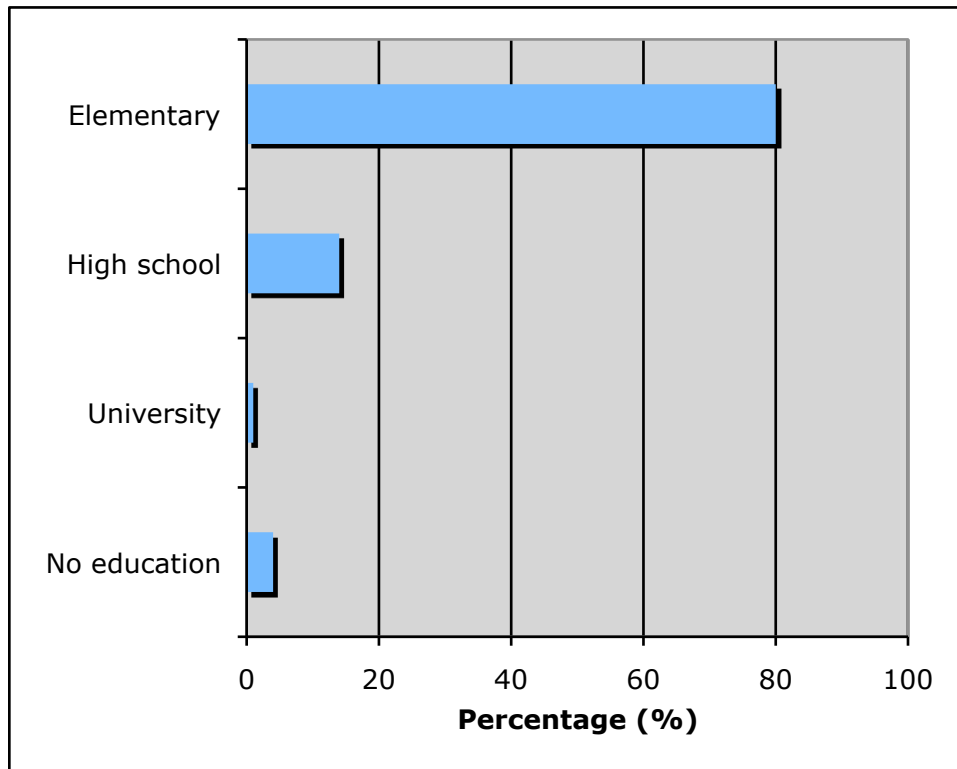


Figure 4.14 Land Tenure for local residents.

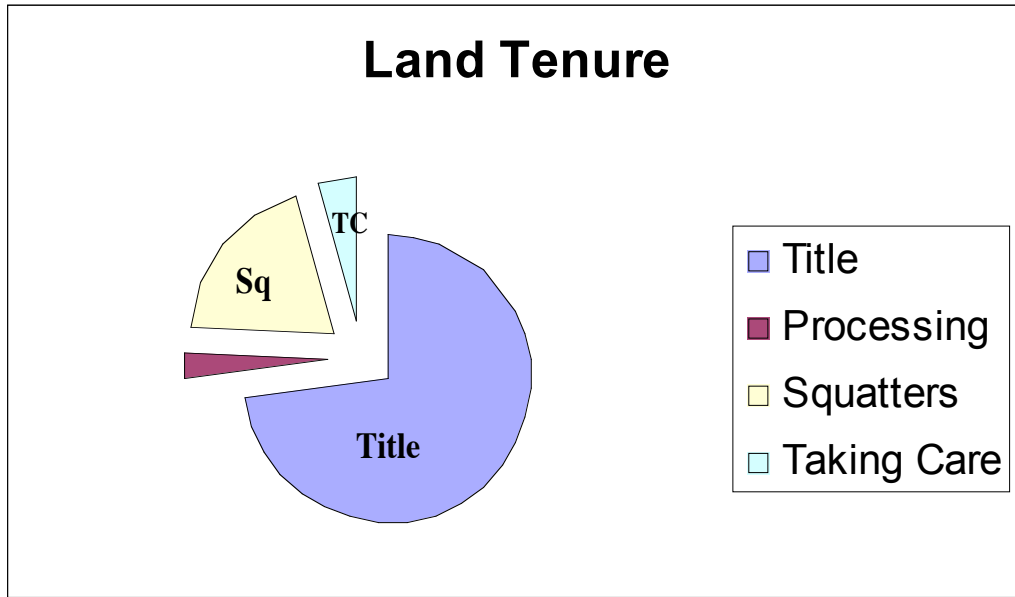
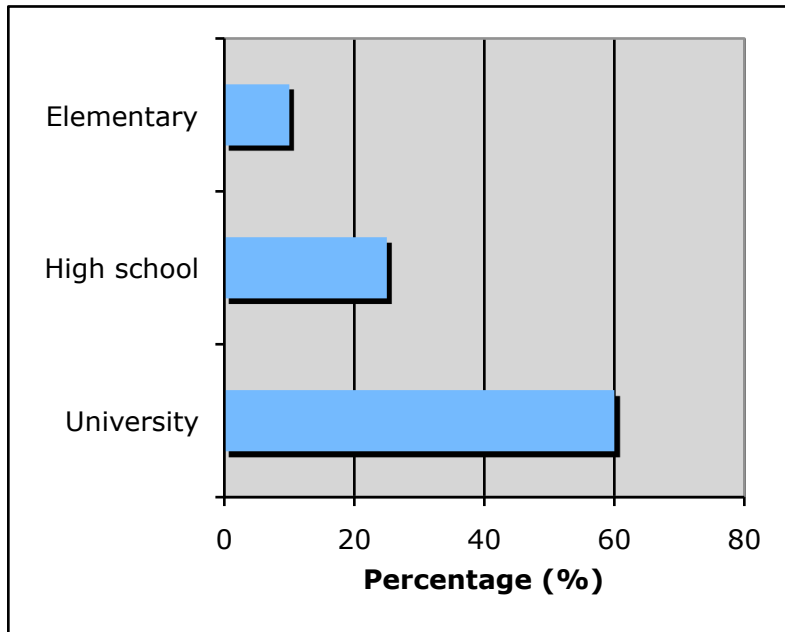


Figure 4.15 Level of education for ranchers.



None of the ranchers were exposed to an environmental education program and they did not receive any visits from agricultural professionals.

All of the land owned by ranchers is with title, and half is in the range of 1,001 to 5,000 hectares, with rest in the range of 5,001 to 10,000 hectares.

Only five out of twelve of the ranchers were involved with public participation in the Asociación Rural del Paraguay (Ranchers Association).

Environmental Professionals

These participants were from different backgrounds with six from NGOs, three government officials, one university instructor and one working as environmental consultant in the private sector. All professionals were from the environmental field. The most important quotes from these experts related to the social situation in the study area were as follows:

- Agr. Eng. Angel Brusquetti (Fundación Moisés Bertoni NGO, Personal communication recorded Monday July 30th, 2007): “Historically, Ñeembucú has been a Department that “losses” people due to the lack of opportunities”.
- Dr. Fatima Mereles (WWF Paraguay, Personal communication recorded Monday August 13th, 2007): “There is a high functional illiterate rate of around 50%; therefore, people are not aware of all the environmental threats”.
- Jose Luis Cartes (Guyra Paraguay NGO, Personal communication recorded Monday August 14th, 2007): “Education is a serious issue in Paraguay. There is a lack of formal and environmental education”.
- Agr. Eng. Rafael Gonzalez (Universidad Nacional de Pilar, Personal communication recorded Thursday August 23rd, 2007): “Young people leave their homes due to a lack of resources. Their elderly parents stay; therefore, we have a population structure with elderly and very young people”. “I still do

not see a collective awareness in regards to community involvement to protect the environment”.

- Dr. Sergio Burgos (Instituto Paraguayo de Protección del Ambiente NGO, Personal communication recorded Tuesday August 28th, 2007): “It is one of the Departments with a high deficiency in water provision, health and education”.
- Dr. Victor Centurión (Government Official, Secretaría de Acción Social, Personal communication recorded Wednesday September 12, 2007): “Whole families live in small isolated communities”.
- Dr. Ramón Fogel (Centro de Estudios Rurales Interdisciplinarios NGO, Personal communication Thursday September 13th, 2007): “Most of the people are living in a precarious situation. They have mobility problems because of the wetlands topography”.
- Sr. Mario Osmar Fernández (Independent environmental consultant, Personal communication Thursday October 4th, 2007): “In the health sector, there are health care workers but no medicines”.

4.4 Discussion

Participants from the San Juan del Ñeembucú District had a relatively high average age of 55.6 years compared to the national average. The 2002 National Census shows that the Paraguayan population is relatively young, being 77% under the age of 39 years of age and only 13% above 50 years of age. This is evidence that the majority of young people leave the area because of the lack of opportunities to work. This agrees with what was expressed by Ag. Eng. Angel Brusquetti and Ag. Eng. Rafael González.

Health care service in this area is very precarious since there is only one health care worker for over 399 inhabitants. Adding to this situation, most local health clinics lack medicine (Fernández, personal communication Thursday October 4th, 2007). This scenario makes it very difficult for people living in the area who get sick. All the days they do not work increases their poverty level. In my study, there was an average of 55.7 working days lost to illness.

People in this area use different types of transportation. The most common is the horse, but this is not appropriate for ill patients and pregnant women. The other most common method of transportation is the public bus. However, there are very few public buses in this area due to poor road conditions and low population.

Landline telephones (only 1% of the participants) are mostly located in the offices of the government and Government Telephone Company (COPACO). Almost all participants (73%) rely on cell phones for their communications. Cell phone use was relatively high compared to the Departmental average of only 20% (Encuesta Permanente de Hogares 2004). The lack of landlines in the area forces the local population to rely on cell phones for their communications.

In relation to utilities within participant's homes, wood was used in 99% of the households, creating a significant environmental impact because forest is depleted in an area with low percentage of forest. According to the data from 2004 (Encuesta Permanente de Hogares 2004), wood use only reached 49% in the whole country.

There is very poor government provision on services in the sanitation area (91% use latrine), showing a strong discrepancy with the 2002 National Census with only 52% latrine users. Also running water system coverage is relatively low (83% use wells). This also does not agree with the 2002 National Census where a value of

60 % of homes had wells in the District. This situation leaves local people with health issue concerns such as the disposal of black water. On the other hand, there is good coverage of electricity, which reaches 91% of the participants.

One of the weakest social points in this District is the level of education. There is a relatively low average years of instruction (4.7 years) compared to the national level of 7.1 years (Censo Nacional de Población y Viviendas 2002), where 80% of the participants had an elementary education. This value is similar to the Departmental level in the 2002 National Census (Censo Nacional de Población y Viviendas 2002) and with what was expressed by Dr. Mereles and Lic. Jose Luis Cartes in regards of education. The positive aspect is that only 3% of the participants were illiterate, a good average considering that the National value is 5% and a Departmental value of 9% (Censo Nacional de Población y Viviendas 2002).

Most of the local work force (91%) is involved in the primary sector (agriculture and ranching), showing a low evolution of the economy and therefore few options for a good income. As mentioned by Fogel (2000), local residents or Campesinos need adequate technological projects supported by the government. This support is important in order to improve their performance in agriculture and animal husbandry. In animal husbandry, improvements could be made through the introduction of beef cattle adapted to the local environment and in agriculture through improved production strategies. Government support would help increase local household income and well-being.

Historically, Ñeembucú has been a Department that “losses” people due to the lack of opportunities. This is in agreement with the 2002 National Census, showing a very low growth rate (0.9) compared to the National average (2%).

One of the most positive aspects in this District is that 73% of the participants have title to their land. Land tenure gives people a sense of ownership, which is very important when implementing conservation practices (Cassara 2007).

Participants showed very little experience (7%) with public participation, which is critical to implement participatory management options, which will be discussed in the conclusions.

The economic status of the ranchers is very different from the local residents. The biggest difference was in education. Approximately seven out of twelve ranchers had university level training providing them with better job opportunities. Having a better social status in this part of the world means families with a good economic standing and good contacts get the best jobs. Because of their economic situation, ranchers have access to better education and training.

Public participation in local decision-making is also a very important issue for ranchers, since only five out of twelve of the interviewed persons participated in these types of meetings. The cultural reason as described previously was what Freire (1970) called “the culture of silence”.

4.5 Conclusions

The information gathered from the survey and interviews enabled a better understanding of the socio-economic situation of the people living in this District. Campesinos live in a very precarious situation with many young people migrating out of the area due to a lack of opportunities. Not only do people leave this area, but they also take with them the local and traditional knowledge from past generations.

Data showed that there is a general lack of a government presence in the area. Roads are generally in bad condition, there are almost no sanitary services, there are

few hospitals with little medicine and few health care workers, there is a general lack of running water, and a very low level of education.

There are a low proportion of people working together; therefore, there is no working network within communities. There are no NGOs working in the District. This lack of opportunities and education make people in this area generally unaware of their environmental situation as it was confirmed during the survey (Fogel 2000). For example there was no sustainable farming practiced by them. This is problematic because conservation cannot be accomplished without the involvement of local people (Pretty and Smith 2004). In this matter, government and NGOs must play an important role in bringing people together to create working groups.

Local community knowledge can be a valuable instrument for use in the Ñeembucú ecoregion. For example, Sah and Heinen (2001) considered it important to support and implement community wetland management in order to promote more sustainable resource use with the participation of the local community in Nepal. Participation of the local community is important in this process because these people make a living from the environment and know the “secrets” of how to manage them in a sustainable way (Fogel 2000). In other words, local community knowledge can help us understand the management and conservation of natural ecosystems (Calheiros et al. 2000).

A participatory management approach could be used as a tool for management of the Ñeembucú wetlands in order to achieve its sustainable use and to contribute to poverty reduction (Conserving Biodiversity, Improving Livelihoods 2007). Poverty reduction could be attained by implementing environmental education programs and promoting alternative activities for the Campesinos or local residents such as

ecotourism, in order to improve local residents off-farm income so that dependency on wetland resources are reduced (Calheiros et al. 2000, Sah and Heinen 2001).

I will end up this chapter by mentioning the title of a report from Roque Gonzalez and Cristino Peralta which appeared in the ABC Newspaper (November 20, 2005) and quote: “The poverty of the Campesino resides in his lack of knowledge (ignorance), not in his laziness”.

You cannot protect what you do not know and understand.

Chapter 5 Changes in Areas of Water Bodies and Other Land Cover Types

5.1 Introduction

Human activities have been changing South American grasslands at a very fast rate over the last 40 years. Not only has a reduction in size of the grasslands occurred but also a fragmentation of the landscape structure (Baldi and Paruelo 2008).

Water bodies are also being threatened, especially wetlands. Half of the wetland habitats that existed in 1900 around the world have disappeared (Hails and Peck 2007). Much of this loss occurred in North America (56-65%) and the rest in Asia (27%), South America (6%) and Africa (2%) (Hails and Peck 2007). These changes have a negative effect on biodiversity and water in the local and regional areas of South American grasslands (Baldi et al. 2006).

Unsustainable land use practices can negatively affect many natural processes causing erosion, land degradation, habitat destruction and water pollution (Apan et al. 2002). The main human activities causing these problems are agriculture, forestry, ranching and construction of dams for hydropower (Grau and Aide 2008, Hails and Peck 2007). Agriculture has had a significant expansion in Paraguay due to technological changes (i.e. non tillage techniques, genetically modified crops) and good market conditions. This is especially true for soybean, which has become a threat to biodiversity, but at the same time, has brought economic benefits to producers, government revenues and people in sectors such as transportation, commercialization and processing of agricultural products (Grau and Aide 2008).

In Paraguay, loss of forests, biodiversity and water are becoming critical environmental problems (Huespe et al. 1994).

In order to conserve wetland resources, it is crucial to inventory and monitor wetlands and other adjacent land cover. This is to avoid further losses and to conserve existing wetland ecosystems, which are very important feeding areas for migratory shorebirds, that breed in the Arctic and winter in southern South America (Boyle et al. 2004, Ozesmi and Bauer 2002).

Wetlands areas are very difficult to map and inventory because they have variable and heterogeneous vegetation and water distribution. Satellite remote sensing has many advantages because it can be used to detect temporal changes in vegetation as well as other changes that occur in wetlands when having multiple years of images are available (Canziani et al. 2003, Rodas et al. 2006).

The objective of this Chapter is to document changes experienced in the water bodies and land cover types in the Ñeembucú ecoregion over time using satellite images from four different decades (1970s, 1980s, 1990s and 2000s) as well as determine the perceptions of the local residents in regards of what is happening to the landscape in the region.

5.2 Materials and Methods

The methods employed in this study were largely qualitative in nature and consisted of individual interviews, analysis of remote sensing (LANDSAT) images, and the use of geographically referenced information.

For the individual interviews, a questionnaire (Appendix 4.1 and 4.2) was administered to local residents and ranchers. Details of the survey instrument (Appendix 1 and 2), sampling method and ethical considerations were described in Chapter four.

The contact source for aerial photographs was the Paraguayan Army Geographic Service. The aerial photographs provided geospatial reference for geocorrection of satellite images. Satellite images, which are good for large geographic areas, were also used. This data was used to monitor changes in wetlands and land cover change over time (Ozesmi and Bauer 2002). For this purpose, satellite images from four different decades (1970, 1980, 1990 and 2000) were compared in order to assess changes. For the 1970s images and early 1980s, a sensor from the series LANDSAT MSS Multi Spectral Scanner was used and for the other decades, LANDSAT TM and ETM were used.

Monthly precipitation data at the Pilar station for the last 37 years were provided by the Dirección de Meteorología e Hidrología del Gobierno Paraguayo (Meteorology and Hydrology Unit from the Paraguayan Government) and was used to compare rainfall over time because fluctuations in water levels could be man-made or the result of natural fluctuations in precipitation. The Pilar station (located in the city of Pilar) is situated approximately 32 kilometers north from the District of San Juan del Ñeembucú.

Study Area

The study area was the District of San Juan del Ñeembucú. This District is located within the Department of Ñeembucú. Details of the study area and the reason for its selection were described on Chapter four.

Acquiring Satellite Images

The satellite sensors used in this study were LANDSAT MSS and LANDSAT TM because they are the most commonly used for wetland identification, classification and inventory (Hails and Peck 2007, Ozesmi and Bauer 2002).

NASA first launched LANDSAT MSS in 1972, with MSS standing for Multi-spectral Scanner (with four bands). Many researchers have use it for mapping wetlands, and for historical and change detection studies. It has a spatial resolution of 80 meters (Ozesmi and Bauer 2002).

LANDSAT TM (Thematic Mapper) sensor was first launched in 1982. This sensor had a better spectral, radiometric, temporal and spatial resolution (30 meters) over the LANDSAT MSS (80 meters) (Lillesand et al. 2004). LANDSAT bands 3, 4 and 5 are the best combination of bands for wetland detection (Ozesmi and Bauer 2002). The reason for this is that band three is useful for plant species differentiation, band four is useful for determining vegetation types, for delineating water bodies, and for soil moisture discrimination and band five is good for indicating vegetation moisture content and soil moisture (Lillesand et al. 2004). These bands are the most commonly used bands in Paraguay in this order:

1. Band 4: red color
2. Band 5: green color
3. Band 3: blue color

In 1999, the LANDSAT 7 ETM+ (enhanced thematic mapper) was launched and it had a 30 meter resolution (Ozesmi and Bauer 2002).

Free satellite images were obtained for this study from the INPE (National Institute for Space Research) from the Brazilian Ministry of Science and Technology, (<http://www.inpe.br/ingles/index.php>) and from the Global Land Cover Facility (GLCF) (<http://glcf.umiacs.umd.edu/index.shtml>) sites.

For the 1970s and 1980s, the sensor LANDSAT MSS was used. For the 1990s and 2000s, the sensors LANDSAT TM and ETM were used. The list of satellite images obtained for this study is provided in Table 5.1.

Geocorrection of Satellite Images

Aerial photographs and satellite images have distortions in their raw data. In order to use these images in GIS, the image must be corrected or rectified in order to fit a map base. Ground control points should be located on the image and on a map. These could be points of reference such as road intersections and bridges (Price 2006). Each scene was geocorrected according to the UTM zone (21), and orthophotographs from 1994 (Figure 5.1) and topographic maps were used as reference data. A mosaic of three 1:100,000 DSGM (Dirección del Servicio Geografico Militar) - NIMA (National Imaginary and Mapping Agency) topographic sheets were used (Table 5.2). More than 30 ground control points were used for geocorrection.

Table 5.1 List of satellite images obtained for this study.

No.	Satellite	Year	Origin Specifications	Geocorrection Specifications
1	LANDSAT MSS	1975	INPE 242 - 78	Level 2 (+ 30 ground control points) UTM 21
2	LANDSAT TM	1987	GLCF 226 - 78	Level 2 (+ 30 ground control points) UTM 21
3	LANDSAT TM	1997	INPE 226 - 78 INPE 226 - 79	Level 2 (+ 30 ground control points) UTM 21
4	LANDSAT ETM	2004	INPE 226 - 78	Level 2 (+ 30 ground control points) UTM 21

Figure 5.1 Orthophotographs from 1994, District of San Juan del Ñeembucú.

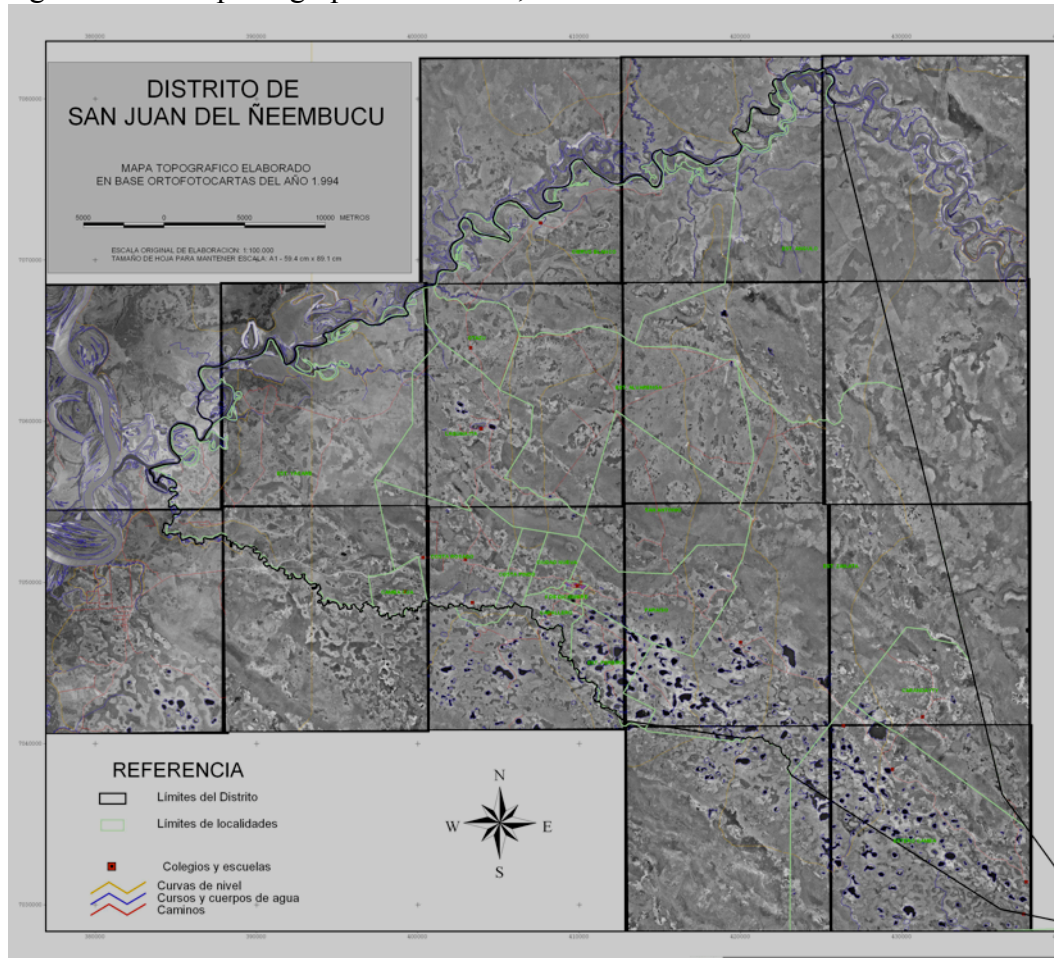


Table 5.2 Topographic maps used for this study.

No.	Name	Edition	Series	Sheet	Country
1	San Juan Bautista del Ñeembucú	1-NIMA	H642	5367	Paraguay
2	Pilar	1-NIMA	H642	5267	Paraguay
3	Villa Oliva	1-NIMA	H642	5368	Paraguay

Area of Interest

Through the analysis of the satellite image from 2004, I was able to discriminate eight land cover classes:

- Woodland Island Oriental
- Woodland Island Occidental
- Crops
- Pastures
- Palm Trees Savannas
- Eucalyptus
- Marshes
- Lagoons

These land cover classes were then subjected to supervised and unsupervised classification.

Classification Methods: Unsupervised and Supervised

The process was completed using the ERDAS Image software on Sun Unix and Windows 2000 systems. Image classification is the process of automatically categorizing each pixel of an image into one of several classes (Hung et al. 1997).

Unsupervised classification or clustering is based on grouping pixels with similar spectral values. This is performed without having any terrain information to produce spectral signatures (Lillesand 2004, Richards and Xiuping 2006). In this study, the unsupervised classification utilized the principal component analysis (PCA) approach with the isodata classifier algorithm. A large numbers of clusters were labeled with the correct land cover class taking advantage of the knowledge of the region and environment. This was done in order to classify all the images related to this area. The isodata was used to obtain the different classes of terrain prevalent in this area.

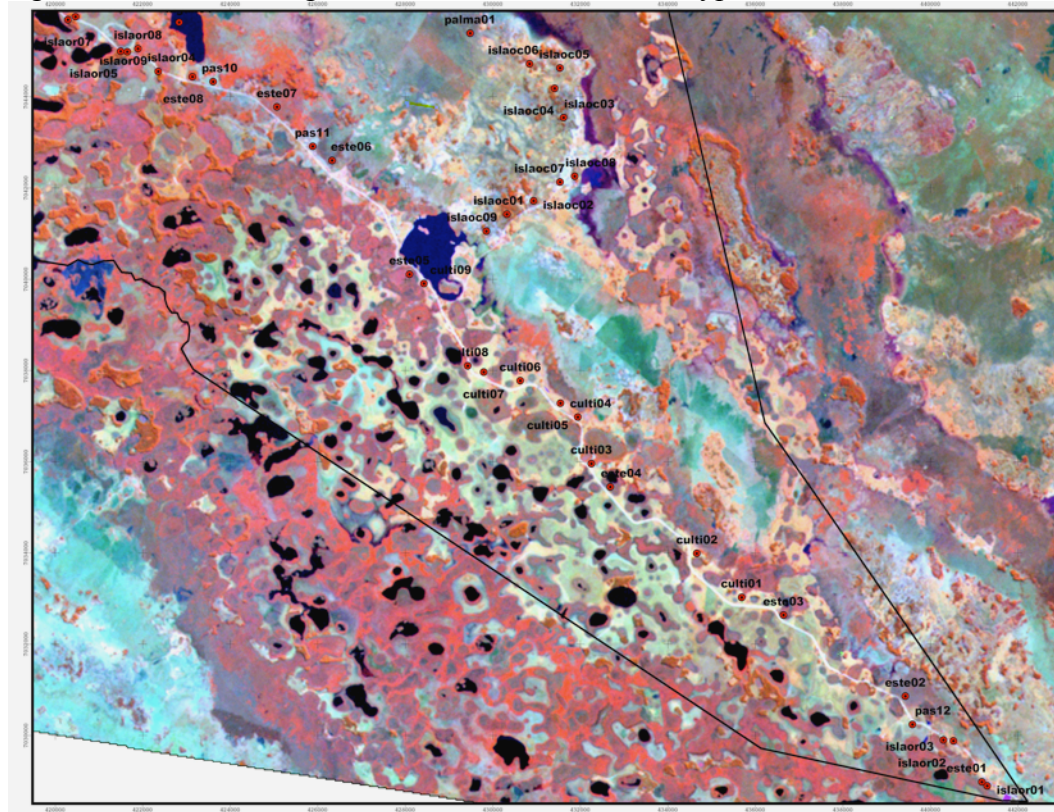
In the supervised classification, the analyst uses training data, areas of pixels with known class types in order to train the computer to recognize the various classes of land covers (Lillesand 2004, Richards and Xiuping 2006). These training areas were based on the analyst's familiarity with the area and it was supported by reliable supplementary sources such as orthophotographs, topographic maps and ground truth data provided from the field work.

For the supervised classification, the maximum likelihood approach quadratic version was used in order to determine the spectral signatures for each training class. This approach is the most commonly used supervised classification technique for mapping wetlands (Ozesmi and Bauer 2002).

I collected ground truth data in order to assess the accuracy of the unsupervised classification. Between September and October 2007 detailed field observations of land cover types were collected. Previous to the field work, several examples of the eight different cover types were identified and named on the LANDSAT satellite image from 2004 (Figure 5.2). Coordinates were obtained for each cover type printed in a spreadsheet. These coordinates were then downloaded into a hand held GPS Garmin XL.

On the ground, a hand-held GPS (Global Positioning Systems) with the aid of the UTM easting and northing data was used in order to verify each land cover identified from the satellite image. A picture also was taken of each cover type as a visual verification. All the data from the hand held GPS were plotted on the 2004 satellite image in order to verify if the cover type identified on the satellite image was the same as identified on the ground.

Figure 5.2 Satellite image from 2004 with land cover types identified.



Data Analysis and Validity

The questionnaire was divided into four areas (Appendix 4.1 and 4.2), which were established to answer my research objective goals, and they were:

- Basic Information,
- Crops and Livestock
- Environmental Situation,
- Personal Information

A spreadsheet program was used in each section to group the results in order to create patterns and draw conclusions.

To validate the findings, three different strategies were used:

1. Triangulation: used data from different sources such as field notes, transcribed interviews, reports and literature to create justification for themes.
2. Peer debriefing: opinion from my guide who was born and raised in this District.
3. Expert opinion: personal communication from Ag. Eng. Rafael Gonzalez who is an expert in the area working for the last 15 years in the local institution Universidad Nacional de Pilar.

5.3 Results

Local Residents or Campesinos

A total of 70 household heads participated in this survey. Almost all of the participants (94%) declared that there has been a change in the rainfall regime in the last five years (2002 – 2007) and this meant a decrease in the amount of rainfall (Table 5.3).

A high percentage of the people interviewed (90%) also mentioned that in the past five years they have seen more extreme droughts (Table 5.3), especially in 2005, 2004 and 2003, in that order.

More than half of the participants (59%) affirmed that the rainfall changes have caused a decreased in the area of water bodies (wetland, lagoons) (Table 5.3).

Table 5.3 Change of the rainfall regime and area of water bodies in the last 5 years in the San Juan del Ñeembucú District.

Decreased rainfall regime	94%
Have seen extreme droughts	90%
Decreased water bodies area	59%

Inappropriate use of fire is an important factor causing change in the land cover types in this District. Gonzalez, (Personal communication, August 23rd, 2007) mentioned some information about this matter: “Burning exerts a big pressure on the prairies. This favors the growth of weeds and palm trees over natural pastures”. In this survey, 53% of the participants burned their fields. The main reasons given for this practice was: pasture re-growth (53%) (as shown in Figure 5.3, grass returns soon after a burn in a very suitable condition for cattle grazing) and weed elimination (42%).

One important factor causing the changes in water levels is construction of roads, which can act as dams. In this District only 10% of the participants indicated that road construction in the area contributed to an increase in water level.

The use of medicinal plants is a strong part of the local culture and all the participants (100%) used them. In this series of interviews, 53 types of medicinal plants were mentioned, including: Hierba Lucero (*Pluchea suaveolens*), Kokú (*Allophyllus edulls*), Burrito (*Wenatia calcyna*), Perdudilla (*Gomphrena decumbens*), Ka'are (*Chenopodium ambrosioides*), and Cedrón (*Lippia citriodora*) in that order. Approximately 1/3 (30%) of the respondents mentioned a decrease in the number of these plants.

The majority (91%) of the participants acknowledged the presence of weeds on their property. About 66% of the participants said that the number of weeds has increased in the last ten years and that 87% were trying to control them. The control method most used was mechanical (hoe or shovel). Twenty-four different types of weeds were mentioned. The most abundant weed was Typicha Hovy (*Eupatorium christieanum*).

Figure 5.3 Grass re-growth after burning the fields.



More than 2/3 (69%) of the participants stated that the status of the wetlands was declining because the amount of water was decreasing.

Ranchers

Twelve ranchers participated in this survey. Almost all of the participants, eleven out of twelve, declared that there has been a change in the rainfall regime in the last five years and this meant a decrease (100%) in the amount of rainfall.

A high percentage of the people interviewed also mentioned that in the past five years they have seen more (10 out of 12) extreme droughts. The years 2007, 2005 and 2006 were mentioned in that order.

Eight out of 12 participants affirmed that these precipitation changes had caused a decreased in the area of water bodies (wetland, lagoons).

The majority of the interviewed ranchers used fire (10 out of 12) as a way to promote re-growth of the pastures.

Only two out of 12 of the participants mentioned roads as the cause of increased water levels in the area. This is because of the dike effect, which is created by roads. The dike effect creates an accumulation of water on one side of the road and lack of water on the other side. And therefore creates an increase in water levels.

Nine out of 12 participants acknowledge the presence of weeds in their property. All of the participants said that the numbers have not increased in the last ten years. The most commonly used control method is fire in 8 out of 12 of the cases. The most frequently mentioned weed was the Caraguatá (*Bromelia serra*) (Figure 5.4).

Ten out of 12 of the participants indicated that the status of the wetlands was not good because weeds were invading the wetlands and wetlands water levels were decreasing.

Environmental Professionals

The participants were from different backgrounds, including: six from NGOs, three government officials, one university instructor and one working as an environmental consultant in the private sector. All professionals were from the environmental field. Important quotes related to the changes of water bodies and land covers were as follows:

- Agr. Eng. Angel Brusquetti (Fundación Moisés Bertoni NGO, Personal communication recorded Monday July 30th, 2007): “Manufactura Pilar (local textile company) historically used wood since the 1930s. Its consumption rate is around 300 to 500 hectares per year. They have a reforestation program but

Figure 5.4 Caraguatá (*Bromelia serra*).



it is not enough for its production”. This is a threat that should be carefully addressed because Monte et al. (2006) discovered in his study that there is a strong link between deforestation with a decrease in the annual rainfall.

- Dr. Fatima Mereles (WWF Paraguay, Personal communication recorded Monday August 13th, 2007): “The Ñeembucú wetlands are very much affected by the anthropogenic action. There is a weed invasion”.
- Agr. Eng. Rafael Gonzalez (Universidad Nacional de Pilar, Personal communication recorded Thursday August 23rd, 2007): “Fifteen years ago, some development projects started to implement drainage in the area. People misunderstood this as a sign of progress”.
- Dr. Sergio Burgos (Instituto Paraguayo de Protección del Ambiente NGO, Personal communication recorded Tuesday August 28th, 2007): “Not only Manufactura Pilar (local textile company) but also the ranchers decimated the local forests. There is a need to protect them”. “In some areas, such as in the

Cambá marshes, the roads built in 1965 increased the water levels from 30cm to 2 meters”.

- Sr. Mario Osmar Fernández (Independent Environmental Consultant, Personal communication Thursday October 4th, 2007): “At the moment, we have areas where the water level is increasing and in others the wetlands are drying out”.

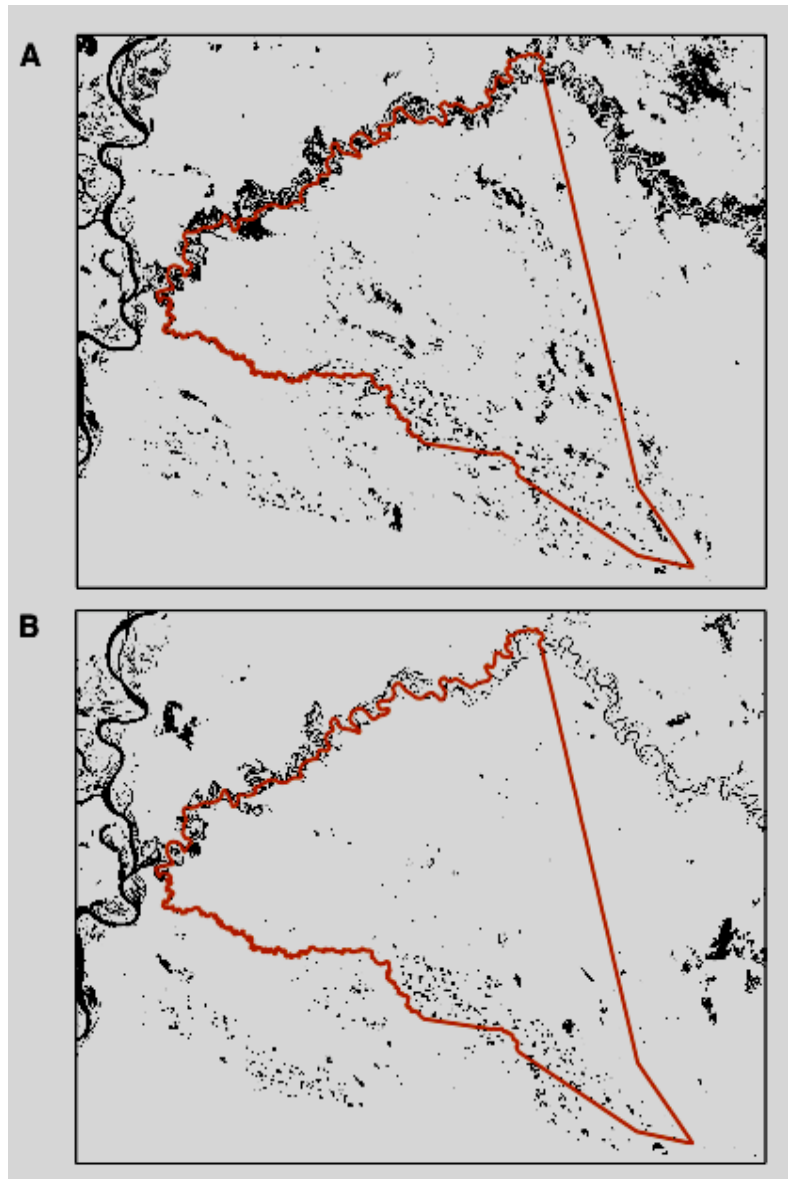
Satellite Images

Satellite images from 1975, 1987, 1997, and 2004 were used in order to determine the change in water area and the distribution of water bodies in the San Juan del Ñeembucú District. For this purpose, a binary image was created from the satellite images. Two colors were used, black for water and white for background (Figure 5.5). This system was used to highlight and compare water bodies over time. An area of approximately 30 kilometers bordering the Tebicuary River was not considered in this analysis. This area was excluded in order to avoid a biased analysis because much of the region is situated in a floodplain that accumulates water rapidly following rain events. The Tebicuary River receives and discharges water from these rains, which occur many kilometers north of the study area, creating patterns of flooding that are not the result of long-term land use or climate change.

Satellite Images: Water Area

There was a decrease in the water area between 1997 (4,394.69 ha) and 2004 (1,585.82 ha) (Figure 5. 6).

Figure 5.5 Binary images for water Bodies. San Juan del Ñeembucú District
A- 1987, B- 2004.



I also found that there was a decreasing tendency in the amount of rainfall during the last three decades (80s, 90s and 2000), which would influence the area of the water bodies (Figure 5.7). Also, 2004 had more annual precipitation than 1997 (Figure 5.8) but less area of water bodies on the ground (Figure 5.6). The opposite would have been expected.

Figure 5.6 Water area in hectares. San Juan del Ñeembucú District, 1975, 1987, 1997, and 2004.

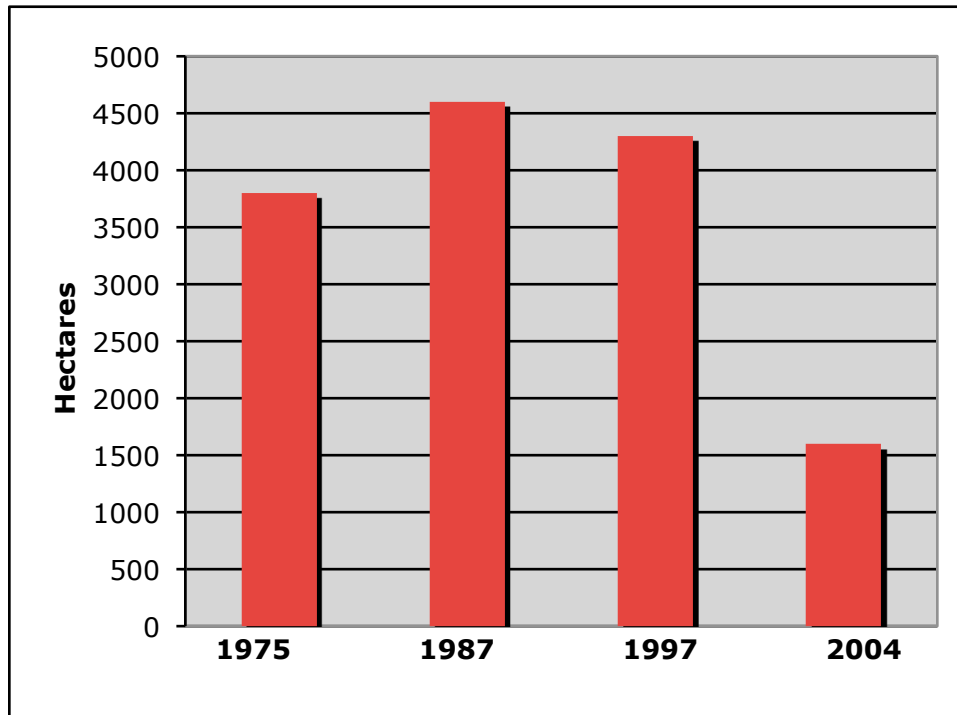


Figure 5.7 Average annual precipitations in four different decades, Pilar Station.

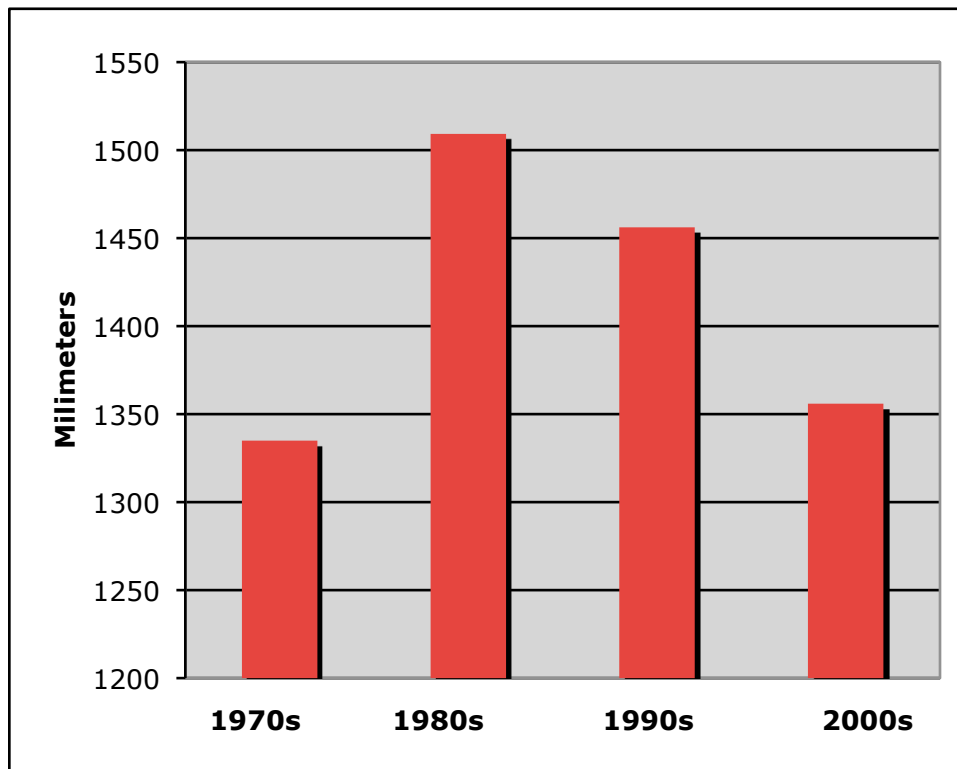
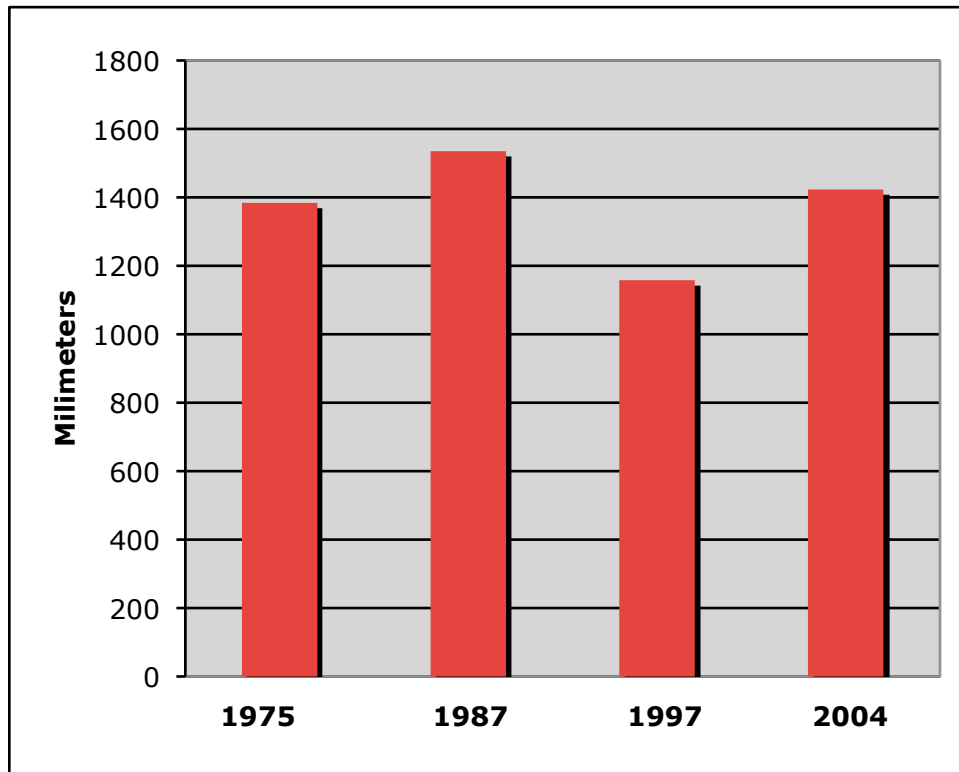


Figure 5.8 Total annual precipitations for four different years, Pilar Station.



Satellite Images: Water Patches or Water Bodies

Water patches or water bodies were defined for the purpose of this study as an area of one hectare or greater. Patches were grouped according to their size, initially into thirteen different groups, and eventually into nine groups. Water patches would include areas of open water such as creeks, ponds or lakes.

I used the terms frequency, cumulative frequency and cumulative relative frequency in order to facilitate the comparison of water patches. Frequency was the number of times a given datum occurs in a data set. Cumulative frequency was used to determine the number of observations that lie above or below a particular value.

The cumulative relative frequency was the proportion of times a patch size occurred. This enabled a better comparison of data sets.

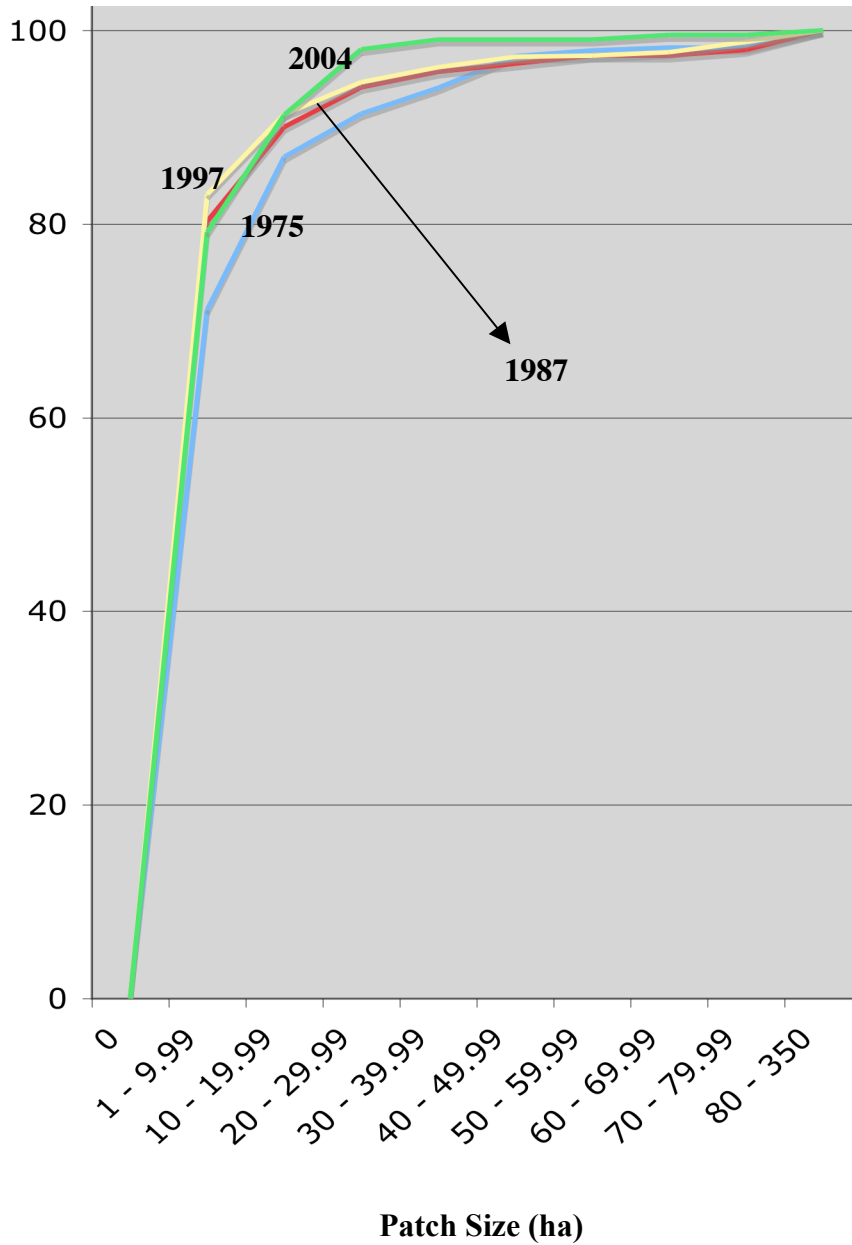
According to the cumulative relative frequency of water patch size, there was a tendency to find more small water bodies over time. Figure 5.9 showed 2004 with higher proportion of small water bodies.

Satellite Images: Cover Types

Comparison between cover type distributions among the different decades was not possible due to several factors such as spatial resolution, spectral resolution and ground information for the supervised classification. The spatial resolution for the 1970s was about 80 meters and for the 1980s and 1990s and 2000s was about 30 meters. The spectral resolution for the 1970s had 4 bands with three visible and one NIR (Near Infrared). The spectral resolution for the 1980s and 1990s had seven bands being three visible, one NIR, two SWIR (Short-Wave Infrared) and one thermal. There was also a lack of ground information for the 1970s and 1980s for supervised classification (Lillesand and Kiefer 2004). These differences created a challenge in defining signature spectra for different cover types. On the other hand, the 2004 imagery is of good quality and do not have all the other inconveniences mentioned above.

Canziani et al. (2003) found that image quality to determine the exact boundary for each cover type was not reliable for the images for the 1970s, 1980s and 1990s. As well, the study area is in a transition zone making it difficult to determine boundaries for each cover type reliably.

Figure 5.9 Cumulative relative frequency of water patch sizes, in four different years, 1975, 1987, 1997 and 2004 representing the distribution of size of the water patches. San Juan del Ñeembucú District.



Because of these important factors, it was decided to only consider the 2004 satellite image for further analysis. The cover type distribution for this District in shown is the Table 5.4.

Table 5.4 Major cover types, Satellite Image from 2004, District of San Juan del Ñeembucú.

2004		
Cover Types	Area in Hectares	%
1- Eucalyptus	1437.92	1.08
2- Wetlands	67599.92	50.89
3- Crops	6261.81	4.71
4- Pastures	16381.81	12.33
5- Palm Trees	11449.15	8.62
6- Forest	26111.49	19.67
7- Water (open water)	3585.99	2.70
TOTAL AREA	132828.09	100.00

Disturbance such as overgrazing and drainage using channels could be observed in the 2004 satellite images (Figure 5.10). In Figure 5.11 a drainage channel is seen to be discharging water into Yacaré Creek. An overgrazed pasture (Figures 5.10 and 5.12) is observed as a light green color.

According to people interviewed in this study (local residents, ranchers and environmental professionals) two major disturbances (overgrazing and drainage) appear to be changing the District's landscape; at the same time, affecting the biodiversity and wellbeing of the local people.

5.4 Discussion

The majority of people interviewed (70 Campesinos, 12 ranchers and 11 environmental professionals) showed a strong concern for water body and landscape changes occurring in the San Juan del Ñeembucú District.

Rainfall regime and water bodies: Almost all the participants (94% Campesinos, 11 out of 12 Ranchers) noticed a decrease in rainfall in the last five years. Drought was seen as the most common occurrence in these five years for the Campesinos

Figure 5.10 Disturbances observed in the satellite imagery from 2004, District of San Juan del Ñeembucú.

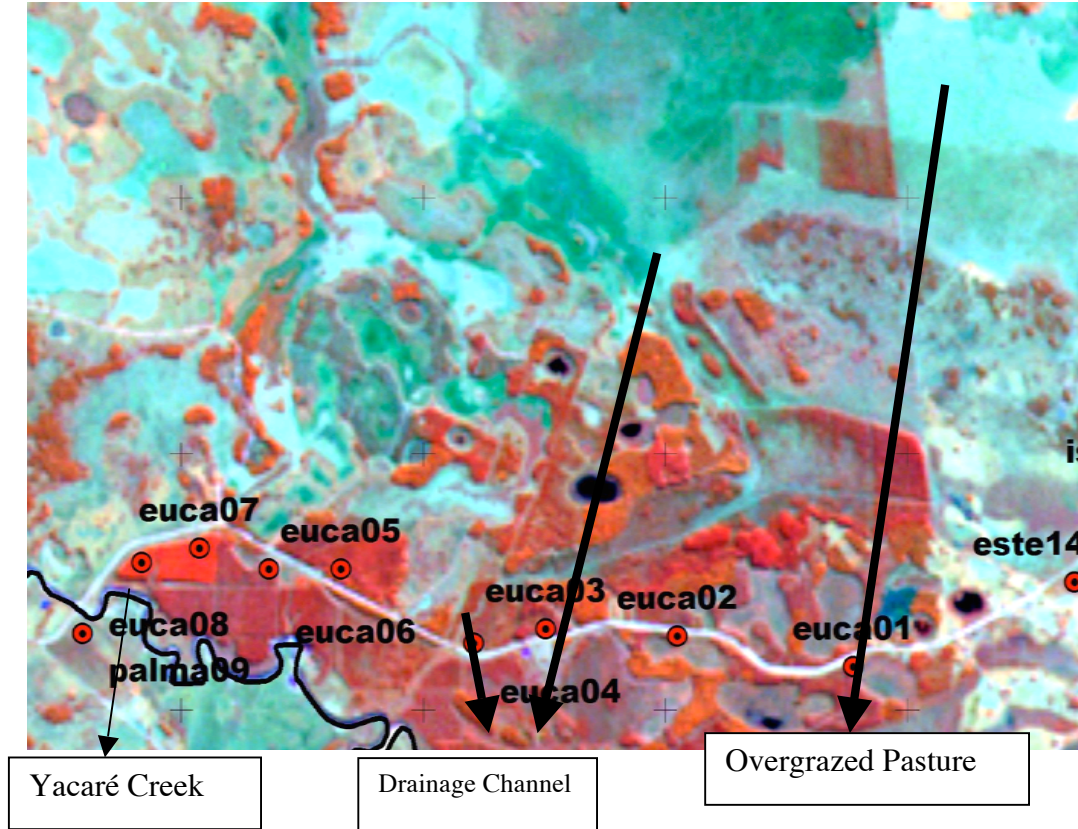


Figure 5.11 Drainage channel discharging water into Yacaré Creek.



Figure 5.12 Overgrazed pasture.



(90%) and for the Ranchers (10 out of 12). Because of these factors, more than half of the Campesinos (59%) and Ranchers (8 out of 12) complained of a decrease in the area of water bodies. Burgos et al. (2006) agrees with these findings stating in their research work that there was a six-year drought (2000 to 2006) mainly due to the phenomenon called “La Niña” and also because of drainage performed in the last 10 years, there was a decrease in the area of water bodies. Two of the professionals interviewed, saw an increase of water levels in some areas and also a decrease in other areas. They mentioned that this was a hydrological problem due to poorly planned roads in the area.

Change in cover types: For some professionals, as well as Burgos et al. (2006), burning was thought to be an important negative factor for change in land cover types, because it favors weed and palm tree growth over native pasture. The survey from this research study shows that little more than half of the Campesinos

(53%) and more than 3/4 of the Ranchers (10 out of 12) burn their fields as a common practice in the area.

A majority of the participants acknowledge the presence of weeds in their fields (91% of Campesinos and 9 out of 12 of Ranchers). The Campesinos mentioned that the number of weeds had increased in the last ten years (66%). On the other hand, 10 out of 12 of Ranchers mentioned that this growth was affecting the wetland status because weeds were invading them.

Almost 1/3 (30%) of the Campesinos mentioned that they observed a decrease in the number of medicinal plants. This was considered to be negative due to the importance of medicinal plants in the local culture. ENPAB (2003) and Mereles (2004b) reached to the same conclusion in their research work mentioning that medicinal plants were decreasing in number due to habitat degradation.

One environmental professional (Brusquetti) mentioned that the local textile company has been using wood for its operations at a rate of 300 – 500 hectares per year for the last 70 years. This dramatic fact affects the wellbeing of the local forest due to deforestation, because the reforestation being implemented by the textile company is not sufficient to balance what they use. Grau and Aide (2008) mentioned in their work that deforestation is a dominant land use trend in Latin America. Burgos et al. (2006) also mentioned in their work that in the Ñeembucú Department native forest is being fragmented due to the wood usage for different activities such as cooking, charcoal and posts for fencing.

Satellite images from different decades were used in order to corroborate what was found in the interviews in relation to changes experienced in the area of water bodies in the District of San Juan del Ñeembucú.

There was an overall decrease in the total area of water bodies from 1987 to 2004 (Figure 5.6). An important point to consider is that precipitation in 2004 exceeded annual precipitation in 1997 (Figure 5.8), but total area of water bodies was substantially less (Figure 5.6). This could be the result of anthropogenic activities such as drainage, and road construction that are modifying the hydrology of the region. Burgos et al. (2006) in their research study performed in the Ñeembucú Department suggest that road construction in the area is contributing to a dike effect and is primarily responsible for increasing the water level.

The amount of rainfall in the area has decreased in the last two decades (Figure 5.7). This may be due to deforestation happening locally and in the rest of the Paraguayan territory. Results from Lean and Rowntree (1997) in Brazil and Nobre et al. (1991) in Brazil found similar tendencies arguing that large-scale conversion of tropical forest into pastures or crops could lead to changes in the climate and precipitation.

The percentage of small water body patches is increasing over time. Burgos et al. (2006) argue that wetlands in the region are all interconnected and drainage for roads and agriculture greatly impact the distribution and abundance of water. He also suggests that the effect of increased drainage may be worsened by the persistent drought in the region. In my study it was found that the area of water bodies are decreasing.

Unsustainable agriculture and ranching practices (such as drainage) have transformed much of this area to eroded farmland and overgrazed pasture. This information was collected during the interviews to the participants of this research study. One of the environmental professionals (Gonzalez) mentioned that overgrazing is a stressor causing a favorable growth of weed invasion and consequently a decrease of pasture area. Local residents mentioned weed invasion, which is a consequence of overgrazing, as one of its major problems in its production units. Yanosky and Salas (2004) and Burgos et al. (2006) mentioned similar tendencies where bad management practice in agriculture (usage of the plow) and in animal husbandry (overgrazing) could lead to bare soil and erosion from water or wind. This erosion decreases the soil productivity.

5.5 Conclusions

The data collected, related to areas of water bodies from the survey and multi-temporal imagery (satellite images 1975, 1987, 1997, 2004) and land cover type from 2004 provided a better understanding of the changes occurring in the San Juan del Ñeembucú District. These are the conclusions:

- In the last five years participants mentioned a decrease in the rainfall regime and the occurrence of several droughts and consequently a decrease in the area of water bodies.
- There are human activities in the area such as deforestation, burning and drainage, which are causing a change in the vegetation complexity of the area.
- Satellite imagery from 2004 showed less area of water bodies and greater numbers of small water patches compared to the 1997

satellite imagery. Even though the 1997 annual precipitation was less. Some of the main concerns in this study were the rain distribution and the amount of water staying on the ground even though the precipitation in the year 2006 was above average (1741 mm), and local residents and ranchers were complaining on a drought. There could be years of good precipitation average with several months of no rain and few months with a lot of rain.

- The increase in the number of small water patches may be linked to drainage and road construction. Because drainage causes certain areas to have less water area and level. On the other hand, road constructions, through the dike effect, create a barrier for the water to continue its regular path and consequently the water accumulates and the water level increases. All of these manmade activities create a fragmentation of the water bodies.
- Bare soil and its consequent erosion are linked to bad agriculture and ranching practices such as plow usage and overgrazing.

The most important actions that need to be taken in order to address these situations are:

- Water management: Sustainable and regional water management plan for the Ñeembucú wetlands. This can be executed in partnership with the local Municipalities; the local university (Universidad Nacional de Pilar); Secretariat of the Environment; and the Ministry of Agriculture.
- Soil Erosion: Implement a program for soil management and for

plants and animals adapted to the area. This can be executed in partnership with the Local Municipalities; local University (Universidad Nacional de Pilar); Secretariat of the Environment; Ministry of Education; and the Ministry of Agriculture.

- Deforestation: Establish reforestation programs. This can be executed in partnership with the Local Municipalities; local University (Universidad Nacional de Pilar); Secretariat of the Environment; Ministry of Education; and the Ministry of Agriculture.

Chapter 6 General Changes in Wildlife Abundance in the Ñeembucú Region with Particular Emphasis on Indicators of Ecosystem Health

6.1 Introduction

The Ñeembucú Department is rich with wildlife. Pedrozo (2007) stated that 41% of the 685 species of birds registered in Paraguay could be found in the Department of Ñeembucú. Clay et al. (2007) mentioned the Ñeembucú region was among the most important ornithogeographic regions in Paraguay.

For mammals, the wetlands of the Ñeembucú department are also very important (Cartes 2004). Mammals represent an important source of protein for the local people (Cartes 2004). The most common mammal in the wetland areas of Paraguay is the Carpincho or Capybara (*Hydrochaeris hydrochaeris*). This mammal is heavily hunted for its meat and leather and was considered in this study as an indicator of ecosystem health because it is found in areas with permanent water and it is native to wetlands of this part of the world (Neris et al. 2002). Also, other important characteristics are mentioned by Cairns et al. (1993) such as biologically relevant to the area, socially relevant, sensitive to stressors and measurable. Terborgh (1992) indicated that species of high fecundity in the neotropics, such as the Capybara, produce more prey biomass per year. This characteristic determines the carrying capacity of the local felid predators.

Waterfowl in Paraguay are ecologically dependant on wetlands (Lesterhuis et al. 2005, Zarza and Morales 2006). Of the 685 species of birds documented in Paraguay, 111 are waterfowl (Clay et al. 2004). Waterfowl use wetlands for nesting

and feeding. During nesting, they use vegetation to support their nests and also as a refuge from predators. These areas are also very important for feeding purposes (Blanco 1999). These birds are important to the local culture, such as the Limpkin or Karau (*Aramus guarauna*), and are also a protein source (Zarza and Morales 2006). The Karau is mentioned in various legends and poems in the local folklore (Fogel 2000).

Among waterfowl, there are many migratory species that travel long distances in search of food and a place to nest. The most important are the migratory shorebirds from the families Charadriidae and Scolopacidae. They have their breeding areas in arctic regions and spend the boreal winter in South America (Blanco 1999). This group of birds is called Nearctic migrants since, they are Western Hemisphere species breeding north of the Tropic of Cancer (latitude 23° 26' 17" North of the Equator) and wintering south of the same latitude (Deinlein 2005).

Bird migrations are the departure from and return to the same area with changing seasons (Raveling 1982). Migration allows birds to take advantage of seasonally abundant food and to avoid places where food and other resources are scarce (Deinlein 2005). In their migration, shorebirds use a succession of staging areas and a variety of habitats for resting and feeding. Wetlands are important to them as they rely on these staging or stopover areas to meet the energy demands during migration (Daniel 2000).

Declines in the numbers of many migratory Nearctic bird species have been detected over the past several decades (Deinlein 2003, Gotthardt and Lanctot 2002, Lanctot et al. 2002, Morrison 2001). The United States Shorebird Conservation

Plan (2004) issued a list of United States and Canadian shorebird populations that were considered highly imperiled and of high, moderate or low conservation concern. The factors considered were: population trend and size, breeding and non-breeding threats, and breeding and non-breeding distribution.

Nineteen shorebirds found in Paraguay were mentioned as follows:

- Highly Imperiled: Red Knot (*Calidris canutus*), Buff-breasted Sandpiper (*Tryngitis subruficollis*).
- High Concern: American Golden Plover (*Pluvialis dominica*), Solitary Sandpiper (*Tringa solitaria*), Upland Sandpiper (*Bartramia longicauda*), Hudsonian Godwit (*Limosa haemastica*), Wilson's Phalarope (*Phalaropus tricolor*).
- Moderate Concern: Black-bellied Plover (*Pluvialis squatarola*), Greater Yellowlegs (*Tringa melanoleuca*), Lesser Yellowlegs (*Tringa flavipes*), Semipalmated Sandpiper (*Calidris pusilla*), Least Sandpiper (*Calidris minutilla*), Stilt Sandpiper (*Calidris himantopus*), Red Phalarope (*Phalaropus fulicarius*).
- Low Concern: Semipalmated Plover (*Charadrius semipalmatus*), Spotted Sandpiper (*Actitis macularius*), White-rumped Sandpiper (*Calidris fuscicollis*), Baird's Sandpiper (*Calidris bairdii*), Pectoral Sandpiper (*Calidris melanotos*).

Researchers have mentioned several causes for the decline in numbers of migratory Nearctic bird species, including: habitat loss due to the fragmentation of breeding habitat and destruction of tropical forests on the wintering grounds,

hunting, burning, road construction and global climate change. These findings demonstrate that if appropriate habitat is not available for a needed stopover, birds must either fly farther or remain in poor habitat and risk starving or becoming easy prey for a predator (Deinlein 2005, Doswald et al. 2009, Erwin et al. 2004, Findlay and Bourdages 2000, Finlayson et al. 2006, Galbraith et al. 2005, Isacch et al. 2004, Junk 2002).

Birds have been used as indicators of ecosystem health providing information on habitat loss, deterioration and pollution. Bradford et al. (1998) mentioned that bird species were useful in detecting landscape-level effects on biological integrity, such as those resulting from habitat fragmentation caused by agriculture, ranching or burning. Waterfowl are very sensitive to water level changes; therefore, they are frequently used as indicators of environment quality and ecosystem health (Zarza and Morales 2006).

The fish fauna is important for the local population since more than four thousand households in the Department of Ñeembucú depend on fishing (Fogel 2000). Paraguay has two hundred and fifty species listed and most of these species are present in the Ñeembucú region (Burgos et al. 2006). The Ñeembucú wetland is an important habitat for the fish fauna since they use it for reproduction (spawning) purposes (Burgos et al. 2006). The main threats for the fish fauna are overfishing and drainage of their reproduction habitat (wetlands). These activities are causing a significant decrease in the fish population (Burgos et al. 2006).

The aim of this chapter is to verify general changes in wildlife abundance in the Ñeembucú region with particular emphasis on indicators of ecosystem health in order to establish the ecohealth status of this wetland area.

6.2 Materials and Methods

Two data collection approaches were selected to gather information on wildlife: interviews and review of available literature and reports.

The information for the study area, the rationale behind the selection of the interviews, elaboration of the questionnaire, interview details, sampling method used and ethical considerations were described in Chapter 4.

Public documents were collected from research done by Paraguayan scientists regarding wildlife populations. These publications were from:

- Secretaría del Ambiente (<http://www.seam.gov.py>), Centro de Datos para la Conservación (Ministry of Environment, Data Centre for Conservation) from the Paraguayan Government.
- Guyra Paraguay NGO (<http://www.guyra.org.py>), Paraguayan Non-Governmental Organization which help institute and coordinate local conservation activities, public policies, and research for the conservation and sustainable use of biological diversity, with an emphasis in birds.
- Ministerio de Agricultura y Ganadería (<http://www.mag.gov.py>), Sub-Secretaría de Estado de Recursos Naturales y Medio Ambiente, Dirección de Parques Nacionales y Vida Silvestre (Ministry of Agriculture and Livestock, Vice-Secretarian of State for Natural Resources and Environment, National Parks and Wildlife Section) from the Paraguayan Government.
- Fundación Moisés Bertoni (<http://www.mbertoni.org.py>), Paraguayan Non-Governmental Organization in Paraguay which works toward

achieving sustainable development, through the conservation of nature with the participation of the citizens.

Data Analysis and Validity

The questionnaire was divided into four different sections or themes that were described in Chapter four, section two. A spreadsheet program was used in each section to group the results in order to create patterns and draw conclusions.

To validate the findings, four different strategies were used:

- Triangulation: used data from different sources such as field notes, transcribed interviews, documents and literature to create justification for themes.
- Peer Debriefing: opinion from my guide who was born and raised in this District.
- Expert Opinion: personal communication from Ag. Eng. Rafael Gonzalez who is an expert in the area working for the last 15 years in the local institution Universidad Nacional de Pilar.

6.3 Results

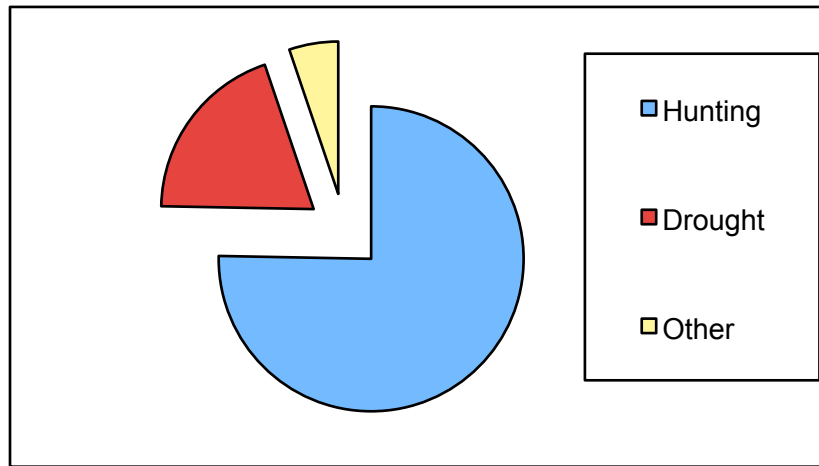
Local Residents or Campesinos

A total of 70 household heads participated in this survey. More than 90% of the participants responded that there has been a decrease in local wildlife populations. Specifically, participants mentioned that there was a decrease in the number of fish (77%). Almost 2/3 (64%) of the participants mentioned that birds stop and nest on their properties.

When asked about the Capybara (one of the animals chosen as a bioindicator) population, almost all the participants (97%) agreed that there was a decrease in their

population. The main causes cited for this decrease were hunting (75%), and drought (20%), with the rest mentioning that the Capybara left because the human population in the area has increased (Figure 6.1).

Figure 6.1 Causes of a decrease in Capybara population as suggested by local residents.



Most (93%) of the participants did not receive any environmental education from the Paraguayan Government.

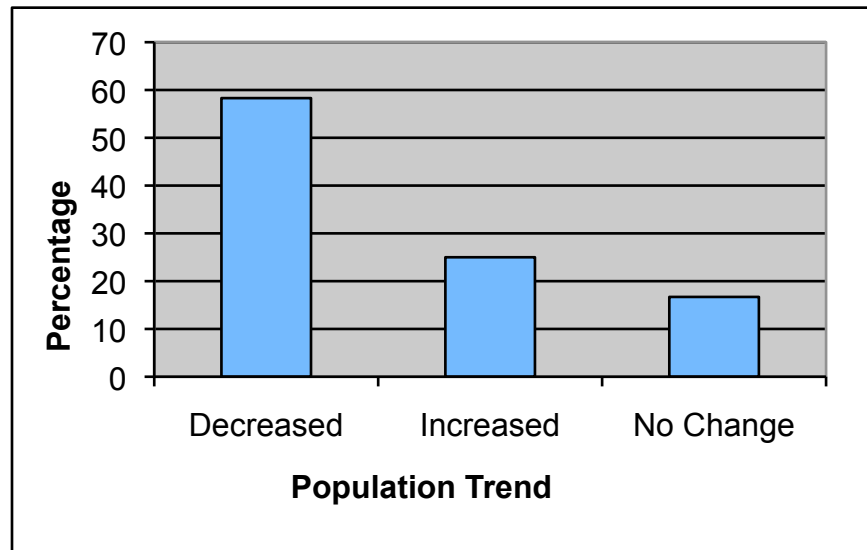
Ranchers

A total of 12 ranchers participated in this interview. All the participants (12 out of 12) mentioned a change in the wildlife population and most of these participants (10 out of 12) indicated a decrease.

Nine out of 12 participants mentioned a change in the fish population and that this was a decrease (10 out of 12) in the number of fish. All participants mentioned that birds stop and nest on their properties.

The ranchers had a different vision of the Capybara population trend. A little more than half of the participants (7 out of 12) mentioned a decrease in the population (Figure 6.2). The main reasons cited for this decrease were hunting (12 out of 12) and drought (4 out of 12).

Figure 6.2 Capybara population trend as suggested by ranchers.



None of the ranchers received any environmental education from the Paraguayan Government

Environmental Professionals

The participants were from different backgrounds with: six from NGOs, three Government Officials, one University instructor and one working as an environmental consultant in the private sector. All professionals were from the environmental field. The most important quotes from these experts relating to changes of the wildlife abundance in the Ñeembucú region were as follows:

- Agr. Eng. Angel Brusquetti (Fundación Moisés Bertoni NGO, Personal communication recorded Monday July 30th, 2007): “As a hunter, I have seen a decrease in duck populations through the years. This decrease was related to the water levels of the marshes and lagoons caused by local drainage”. “The Capybara has been historically important for the local people as a protein source and because of its leather”. “The decrease in numbers of Capybara is due to the commercialization of its meat and leather”.
- Agr. Eng. Francisco Fracchia (Environmental and Sustainable Production Committee, Paraguayan Ranchers Association, Personal communication recorded Thursday August 2nd, 2007): “Ranchers usually do not like hunting on their property due to their management basically because they fear cattle theft”.
- Dr. Fatima Mereles (WWF Paraguay, Personal communication recorded Monday August 13th, 2007): “Flora and fauna are very linked to each other. If we are destroying the flora due to drainage for agriculture and ranching; obviously we are losing fauna”.
- Agr. Eng. Rafael Gonzalez (Universidad Nacional de Pilar, Personal communication recorded Thursday August 23rd, 2007): “Ten to fifteen years ago, the numbers of ducks and shorebirds were bigger”.
- Dr. Sergio Burgos (Instituto Paraguayo de Protección del Ambiente NGO, Personal communication recorded Tuesday August 28th, 2007): “There is a 50% decrease in catch in the last ten years. There is an excessive number of fishermen”.

- Lic. Narciso Vázquez (Environmental Official of the Ñeembucú Department, Personal communication recorded Tuesday September 18th, 2007): “People take colored fishes to Argentina and later on to Europe to be sold at a good price for aquarium purposes. Some species are near extinction because the locals take what they need to survive”.
- Sr. Mario Osmar Fernández (Independent environmental consultant, Personal communication Thursday October 4th, 2007): “People come as tourists and they hunt and fish. Wildlife migrates to remote places on the rancher’s properties because of the hunting going on”.

Cartes (2006) mentioned that Marsh Deer (*Blastocheirus dichotomus*) and Giant Anteater (*Myrmecophaga tridactyla*) are considered to be threatened in the Department of Ñeembucú. The Marsh Deer is much in demand, especially by poachers for meat and hide.

In 1997, the Ministry of Agriculture and Ranching and the Fundación Moisés Bertoni with the support of the USAID (United States Agency for International Development) and local Paraguayan researchers developed the first list of threatened Paraguayan fauna. The goal of this work was to document the actual status of Paraguayan fauna.

For birds, 86 birds (13%) were categorized as threatened due to loss of habitat. The main causes of habitat loss were deforestation and wetland drainage. In the case of mammals, 15 families and 38 species were found as threatened. The main reasons were habitat loss, hunting and road construction.

The Ministry of Environment conducted a research project in the Ñeembucú Department. Pedrozo (2007) found that 23% of the birds living in this

Department were threatened. Some migratory Nearctic shorebirds such as the Upland Sandpiper, Solitary Sandpiper, and Pectoral Sandpiper were in this group. The main reasons for this status were high anthropogenic pressure from activities such as deforestation, burning, and drainage. All these activities cause a loss of habitat.

6.4 Discussion

There was a consensus regarding wildlife population trends in the area among the three groups interviewed in this study. Local residents, ranchers and the professionals agreed that changes meant a reduction in the population of fish, birds and mammals. Morales et al. (2006) in their research work found 25 bird species at risk in this area. Another research work performed by Burgos et al. (2006) also found a decreased in the local fauna. He stated that 23% of the birds and 72% of the mammals are threatened in this area; one of them being the Capybara. All the findings of these researchers agreed with the results of this research study.

All the participants mentioned that Capybara, a bioindicator of the area, faces extraordinary pressure because of hunting and the drought during the past decade. There has been change in wildlife populations in the Ñeembucú Department and this change means a dramatic decrease in the number of individuals, specially the one chosen (Capybara) as a bioindicator of ecosystem health. Most of the local residents have not seen a Capybara in years (10 years) and they mentioned watching Capybaras crossing their back yard in the past. At the same time, environmental professionals mentioned a strong decrease of ducks in the area. Researchers such as Burgos et al. (2006) and Cartes (2004) agreed with these findings mentioning that local residents

consider this animal as a source of protein and that local practice such as burning, drainage and hunting are threatening their population. Fire interrupts reproduction or wildlife rearing when grass is burned, and consequently bird eggs, as well.

The main reason mentioned in the interviews for this wildlife population decrease was hunting. Local residents see wildlife as an important protein source. Professionals mentioned that local residents hunt because of lack of options; therefore, there is a need to create alternative work for their income or alternative protein sources (eg. raise chickens).

In North America, wildlife is managed through a set of guidelines known as “The Seven Sisters for Conservation” (The Seven Sisters for Conservation 1999). This North American Wildlife Conservation Model is unique in the world. These guidelines are strongly enforced by the Governments of Canada and the United States. In Paraguay, flora and wild fauna are managed under the local civil code through Law N^o 96 from 1992. This Law has only general clauses, without being specific with regards of hunting season for different species, and lacks enforcement from the authorities. Paraguay needs to bring the successful experience from the North America Wildlife Conservation Model in order to help preserve its local fauna.

The rancher’s perspective of the Capybara population trend is not so dramatic since they ban hunting on their properties; therefore, the main threat for Capybaras in these properties are poachers. This situation was confirmed by Burgos et al. (2006) that Campesinos, who were interviewed, own firearms and poach wildlife and cattle.

During the interviews, local residents and ranchers indicated that

Government environmental education was almost nonexistent in the Department, as indicated by Burgos et al. (2004), as well.

Paraguay has an official document elaborated by the Ministry of Agriculture and Livestock; Sub-Secretariat of State of Natural Resources and Environment; Department of National Parks and Wildlife and Fundación Moisés Bertoni; “Fauna Amenazada del Paraguay” (Threatened Fauna of Paraguay) published in 1998 (Fauna Amenazada del Paraguay 1998). This publication shows a Paraguayan fauna decreasing in population and under a lot of anthropogenic pressure such as burning, drainage, hunting, and deforestation. These activities are causing a loss of habitat and consequently a decrease in the population of many animals. In this publication, the number of threatened birds species in Paraguay is 86 and the number of mammal’s species is 38. All these findings agree with the results of this research study on the decreasing trend of wildlife population.

As mentioned by Cartes (2004) and Zarza and Morales (2006), most of the research on local animal populations consists of animal counts in a limited numbers of areas and literature reviews from other countries. More specific research on the local wildlife populations of the Ñeembucú is needed.

Another very important part of this problem is that environmental education in the area is practically absent. As mentioned before, “you can not protect something that you do not understand and appreciate”.

6.5 Conclusions

The most important actions that need to be taken in order to address this situation are:

- Environmental education: develop educational programs tailored to the Ñeembucú Department in order to create environmental awareness especially with decision makers. This can be executed in partnership with the local University (Universidad Nacional de Pilar); Ministry of Education; and the Secretariat of the Environment.
- Promote technical assistance and employment alternatives (e.g. ecotourism) for local residents: For sustainable use of the environment, improvement of the livelihoods of local residents and consequently mitigating their anthropogenic pressure on the environment is needed. This can be done in partnership with the local University (Universidad Nacional de Pilar); Ministry of Tourism; Secretariat of the Environment; and the Ministry of Agriculture.
- Wildlife Population Census: data are needed for wildlife populations from different years in order to compare and determine the exact status in the Ñeembucú Department as mentioned by different Paraguayan researchers (Morales et al. 2006, Zarza and Morales 2006, Yanosky and Cartes 2008a). This can be executed in partnership with the local University (Universidad Nacional de Pilar); Secretariat of the Environment; the Ministry of Agriculture; and local invited NGOs (Non Governmental Organizations).
- Trans-boundary Projects: for migratory Nearctic birds, as stated by Donaldson et al. (2006): “we cannot sustain populations in Canada if

effective conservation is not occurring in other parts of their range”, it is important to establish and fund research projects in the Neotropics. This can be executed in partnership with the local University (Universidad Nacional de Pilar); Secretariat of the Environment; the Ministry of Agriculture; and local and international invited NGOs (Non Governmental Organizations).

Chapter 7 Changes Associated with Cattle and Crop Production in the San Juan del Ñeembucú District

7.1 Introduction

Agriculture is the primary cause of loss of natural ecosystems around the world (Baldi et al. 2006, Fearnside 2001). In southern South America, grasslands are being rapidly converted to croplands (Baldi et al. 2006). The main crop, in southern South America, threatening tropical biodiversity, is soybeans (Fearnside 2001). Brazil, Bolivia and Paraguay are the focus of its expansion. This crop has important environmental and social impacts in the region. The environmental impact is represented by use of agrochemicals and land use transformation to agriculture and the social impact is represented by displacement of small farmers to marginal areas (Fearnside 2001).

Ranching also affects wetlands indirectly by large-scale changes in vegetation cover of the catchments and related changes in hydrology and sediment input (Junk 2002). Grazing animals can affect water quality negatively through erosion caused by high-density stocking and sediment transport into surface water (urine and feces from animals). Nitrogen and phosphorus are the two nutrients of main concern in water quality (Fortney 2000, Hubbard et al. 2004). Riparian buffer systems have been used to reduce water pollution from agriculture and ranching. Nitrogen loading in surface runoff and subsurface flow are reduced after passage through a riparian forest (Hubbard et al. 2004).

Intensive grazing removes vegetative growth, which in turns reduces root growth. If overgrazing continues, native plants are grazed out creating patches of

bare soil and facilitating the appearance of invasive flora.

Under drought conditions the consequences are even more dramatic (Evans 1998, Marino 2008). In wetland areas, erosion is a factor that can change the rate of sedimentation by slowing down water flows and creating flooding problems (Simonit et al. 2005).

Belsky et al. (1999) noted that livestock grazing has damaged 80% of stream and riparian ecosystems in the western United States because of overgrazing. This situation can result in grass trampling, soil erosion, loss of stream-bank stability, declining water quality, weedy pastures and consequently a low production pasture (Belsky et al. 1999, Trottier 1992). Other studies have shown that by improving grazing methods (e.g. reducing livestock number), these conditions could be minimized and the pasture will be vigorous and of high production (Belsky et al. 1999, Kie et al. 1996, Sarmiento et al. 2004). Overgrazing is also detrimental to nesting waterfowl and other grassland birds because most waterfowl need residual vegetation for nesting (Kadlec and Smith 1992).

Another important threat to biodiversity is the improper use of fire (Marino 2008). Fire impacts biodiversity by creating a stress to the prairies and increasing the possibilities of weed invasion (Marino 2008). It is used by ranchers to obtain grass re-growth before fall or at the beginning of the spring season (Pot and Pot 2004).

In the District of San Juan del Ñeembucú, local people practice subsistence agriculture (Figure 7.1). This is due to the topography of the region, which results in more than 51% of wetland area. Therefore, the land base is quite restricted for local people to use for production other than meeting their own needs.

Figure 7.1 Garden of a survey participant.



Paraguay has a long-standing tradition in ranching. The first cows were brought to Paraguay, and to southern South America, in 1554. The first ranch established in southern South America was in Paraguay in 1571 (Liebig's 1965).

The Ñeembucú Department also has a long-standing tradition in ranching (Burgos et al. 2004). In the District of San Juan del Ñeembucú, one of the most important ranches of Paraguay, at the time, was established in the year 1898 and its name was Yacaré (Liebig's 1965).

Heitschmidt et al. (2004) indicated that properly managed grazing is ecologically sustainable since it is the oldest and most natural form of agriculture. Therefore, efficient pastureland management is important for sustainability of the environment. MacLachlan et al. (2005) define it as: "The planned and sustainable use of a grass covered landscape by humans to feed and accommodate livestock".

The aim of this chapter is to determine how to minimize negative changes to the environment in this ecoregion resulting from cattle and crop production.

7.2 Materials and Methods

For this Chapter, two data collection types were used to gather information: interviews and a review of the available literature and reports.

The information about the study area, the rationale behind the selection of the interviews, elaboration of the questionnaire, interview details, sampling method used and ethical considerations were described in the previous chapter (Chapter 4).

Public documents were collected from two Paraguayan Government Institutions. These publications were from:

- Censo Agropecuario Nacional 1991 (Paraguay Agricultural Census 1991). Ministerio de Agricultura y Ganadería (Ministry of Agriculture and Livestock), Dirección de Censos y Estadísticas Agropecuarias (Agricultural Census and Statistics Division).
- Servicio Nacional de Calidad y Salud Animal (SENACSA) (National Service of Animal Health), Region Sanitaria Oriental Sur No. 5 (Oriental Health Region No. 5), Unidad Zonal: San Juan Ñeembucú (Zonal Unit: San Juan Ñeembucú).

Data Analysis and Validity

The questionnaire was divided into four different sections or themes that were described in Chapter 4, section 2. A spreadsheet program was used in each section to group the results in order to create patterns and draw conclusions.

To validate the findings, four different strategies were used:

- Triangulation: used data from different sources such as field notes, transcribed interviews, reports and literature to create justification for themes.
- Peer Debriefing: opinion from my guide who was born and raised in this District.
- Expert Opinion: personal communication from Ag. Eng. Rafael Gonzalez who is an expert in the area working for the last 15 years in the local institution Universidad Nacional de Pilar.

7.3 Results

Years Spent Farming in the Area

Local residents (27.6 years) had little difference (4.8 years) in years spent farming compared to Ranchers (22.8 years).

Farm Size

Average farm size of local residents was 40.9 hectares with a total area of 3,146 hectares for all 70 householders interviewed. Six of the 12 ranchers had ranches in the range of 1,001 to 5,000, five of them 5,000 to 10,000, and one with an area of + 10,000 hectares.

Changes Introduced to Lowlands

There were changes introduced to lowlands according to the different groups interviewed. Only 11% of the local residents have introduced changes; whereas, more than half (7 out of 12) of the ranchers have done so. The changes introduced were mainly channels to drain wetlands and roads for transportation.

All ranchers were satisfied with their changes because it meant more area

for pastures and better transportation. The improvement in transportation resulted from ranchers building roads, and these roads were then utilized by man (for transportation purposes) and by cattle (place to rest in inundated areas within the ranch).

Farming

Most of the local residents (99%) farm, but only half of the ranchers do.

Crops grown by local residents were: yucca (18%), corn (18%), sweet potato (16%), beans (14%), citrus (14%), cotton (14%) and others (13%). Ranchers farmed to feed their cattle, growing crops such as grass, sugar cane and sorghum.

Fertilizers

More than 87% of local residents use fertilizers in their farming, but none of the ranchers do. Local residents primarily use organic fertilizers (mainly cow manure) (92%) in addition to chemical fertilizers.

Rotation of Crops

Only local residents were asked if they rotated crops since they were the ones doing most of the farming. Very few participants shifted their crop production (9%), from farming cotton, due to low price, and a decrease in performance and soil fertility.

Sources of Knowledge

Local residents mentioned they used mainly traditional knowledge (81%) and local knowledge or experience (12%) in order to make decisions on what crops to grow and how to manage them. Only a few of the Campesinos used knowledge from agriculture specialists.

On the other hand, the ranchers relied a little bit more in the experience (7 out of 12) and advise from experienced professionals (5 out of 12).

Livestock: Amount and Type

All local residents and ranchers own livestock of different types as shown in Table 7.1. Local residents own the seven types of livestock mentioned in the survey. Ranchers did not mention any goat and pigs but the average of animals for beef, dairy and horses is higher compared to the local residents.

Table 7.1 Types of livestock in the study area for local residents (LR) and ranchers who participated in the survey.

Livestock	LR %	Ranchers %	LR Average # of animals	Ranchers Average # of animals
Beef	53	100	32	NA
Dairy	99	92	13	30
Sheep	46	92	13	90
Goat	4	0	20	0
Pigs	54	0	3	0
Horses	86	100	3.4	72.5
Chicken	99	75	20	24

Table 7.2 shows the total amount of cattle in Paraguay and in the Department of Ñeembucú. Ñeembucú represents 4% of the cattle production in Paraguay.

Table 7.3, shows that 71% of cattle are in the hands of only 7% of the owners in the San Juan del Ñeembucú District in 2007.

Table 7.2 Total number of cattle in Paraguay and in the Ñeembucú Department; and percentage of Ñeembucú bovine production representing to Paraguay.

Source: Paraguay Agricultural Census 2001, Ministry of Agriculture and Livestock

	Amount of Cattle
Paraguay	9,889,255
Ñeembucú	429,658 (4%)

Table 7.3 Numbers of cattle and owners in the San Juan del Ñeembucú District.

Source: National Service of Animal Health, South Oriental Sanitary Region N^o 5, Zonal Unit: San Juan Ñeembucú

Head of Cattle	Owners	Animals
1 - 99 head	1,207	24,376
100 - 500 head	57	11,827
500 +	27	46,494
TOTAL	1,291	82,697

Production Sold

Only local residents were asked since all the ranchers make a living selling beef cattle. Most of the local residents (97%) sell very little amount of what they produce on their properties (Table 7.4) and it is used for petty cash and to cover household expenses.

Problems

Local residents as well as ranchers mentioned problems that they have experienced while farming. There are two problems that were mentioned by both groups which were poor roads and animal theft. This illustrate a weak government presence in the area unable to provide these services. Tables 7.5 and 7.6 show the incidence of problems reported by both groups.

Table 7.4 Local residents products and percentage of people selling it in the study area.

Product	% selling
Animals	83
Cheese	79
Cotton	34
Corn	16
Vegetables	6
Milk	4
Others	4

Table 7.5 Local residents problems and their incidence in the study area.

Problem	Occurrence (%)
No Credit	29
Animal theft	27
Diseases	26
Weeds	23
Roads	21

Table 7.6 Rancher problems and their incidence in the study area

Problem	Occurrence (%)
Roads	32
Employee's efficiency	29
Animal theft	26
No credit	5

Ranchers: Types of Production and Trends.

All ranchers categorized their production as calf producers. When asked about their production trends, almost half (5 out of 12) mentioned they were producing the same amount, and 7 out of 12 affirmed they were improving their production

performance. None of them mentioned any problem in regard to overgrazing of their pastures. Only half of the ranchers have introduced cultivated grasses on their property.

Ranchers: Herd Pregnancy Rate

Ranchers indicated that the mean pregnancy rate (percentage of pregnant females) of their herds in this District was 72%. More than half of the participants also mentioned that they were satisfied with this result considering the topography of the area.

Ranchers: Bovine Breed Type and Herd Size per Rancher

Nine out of twelve of the participants indicated that Indian hybrid cattle were their preferred breed. Indian hybrids (Figure 7.3) are the product of having a *Bos indicus* phenotypic appearance as well as a high percentage of *Bos indicus* blood. Table 7.7 shows the main types of cattle breeds in Paraguay and the Ñeembucú Department.

Table 7.7 Owners with cattle breed types in Ñeembucú and in Paraguay.

Source: Paraguay Agricultural Census 2001, Ministry of Agriculture and Livestock

	Paraguay	Ñeembucú
Owners w/ Bovine Cattle	229,478	7,687
Indian Hybrid Breeds	163,086 (71%)	5,440 (71%)
Indian Breeds	25,582 (11%)	1,472 (19%)
<i>Bos taurus</i> Breeds	18,191 (8%)	122 (2%)
Other Breeds	22,619 (10%)	653 (9%)

Land Use

The Ministry of Agriculture and Livestock obtained the land use data for the District of San Juan del Ñeembucú from the Paraguay Agricultural Census 1991. It shows that the main use (64%) for the land was for permanent natural pastures (Figure 7.2).

Figure 7.2 Land use, District of San Juan del Ñeembucú in 1991.
Source: Paraguay Agricultural Census 1991
Ministry of Agriculture and Livestock

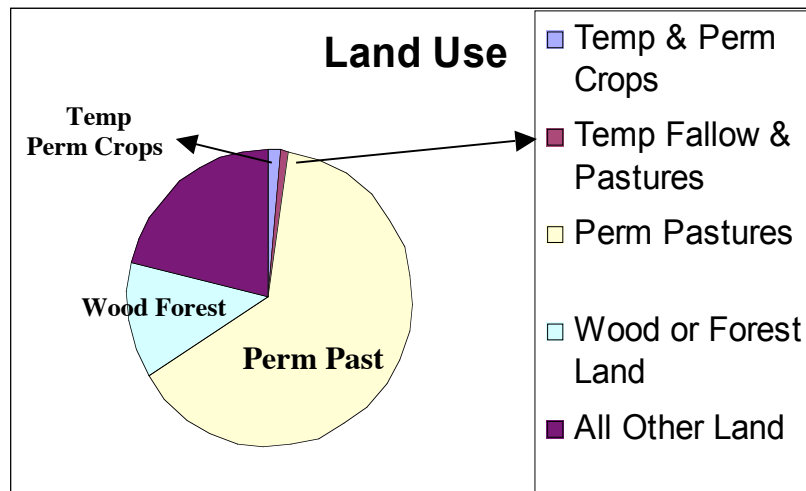


Figure 7.3 Indian hybrid cattle in the study area.



Environmental Professionals

Participants were from different backgrounds, including six NGO officers, three government officials, one University instructor and one working as an environmental consultant in the private sector. All of these professionals were from the environmental field.

Important quotes related to the changes associated with cattle and crop production in the Ñeembucú region were as follows:

- Agr. Eng. Angel Brusquetti (Fundación Moisés Bertoni NGO, Personal communication recorded Monday July 30th, 2007): “People here practice agriculture for their subsistence”. “Historically, ranching in the area is way behind the rest of the country”. “Few ranchers are introducing breeds which are adapted to this ecosystem”.
- Agr. Eng. Francisco Fracchia (Environmental and Sustainable Production Committee, Paraguayan Ranchers Association, Personal communication recorded Thursday August 2nd, 2007): “Ranchers see wetlands as a source of pastures during droughts”. “Some ranchers have mainly wetland areas in their properties that they have to drain. This situation is very complicated”. “Nowadays, the big ranchers hire trained professionals”.
- Jose Luis Cartes (Guyra Paraguay NGO, Personal communication recorded Monday August 14th, 2007): “Some ranchers are changing their

old style management, because their sons have a university background”.

- Agr. Eng. Rafael González (Universidad Nacional de Pilar, Personal communication recorded Thursday August 23rd, 2007):
“Some ranchers do not want to cut their trees because it will be used as shelter for their livestock”. “The people from this area see water as their enemy and they drain, but they are the first ones to complain when there is lack of water”.
- Dr. Sergio Burgos (Instituto Paraguayo de Protección del Ambiente NGO, Personal communication recorded Tuesday August 28th, 2007): “People are introducing bovine breeds not adapted to this area. They are trying to get the wetlands to adapt to the breeds and not the other way around”. “Flora and fauna are still generally in good condition due to the type of extensive ranching practiced in the area”.
- Lic. Narciso Vázquez (Environmental Official of the Ñeembucú Department, Personal communication recorded Tuesday September 18th, 2007): “Ranchers just want land for pasture and they do not give the proper value to the water by executing ecotourism projects”.
- Sr. Mario Osmar Fernández (Independent environmental consultant, Personal communication Thursday October 4th, 2007): “People planting trees built drainage channels. The wetland was deep but now the water is being drained by these channels causing a negative effect”.

7.4 Discussion

Both groups of participants (local residents and ranchers) have more than 20 years of experience working in this area. This shows a significant level of belonging, commitment and knowledge of the area and natural resources. These are very important assets to start an environmental community program.

There was a big difference between the two groups in regards to the size of their holdings and the number of animals they owned. Local residents had an average property of 40.9 hectares and 45 cattle each. On the other hand, ranchers had properties in the range of 1,000 to more than 10,000 hectares, and more than 1,000 head of cattle each. About 2% of the cattle owners own 56 % of the cattle. This is a concentration of cattle ownership into a small sector. A similar tendency was observed in the 1991 Paraguay Agricultural Census executed by the Ministry of Agriculture and Livestock.

More than 60% of the land use in this District was for permanent natural pastures, indicating that this District is mainly used for cattle production.

Ranchers were the main builders of channels and roads (7 out of 12) versus local residents (11%). Ranchers have a higher economic status and can afford to undertake these activities. Ranchers mentioned that these actions were beneficial to their business because they meant better transportation (roads) to access their ranches and more area (drainage) for pastures. This same trend was mentioned by Burgos et al. (2006) and Fogel (2000).

The group that farmed the most were local residents since they practiced subsistence agriculture (they sell a very small amount). Ranchers farmed by planting cultivated grass, sugar cane and sorghum to feed their cattle (Fogel 2000). Similar findings by Burgos et al. (2006) mentioned that local residents practice small scale and traditional agriculture. This usually means that animals are used to pull agricultural implements.

Local residents use rudimentary farming techniques and undertake very few changes in their activities. Eighty-one percent of the local residents relied on traditional knowledge to do their farming. Fogel (2000) also found that local residents use knowledge gained from their ancestors to manage their farms. I found that ranchers, because of their economic status, have the ability to hire professionals to help them manage their operations using the latest technology (42%). Burgos et al. (2006) also found that ranchers were introducing new technologies for their beef cattle production, for example through genetic improvement of the herd.

Both groups experienced problems in their operations. Problems identified were lack of government presence in the area and a lack of technological support. Local residents (most have their cattle in communally managed land) but no ranchers, mentioned weeds in their pastures as one of their main concerns. Weed invasion of pastures is a consequence of overgrazing. Overgrazing happens when stocking rates are too high. These findings are similar to the research work performed by Glatzle (2008) in Paraguay where he mentioned that overgrazing rarely happens in private lands but it does happen in communal land.

Most (90%) of the cattle herds have Indian breed background and have a

low average pregnancy rate, only 72%. The main reason may be that this breed type is not appropriate for the local topography. Burgos et al. (2006) mentioned that many breeders are now aware that they have to genetically improve their herds in order to have cattle better adapted to the local area. Crossbreeding is a widely accepted tool of incorporating desirable traits from different breeds (Lunstra and Cundiff 2003).

The most common breed in this area is the *Bos indicus* type (Indian breed), which are very well adapted to tropic and subtropic areas. These cattle have low reproductive rates, later maturing, slower growth rate, lower beef quality and are not well adapted to wetland areas. A better choice would be to use crossbreeding (with *Bos taurus*), which would improve their genetic potential, as well as their reproductive efficiency (Abeygunawardena 2004, de Jong and Bijma 2002, Turner 1980).

Several of the environmental professionals interviewed agreed that ranch productivity is behind the rest of the country; ranchers drain wetlands to increase pastures, and ranchers are starting to use technology in order to increase production. Similar tendencies were mentioned by Fogel (2000) who stated that ranching productivity in the Department of Ñeembucú is low and genetic improvement of the herd is required. Fogel (2000) also mentioned that ranchers were starting to use technologies such as crossbreeding for herd improvement.

7.5 Conclusions

Since ranching and farming are the major activities in the study area, ranchers and farmers must execute sustainable agriculture practices. Producers

should improve production but minimize the impact to the ecosystem by using an approach that emphasizes ecological goals (Duerksen 2006, Marino 2008, Rook and Tallowin 2003). For example, Marino (2008) suggests that a productive pasture management should look at pastures with the eyes of a cow and also of a deer.

Some important sustainable agriculture initiatives that are friendly to the environment and will improve production are stocking rate, fire management, crossbreeding and technical support.

- Stocking rate: The number of animals that can be grazed on a given hectare of land is known as the stocking rate. The main cause for pasture degradation and erosion is overgrazing (more animals than the pasture can carry). Stocking rate adjustment will balance the grass supply with the amount of animals in the pasture. An adequate stocking rate is important for cattle production and for pasture productivity (Glatzle 2008). An adequate stocking rate is met when there is enough grass for the whole herd and the production rate (pregnancy rate, calving rate, kilogram of body weight per hectare) does not decline. There is a need for a recommended stocking rate for the different ecoregions in the Paraguayan territory since none currently exists. This could be done by the Paraguayan Government through the Ministry of Agriculture and Livestock.
- Fire management: Many scientists and environmentalists have said that fire harms the soil and should not be used for pasture management. Marino (2008) mentioned that fire could be a good management tool when used in

an effective manner. Fire improves grass productivity and at the same time maintains a bi-stratified pasture, which is ideal for wildlife. Bi-stratified means: pastures in different layers or height depending if it is a bush type or a smaller height grass (Marino 2008). In the tropics, if a pasture is not burned and grows very tall, it will contain a high lignin content resulting in a 'woody' pasture with low palatability. Cattle will not eat this type of grass in a pasture (Marino 2008). On the other hand, if pastures are burned, they improve in quality and are more palatable. Other researchers (Kadlec and Smith 1992) have mentioned that fire suppression has done severe damage to prairies in North America because it suppresses brush expansion. With this correct burning management, cattle will increase their body weight, which is very important for the ranching business.

Marino (2008) provides recommendation for managing a proper fire. Effective fire management requires that: the area be secured and counter-fires be used to prevent the fire from spreading, fire must be properly managed, the wind speed should be below 30 km/h; a relative humidity of +30% and a temperature below 30⁰ C.

- Crossbreeding: Burgos (2007) mentioned, in a recorded interview, "...they are trying for the wetlands to adapt to the breeds and not the other way around". In other words, according to the topography of the area, the producer should choose the breed that best performs on it.

- Technical support: The Paraguayan Government and NGOs should support local producers with updating their technology through extension programs that could be run by the Ministry of Agriculture and Livestock. A good example is the Rangeland Stewardship Project (2009), which helps producers to adopt sustainable management practices into their operations.

Chapter 8 Socioeconomic Initiatives for Ranchers and Farmers to Balance Production and Environmental Priorities

8.1 Introduction

The aim of ecosystem management is to promote sustainable development and minimize social conflicts with stakeholders (Da Silva and Girard 2004). Any production unit, agriculture or ranching, could be sustainable if natural resources are used in a rational way (Burgos et al. 2004, Corrales Roa 2002). The Bruntland Commission (1987) defined environmental sustainability as “The ability to meet humanity’s current needs without compromising the ability of future generations to meet their needs”.

Sustainable production consists of producing but at the same time maintaining nature’s potential in order for future generations to use them (Burgos et al. 2004). For this to happen, producers must use renewable natural resources and adequate technology to produce without degrading the natural capital (Corrales Roa 2002). Bucher et al. (1997) mentioned that to reach a sustainable development one must combine environment and economics in the decision-making process. Sick (2002) considered that adding the social factor is very important for an equitable and sustainable management of natural resources.

The ecosystem management approach is increasingly being used for sustainable conservation of different ecosystems because it is directly connected to the concepts of sustainable development and integrates ecological, social and economic components (Baydack 2008).

The participation of all stakeholders is important for successful ecosystem management (Ripa de Marconi et al. 2001). Working in partnerships brings

different skills, experience and expertise in order to find sustainable solutions for people and biodiversity (Thomas 2006). Stakeholders or participants in an ecosystem management initiative usually include individuals who are needing for solutions to be viable. Examples of participants are: private landowners; environmental organizations; government institutions; non governmental organizations; business; commodity users; recreationists; international commissions; and professionals (The Keystone National Policy Dialogue on Ecosystem Management 1996).

For example, the Participatory Rural Appraisal (PRA) approach is a practical way to facilitate community participation. It helps to gather information from local people (local and traditional knowledge), and organize their activities related to natural resources management (Chambers 1994, Njeremani et al. 2000).

Stolk et al. (2006) indicated that the future of wetlands relies on the possibility of finding mechanisms to capture and turn wetland values into cash flow. Stakeholders need to understand the economic benefits of conserving natural areas. Some of these mechanisms are ecotourism, environmental education to create awareness, creation of protected areas and incentive programs (Burgos et al. 2004).

Ecotourism is defined by Trent (2000) as: “the concept of actively using nature-based tourism to help preserve biodiversity and benefit local communities”. Ecotourism is playing an important role in preserving tropical wetlands and natural prairies in Latin America. Some examples are ranching tourism, agro tourism and bird watching (Junk 2002, Marino 2008).

Financial incentive programs are very important tools to encourage landowners to restore wetlands on their property. In North America, there are

several examples of different types of incentives such as the ALUS (Alternative Land Use Services) and the Manitoba Water Stewardship Program in Canada. ALUS is an incentive-based program, which provides farmers and ranchers the necessary tools and capacity to work on environmental practices on their properties (Alternative Land Use 2009).

The Manitoba Water Stewardship Program, which also provides technical support and advice to accomplish restoration of wetlands (Wetland Restoration Incentive Program 2008). CRP is a voluntary program for agricultural landowners, which provides: “annual rental payments and cost-share assistance to establish long-term, resource conserving covers on eligible farmland” (Conservation Reserve Program 2009).

In Paraguay, environmental incentives are barely developed (SEAM 2006). There are two environmental incentive initiatives that could be mentioned; the Tropical Forest Conservation Act (TFCA) and the Tradable Development Rights Mechanism (TDRM) initiative. The TFCA is a debt exchange for nature where funds are committed to conserve and protect high value tropical forests in the southern corridor of the Atlantic Forest of Alto Paraná. This program is executed in partnership with the United States Government (SEAM 2006). The TDRM is a mechanism where landowners who deforested their land have the opportunity to payback their “forest debt” through different options such as reforestation, natural regeneration, purchase forested land or enter legal agreement with other landowners who can supply the forest coverage required (Mereles and Delphin 2008).

Most developing countries require intensive assistance from the international community. However, it would be a tragic error to simply transfer temperate-region

wetland models and management methods to the tropics. Most of them are not suitable for tropical wetlands, because they are cost intensive and do not fit with the ecological and socio-economic requirements of the respective countries (Junk 2002).

The purpose of this chapter is to identify and establish further socio-economic initiatives with stakeholders in order to balance production and environmental priorities in the Ñeembucú District.

8.2 Material and Methods

For this Chapter, two data collection types were selected to gather information: interviews and a review of the available literature and reports. The information about the study area, the rationale behind the selection of the interviews, elaboration of the questionnaire, interview details, sampling method used and ethical considerations were described in Chapter four.

Public documents were collected from two Paraguayan Government Institutions. These publications were from:

- Secretaría Nacional de Turismo (SENATUR) (Secretariat of Tourism).
Plan Maestro del Desarrollo del Sector Turístico de Paraguay (Master Plan for the Development of the Paraguayan Touristic Sector).
- Secretaría del Ambiente (SEAM) (Secretariat of Environment), Sistema Nacional de Areas Protegidas del Paraguay (SINASIP) Nacional Protected Areas System.

Public documents were collected from two Non Governmental Organizations. These publications were from:

- World Wildlife Fund – Paraguay, tradable development rights mechanism.

- Guyra Paraguay NGO, Important Bird Areas (IBA); Alliances for the Grasslands.

Data Analysis and Validity

The questionnaire was divided into four different sections or themes that were described in Chapter four. A spreadsheet program was used in each section to group the results in order to create patterns and draw conclusions.

To validate the findings, four different strategies were used:

- Triangulation: used data from different sources such as field notes, transcribed interviews, documents and literature to create justification for themes.
- Peer Debriefing: opinion from my guide who was born and raised in this District.
- Expert Opinion: personal communication from Ag. Eng. Rafael González, an expert working in the area for the last 15 years in the local institution Universidad Nacional de Pilar.

8.3 Results

Local Residents and Ranchers

A total of 70 household heads of local residents and 12 ranchers participated in this survey. Only 56% of the local residents participated in community groups as decision-maker. Local residents organized groups for the following activities: technical assistant for soil management techniques (29%), loans (22%), school (12%), road (10%), and church committees (10%). Ranchers also had little participation (42%), and only in the rancher association.

Environmental Professionals

The participants were from different backgrounds with six from NGOs, three government officials, one University instructor and one working as environmental consultant in the private sector. All these professionals were from the environmental field. The most important quotes from these experts related to the socio-economic initiatives in this study area were as follows:

- Agr. Eng. Francisco Fracchia (Environmental and Sustainable Production Committee, Paraguayan Ranchers Association, Personal communication recorded Thursday August 2nd, 2007): “We need to consider alternatives, which will help production but not harm the environment”. There are no real incentives for the producers to protect the environment”. “Ranchers would like to work with the government in order to have laws that could be practical and beneficial for natural resources”.
- José Luis Cartes (Guyra Paraguay NGO, Personal communication recorded Monday August 14th, 2007): “We are now working closer with ranchers in order to obtain production models which will help biodiversity”
- Agr. Eng. Rafael González (Universidad Nacional de Pilar, Personal communication recorded Thursday August 23rd, 2007): “The zero deforestation law had a positive effect in the sense that deforestation was stopped but it also has a negative effect because there is no compensation for the producers”.

The Secretariat of Tourism (SENATUR) elaborated in 2008 a master plan for the Development of the Paraguayan Touristic Sector (Plan Maestro del Desarrollo del Sector Turístico de Paraguay 2008). The main objectives were to:

- Identify and evaluate existing and potential resources
- Make improvements in the tourism sector
- Increase the number of tourists

In this Master Plan, the Ñeembucú Department was mentioned as one of the most important areas for environmental and historical reasons (Table 8.1).

Table 8.1 Important tourism resources in the Ñeembucú Department.

Source: Secretaría Nacional de Turismo (SENATUR)

Resources	Important	Complementary
Paraguay, Paraná and Tebicuary Rivers	X	
Wetlands and Prairies	X	
Museums	X	
Historic Sites	X	
Textile Factory		X
Crafts		X
Fishing Tournaments		X

These resources are related to the touristic sectors such as historic, cultural, nature (specially bird watching), adventure, fishing and recreation. Two main international institutions were cited in this Department, which were elaborating projects in the area: Capilano College (Canada) through its sustainable tourism project in the Ñeembucú Department and the University of Manitoba (Canada) through my research study project.

The Secretariat of Environment (SEAM) mentioned the important role protected areas play in Paraguay for biodiversity and also as an important source of revenue from activities such as ecotourism (Acevedo et al. 1990). The Ñeembucú

wetlands were mentioned as number 10 in order of importance for Paraguayan priorities areas for conservation. Within SEAM, the SINASIP (National Protected Areas System) is the unit taking care of protected areas. SINASIP divided the wildlife and flora protected areas of Paraguay in 9 (nine) different categories (Areas silvestres protegidas del Paraguay 2007) (Table 8.2).

The total protected area for wildlife and flora in the Paraguayan territory is 6,066,207 hectares. This represents 15% of the country, which has a total of 40,675,200 hectares (Areas silvestres protegidas del Paraguay 2007).

The World Wildlife Fund – Paraguay and the Paraguayan Attorney General’s Office (Fiscalía) initiated in 2004 the Tradable Development Rights Mechanism initiative (TDRM) (Mereles and Delphin 2008). In Paraguay, forest laws state that landowners of more than 20 hectares should retain 25% of their land as forests as well as keep 100 m of forest along each side of rivers and streams. With the aid of Geographic Information Systems Technology, it was possible to check which owner complied with the law and who was in “forest debt”. For this reason, landowners have the opportunity to sign up to have their situation assessed by the Attorney General Office.

If the landowner does not have the approved 25% of forest reserve, they have four options to pay back:

- Reforestation of the area in debt
- Allow natural regeneration of the area in debt
- Purchase forested land equivalent to the debt
- Use the TDRM mechanism by entering a legal agreement with another landowner who can supply the forest coverage required.

Table 8.2 Wildlife and flora protected areas of Paraguay.
Source: Areas silvestres protegidas del Paraguay. 2007.

Category	Purpose	Ownership	Area (ha)
National parks	Education, culture and recreation	Government	2,079,181
Protected landscapes	Landscape conservation and recreation	Government and Private	44
Reserve for managed resources	Forestry, fauna wild flora, pastures, recreation, and biological corridors	Government	24,000
Wildlife refuge	Wilderness and ecosystem conservation	Government	30,000
Ecological reserve	Representative ecosystems	Government	3,385
Natural monuments	Area with specific natural or natural/cultural features	Government	130,340
Private natural reserves	Reserve areas	Private	236,246
Biological reserve/refuge Itaipú and Yacyretá	Reservoir protection	Itaipú and Yacyretá	45,546
Biosphere reserve	Conservation under the man and the biosphere programme of the United Nations Educational and Cultural Organization (UNESCO)	Government Private	3,517,465

The TDRM initiative mechanism can benefit biodiversity by protecting existing and regenerating forest. In the case of the Ñeembucú Department, this program could be implemented but protecting wetlands instead of forest.

Another public document collected from a local Non Governmental Organization was from Guyra Paraguay NGO and the article was related to the Important Bird Areas (IBA) initiative. This initiative is carried out by BirdLife International (<http://www.birdlife.org>) and implemented by its partners such as Guyra Paraguay since 1997 (Guyra Paraguay 2008). The IBA concept is defined as “places of high priority for birds and biodiversity conservation, forming a world-wide network of sites for the conservation of nature”. The IBAs are selected in Paraguay for the following reasons (Guyra Paraguay 2008):

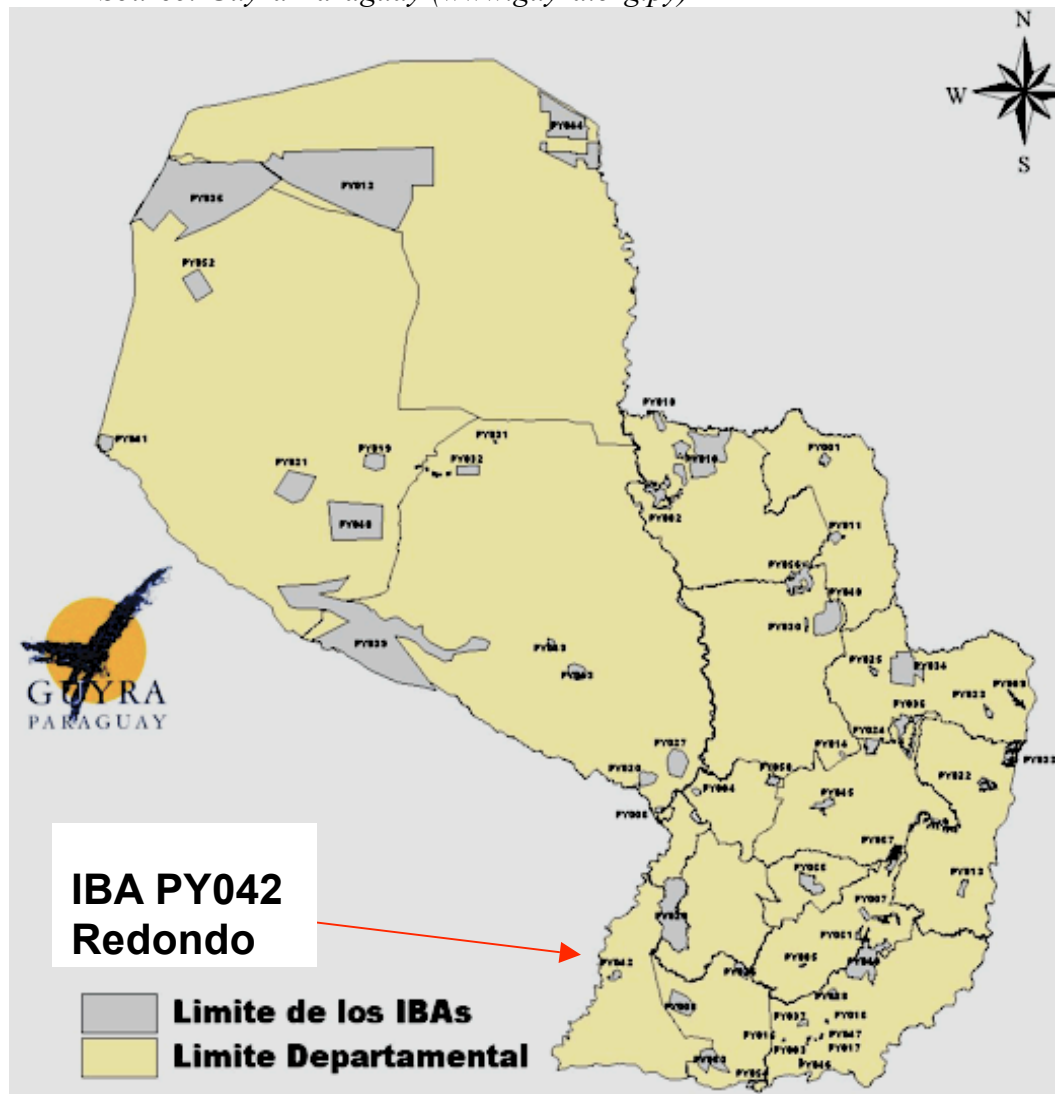
- Species of global conservation concern.
- Assemblages of restricted-range bird species.
- Assemblages of biome-restricted bird species.
- Globally important congregation of birds.

There are currently 57 IBAs to date in Paraguay (Figure 8.1) and one of them (PY042 Redondo) is located in the study area (District of San Juan del Ñeembucú). Tourism associated with IBAs creates a very important example for a sustainable use and revenue. Birdwatching is an excellent example (Guyra Paraguay 2008, Yanosky and Cartes 2008).

Another initiative implemented by Guyra Paraguay is called Alliances for the Grasslands (www.pastizalesdelconosur.org). This initiative is carried out by a group of organizations sharing the grasslands of the Southern Cone of the South American continent. These organizations are: Aves Argentinas (www.avesargentinas.org.ar), Aves Uruguay (www.avesuruguay.org.uy), SAVE

Figure 8.1 Map of the Paraguayan IBAs. September 2005. IBA PY042 Redondo situated in the San Juan del Ñeembucú District. IBA areas are colored in gray.

Source: Guyra Paraguay (www.guyra.org.py)



Brazil (www.savebrasil.org.br), and Guyra Paraguay (www.guyra.org.py) and they are associates of BirdLife International.

The main activities of this project are (Alliances for the Grasslands 2008):

- Information exchange.
- Support legal protection for important biodiversity sites.

- Promote incentives (conceding fiscal, commercial and public image incentives) for landowners.
- Support ecotourism.
- Land planning.
- Prairie restoration.
- Publish materials related to prairie management.
- Local alliances with landowners, conservationists and governmental agencies.

The Southern Cone Grasslands covers an area of approximately a million square kilometers and is shared by four countries (Figure 8.2): Argentina, Brazil, Paraguay, and Uruguay. This region has an outstanding biodiversity and many Nearctic migratory birds use it as a migratory route. The Ñeembucú Department is part of the southern cone grasslands and must take advantage of this situation by joining this project through their educational institutions such as the local University (Universidad Nacional de Pilar).

8.4 Discussion

It was very obvious in this study that ‘people behave as islands’. They do not have any connection or network in order to collaborate or help each other to produce more and better and thereby benefit each other and the environment. A little more than half (56%) of local residents participated in decision-maker groups. These were not groups to create a permanent network but were only for a specific purpose. Ranchers showed a lower participation rate (42%) even though they are better educated. The same results were mentioned in World Resources 2008: Roots of Resilience (2008) where the formation of community networks was considered

Figure 8.2 Grasslands areas of the Southern Cone of South America. Semi-arid Pampa (1), Humid Pampa (2), Uruguayan Savanna (3), Mesopotamic Savanna (4), and Southern Paraguay Grasslands (5).

Source: www.pastizalesdelconosur.org



fundamental for the rural poor to sustainably manage natural resources and generate income.

The environmental professionals interviewed also mentioned their concern in the rate of participation and the socio-economic initiatives carried out by both groups. Fracchia (personal communication, August 2007) mentioned that ranchers want to produce without harming the environment and expect a more supportive government with friendlier laws. González (personal communication, August 2007) also pointed out that the Government does not compensate producers for keeping their forest intact. On the other hand, Cartes (personal communication, August 2007)

expressed his satisfaction of starting collaborative work with producers with the final objective of creating friendlier production models, which would benefit biodiversity in the long run.

The central Government has started several initiatives and I consider two of these initiatives as the most important because of their significance and impact in the environmental field. One of them is the Master Plan for Tourism launched in 2008 by the Secretariat of Tourism (SENATUR). This plan creates expectations because it will have a positive impact on revenue for the Government and local residents of these areas because new alternatives may arise such as ecotourism. At the same time, the environment will have to be preserved in order for ecotourism to take place and this will be beneficial to the ecosystem. van Humbeck (2008) mentioned that ecotourism is practiced in areas where there are almost no disturbances so tourists may enjoy a pristine nature.

The other Governmental institution that started an important initiative was the Secretariat of Environment (SEAM). They started the National Protected Areas System (SINASIP) initiative, which divided the protected areas into nine different categories that cover the country. The total wildlife protected area in Paraguay represents an important percentage of its territory (15%). In the Ñeembucú Department these different types of protected areas are nonexistent and there is a need to create them in order to protect the local biodiversity.

Two Non Governmental Organizations have also started some important environmental initiatives. The World Wildlife Fund – Paraguay and the Paraguayan Attorney General's Office started the Tradable Development Rights Mechanism (TDRM), which will start the recovery of the depleted Paraguayan Atlantic Forest in

the east region of the Paraguayan territory. This initiative will help producers with “forest debt” to improve their situation and will benefit producers with “forest credit”. These types of benefits or incentives are new to Paraguayan producers.

The other NGO is Guyra Paraguay, which has two important initiatives. The first initiative is called IBA and the other one is the Alliances for the Grasslands. Both programs will benefit the environment (e.g. land planning, prairies restoration) and will also help landowners because it will represent new sources of income from different activities such as bird watching.

8.4 Conclusions

There is a lack of a network and joint work among local residents, ranchers, NGOs and the central Government in the Ñeembucú Department (Burgos et al. 2006). There is a need for a well-designed community-based enterprise in order to improve the way local residents and ranchers use natural resources (World Resources 2008). Three important components are needed for this to happen:

- Ownership: Own the land where they are living and this will translate into better management of local resources.
- Capacity: Government and NGOs provide landowners with technical and business skills to manage ecosystems competently.
- Networks: Create networks among landowners, Government and NGOs in order to manage natural resources and generate income.

If all three elements are present, communities will have increased resilience: economic, social and environmental (World Resources 2008). The main differences between developed and developing countries are that

developed countries have a very skilled labor force, good established commercial and social network, and a high level of economic activity (World Resources 2008).

Involving stakeholders to create a network system is very important since they will feel part of the management process and its outcomes (Chatterjee et al. 2008). Another network characteristic is that each one of the members will bring different skills, experience and expertise in order to find sustainable solutions for people and biodiversity (Thomas 2006).

Landowners need to understand how their involvement will deliver benefits to them. A good management plan has to consider not only benefiting the environment but also the local community (Chatterjee et al. 2008). One example in Paraguay is the payment for environmental services implemented in the TDRM approach (Mereles and Delphin 2008). Another incentive in North America is Carbon Trading where landowners are paid for the carbon dioxide their grasslands are absorbing (Ahearn 2008). There are none of these type of incentives in the Ñeembucú Department and it will be important to have them because it will help to create awareness among landowners toward protecting the environment.

Nature tourism has been growing in Paraguay for the last five years (van Humbeck 2008). Silgueira (2009) in a newspaper interview with French tourists stated that Paraguay is a perfect place for ecotourism but there is a lack of information and infrastructure for it to grow in the future. There was also another article in ABC Color newspaper (ABC Color 2009) mentioning sport hunting (doves) which attracted 300 tourists from around the world and left US\$ 4 million dollars in the country. There are some weaknesses for ecotourism to develop such

as limited accessibility because of poor road conditions. The Ñeembucú Department has great potential for nature tourism and historic tourism because of its great biodiversity and rich history. But at the same time, Ñeembucú lacks good infrastructure to welcome tourists.

Other weaknesses to be mentioned and which need improvement are: accessibility to protected areas (better roads), lack of good environmental management, capacity building, coordination of public policies and logistics (hire more trained personnel) for the protected areas and Government institutions. There is a desperate need to develop pilot projects that link production and conservation with beneficial results (Guyra Paraguay 2008, Plan maestro del desarrollo del sector turístico de Paraguay 2008).

Chapter 9 Summary and Contribution to New Knowledge

9.1 General Conclusions

The main conclusion of this research is that an ecosystem management approach is desirable to enhance sustainable development in the Ñeembucú Department of Paraguay. This approach would allow the environment to be enhanced while not forgetting to pay attention to important social and economic components. The key to success will be the involvement of local people in decision-making, something that has not occurred in this country.

Throughout the execution of this research project many challenges that stakeholders, NGOs and the Government face were encountered.

One of these problems is weak government institutions in Paraguay, where institutions such as the Secretariat of the Environment (SEAM) are understaffed and underpaid with a budget that sometimes is less than some local NGOs. Professional training in governmental institutions is also an important factor because the lack of it prevents government officials from providing proper answers and solutions to environmental issues.

Erratic government policies are another challenging factor. Long-term political and financial continuity is difficult because projects are planned to last only one government term. For example, a new government official will not continue executing the policies implemented by a previous official because of partisan differences.

The social factor in Paraguay is perhaps the most important challenge to overcome. Complex social factors operating in the region including poverty

(extreme poverty is increasing to high levels, especially in the rural areas), violence, absence of institutions, insecurity, injustice and lack of public participation limit the application of planning processes. The cultural reason behind the lack of public participation in local decision-makers is what Freire (1970) describes as “the culture of silence”. This is a result of the oppression exerted in the Paraguayan people during thirty-four years of dictatorship, discouraging the formation of public participation groups.

Campesinos live in a very precarious situation with many young people migrating out of the study area due to a lack of opportunities. Not only do people leave this area, but they also take with them the local and traditional knowledge from past generations. Consequently, due to poverty in Paraguay there is an urgent need to implement a specific strategy, to reduce poverty levels, that must also consider aspects of conservation and a rational use of natural resources.

For this purpose, local knowledge and its incorporation into management plans is very important because it provides a base upon which new measures can be adapted for the changing needs of conservation (Seixas 2002).

For this reason, stakeholders could be involved in natural resource management decisions and actions through Ecosystem Management and Participatory Rural Appraisal initiatives. The Ecosystem Management approach follows a three-context model considering the ecological, socioeconomic, and institutional perspectives in the search for solutions and considers the local people and their culture as dynamic agents and transformers of natural ecosystems

(Andrade Perez 2008, Meffe et al. 2002, Shepherd 2004). By using the Participatory Rural Appraisal approach, it will enable local people to express, enhance, share, and analyze their knowledge of life and conditions, in order to plan and to act (Chambers 1994).

Parkes et al. (2008) mentioned that watershed management could act as a buffer against poverty because of its potential to enhance sustainable livelihoods of people living in these watersheds. If local people become involved in participatory watershed management, it would empower local communities through the creation of watershed councils that represent stakeholder's interests (Parkes et al. 2008).

9.2 Beneficiaries of the Research

The stakeholders in the San Juan del Ñeembucú District are the following groups of people:

- Local Residents or Campesinos
- Ranchers
- Government Agencies: Municipalities, Department's Government, Ministry of Agriculture, Secretariat of Environment (SEAM), Secretariat of Tourism (SENATUR).
- Industries: Textile Industry (Manufactura Pilar)
- Non Governmental Organizations
- National University of Pilar

9.3 Potential Use of Results

Since there is a very limited database on the socio-economic, ecological and natural resources characteristics of this ecoregion, this research project will serve as the starting point for future research projects.

The results of this research study will help other researchers identify the different disturbances affecting the environment in the Ñeembucú ecoregion. The most important strategies and methodologies that could be implemented in order to address these different environmental issues are:

- Develop an Adaptive Management Plan

Adaptive Management is a significant departure from past approaches to manage natural resources. Local and traditional knowledge will play an important role.

- Environmental Education

Environmental education is a basic tool to know, appreciate and love our environment and our lives. Environmental education using local and traditional knowledge could be a way to involve stakeholders to maintain sustainable uses of natural resources but now, in a more conscious way based on ecological and conservationists ideas (Calheiros et al. 2000). For this purpose, the Ñeembucú wetlands should have an environmental education program tailored to the area.

- Public Participation

A basic step in order to have a healthy environment is that the local public must participate in decision-making on how the natural resources will be used. These resources could be: economical, financial, natural, human and cultural. For this reason, the Participatory Rural Appraisal approach could be implemented. An important barrier for public participation by local decision-makers is “the culture of silence” and this must be overcome. My experience in this research study indicates that this is possible because people have expressed a desire to start working together.

- Departmental and Municipal Policies

The municipalities must participate more closely in environment protection and at the same time issue environment protection policies, with special emphasis on wetlands. Environmental education programs could play an important role in creating awareness, especially with decision maker groups. Educational programs and Departmental and Municipal policy implementation could be executed in partnership with the local University (Universidad Nacional de Pilar); Ministry of Education; the Secretariat of the Environment; Local Municipalities and the Governor’s office.

- Wildlife Protected Areas

The Ñeembucú Department needs a conservation area such as a national park or wildlife-protected area since there is currently not one present in this Department. This could be achieved through a close partnership with the

local University (Universidad Nacional de Pilar), the Secretariat of the Environment, Local Municipalities and the Governor's office.

- Research and Partnership

Create partnerships with environmental related organizations in Paraguay (both in the public and private sectors) and also at the international level.

The partnership would work together to raise funds (financial resources) for research. The research would create national and international awareness for this important ecoregion. At the present, there is no important environmental research project being done in this region. One of the main obstacles for my research work was the lack of data available for this area.

- Tourism

This ecoregion has a rich cultural history and biodiversity. It will be very beneficial to the local community to put in place a plan to use these features for ecological, rural and historic tourism. Tourism will provide alternatives sources of income for local residents (e.g. tourist guides, selling handcrafts), which at the same time will improve their overall wellbeing. This can be done in partnership with the local University (Universidad Nacional de Pilar), Ministry of Tourism through its Master Plan (Plan Maestro del Desarrollo del Sector Turístico de Paraguay 2008), Secretariat of the Environment, Local Municipalities, and the Governor's office.

- Water Management

A regional water management plan for the Ñeembucú wetlands is needed.

This can be executed in partnership with the Local Municipalities; local

University (Universidad Nacional de Pilar), Secretariat of the Environment, and the Ministry of Agriculture.

- Soil Erosion

Implementation of proper agriculture practices, soil management, and selection of crops and livestock. This can be executed in partnership with the local Municipalities, local University (Universidad Nacional de Pilar), Secretariat of the Environment, Ministry of Education; and the Ministry of Agriculture.

- Deforestation

Establish reforestation programs. This can be executed in partnership with the Local Municipalities, local University (Universidad Nacional de Pilar), Secretariat of the Environment; Ministry of Education, and the Ministry of Agriculture.

- Wildlife Population Census

Data are needed on wildlife populations from different years in order to compare and determine the status in the Ñeembucú Department as mentioned by different Paraguayan researchers (Morales et al. 2006, Zarza and Morales 2006, Yanosky and Cartes 2008a). This can be executed in partnership with the local University (Universidad Nacional de Pilar), Secretariat of the Environment, the Ministry of Agriculture; and local invited NGOs (Non Governmental Organizations).

- Trans-boundary Projects

For migratory Nearctic birds, as stated by Donaldson et al. (2006): “we cannot sustain populations in Canada if effective conservation is not occurring in other parts of their range”, it is important to establish and fund research projects in the Neotropics. This can be executed in partnership with the local University (Universidad Nacional de Pilar), Secretariat of the Environment, the Ministry of Agriculture, and local and international NGOs.

- Livestock improvement

Burgos (2007) mentioned, in the recorded interview, “...they are trying for the wetlands to adapt to the cattle breeds and not the other way around”. In other words, according to the topography of the area, producers should choose cattle breeds that best perform in the area and crossbreeding is the widely accepted tool of incorporating desirable traits from various breeds (Lunstra and Cundiff 2003).

- Technical support

The Paraguayan Government and NGOs should support local producers through extension programs that could be run by the Ministry of Agriculture and Livestock. A good example is the Rangeland Stewardship Project (2009), which helps producers to adopt

sustainable management practices into their operations.

For the Ecosystem Management approach to be successfully implemented in the Ñeembucú study area, some obstacles will need to be overcome. Firstly, a general lack of public participation is prevalent in this area, as local residents do not have past experience and precedent to draw upon in terms of providing input to program planning initiatives. This issue can likely best be addressed through public education programs that emphasize the importance of individuals expressing their viewpoints without repercussion. As well, government planning programs need to encourage, and perhaps even require, public input through the development of a formal ‘Public Involvement Program’ in all future planning efforts.

Secondly, continuity in long-term government policies is also not typical of the Paraguayan political process. Although many countries of the world face this same dilemma, Paraguayan culture is perhaps more directed toward change when governing power shifts from one political party to another. This is likely due to a strong ‘competitive’ nature of Paraguayan politicians, in part related to their need to distance themselves from past dictatorial regimes, where governing entities want to establish themselves as being very different from their predecessors. Although difficult to affect, political parties should be encouraged by media commentators to be more cognizant of the benefits of maintaining government strategies, especially as related to principles of sustainability.

Thirdly and perhaps most importantly, the need for stakeholders to work in partnership with a common goal must be increasingly emphasized. Once again,

public education is a key element in ensuring that this type of direction is achieved. However, central government programs could be used to provide incentives for the establishment and implementation of local planning committees. Experience in the development of this area could be provided from the Canadian Model Forest Program (<http://www.modelforest.net/cmfn/en/>), where input to local community planning has been encouraged through extensive local resident and organizational participation on planning and development boards.

There are examples of stakeholder forums that could work to bring effective Ecosystem Management to Ñeembucú. A recent example of an ecosystem initiative in Paraguay is Fundación Moisés Bertoni's connectivity strategy at Mbaracayú forest biosphere reserve created and recognized by UNESCO in the year 2000 (Salas-Dueñas and Garcia 2008). In this project, the social, environmental and economic aspects were included. The social component is represented by environmental awareness education workshops and the creation and consolidation of a management committee in the local communities. The environmental component is represented by reforestation activities and building of green corridors. In terms of the economic aspect, communities are benefitting by the creation of employment, for example, through reforestation. Therefore, this ecosystem project that was successfully applied has brought excellent environmental, social and economic results and could be used as a model for ecosystem management in Paraguay.

There are two NGOs in Paraguay that have created forums where people can get together and discuss issues related to environment and individual sustainability. These include Fundación Moisés Bertoni, and Guyra Paraguay. Both NGOs work organizing capacity building workshops with local groups such as stakeholders, local communities, and government officials. They have also created environmental programs and discussion panels at local radio stations that are aired with the participation of individuals from the targeted area. Guyra Paraguay and Moisés Bertoni have also created centres for environmental information where interested parties (campesinos, aboriginals, groups of students, researchers, teachers) can come together to share and document traditional knowledge, as well as gather documented information that could otherwise be lost.

The central government is also responsible for administering a forum, Consejo Nacional del Ambiente (National Council for Environment), that encompasses the central, local and municipal government departments as well as local environmentalist NGOs and stakeholder organized associations. The Office of the Secretariat of the Environment is in charge of this Council. The aim of this official forum is to define, oversee and evaluate national environmental policies. All these above mentioned forums have been created during the last decade.

The existence of these forums is encouraging since there is already an organized body with trust and true partnership where stakeholders, government and private institutions can discuss their issues without prejudice. They can be used to channel communications when trying to implement an ecosystem

management approach that tries to combine social and environmental consciousness with collaboration in sustainable development to improve people's well being.

My research study recommends that similar efforts be implemented in the Ñeembucú region that will serve as a legacy for the management of this wetland area. There is a need for the creation of a local forum in the Ñeembucú, which will address technical, political, institutional and social standards with active participation of the local people. This forum will be important for capacity building and will facilitate learning among all the stakeholders and sectors involved. This forum will coordinate activities among communities in close relation with the scientific and academic sectors.

Actors from different sectors will be involved to better integrate this forum. From the local sector, I identified Universidad Nacional de Pilar, local Municipalities, the Governor of the Department of Ñeembucú, the local textile company (Manufacturas Pilar) and local community representatives as important contributors. These actors will bring their experience to the forum and the local population will feel represented by their own people. The management of this forum should have a democratic organization with the participation of the local community, which is a very important factor for a social, ecological and economic sustainability.

From the national sector: the National Council for the Environment (CONAM) and two NGOs (Fundación Moisés Bertoni and Guyra Paraguay) should be included. The CONAM will provide the experience and structure for

administering an environmental forum. The two NGOs will bring to this forum all their experiences in working with people and the environment towards ensuring sustainability and community wellbeing.

International partners will also need to be involved, such as educational institutions (universities), NGOs, and financial agencies. These institutions will act as mediators for the different actors of this forum that currently do not particularly communicate with each other or trust one another. At the same time, these international agents will be able to provide expertise and experience in these types of endeavors. Source of funding from recognized international financial institutions will provide long-term sustainability, which is crucial for the monitoring and adaptive management approach necessary in the 5th step of the ecosystem management approach.

This forum for dialogue will help overcome the main obstacles for the ecosystem management approach encountered in this study, which were located in step four (establish society's goals and objectives) and in step five (implementation and evaluation). In these two steps, working in partnership, long-term planning and implementation (continuity) are key elements to successful use of the ecosystem management approach. This specific proposal will be very important to avoid the current pattern, which is so prevalent throughout Paraguay, that projects are planned to last one government term. This proposed discussion forum in the Ñeembucú would enable conservation and sustainable use initiatives in this wetland area to be carried out for the long-term, and would contribute to improved governance through integration processes.

References

- ABC Color. 2009 Jan 7. Caza de palomas se inicia en febrero, anuncia Seam.
[Internet]. [cited 2009 Jan 7]. Available from:
<http://www.abc.com.py/2009-01-07/articulos/484881/caza-de-palomas-se-inicia-en-febrero-anuncia-seam>.
- Abeygunawardena H, Dematawewa CMB. 2004. Pre-pubertal and Postpartum Anestrus in Tropical Zebu Cattle. *Animal Reproduction Science* 82-83: 373-387.
- Acevedo C, Fox J, Gauto R, Granizo T, Keel S, Pinazzo J, Spinzi L, Sosa W, Vera V. 1990. Áreas prioritarias para la conservación en la región Oriental del Paraguay. Asunción (Paraguay): Ministerio de Agricultura y Ganadería, Centro de Datos para la Conservación.
- Agua un bien común. El río y sus ecosistemas. [Internet]. 2002. Rosario (Argentina): SENASA, Dirección de vías navegables de la nación; [cited 2008 Dec 1]. Available from:
<http://www.taller.org.ar/Megaproyectos/Hidrovia/Privatizacion-del-rio.pdf>
- Ahearn A. 2008. Carbon Cowboys. *Scientific American Earth* 3.0. 18 (5): 52 – 57.
- Alliances for the Grasslands. 2008. [Internet] birdlife International; [cited 2009 Mar 27]. Available from:
<http://www.pastizales.delconosur.org/eng/quienes.html>
- Alternative Land Use Services. [Internet]. Winnipeg (MB): Delta Waterfowl; [cited 2009 Mar 27]. Available from: <http://www.deltawaterfowl.org/alus/index.php>
- Andrade Perez A. 2008. Applying the Ecosystem Approach in Latin America. Gland

- (Switzerland): International Union for Conservation of Nature and Natural Resources (IUCN). Ecosystem Management Series No. 7. p 102.
- Antas PTZ. 1983. Migration of Nearctic Shorebirds (*Charadriidae and Scolopacidae*) in Brazil-flyways and their Different Seasonal Use. Wader Study Group Bull. 39:52-56.
- Apan A A, Raine S R, Paterson M S. 2002. Mapping and Analysis of Changes in the Riparian Landscape Structure of the Lockyer Valley Catchment, Queensland, Australia. *Landscape and Urban Planning*. 59 (1): 43-57.
- Arce JP, Rivarola N, Pedrozo C, Pin A, Rodriguez A. 2005. Un marco de implementación de políticas ambientales para prácticas sustentables de conservación en la región del acuífero Guaraní en Paraguay. Asunción (Paraguay): Nature Serve, Secretaría del Ambiente.
- Areas silvestres protegidas del Paraguay. 2007 [Internet]. Asunción (Paraguay): Secretaría del Ambiente; [cited 2009 Mar 27]. Available from; <http://www.seam.gov.py/areas.php>
- Azevedo-Ramos C, Domingues Amaral B, Nepstad DC, Soares Filho B, Nasi R. 2006. Integrating Ecosystem Management, Protected Areas, and Mammal Conservation in the Brazilian Amazon. *Ecology and Society* 11 (2): 17.
- Baldi G, Guerschman J P, Paruelo J M. 2006. Characterizing Fragmentation in Temperate South American Grasslands. *Agriculture, Ecosystems and Environment*. 116 (3-4): 197-208.
- Baldi G, Paruelo J M. 2008. Land-Use and Land Cover Dynamics in South American Temperate Grasslands. *Ecology and Society*. 13 (2): 6.

- Baydack RK, Campa III H. 1999. Setting the Context. In: Baydack RK, Campa III H, Haufler JB, editors. Practical Approaches to the Conservation of Biological Diversity. Washington (DC): Island Press. p 3-16.
- Baydack RK. 2008. An Ecosystem Management Approach for Sustainable Wetland Conservation. Proceedings from the 3er curso nacional de ecología de humedales; 2008 Sept 4; Pilar (Paraguay): Universidad Nacional de Pilar.
- Becker CD, Ghimire K. 2003. Synergy between Traditional Ecological Knowledge and Conservation Science Supports Forest Preservation in Ecuador. Conservation Ecology [Internet]. [cited 2008 Feb 12] 8 (1): 1 Available from: <http://www.consecol.org/vol8/iss1/art21>
- Belsky AJ, Matzke A, Uselman S. 1999. Survey of Livestock Influences on Stream and Riparian Ecosystems in the Western United States. Journal of Soil and Water Conservation 54 (1): 419-431.
- Berkes F, Colding J, Folke C. 2000. Rediscovery of Traditional Ecological Knowledge as Adaptive Management. Ecological Applications 10 (5): 1251-1262.
- Bertoni A W. 1899. Catalogo descriptivo de las aves útiles del Paraguay. Revista de Agronomía No. 1, p 377-410.
- Bhandari B B. 2003. Participatory Rural Appraisal. Institute for Global Environmental Strategies (IGES) [Internet]. [cited 2008 Feb 18] Module 4. Available from: http://www.iges.or.jp/en/pub/elearning/waterdemo/bhandari_m4.pdf

- Blanco DE. 1999. Los humedales como hábitat de aves acuáticas. In: Malvarez AI, editor. Tópicos sobre humedales subtropicales y templados de Sudamérica. Montevideo (Uruguay): UNESCO. p 219-228.
- Boyle T P, Caziani S M, Waltermire R G. 2004. Landsat TM Inventory and Assessment of Waterbird Habitat in the Southern Altiplano of South America. *Wetlands Ecology and Management*. 12: 563-573.
- Bradford DF, Franson SE, Neale AC, Heggem DT, Miller GR, Canterbury GE. 1998. Bird Species Assemblages as Indicators of Biological Integrity in Great Basin Rangeland. *Environmental Monitoring and Assessment* 49 (1): 1-22.
- Bramwell SA, Prasad D. 1995. Performance of a Small Aquatic Plant Wastewater Treatment System under Caribbean Conditions. *Journal of Environmental Management* 44 (3): 213-220.
- Brinson MM, Malvarez AI. 2002. Temperature Freshwater Wetlands: Types, Status, and Threats. *Environmental Conservation* 29 (2): 115-133.
- Brook R, M'Lot M, McLachlan S. 2006. Pitfalls to Avoid when Linking Traditional and Scientific Knowledge. In: Riewe R, Oakes J, editors. *Climate Change: Linking Traditional and Scientific Knowledge*. Winnipeg (MB): Aboriginal Issues Press. p 13-20.
- Bruntland G. 1987. *Our Common Future: The World Commission on Environment and Development*. Oxford (UK): Oxford University Press.
- Bucher E, Castro G and Floris V. 1997. *Conservación de ecosistemas de agua dulce: Hacia una estrategia de manejo integrada de recursos*

hídricos. Washinton (DC): Banco Interamericano de Desarrollo.

No. ENV-114.

Bullock A, Acreman M. 2003. The Role of Wetlands in the Hydrological Cycle.

Hydrology and Earth System Sciences 7 (3): 358-389.

Burgos S, Gonzalez R and Rodas O. 2004. Guía para la conservación de los humedales del Ñeembucú. San Lorenzo (Paraguay): Instituto Paraguayo de Protección Ambiental (IPPA).

Burgos SM, Galeano C, Garcete B, Gomez E, Gomez D, Mandelburger D, Mereles F, Pedrozo C, Rodas O, Voght C. 2006. Diagnóstico ambiental participativo de la cuenca del arroyo Ñeembucú, Paraguay. San Lorenzo (Paraguay): Instituto Paraguayo de Protección Ambiental. p 90.

Burgos SM. 2006. Geotecnología en el Pantanal del Paraguay: Estado del arte; Proyectos en desarrollo y perspectivas futuras. Proceedings from the 1er Simpósio de Geotecnologias no Pantanal; 2006 Nov 11-15; Campo Grande (Brazil): Embrapa Informática Agropecuaria/INPE. p 732-738.

Caballero W and Gaona G. 2005. Maquinarias del MAG benefician a hermano de Maciel Pasotti. ABC newspaper, Local section [Internet]. [cited 2005 Jun 11]. Available from: [http:// archivo.abc.com.py/2005-06-11/articulos/184365/maquinarias-del-mag-benefician-a-hermana-de-maciel-pasotti](http://archivo.abc.com.py/2005-06-11/articulos/184365/maquinarias-del-mag-benefician-a-hermana-de-maciel-pasotti)

Caceres MS, Machain M. 2001. Manual de uso de hierbas medicinales del Paraguay [Internet]. [cited 2008 Dec 10] Fundación Celestina Pérez de

Almada, UNESCO, Oficina Regional de Ciencia y Tecnología para América Latina y el Caribe. Available from:

<http://www.unesco.org.uy/educacion/hierbasmedicinales.pdf.pdf>

Cairns J, McCormick PV, Niederlehner BR. 1993. A Proposed Framework for Developing Indicators of Ecosystem Health. *Hydrobiologia* 263 (1): 1-44.

Calera A, Medrano J, Vela A, Castano S. 1999. GIS Tools Applied to the Sustainable Management of Water Resources. *Agricultural Water Management* 40 (1999): 207-220.

Calheiros D F, Seidl AF, Ferreira CJA. 2000. Participatory Research Methods in Environmental Science: Local and Scientific Knowledge of a Limnological Phenomenon in the Pantanal Wetland of Brazil. *Journal of Applied Ecology* 37 (4): 684-696.

Canziani G, Ruiz D, Vargas MD, Dukatz F, Ferrati R. 2003. Remote sensing in the conservation of wetlands in MERCOSUR [Internet]. [cited 2008 Feb 15] REGWET Project. Available from:

<http://users.exa.unicen.edu.ar/~wetland/REGWET/Publications/RegWet.pdf>

Cartes JL. 2004. Importancia de la conservación de los humedales para los mamíferos. In: Salas-Dueñas D, Mereles F, Yanosky A, editors. *Humedales de Paraguay*. 1st ed. Asunción (Paraguay): Comité Nacional de Humedales. p 141-165.

Cartes JL. 2006. Mamíferos del Río Paraguay. In: *Guyra Paraguay and*

- Transbarga Navegación editors. Biodiversidad del Río Paraguay.
Asunción (Paraguay): Guyra Paraguay, Transbarga Navegación. p. 77-92.
- Cartes JL. 2008. El concepto de los IBAs en relación a la conservación de áreas: Una visión general. In: Guyra Paraguay, editor. Áreas importantes para la conservación de las aves del Paraguay. 1st ed. Asunción (Paraguay): Guyra Paraguay/BirdLife International. p 45-62.
- Cartes JL, Centron S, de Egea J, Castillo H, Balbuena C, Lesterhuis A, Lopez L, Esquivel A, Clay RP. 2008. Áreas de importancia para la conservación de las aves en Paraguay. In: Guyra Paraguay, editor. Áreas importantes para la conservación de las aves del Paraguay. 1st ed. Asunción (Paraguay): Guyra Paraguay/BirdLife International. p 79-84.
- Cassara A. 2007. The Importance of Tenure in Sustainable Development. World Resources Institute, Earth Trends [Internet]. [cited 2009 Jan 27]. Available from: <http://earthtrends.wri.org/updates/node/212>
- Castillo H, Clay RP, De Egea J, Rodas O, Cabral H, Morales V. 2005. Atlas de las aves de Paraguay. Asunción (Paraguay): Guyra Paraguay. p 212.
- Cataldo J. 1968. La flora medicinal Paraguaya. Asunción (Paraguay). p 460.
- Catterson TM, Fragano FV. 2004. Tropical Forestry and Biodiversity Conservation in Paraguay. Asunción (Paraguay): United States Agency International Development. Final Report of a Section 118/119 Assessment EPIQ II Task Order No. 1.
- Censo Agropecuario Nacional. 1991. San Lorenzo (Paraguay): Ministerio de Agricultura y Ganadería. Dirección de Censos y Estadísticas Agropecuarias.

- Censo Nacional de Población y Viviendas Año 2002. 2002. Fernando de la Mora (Paraguay): Dirección General de Estadísticas Encuestas y Censos (dgeec).
- Chambers R. 1994. Participatory Rural Appraisal (PRA): Analysis of Experience. *World Development* 22 (9): 1253-1268.
- Chatterjee A, Philips B, Stroud DA. 2008. *Wetland Management Planning. A Guide for Site Managers*. Gland (Switzerland): WWF, Wetlands International, IUCN, and Ramsar Convention. p 76.
- Clay RP, Lesterhuis AJ, López L. 2004. Aves de los humedales de Paraguay. In: Salas-Dueñas D, Mereles F, Yanosky A, editors. *Humedales de Paraguay*. 1st ed. Asunción (Paraguay): Comité Nacional de humedales. p 175-190.
- Clay R, Lesterhuis A, Castillo H. 2007. *Guía de los patos del Paraguay*. Asunción (Paraguay): Asociación Guyra Paraguay.
- Clay RP, De Egea J, Castillo H. 2008. Paraguay: Contextos geográficos, ecoregionales y socioeconómicos. In: Guyra Paraguay, Birdlife International editors. *Aves de importancia para la conservación de las aves en Paraguay*. 1st ed. Asunción (Paraguay): Guyra Paraguay, Birdlife International. p 33-44.
- Conservation Reserve Program. [Internet]. 2009. Washington (DC): United States Department of Agriculture, Farm Service Agency; [cited 2009 Oct 26]. Available from:
<http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>
- Conserving Biodiversity, Improving Livelihoods. [Internet]. 2007. Cambridge (UK): BirdLife International; [cited 2009 Jan 9]. Available from:

<http://www.birdlife.org/>

- Corrales Roa E. 2002. Sostenibilidad agropecuaria y sistemas de producción campesinos, cuadernos tierra y justicia N°.5. Bogotá (Colombia): Instituto de Estudios Rurales.
- Creswell J W. 2003. Research Design. Qualitative, Quantitative and Mixed Method Approaches. 2nd ed. Thousand Oaks (CA): Sage Publications.
- Cuevas N. 2003. Diagnósticos Rurales Participativos: Una aproximación a la realidad campesina para diseñar proyectos de desarrollo rural. Asunción (Paraguay): Fundación Moisés Bertoni and Fondo Francés para el Medio Ambiente Mundial (FFEM). p. 14 - 15.
- Daniel L. 2000. Shorebirds. Alaska Department of Fish and Game [Internet]. [cited 2009 Mar 4]. Available from:
http://www.habitat.adfg.state.ak.us/geninfo/kbrr/coolkbayinfo/kbec_cd/html/ecosys/species/shorebrd.htm
- Da Silva C J and Girard P. 2004. New Challenges in the Management of the Brazilian Pantanal and Catchment Area. Wetland Ecology and Management 12 (6): 553-561.
- Deinlen M. 2003. Travel Alert for Migratory Birds: Stopover Sites in Decline. Smithsonian Migratory Bird Center. [Internet]. [cited 2008 Dec 1]. Fact Sheet N° 6. Available from:
http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Fact_Sheets/default.cfm?fxsht=6
- Deinlein M. 2005. Neotropical Migratory Bird Basics. Smithsonian Migratory Bird

Center. [Internet]. [cited 2008 Dec 1]. Fact Sheet N° 5. Available from:
<http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/FactSheets/default.cfm?fxst=5>

de Jong G, Bijma P. 2002. Selection and Phenotypic Plasticity in Evolutionary Biology and Animal Breeding. *Livestock Production Science* 78 (3): 195-214.

Devonport C, Bull A. 1999. The Role of GIS and Remote Sensing Technology. In: Finlayson CM, Spiers AG, editors. *A Compendium of Information for Managing and Monitoring Wetlands in Tropical Australia*. Canberra (Australia): Supervising Scientist Report 148, Supervising Scientist. p 81-86.

Donaldson G.M, Hyslop C, Morrison R, Dickson H and Davidson I. 2006 Canadian Shorebird Conservation Plan (CSCP). Canadian Wildlife Services [Internet]. [cited 2008 Dec 1]. Available from: <http://www.cws-scf.ec.gc.ca>

Dorma C. 2001. Achieving Biodiversity of Conservation Objectives: A Case Study of Canada's Forest Industry [dissertation]. [Winnipeg (MB)]: University of Manitoba.

Doswald N, Willis SG, Collingham YC, Pain DJ, Green RE, Huntley B. 2009. Potential Impacts of Climatic Change on the Breeding and Non-Breeding Ranges and Migration Distance of European *Sylvia* Warblers. *Journal of Biogeography* [Internet]. [cited 2009 Apr 17]. March 19, 2009. Available from: <http://www3.interscience.wiley.com/journal/122267958/abstract>

Duerksen M. 2006. Ganaderos deben buscar modelos productivos de mayor

sostenibilidad. ABC newspaper, Interior section. [Internet]. [cited 2006 Jun 5]. Available from: <http://www.abc.com.py/2006-06-05/articulos/256666/ganaderos-deben-buscar-modelos-productivos-de-mayor-sostenibilidad>

Encuesta permanente de hogares 2004, Departamento de Ñeembucú 2004. 2004.

Fernando de la Mora (Paraguay): Dirección General de Estadísticas Encuestas y Censos (dgeec).

Erwin RM, Sanders GM, Prosserb DJ. 2004. Changes in Lagoonal Marsh Morphology at Selected Northeastern Atlantic Coast Sites of Significance to Migratory Waterbirds. *Wetlands* 24 (4): 891-903.

Estrategia Nacional y Plan de Acción para la Conservación de la Biodiversidad del Paraguay (ENPAB). 2003. Asunción (Paraguay): Secretaría del Ambiente (SEAM). 2nd edition. p 110.

Estudios de impacto ambiental ruta N° 4 José Eduvigis Díaz. 1994. Asunción (Paraguay): Consorcio Leme-Consol. Ministerio de Obras Públicas y Comunicaciones.

Evans R. 1998. The Erosional Impacts of Grazing Animals. *Progress in Physical Geography* 22 (2): 251-268.

Facetti-Fernández J F. 2002. Estado ambiental del Paraguay: presente y futuro. Asunción (Paraguay): Proyecto Estrategia Nacional para la Protección de los Recursos Naturales (ENAPRENA). Secretaría del Ambiente, GTZ. p 236.

Fauna Amenazada del Paraguay, 1997. 1998. Fauna amenazada del Paraguay,

1997. Asunción (Paraguay): Ministerio de Agricultura y Ganadería, Fundación Moisés Bertoni.
- Fearnside PM. 2001. Soybean Cultivation as a Threat to the Environment in Brazil. *Environmental Conservation* 28 (1): 23-38.
- Findlay CS, Bourdages J. 2000. Response Time of Wetland Biodiversity to Road Construction on Adjacent Lands. *Conservation Biology* 14 (1): 86.
- Finlayson CM, Gitay H, Bellio M, vanDam R, Taylor I. 2006. Climate Variability and Change and Other Pressures on Wetlands and Waterbirds; Impacts and Adaptation. In: Boere GC, Galbraith CA, Stroud DA, editors. *Waterbirds Around the World*. Edinburgh (UK): The Stationery Office. p 88-97.
- Fink A. 2003. *The Survey Handbook*. 2nd ed. Thousand Oaks (CA): Sage Publications.
- Fogel R. 2000. La ecorregión del Ñeembucú: infortunio, dignidad y sabiduría de sus antiguos pobladores. Asunción (Paraguay): Centro de Estudios Rurales Interdisciplinarios and Universidad Nacional de Pilar. p 206.
- Fortney RH. 2000. Cattle Grazing and Sustainable Plant Diversity in the Pantanal: What Do We Know? What Do We Need to Know? In: Swarts F, editor. *The Pantanal: Understanding and Preserving the World's Largest Wetland*. St. Paul (MN): Paragon House. p 127-134.
- Frank O, Snijders T. 1994. Estimating the Size of Hidden Populations Using Snowball Sampling. *Journal of Official Statistics* 10 (1): 53-67.
- Freire P. 1970. *Cultural Action for Freedom*. Cambridge (MA): Harvard

Educational Review.

- Galbraith H, Jones R, Park R, Clough J, Herrod-Julius S, Harrington B, Page G. 2005. Global Climate Change and Sea Level Rise: Potential Losses of Intertidal Habitat for Shorebirds. Washington (DC): USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.
- Gilligan J, Clifford-Pena J, Ede-Rowntree J, Johansson K, Gislason R, Green T, Arnold G, Heath J, Brook R. 2006. The Value of Integrating Traditional, Local and Scientific Knowledge. In: Riewe R, Oakes J, editors. Climate Change: Linking Traditional and Scientific Knowledge. Winnipeg (MB): Aboriginal Issues Press. p 3-12.
- Gliessman SR. 1992. Agroecology in the Tropics: Achieving a Balance between Land Use and Preservation. *Environmental Management* 16 (6): 681-689.
- Glatzle A. 2008. Sistemas ganaderos en base a pastures implantadas, servicios ecológicos o amenaza ambiental? *Revista Brangus* 30 (56): 30-34.
- Gómez JM. 2006. Breves Conceptos Antropológicos de la Región. Proceedings of the Seminario Regional sobre la Perspectiva Ambiental de la Región Sur Oeste del Paraguay; 2006 Oct 21; Pilar Paraguay. Pilar (Paraguay): Universidad Nacional de Pilar.
- González R, Delpino M, Portillo VM. 2004. El uso de sensores remotos en la educación superior en zona de humedales del Paraguay: el caso de la UNP en el Departameto de Ñeembucú. Proceedings from the 4^{ta} Jornada de Educacao em Sensoriamento Remoto no Ambito do Mercosul; 2004 Aug 11-13; Sao Leopoldo (Brazil).

- González R. 2006. Perspectiva de la Region Sur Oeste del Paraguay: Humedales del Ñeembucú. Proceedings from the Seminario Regional sobre la Perspectiva Ambiental de la Region Sur Oeste del Paraguay; 2006 Oct 21; Pilar Paraguay. Pilar (Paraguay): Universidad Nacional de Pilar.
- Gotthardt T, Lanctot R. 2002. Status Report on the Buff-Breasted Sandpiper (*Tryngites subruficollis*). Anchorage (Alaska); U.S. Fish and Wildlife Service, Ecological Services.
- Grau H R, Aide M. 2008. Globalization and Land-Use Transitions in Latin America. *Ecology and Society* 13 (2): 16.
- Gregory S. 1978. *Statistical Methods and the Geographer*. 2nd ed. London (UK): Longmans, Green and Co. Ltd.
- Grumbine RE. 1994. What is Ecosystem Management? *Conservation Biology* 8 (1): 27-38.
- Guyra Paraguay. 2008. Áreas de importancia para la conservación de las aves en Paraguay. 1st ed. Asunción (Paraguay): Guyra Paraguay, BirdLife International.
- Hails S, Peck D. 2007. *Wetland Inventory: A Ramsar Framework for Wetland Inventory*. Gland (Switzerland): Ramsar Convention Secretariat. Ramsar Handbooks for the Wise Use of Wetlands, 3rd ed., vol. 12.
- Hamilton SK. 1999. Potential Effects of a Major Navigation Project (Paraguay-Paraná Hidrovía) on Inundation in the Pantanal Flood Plains. *Regul. Mgmt.* 15: 289-299.
- Hayes FE, Goodman SM, Fox JA, Granizo T, López NE. 1990. North American

- Bird Migrants in Paraguay. *The Condor* 92 (3): 947-960.
- Hayes FE, Fox JA. 1991. Seasonality, Habitat Use, and Flock Sizes of Shorebirds at the Bahía de Asuncion, Paraguay. *Wilson Bull.* 103(4): 637-649.
- Hayes F E. 1995a. Status, Distribution and Biogeography of the Birds of Paraguay. Albany (New York): American Birding Association. *Monographs in Field Ornithology*, N° 1. p 224.
- Hayes FE. 1995b. Definitions for Migrant Birds: What is a Neotropical Migrant? *The Auk* 112 (2): 521-523.
- He HS, Mladenoff DJ, Radeloff VC, Crow TR. 1998. Integration of GIS Data and Classified Satellite Imagery for Regional Forest Assessment. *Ecological Applications* 8 (4): 1072-1083.
- Heinohen S. 2007. Esteros del Iberá, importancia de su conservación. (Argentina): Conservation Land Trust (CLT). p 57.
- Heitschmidt RK, Vermeire LT, Grings EE. 2004. Is Rangeland Agriculture Sustainable? *J. Anim. Sci.* 82 (E. Suppl.): E138 – E146.
- Howe MA, Geissler PH, Harrington BA. 1989. Population Trends of North American Shorebirds Based on the International Shorebird Survey. *Biological Conservation* 49 (3): 185-199.
- Huang C, Kim S, Altstatt A, Townshend JRG, Davis P, Song K, Tucker CJ, Rodas O, Yanosky A, Clay R, Musinsky J. 2007. Rapid Loss of Paraguay's Atlantic Forest and the Status of Protected Areas – a Landsat Assessment. *Remote Sensing of Environment* 106 (4): 460-466.
- Hubbard RK, Newton GL, Hill GM. 2004. Water Quality and the Grazing

Animal. J. Anim. Sci. 82 (E. Suppl.): E255 – E263.

- Huespe H, Spinzi L, Burgos S, Rodas O. 1994. Uso de la tierra y deforestación en la región oriental del Paraguay período 1984-1991. San Lorenzo (Paraguay): Universidad Nacional de Asunción, Facultad de Ingeniería Agronómica, Carrera de Ingeniería Forestal. Vol. 1.
- Huespe H, Spinzi L, Curiel MA, Burgos S, Rodas O. 1995. Atlas ambiental de la Region Oriental del Paraguay. Vol. II. San Lorenzo (Paraguay): Universidad Nacional de Asunción, Facultad de Ciencias Agrarias.
- Hung C, Fahsi A, Tadesse W, Coleman T, editors. 1997. A Comparative Study Of Remotely Sensed Data Classification Using Principal Components Analysis and Divergence. Proceedings of the IEEE International Conference on Systems, Man and Cybernetics: Orlando, Fl. Orlando (FL): Computational Cybernetics and Stimulation. p 2444 - 2449.
- Huntington HP. 1998. Observations on the Utility of the Semi-direct Interview for Documenting Traditional Ecological Knowledge. Arctic 51 (3): 237-242.
- Huntington HP. 2000. Using Traditional Ecological Knowledge in Science: Methods and Applications. Ecological Applications 10 (5): 1270-1274.
- Integrated Management and Conservation of Key Grasslands in “MERCOSUR”, Countries of the Southern Cone of South America. 2003. [Internet]. [cited 2008 Mar 26]. Global Environment Facility Project ID P091659; Available from: http://www.pastizalesdelconosur.org/eng/pdf/seccion_8/
- Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis. Geneva (Switzerland): Summary of Policymakers,

Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 10th Session, Paris, France, February 2007. Available from: <http://www.ipcc.ch>

Iriondo M. 2004. Large Wetlands of South America: a Model for Quaternary Humid Environments. *Quaternary International* 114 (1): 3-9.

Isacch JP, Holz S, Ricci L, Martínez MM. 2004. Post-Fire Vegetation Change and Bird Use of a Salt Marsh in Coastal Argentina. *Wetlands* 24 (2): 235-243.

Jepson W. 2005. A Disappearing Biome? Reconsidering Land-cover change in the Brazilian Savanna. *The Geographical Journal* 171 (2): 99-111.

Junk WJ, Furch K. 1993. A General Review of Tropical South American Flood Plain. *Wetland Ecology and Management* 2 (4): 231-238.

Junk WJ. 2002. Long-term Environmental Trends and the Future of Tropical Wetlands. *Environmental Conservation* 29 (4): 414-435.

Junk WJ. Ecology and Management of large South American Rivers and their Floodplains [Internet]. [cited 2008 Mar 26] Available from: <http://www.riversymposium.com/index.php?element=26>

Kadlec JA, Smith LM. 1992. Habitat Management for Breeding Areas. In: Batt BDJ, Afton AD, Anderson MG, Ankney CD, Johnson DH, Kadlec JA, Krapu GL, editors. *Ecology and Management of Breeding Waterfowl*. Minneapolis (MN): University of Minnesota Press. p 590-610.

Kerry R, van den Bergh J, Soderquist T, Barendreg TA, van der Straaten J, Maltby E, van Ierland E. 2000. *Ecological-economic Analysis of Wetlands: Scientific Integration for Management and Policy*. Ecological Economics

35 (1): 7-23.

- Kie JG, Bleich VC, Medina AL, Yoakum JD, Thomas JW. 1996. Managing Rangelands for Wildlife. In: Bookhout TA, editor. Research and Management Techniques for Wildlife and Habitats. 5th ed. Bethesda (Md): The Wildlife Society. p 663-683.
- Lanctot RB, Blanco DE, Dias RA, Isacch JP, Gill VA, Almeida JB, Delhey K, Petracci PF, Bencke GA, Balbuena RA. 2002. Conservation Status of the Buff-Breasted Sandpiper: Historic and Contemporary Distribution and Abundance in South America. *The Wilson Bulletin* 114 (1): 44-72.
- La Plata River Basin. 2005. Washington (DC): Organization of American States, Office for Sustainable Development & Environment. Water Project Series, N° 6. [cited 2008 Dec 2]. Available from:
http://www.oas.org/dsd/Events/English/Documents/OSDE_6LaPlata.pdf
- Lean J, Rowntree P. 1997. Understanding the Sensitivity of a GCM Simulation of Amazonian Deforestation to the Specification of Vegetation and Soil Characteristics. *Journal of Climate*. 10 (6): 1216-1235.
- Lesterhuis A J, Clay R P and Cabrera E. 2005. Paraguay: Informe anual 2004. In: López-Lanus B and Blanco D, editors. El censo Neotropical de aves acuáticas 2004. Global Series Number 17. Buenos Aires (Argentina): Wetlands International p 75-81.
- Liebig's. 1965. Liebig's en el Paraguay: Libro de Homenaje en el Centenario de la Fundación de la Liebig's Extract of Meat Company Limited 1865-1965. Zeballos Cué (Paraguay). p 238.

- Lillesand TM, Kiefer RW, Chipman Jw. 2004. Remote Sensing and Image Interpretation. 5th ed. New York (NY): John Wiley & Sons, Inc.
- Loiselle S, Rossi C, Sabio G, Canziani G. 2001. The Use of Systems Analysis Methods in the Sustainable Management of Wetlands. *Hydrobiologia* 458: 191-200.
- Loiselle SA, Bastrianoni S, Bracchini L and Rossi C. 2004. Neotropical Wetlands: New Instruments in Ecosystem Management. *Wetlands Ecology and Management* 12 (6): 587-596.
- Lombardi I. 2007. Population and Health Data. Pilar (Paraguay): Ministerio de Salud Pública y Bienestar Social, Departamento de Bioestadística. August 23 2007.
- Longley PA, Goodchild MF, Maguire DJ, Rhind DW. 2005. Geographic Information Systems and Science. West Sussex (England): John Wiley And Sons, 2nd ed. p 517.
- Lunstra DD, Cundiff LV. 2003. Growth and Pubertal Development in Brahman, Boran, Tuli, Belgian Blue, Hereford and Angus Sired F1 Bulls. *J. Anim. Sci.* 81 (6): 1414-1426.
- MacLachlan I, Bateman NG, Johnston TRR. 2005. Cultivating a New Cattle Culture: Lifelong Learning and Pasture Land Management. In: Humphrys G, Williams M, editors. Presenting and Representing Environments. Dordrecht (The Netherlands): Springer. p 181-195.
- Mandelburger D, Franco B, Gerard V, Ghiglione E. 2006. Conservación de la

Diversidad Biológica en el Paraguay: Una propuesta de la Secretaría del Ambiente, Vol. 1, 1st ed., p 130.

Marino GD. 2008. Buenas prácticas ganaderas para conservar la vida silvestre de las Pampas: Una guía para optimizar la producción y conservar la biodiversidad de los pastizales de la Bahía Samborombón y la Cuenca del Río Salado. 1st ed. Buenos Aires (Argentina): Aves Argentinas, Asociación Ornitológica del Plata.

Meffe GK, Nielsen LA, Knight RL, Schenborn DA. 2002. Ecosystem Management: Adaptive, Community-based Conservation. Washington (DC): Island press. p 313.

Méndez J, Benítez C, Rojas A, Gerard V, Céspedes R, Barrios E, Mendoza F, Muñoz A. 2007. Cambio climático: riesgos, vulnerabilidad y desafío de adaptación en el Paraguay. Asunción (Paraguay): Programa de las Naciones Unidas para el Desarrollo (PNUD). Desarrollo Humano Paraguay.

Mereles MF. 2004a. Los humedales del Paraguay; Principales tipos de vegetación. In: Salas-Dueñas D, Mereles F, Yanosky A, editors. Humedales de Paraguay. 1st ed. Asunción (Paraguay): Comité Nacional de Humedales. p 67-87.

Mereles MF. 2004b. Las plantas útiles de los humedales del Paraguay. In: Salas-Dueñas D, Mereles F, Yanosky A, editors. Humedales de Paraguay. 1st ed. Asuncion (Paraguay): Comité Nacional de Humedales. p 89-125.

Mereles F, Delphin S. 2008. La herramienta “Derechos y Obligaciones

Canjeables y Negociables”: Una excelente opción para la conformación de corredores biológicos de conservación en la Región Oriental del Paraguay. WWF Paraguay [Internet]. [cited 2009 Mar 27]. Available from:

http://www.wwf.org.py/sala_redaccion/articulos/

Métraux A. 1996. Etnografía del Chaco. Asunción (Paraguay): El Lector, Centro de Estudios Antropológicos de la Universidad Católica “Nuestra Señora de la Asunción”.

Millenium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington (D.C.): Island Press.

Miraglia L. 1975 December. Caza, recolección y agricultura entre indígenas del Paraguay. Suplemento Antropológico, Centro de Estudios Antropológicos de la Universidad Católica “Nuestra Señora de la Asunción”, Paraguay 1-2 (10): 9-92.

Miro M. 2004. El entorno cultural de los humedales del Ypoa. In: Salas-Dueñas D, Mereles F, Yanosky A, editors. Humedales de Paraguay. 1st ed. Asunción (Paraguay): Comité Nacional de Humedales. p 41-52.

Moller H, Berkes F, O’Brian LP, Kislalioglu M. 2004. Combining Science and Traditional Ecological Knowledge: Monitoring Populations for Co-Management. Ecology and Society. 9 (3): 2.

Monte R, Gaona A, Mendez J, Monte F, Otter T, Benitez C, Barrios E, Gerard V. 2006. Usos y gobernabilidad del agua en el Paraguay. Asunción (Paraguay): Programa de las Naciones Unidas para el Desarrollo (PNUD),

Paraguay. p 114.

Morales C, Clay RP, Castillo H. 2006. Aves del Río Paraguay. In: Guyra Paraguay and Transbarge Navegación editors. Biodiversidad del Río Paraguay. Asunción (Paraguay): Guyra Paraguay, Transbarge Navegación. p 59-76.

Morrison RIG. 2001. Shorebird Population Trends and Issues in Canada, an Overview. In: Kennedy J, editor. Bird Trends. Number 8. Hull (Quebec): Canadian Wildlife Service. p 1-4.

Motte M, Caccialli P, Aquino L, Yanosky A. 2004. Anfibios y reptiles de los humedales del Paraguay. In: Salas-Dueñas DA, Mereles F, Yanosky A editors. Humedales de Paraguay. Asunción (Paraguay): Comité Nacional de Humedales. p 167-174.

Murdoch J, Barnes JA. 1998. Statistical Tables for Science, Engineering, Business Management and Finance. 4th ed. London (UK): Palgrave Macmillan.

Naumann CM, Coronel MMC. 2008. Atlas ambiental del Paraguay: con fines educativos. Asunción (Paraguay): Cooperación Técnica Alemana (GTZ), Secretaría del Ambiente del Paraguay (SEAM). p 88.

Neiff JJ. 2000. Diversity in Some Tropical Wetland Systems of South America. In: Gopal B, Junk WJ, Davis JA, editors. Biodiversity in Wetlands: Assessment, Function, and Conservation. Vol. 2. Leiden (The Netherlands): Backhuys Publishers. p 31-60.

Neiff JJ. 2004. El Iberá... En peligro? 1st ed. Buenos Aires (Argentina):

Fundación Vida Silvestre Argentina. p 104.

Neiff JJ, Malvarez A. 2006. Grandes humedales fluviales [Internet]. [cited 2006

Sept 6]. Centro de Ecología Aplicada del Litoral (CECOAL).

Available from: <http://www.neiff.com.ar/downloads/23.doc>

Neris N, Colman F, Ovelar E, Sukigara N, Ishii N. 2002. Katos's Data Book on larger Mammals of Paraguay, Distribution, Population Trends, and Utilization. Asunción (Paraguay): Secretaría del Ambiente (SEAM).

Njeremani D, Muthoka S, Lelo F. 2000. Participatory Rural Appraisal (PRA): A Summary Statement. Profiles of the Egerton University PRA Team [Internet]. [cited 2008 Feb 18] Available from:

<http://www.clark.edu/departments/idce/research/ccbd/pras.html#participatory>

Nobre CA, Sellers PJ, Shukla J. 1991. Amazonian Deforestation and Regional Climate Change. *Journal of Climate*. 4 (10): 957-988.

O'Harra D. 2002. Shorebirds: Winging Between Hemispheres. U. S. Fish & Wildlife Service, Division of Migratory Bird Management [Internet]. [cited 2008 Dec 2]. Available from:

<http://www.fws.gov/migratorybirds/shrbird/shrbird.html>

Ozesmi SL, Bauer ME. 2002. Satellite Remote Sensing of Wetlands. *Wetlands Ecology and Management* 10 (5): 381-402.

Parfitt J. Questionnaire Design and Sampling. In: Flowerdew R, Martin D, editors. *Methods in Human Geography: a Guide for Students doing Research Projects*. 2nd ed. Essex (UK): Pearson Education Limited, c2005. p 78-109.

- Parkes MW, Morrison KE, Bunch MJ, Venema HD. 2008. Ecohealth and Watersheds: Ecosystem Approaches to Re-integrate Water Resources Management with Health and Well-being. Winnipeg (MB): Network for Ecosystem Sustainability and Health, International Institute for Sustainable Development. Publication Series N^o 2.
- Pedrozo C. 2007. Diagnóstico ambiental participativo de las lagunas y esteros de la cuenca del Ñeembucú. Asunción (Paraguay): Dirección General de Gestión Ambiental, Centro de Datos para la Conservación, Secretaría del Ambiente.
- Pérez de Molas LF. 2003. Formaciones vegetales Region Oriental del Paraguay. San Lorenzo (Paraguay): Universidad Nacional del Paraguay, Facultad de Ciencias Agrarias.
- Pérez de Molas LF. 2003. Vegetación y flora de humedales del Paraguay. San Lorenzo (Paraguay): Universidad Nacional del Paraguay, Facultad de Ciencias Agrarias.
- Petean J. 2008. The Paraguay-Paraná Wetland System: an Initiative in Progress. In: Andrade Perez A, editor. Applying the Ecosystem Approach in Latin America. Gland (Switzerland): International Union for Conservation of Nature and Natural Resources (IUCN). p 45-52.
- Pierotti R, Wildcat D. 2000. Traditional Ecological Knowledge: the Third Alternative (Commentary). *Ecological Applications* 10 (5): 1333-1340.
- Pimbert MP, Pretty JN, editors. 1997. Diversity and sustainability in community Based conservation. Proceedings of the UNESCO-IIPA regional workshop

on Community-based Conservation; 1997 Feb 9-12; India.

Plan Maestro del Desarrollo del Sector Turístico de Paraguay. 2008. [Internet]

Asuncion (Paraguay): Secretaría Nacional de Turismo (SENATUR);

[cited 2009 Mar 27]. Available from:

<http://www.senatur.gov.py/index.php?language=2>

Pott A, Pott VJ. 2004. Features and Conservation of the Brazilian Pantanal

Wetland. *Wetlands Ecology and Management* 12 (5): 547-552.

Pretty J, Smith D. 2004. Social Capital in Biodiversity Conservation and

Management. *Conservation Biology* 18 (3): 631-638.

Price M. 2006. *Mastering ArcGIS*. 2nd ed. New York (NY): McGraw-Hill. p 609.

Proceso Río +10 Informe Nacional Paraguay. 2001. Asunción (Paraguay):

Secretaría Técnica de Planificación, Programa de las Naciones Unidas
para el Desarrollo (PNUD).

Proyecto de Desarrollo Rural y Mejoramiento Ambiental del Sur de Pilar

(DERMASUR). 1992. Asunción (Paraguay): Ministerio de Agricultura y
Ganadería de la República del Paraguay.

Puhe J. 1997. *Ecología y sistemas naturales con énfasis en Sudamérica*. Asunción

(Paraguay): Centro de Estudios Rurales Interdisciplinarios, Universidad
Nacional de Pilar. p 323.

Rangeland Stewardship Project [Internet]. 2009. Guelph (ON): Syngenta Crop

Protection Canada Inc, Ducks Unlimited Canada; [cited 2009 Mar 12].

Available from: <http://www.syngenta.ca/en/stewardship/sustainable.aspx>

Raveling DG. 1982. Migration Reversal: a Regular Phenomenon of Canada Geese.

- In: Ratti JT, Flake LD, Wentz WA, editors. Waterfowl Ecology and Management: Selected Readings. Bethesda (Maryland): The Wildlife Society. p 1174-1176.
- Richards J A, Xiuping J. 2006. Remote Sensing Digital Image Analysis, An Introduction. 4th ed. Secacus (NJ): Springer-Verlag New York, Inc.
- Ríos E, Zardini E. 1989. Conservation of Biological Diversity in Paraguay. Conservation Biology 3 (2): 118-120.
- Ripa de Marconi M, Smith RD, Maltby E. 2001. The Ecosystem Approach under the CBD: from Concept to Action. In: Report from South American Regional Pathfinder Workshop; 2001 Sep 18-20; Villa Leyva (Colombia): Bureau of The Convention on Wetlands and WWF-International.
- Riquelme B. 1974. La Villa de Nuestra Señora del Pilar del Ñeembucú. Pilar (Paraguay): No publisher available.
- Rodas O, Cabral H, Balbuena C. 2006. Cobertura del suelo en ecosistemas asociados al Río. In: Guyra Paraguay and Transbarga Navegación editors. Biodiversidad del Río Paraguay. Asunción (Paraguay): Guyra Paraguay, Transbarga Navegación. p. 32-39.
- Roguet DJ. 2009. Ethnobotany - the Scientific Vehicle for ESD: A Case Study from Paraguay. BGCI International Organization, Conservatoire et Jardin Botaniques de la Ville de Genève [Internet]. [cited 2009 Sep 30]. Available from: <http://www.bgci.org/education/1693/>
- Rook AJ, Tallowin JRB. 2003. Grazing and Pasture Management for Biodiversity Benefit. Anim. Res. 52 (2): 181-189.

- Sah J P, Heinen JT. 2001. Wetland Resource Use and Conservation Attitudes among Indigenous and Migrant People in Ghodaghodi Lake area, Nepal. *Environmental Conservation* 28 (4): 345-356.
- Salas-Dueñas D, Mereles F and Yanosky A. 2004. Humedales de Paraguay. Asunción (Paraguay): Comité Nacional de Humedales del Paraguay. p 192.
- Salas- Dueñas A, Garcia E. 2008. A Connectivity Strategy for the Mbaracayú Forest Biosphere Reserve and the Ecosystem Approach. In: Andrade Perez A, editor. *Applying the Ecosystem Approach in Latin America*. Gland (Switzerland): International Union for Conservation of Nature and Natural Resources (IUCN). Ecosystem Management Series No. 7. p 53 – 59.
- Sample AA. 1995. Remote Sensing and GIS in Ecosystem Management. *The Journal of Wildlife Management* 59 (3): 623.
- Sarmiento G, Pinillos M, da Silva MP, Acevedo D. 2004. Effects of Soil Water Regime and Grazing on Vegetation Diversity and Production in a Hyperseasonal Savanna in the Apure Llanos, Venezuela. *Journal of Tropical Ecology* 20 (2): 209-220.
- SEAM. 2006. Conservación de la diversidad biológica en el Paraguay: una Propuesta de la Secretaría del Ambiente para la guía de acciones. Vol. 3: Incentivos para la conservación de la biodiversidad en el Paraguay: una primera aproximación. Asunción (Paraguay): Secretaría del Ambiente. 1st ed. p 86.

- Seixas C S. 2002. Social-Ecological Dynamics in Management Systems:
Investigating a Coastal Lagoon Fishery in Southern Brazil. [thesis].
[Winnipeg (MB)]: University of Manitoba.
- Shepherd G. 2004. The Ecosystem Approach: Five Steps to Implementation.
Gland (Switzerland) and Cambridge (UK): IUCN. p 30.
- Sherman K, Duda AM. 1999. An Ecosystem Approach to Global Assessment and
Management of Coastal Waters. Marine Ecology Progress Series 190:
271-287.
- Shifley SR, Thompson FR, Larsen DR, Mladenoff DJ. 1997. In: Pallardy SG,
Cecih RA, Garrett HG, Johnson PS, editors. Proceedings of the 11th Central
Hardwood Conference; 1997 Mar 23-26; Columbia (MO): General
Technical Report NC-188, St. Paul (MN) p 231-241.
- Sick D. 2002. Managing Environmental Processes Across Boundaries: A Review
Of the Literature on Institutions and Resource Management. Ottawa (CA):
International Development Research Centre. Working Paper 10.
- Silgueira PG. 2009. La impresión de un grupo de turistas franceses. ABC Color
[Internet]. [cited 2009 Mar 29]. Available from:
<http://www.abc.com.py/2009-03-29/articulos/508105/paraguay-un-pais-perfecto-para-el-ecoturismo-en-la-optica-de-europeos>
- Simonit S, Cattaneo F, Perrings C. 2005. Modeling the Hydrological
Externalities of Agriculture in Wetlands: the Case of Rice in Esteros del
Iberá, Argentina. Ecological Modeling 186 (1): 123-141.
- Sparks RE. 1995. Need for Ecosystem Management of Large Rivers and their

- Floodplains. *Bio Science* 45 (3): 168-182.
- Stolk ME, Verwei PA, Stuij M, Baker CJ, Oosterberg W. 2006. Valoración socioeconómica de los humedales en América Latina y el Caribe. Wageningen (Netherlands): Wetlands International p 35.
- Strahler A and Strahler A. 2005. *Physical Geography: Science and Systems of the Human Environment*. 3rd ed. Danvers (MA): John Wiley & Sons, Inc.
- Sudmeier-Rieux K, Masundire H, Rizvi A and Rietbergen S. 2006. *Ecosystem, Livelihoods and Disasters, An Integrated Approach to Disaster Risk Management*. Gland (Switzerland) and Cambridge (UK): International Union for Conservation of Nature and Natural Resources (IUCN). Ecosystem Management Series N^o 4.
- Susnik B. 1982. Los aborígenes del Paraguay. Asunción (Paraguay): IV Cultura Material, Museo Etnográfico “Andrés Barbero”. p 237.
- Terborgh J. 1992. Maintenance of Diversity in Tropical Forests. *Biotropica* 24 (2b): 283-292.
- Terer T, Ndiritu GG, Gichuki NN. 2004. Socio-economic Values and Traditional Strategies of Managing Wetland Resources in Lower Tana River, Kenya. *Hydrobiologia* 527 (1): 3-14.
- The Annotated Ramsar List: Paraguay. [Internet]. 2005. Gland (Switzerland): Ramsar Convention Secretariat; [cited 2008 Dec 1]. Available from: http://www.ramsar.org/profile/profiles_paraguay.htm
- The Keystone National Policy Dialogue on Ecosystem Management. 1996. The Keystone Center (CO): Final Report October 1996.

- The Seven Sisters for Conservation International [Internet]. [updated 1999]. Missoula (MT): Rocky Mountain Elk Foundation; [cited 2009 Oct 23]. Available from:
<http://www.rmef.org/Hunting/HuntersConservation/Model.htm>
- Thomas D. 2006. Livelihoods and the Environment at Important Bird Areas: Listening to Local Voices. BirdLife International [Internet]. [cited 2009 Mar 27]. Available from:
http://www.birdlife.org/news/news/2007/01/listening_to_local_voices.html
- Trent D. 2000. Ecotourism in the Pantanal and its Role as a Viable Economic Incentive for Conservation. In: Swarts F, editor. The Pantanal: Understanding and Preserving the World's Largest Wetland. St. Paul (MN): Paragon House. p 107-116.
- Trottier GC. 1992. Conservation of Canadian Prairie Grasslands: A Landowner's Guide. Edmonton (AB): Canadian Wildlife Service. p 92.
- Turner JW. 1980. Genetic and Biological Aspects of Zebu Adaptability. *J. Anim. Sci.* 50 (6): 1201-1205.
- Turner NJ, Ignace MB, Ignace R. 2000. Traditional Ecological Knowledge and Wisdom of Aboriginal Peoples in British Columbia. *Ecological Applications* 10 (5): 1275-1287.
- U.S. Shorebird Conservation Plan. 2004. High Priority Shorebirds – 2004. Arlington (VA): U.S. Fish and Wildlife Service.
- Usher PJ. 2000. Traditional Ecological Knowledge in Environmental Assessment and Management. *Arctic* 53 (2): 183-193.

- van Dam R, Gitay H, Finlayson M. 2002. Climate Change and Wetlands: Impacts, Adaptation and Mitigation. In: Ramsar COP 8, DOC. 11, Information Paper from the Proceedings of the 8th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands; 2002 Nov 18-26; Valencia (Spain). p 1-56.
- van Humbeck A. 2008. El Turismo de naturaleza. Proceedings of the 3er curso nacional de ecología de humedales; 2008 Sept 4; Pilar (Paraguay): Universidad Nacional de Pilar.
- Vera H, Castillo H. 2006. Peces del río Paraguay. In: Guyra Paraguay and Transbarga Navegación editors. Biodiversidad del Río Paraguay. Asunción (Paraguay): Guyra Paraguay, Transbarga Navegación. p 40-58.
- Vogt C, Mereles MF. 2005. Una contribución al estudio de los humedales de la cuenca del Arroyo Ñeembucú, Departamento de Ñeembucú, Paraguay. *Rojasiana* 791: 5-20.
- Warner BG, Rubec CDA. 1997. The Canadian Wetland Classification System. Waterloo (ON): National Wetlands Working Group, 2nd ed. p 68.
- Wear DN, Turner MG, Flamm RO. 1996. Ecosystem Management with Multiple Owners: Landscape Dynamics in a Southern Appalachian Watershed. *Ecological Applications* 6 (4): 1173-1188.
- Wetland Values and Functions [Internet]. 2002. Gland (Switzerland): Ramsar Convention on Wetlands; [cited 2006 November 29]
Available from: http://www.ramsar.org/info/values_intro_e.htm
- Wetland Restoration Incentive Program [Internet]. C2008. Winnipeg (MB):

Manitoba Water Stewardship; [cited 2009 Ap 1]. Available from:
http://www.gov.mb.ca/waterstewardship/water_info/riparian/wetland_restoration.html

World Resources 2005: the Wealth of the Poor – Managing Ecosystems to Fight Poverty [Internet]. 2005. Washington (D.C.): World Resources Institute; [cited 2009 Jan 8]. Available from: <http://www.wri.org>

World Resources 2008: Roots of Resilience – Growing the Wealth of the Poor. [Internet]. 2008. Washington (D.C.): World Resources Institute; [cited 2009 Mar 27]. Available from: <http://www.wri.org>

Yahnke CJ, Gamarra de Fox I, Colmán F. 1998. Mammalian Species Richness in Paraguay: The Effectiveness of National Parks in Preserving Biodiversity. *Biological Conservation* 84 (3): 263-268.

Yanosky A, Salas-Dueñas D. 2004. Amenazas a los humedales paraguayos. In: Salas-Dueñas DA, Mereles F, Yanosky A, editors. *Los Humedales de Paraguay*. Asunción (Paraguay): Comité Nacional de Humedales. p 13-28.

Yanosky A, Cartes JL. 2008a. La conservación de las IBAs en Paraguay: Desafios estratégicos y próximos pasos. In: Guyra Paraguay, editor. *Áreas Importantes para la Conservación de las Aves del Paraguay*. 1st ed. Asunción (Paraguay): Guyra Paraguay/BirdLife International. p 411-418.

Yanosky A, Cartes JL. 2008b. La potencialidad de las IBAs en un contexto socioeconómico. In: Guyra Paraguay, editor. *Áreas Importantes para la Conservación de las Aves del Paraguay*. 1st ed. Asunción (Paraguay): Guyra Paraguay/BirdLife International. p 335 - 354.

Zarza R, Morales C. 2006. Reporte final aves acuáticas en Paraguay. Asunción
(Paraguay): Asociación Guyra Paraguay.

Appendix I Questionnaire for local residents.
SAN JUAN DEL ÑEEMBUCÚ DISTRICT
GENERAL QUESTIONNAIRE - SURVEY YEAR 2007

ADDRESS: _____ SAMPLE No.

DATE: _____

I. BASIC INFORMATION

1. In the year 2006, what was the major source of household income?

- Ranching..... 2
- Hunting..... 3
- Fishing..... 4
- Commerce..... 5
- Construction..... 6
- Government Low Level..... 7
- Government High Level..... 8
- Other..... 9

2. Approximately what fraction of this income comes from this activity?

<1/4 - 1, 1/4 to 1/2 - 2, 1/2 to 3/4 - 3, > 3/4 - 4

3. If the answer is 1 or 2, then, what other source of household income is there?

- Agriculture..... 1
- Ranching..... 2
- Hunting..... 3
- Fishing..... 4
- Commerce..... 5
- Construction..... 6
- Government Low Level 7
- Government High Level 8
- Other..... 9

4. The size (ha) and status of the land you occupy is:

Own with title.....	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Owned with processing	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Rent.....	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Squat.....	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Caretaker.....	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

5. What percentage of your property is low land?

6. Of the low land areas, have you done anything to improve these areas?

No..... 0
Yes..... 1

Please explain.

7. Are you satisfied with the results?

No..... 0
Yes..... 1

Please explain

8. In the past 5 years, did you have a visit from an extension officer?

No..... 0
Yes..... 1

If yes, then how did she/he assist you?

Land Use..... 1
Farm Management..... 2
New Seeds..... 3
Drainage..... 4
Pest Control..... 5
Other..... 6

9. Over the last 5 years, did you work in cooperation with other groups of farmers/ranchers?

No..... 0
Yes..... 1

If yes, what type of cooperation?

Explain

II. CROPS AND LIVESTOCK

1. Years have you been involved
in farming/ranching?

2. On your holding, do you grow any crops?

No..... 0
Yes..... 1

If yes, what types of crops do
you usually grow?

Cotton.....
Yucca.....
Corn.....
Beans.....
Soya.....
Sweet Potato.....
Citrus Fruits.....
Others (Specify).....

3. How do you decide where and why you plant a particular crop?

Family Tradition.....	
Advice of Ext. Instructor.....	
Advice of Friend/Neighbours.....	
Personal Exp./Knowledge.....	
Market Demand.....	
Personal Needs.....	

4. Over the last 5 years have there been major changes in the crops you grow?

No.....0

Yes.....1

If yes, then what specifically.
Explain

5. Do you fertilize/manure your crop?

No.....0

Yes.....1

If yes, then what type(s)

Manure.....	1	
Chemical.....	2	<input type="checkbox"/>
Both.....	3	

6. If you fertilize your crops, do you leave a buffer zone between your crops and the water bodies (wetlands, ponds)?

No.....0

Yes.....1

7. Do you own any livestock?

No.....0

Yes.....1

If yes, what type and how many?

Beef Cattle.....		
Dairy Cattle.....		
Sheep.....		
Goats.....		
Pigs.....		
Horses.....		
Chickens.....		
Others.....		

8. If beef then, what breeds do you own?

Indian.....	
European.....	

Hybrid

9. If dairy then, what breeds do you own?

Indian.....
 European.....
 Hybrid.....

10. Do you regularly sell farm commodities?

No.....0
 Yes.....1

If yes, cite the three more important.

- a)
- b)
- c)

11. In 2006, did you have any agricultural/livestock problems?

No.....0
 Yes.....1

And if so, then which ones.

	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree	Do not Know
Roads								
Market Prices								
Quality Labour								
Credit								
Disease								
Livestock Theft								
Flooding								
Water Level								
Fencing								
Water Quality								
Land Tenure								
Weeds								

III. ENVIRONMENTAL SITUATION

1. Since you are occupying this property, if applicable, did you notice a change in the rainy season in the last 5 years?

No.....0
 Yes.....1

2. Have you ever experienced exceptional flooding?

No.....0
Yes.....1

If yes, in what years in the last 10 years?

3. Have you ever experienced exceptional droughts?

No.....0
Yes.....1

If yes, in what years in the last 10 years?

If NO in 2 and 3 skip to question 5.

4. Given the changes in climate, what happen to the lagoons, ponds and wetlands?

Decreased.....1
Remained the same..... 2
Increased..... 3
Do not know..... 4

5. According to your concept, what does the wetland areas represent in your property?
Explain.

6. Have you notice any change in the fish population?

No.....0
Yes.....1
If yes, then
Decreased.....0
Increased..... 1

7. Do waterfowl use your property for nesting or stop-over only, particularly if you live near large water bodies or streams?

Nesting.....1
Stop-over.....2
Both.....3
Do not know.....4

8. Do you have marsh areas or pastures that are not grazed on your property that would encourage waterfowl to stay?

No.....0
Yes.....1

9. About the wildlife, did you notice a change?

No..... 0
Yes..... 1

If yes, then

Decreased.....0
Increased.....1

10. What species do you use for consumption?

11. Have you seen any changes in these species?

No..... 0
Yes.....1

If yes, then

Decreased.....0
Increased.....1

12. If it decreased, do you have any idea what the cause might be?
Explain.

13. Do you use fire in your property as a management tool?

No..... 0
Yes.....1
Explain.

14. If yes, when and how often?

15. Has there been any road construction that affected the water level in your property?

No..... 0
Yes..... 1

If yes, how has this affected your operation?
Specify.

16. From whom and where the management practices used in your property were obtained?
Explain.

17. Have you attended any government environmental education seminar?

No..... 0
Yes..... 1

18. What are the medicinal herbs you can find here?

19. Was there any change in these plants in the last 10 years?

Decreased.....0
Increased.....1

20. What could be the cause of this change?

21. Are there native weeds to the area in your pasture?

No..... 0

Yes..... 1

If yes, name them.

22. In the last 10 years, did they increase drastically?

No..... 0

Yes..... 1

23. Have you tried to eliminate them?

No..... 0

Yes..... 1

Explain.

24. What is the general situation of the prairies?

25. According to your point of view, what is the environmental situation of the wetlands in your zone?

26. Have you notice any changes in the numbers of capybaras in your property in the last 10 years?

Decreased.....0

Increased.....1

27. What could be the cause for this change?

IV. PERSONAL INFORMATION

1. Gender

Female.....1

Male.....2

2. Age

<input type="text"/>	<input type="text"/>
----------------------	----------------------

3. Civil Status

Single..... 1

Cohabiting.....2

Married.....3

Widowed.....4

Divorced/Separated.....5

4. For how many children and other members of your family are you responsible?

< 5 years.....

5 – 15 years.....

> 15 years.....

5. Have you had any illness over the past year?

No.....0

Yes.....1

If yes, what was the nature of your complaint?

Explain.

Because of this problem, how many days were you unable to work in the past 12 months?

6. What source(s) of transportation do you use?

Bus.....

Car.....

Horse.....

Cart.....

7. Do you have electricity?

No..... 0

Yes.....1

8. Is there a telephone in the house?

No.....0

Yes.....1

If yes, what kind?

Land phone..... 1

Cellular phone.....2

Both.....3

9. Fuel(s) you use to cook with?

Coal.....

Wood.....

Gas.....

Kerosene.....

10. What type of bathroom facility do you have?

Septic Tank.....1

Latrine.....2

Hole in the ground.....3

11. Your source of water is through:

Running water inside house...1

Running water outside house..2

Well.....3

Cistern.....4

12. What was the highest level of education that you achieved?

- Elementary.....1
- High School.....2
- Vocational.....3
- University.....4
- None.....5

If 1 or 2, what grade?

13. Have you ever had environmental awareness program taught to you?

- No.....0
- Yes.....1

If yes, which institution(s) implemented this program?

- Municipality.....
- Government.....
- NGO.....
- University.....

14. Have you ever had public participation in decision making groups?

- No.....0
- Yes.....1

If yes, then specify.

Appendix II Questionnaire for ranchers.
SAN JUAN DEL ÑEEMBUCÚ DISTRICT
RANCHERS QUESTIONNAIRE - SURVEY YEAR 2007

ADDRESS: _____ SAMPLE No.

DATE: _____

I. BASIC INFORMATION

1. In the year 2006, what was the major source of household income?

- Agriculture..... 1
- Ranching..... 2
- Hunting..... 3
- Fishing..... 4
- Commerce..... 5
- Construction..... 6
- Government Low Level..... 7
- Government High Level..... 8
- Other..... 9

2. Approximately what fraction of this income comes from this activity?

- <1/4 - 1, 1/4 to 1/2 - 2, 1/2 to 3/4 - 3, >3/4 - 4

3. If the answer is 1 or 2, then, what other source of household income is there?

- Agriculture..... 1
- Ranching..... 2
- Hunting..... 3
- Fishing..... 4
- Commerce..... 5
- Construction..... 6
- Government Low Level..... 7
- Government High Level..... 8
- Other..... 9

4. The size (ha) of the land you occupy is:

- 500 - 1000..... 1
- 1001 - 5000..... 2
- 5001 - 10,000..... 3
- +10,000..... 4

5. The land you occupy is:

- Owned..... 1
- Rented..... 2
- Both..... 3

6. What percentage is low land?

7. Of the low land areas, have you done anything to improve these areas?

No.....0

Yes.....1

Please explain.

8. Are you satisfied with the results?

No.....0

Yes.....1

Please explain.

9. Do you have cultivated grass in your property?

No.....0

Yes.....1

If yes, how many hectares?

10. Do you classify your cattle in categories?

No..... 0

Yes..... 1

If yes, name the categories?

11. How do you determine the amount_of bovine assigned per pasture?

Explain.

12. In the past 5 years, did you have a visit from an extension officer?

No..... 0

Yes..... 1

If yes, then how did she/he assist you?

Land Use..... 1

Farm Management..... 2

New Seeds..... 3

Drainage..... 4

Pest Control..... 5

Other..... 6

13. Over the last 5 years, did you work in cooperation with other groups of group of ranchers?

No..... 0

Yes.....1

If yes, what type of cooperation?

Explain.

II. CROPS AND LIVESTOCK

1. How many years have you been ranching in this area?

--	--

2. On your holding, do you grow any crops?

No..... 0

Yes..... 1

If yes, what are your three major crops and how much?

- a)
- b)
- c)

3. Of the following categories, what types of livestock you keep and how many?

- Beef Cattle
- Dairy Cattle
- Sheep
- Horses
- Chickens
- Others

4. Of the following breeds, what percentage do you have?

- Indian.....
- European.....
- Hybrid.....

5. Which of the following describes your beef operation? Select all that apply

- Cow/Calf Producer.....
- Breeding Stock.....
- Steer Producer.....
- Other (Specify).....

6. Over the last 5 years, can you tell me what was your pregnancy rate?

7. Are you satisfied with this pregnancy rate?

No..... 0

Yes..... 1

8. How have your livestock operation changed over the last 5 years?

Decreased.....1

Remain the same.....2

Increased.....3

9. In 2006, did you have any agricultural/livestock problems?

No..... 0
 Yes..... 1

10. Please identify the major problems your ranching operation faces

	Strongly Agree	Agree	Somewhat Agree	Neutral	Somewhat Disagree	Disagree	Strongly Disagree	Do not Know
Road	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market Prices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Quality Labour	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Credit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Disease	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Livestock theft	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flooding	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water Level	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fencing	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Water Quality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Land Tenure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Weeds	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

III. ENVIRONMENTAL SITUATION

1. Since you are occupying this property, if applicable, did you notice a change in the

rainy season in the last 5 years?

No..... 0
 Yes..... 1

If yes, how?

Decrease..... 0
 Increase..... 1

2. Have you experienced exceptional flooding?

No..... 0
 Yes..... 1

If yes, in what years in the last 10 years?

3. Have you experienced exceptional droughts?

No..... 0
 Yes..... 1

If NO in 2 and 3 skip to question 5.

4. Given the changes in climate, what happen to the lagoons, ponds and wetlands?

- Decreased.....1
- Remained the same.....2
- Increased.....3
- Do not know.....4

5. According to your concept, what is the role of the wetland areas in your property?
Please explain.

6. Have you notice any change in the fish population?

- No.....0
- Yes.....1

If yes, then

- Decreased.....0
- Increased.....1

7. Do waterfowl use your property for nesting or stop-over only, particularly if you live near large water bodies or streams?

- Nesting.....1
- Stop-over.....2
- Both.....3
- Do not know.....4

8. Do you have marsh areas or pastures that are not grazed on your property that would encourage waterfowl to stay?

- No.....0
- Yes.....1

9. About the wildlife, did you notice a change?

- No.....0
- Yes.....1

If yes, then

- Decreased.....0
- Increased.....1

10. If it decreased, do you have any idea what the cause might be?
Explain.

11. Do you use fire in your property as a management tool?

- No.....0
- Yes.....1

Please explain.

12. If yes, when and how often.

13. Has there been any road construction that affected the water level in your property?

No..... 0

Yes..... 1

If yes, how has this affected your operation?

Specify.

14. From whom and where the management practices used in your property were obtained?

Explain.

15. Have you attended any government environmental education seminar?

No..... 0

Yes..... 1

If yes, then was it useful?

No..... 0

Yes..... 1

16. Are there native weeds to the area in your pasture?

No..... 0

Yes..... 1

If yes, name them.

17. In the last 10 years, did they increase drastically?

No..... 0

Yes..... 1

18. Have you tried to eliminate them?

No..... 0

Yes..... 1

Explain.

19. What is the general situation of the prairies?

20. According to your point of view, what is the environmental situation of the wetlands in your zone?

21. Have you notice any changes in the numbers of capybaras in your property in the last 10 years?

Decreased.....0

Increased.....1

22. What could be the cause for this change?

IV. PERSONAL INFORMATION

1. Gender

Female..... 1
Male..... 2

2. Age

3. Civil Status

Single..... 1
Cohabiting..... 2
Married..... 3
Widowed..... 4
Divorced/Separated..... 5

4. For how many children and other members of your family are you responsible?

< 5 years.....
5-15 years.....
> 15 years.....

5. What was the highest level of education did you achieve?

Elementary..... 1
High School..... 2
Vocational..... 3
University..... 4

If 1 or 2, then what grade?

6. Have you ever had environmental awareness program taught to you?

No..... 0
Yes..... 1

If yes, which institution(s) implemented this program?

Municipality.....
Government.....
NGO.....
University.....

7. Have you ever had public participation in decision-making groups?

No..... 0
Yes..... 1

If yes, then specify.

**Appendix III Questionnaire for environmental professionals.
Five open-ended questions
Recorded**

1. What is the situation of the wetlands in Paraguay and in the Ñeembucú?

2. What is the socioeconomic condition of the people living in the Ñeembucú?

3. Talk to me about the flora and fauna of the region.

4. What role do ranchers play in this wetland?

5. What is the environmental perspective from a Government, NGO and community point of view in this area?