AN ECOLOGICAL APPROACH TO COMMUNITY-BASED CONSERVATION:

MANAGEMENT OF *PODOCNEMIS* RIVER TURTLES IN NOEL KEMPFF MERCADO

NATIONAL PARK, BOLIVIA

by

ALISON JEANNINE LIPMAN

(Under the Direction of C. RONALD CARROLL)

ABSTRACT

The essential role that science plays in conservation is widely recognized in the literature and in conservation legislation. However, there is often a disconnect between science and conservation in practice, especially in locally-based projects, where the results of ecological research rarely translate to a local ethic. This is especially true in “community-based” conservation efforts, which attempt to include local people in conservation, so as to create projects that are more equitable, locally relevant, and conserve biodiversity outside of protected areas. I address the often cited failure of community-based projects to both conserve biodiversity and provide locally relevant planning. I present a turtle conservation project based in ecological research and directly managed by local people in Noel Kempff Mercado National Park (PNNKM), in the Amazon Basin of Bolivia. It is collaboration between PNNKM administration and local indigenous communities that works to conserve *Podocnemis unifilis* (yellow-spotted Amazon river turtle) and *P. expansa* (giant South American river turtle), declining river turtles that are important biodiversity components and have regionally important cultural and economic values. I present ecological and social research, collected by local people, with my scientific collaboration, that will inform a community-based PNNKM management plan for the species. Ecological research investigates local population viability and threats (human and natural) to the species. Studies include: (1) a nesting study that compares turtle reproduction (number of nests laid, female turtle size, hatchling size, and nest survival) between sites at different levels of human use; (2) a social study that investigates local consumption of the species; and (3) interviews that query local knowledge of the species and opinions and ideas for the management plan. Results document strong negative effects in turtle populations that are close to human settlements, high levels of local consumption of the species, and high levels of nest mortality caused by animal predation and river inundation. Social studies document majority local support for the project and belief that a management plan will be necessary for local conservation of the species. Results will directly inform the PNNKM community-based management plan. Methods and results could be relevant to conservation schemes throughout the tropics.

INDEX WORDS: Podocnemis expansa, Podocnemis unifilis, river turtle, turtle conservation, Bolivia, community-based conservation, tropical conservation

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DEDICATION

I dedicate this dissertation to Bill Young and Bruce Haines, two men who had a great impact on my life and passed unexpectedly last year. Both men dedicated their lives to helping young people improve themselves and gain a greater appreciation of the natural world. Bill Young, as my Girl Scout leader and extended family, was an influential force throughout my entire life. I loved him greatly and will never forget one of the lessons of his life- that showing young people love, and giving them new opportunities, is the most important way we can change this world. Bruce Haines, as my professor and member of my Ph.D. advisory committee, was an influential force throughout my time at UGA. I respected him greatly as a scholar, colleague, and friend. He taught me that the study of Ecology has everything to do with passion and collaboration.

Above all, I dedicate this dissertation to my parents, David and Susan Lipman, and to my sister, Karin Lipman Nassar. Without the love, support, and understanding of these three people, throughout my entire life, I would not be the person I am today, nor would I have accomplished all I have. If I ever needed a role model, for how to live my life or how to go about my work, I had to look no further than my family. Each in their own way has had (and continues to have) a great impact in the world, by improving the lives of other people. They are selfless people who give of their time to others, when at times I feel that I could not. I learned my love of the natural world from my parents, and I share my love of the natural world with all three. I love my parents and sister truly. It is their belief and support in me and what I do that makes me strong always.

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CHAPTER 1

INTRODUCTION

The essential role that science plays in conservation planning is broadly recognized in the literature (Ehrlich & Daily 1993; Meyer & Helfman 1993; Mooney & Sala 1993; Policansky 1993; Rubenstein 1993; Western 2000). Science both motivates and informs conservation legislation and international treaties, such as the U.S. Endangered Species Act and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), where scientific documentation of species' declines is a prerequisite for their listing. After listing, management plans, informed by species' life histories, documented threats, and ecological monitoring, are created to target relevant conservation action.

Despite this connection between large-scale conservation planning and science, it goes largely unnoticed that science is often lacking, or weakly applied, at the local or community level, where most resource-use issues are played out. This is partly because although scientific research can be highly localized, the knowledge derived from it is rarely shared at the small-scale of people and communities. This is seen throughout the tropics, where endangered species legislation (both national and international laws) is largely ineffective at protecting species (Ojasti & Rutkis 1965; Ojasti 1972); because, the infrastructure necessary to enforce conservation laws does not exist, and the scientific justification that backs the laws is often not translated into a local ethic (e.g., perceived need for biodiversity conservation at the local level).

Scientific knowledge related to biodiversity decline and conservation is thus most lacking where it would be most relevant: in the communities that directly utilize and depend on imperiled species. Local people are sometimes a major source of risk to endangered species, but they also have self-interest in the sustainable management of the species. For this reason, local communities are both part of the problem and part of the solution for species survival, and their involvement in conservation programs should be seen as essential. However, even where local conservation efforts are organized, the necessary science to inform them (and make them successful), is often lacking.

I put forth three general reasons for the lack of science to inform local conservation: (1) The direct goal of most ecological research is not conservation per se of the organisms and systems it studies but rather more generalized knowledge; therefore, results are not directly applicable to conservation; (2) People involved in conservation within their communities have limited access to scientific tools or the banks of knowledge (jargon-filled scientific journals) they create; and (3) Ecological science, that could be relevant to local conservation, is often conducted by outsiders who export all research data and results back to their countries of origin. Because of this disconnect, the need for scientists to actively inform conservation planning at all levels is now widely recognized in the field (Costanza 1993; Ehrlich & Daily 1993; Fuentes 1993; Meyer & Helfman 1993; Rubenstein 1993; Salwasser 1993; Groom et al. 2006).

In this dissertation, I specifically address the need for scientific collaboration in locally-based conservation projects, including what are often termed “community-based” or “participatory action” projects. These projects have been widely promoted by both local and international conservation agendas, especially beginning in the 1980s, as a response to: (1) the recognition that protected areas are not large enough to conserve most biodiversity, (2) the failure of top-down conservation initiatives, in human-dominated landscapes, that exclude, and are thus not supported by, local people, and (3) human justice issues; namely, recognition that, while conservation initiatives in developing countries have origins in colonial protectionist schemes imposed upon indigenous people (in subsistence-based high poverty regions), local people have rights to be stewards of the natural resources upon which they depend (Brosius et al. 1998; Newmark & Hough 2000; Western 2000; Berkes 2007; Horwich & Lyon 2007). These projects have become especially prevalent and promoted by international conservation organizations in developing (many tropical) countries, where there is little financial support to enforce top-down environmental initiatives.

Despite what appears to be a more equitable and collaborative approach to conservation, counter-arguments in the literature document the perceived failure of "community-based" efforts to conserve natural resources (Oates 1999; Newmark & Hough 2000; Terborgh 2000; Terborgh et al. 2002). Two reasons for this are that: (1) although labeled "community-based," these projects often lack true local governance and fail to protect local livelihoods. Instead, they are planned by outsiders who have little knowledge of local conditions and are thus not relevant to or supported by local people (Newmark & Hough 2000; Brechin et al. 2002; Wilshusen et al. 2002; Brosius & Russell 2003; Horwich & Lyon 2007). And (2), as discussed above, community-based projects are often not informed by scientific knowledge or monitoring; their basic design then fails to produce sustainability (Newmark & Hough 2000). I see the underlying problem as a disconnect between conservationists, local people, and scientists.

This dissertation was initiated as a collaboration- between Noel Kempff Mercado National Park (PNNKM) and local indigenous communities of the Bajo Paraguá TCO (Tierra Comunitario de Origen) of Santa Cruz, Bolivia - on a conservation project that both parties agreed had two prerequisites: (1) that it truly be locally-based and co-managed by local communities and (2) that it be informed by ecological study. As such, it addresses the disconnect described above. The project is situated in a subsistence-based region of the Amazonian tropics, on the Paraguá and Itenéz/Guaporé Rivers in and near PNNKM, a World

Heritage Site in Bolivia. Its conservation foci are *Podocnemis unifilis* (yellow-spotted Amazon river turtle, locally "tracayá") and *P. expansa* (giant South American river turtle, locally "tataruga"), rapidly declining river turtles that have regionally important cultural and economic value and can act as keystone species in their habitats (Turtle Conservation Fund 2002).

Both species were once ubiquitous throughout the Amazon and Orinoco river basins; they are now listed in the IUCN Red List of Threatened Species (Species Survival Commission 2008) and classified as "Endangered" by the U.S. Fish & Wildlife Service (October 5, 2007). Hunting pressure is documented as the basis for their decline, as breeding females and their eggs are principal sources of protein for local people (Ojasti 1971; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Cantarelli 1997). Human land use that affects turtle habitat is documented as a secondary threat (Ojasti & Rutkis 1965; Food and Agriculture Organization 1988; Fachín Terán 1994; Thorbjarnarson et al. 1997; Escalona & Fa 1998).

The general objective of the project is to conserve and manage viable populations of *P. unifilis* and *P. expansa* within and near PNNKM, in conjunction with the rights and livelihoods of local ribereño (riverside) human communities. My specific objectives in this dissertation were:

1) To present the results of two years (2005-2006) of ecological and oral history research, which investigated the status of local *Podocnemis* populations and identified key threats to their survival, that will inform management actions directed towards recuperation and conservation of the species.

2) To present the results of two years of project capacity building and education programs, which are essential to project sustainability.

3) To identify mechanisms for creating favorable conditions in the natural habitat for recuperation and survival of the species.

4) To identify actions for a sustainable subsistence use of the species in local indigenous communities.

5) To present a framework for the PNNKM *Podocnemis* Management Plan, which will be based in local communities and local government, and informed by ecological research and monitoring.

The project is locally-initiated and managed, yet it is supported by collaborative alliances that ensure its scientific integrity and long-term sustainability. It is a response to reports of *Podocnemis* population decline in PNNKM, made by concerned local people who depend on turtles as a subsistence protein source. This reported decline expresses the stake that local people have in sustainable turtle management, and it is the basis from which the framework for the community-based turtle conservation plan has been forged. I use the ecological research presented here, conducted largely by local citizens under my training and supervision, to describe the status of this natural resource and to create a framework for planning and implementing conservation relevant to local people.

Project Location

The Amazon Basin

The geographic context of this project was a major driver in its initiation. At the large scale, the Amazon Basin is the world's most biodiverse terrestrial ecoregion, containing over half of the world's remaining tropical rainforests, which are being destroyed faster than any other forest in the world (Mittermeier et al. 2003). Its natural forest area decreases in size year by year, as deforestation rates rise due to unsustainable land conversion practices. These rapid changes will have unprecedented effects on biodiversity, regional hydrology, forest composition, and the global carbon cycle (Laurance 1998; Intergovernmental Panel on Climate Change (IPCC) 2007). The increasing pressures on biodiversity in the Amazon create an intense need for an approach to conservation that works. I theorize that only collaborative approaches to conservation, which combine the tools of science and ecological knowledge with the needs of the people who put biodiversity at risk, can halt unsustainable development where it is occurring- at the local level.

Bolivia

Bolivia, situated on the southern edge of the Amazon Basin, is a unique country in Amazonia. It has the sixth largest area of tropical forests in the world (Laurance 1998), and due to historically low rates of deforestation, its forests remain relatively intact amidst the rapidly dwindling forests surrounding it (Hindery 1997). As of 1990, only 5.6% of the original forested area in the Bolivian Amazon had been cleared (Kaimowitz et al. 1999). However, since the 1980's, a severe economic crisis caused the national government to institute structural adjustment policies, through reductions in urban public sector spending, currency devaluation, and fiscal incentives, that opened the Amazon region to colonization and development (Hindery 1997). These policies placed economic pressures on displaced peoples to migrate from the highlands to the lowlands, promoted road improvements into forest areas, and stimulated forest clearing for agricultural export products (Hindery 1997). This caused a drastic expansion of deforestation practices in the Bolivian Amazon, through an increase in unsustainable agriculture and forestry implemented by a tremendous influx of people. It also opened up the region to the controversial but increasing development of Bolivia's natural petroleum reserves.

All of this eventually led to the expansion of Bolivia's soybean exports, which was at the heart of the World Bank's strategy for improving Bolivia's foreign exchange situation (Hindery 1997). However, most benefits of this agricultural expansion went to a few hundred wealthy individuals, of whom 80% are not Bolivians, but Mennonite, Japanese, and Brazilian immigrants who took advantage of the situation (Hindery 1997). And, these benefits have most often been at the expense of the Bolivian people and the natural biodiversity of Bolivia's Amazon region.

Bolivia has the largest indigenous population in Latin America, a long and recent history of political unrest, and it is one of the poorest countries in the western hemisphere (Kaimowitz et al. 1999; CIA 2007). The push for colonization of the lowlands caused much disturbance to local socio-economies and cultures, which simultaneously placed a new and increasing pressure on Bolivia's tropical resources (Hindery 1997). Increasing numbers of poor and subsistence-based people have come to depend on resources that cannot sustain their unregulated use. And, up to and including the present time, national funding has not been available or prioritized for management of these same resources. Given the country's cultural and economic situation, there is a strong need in Bolivia for a conservation initiative that is local and can address both the scientific and social realms relevant to the problem- one that can simultaneously benefit the environment and the often poor people that depend on it. The project I present here addresses the human needs specific to the geographic location in eastern Bolivia, which could be representative of subsistence-based human needs throughout the tropics.

Noel Kempff Mercado National Park

The specific location of this project, Noel Kempff Mercado National Park, is located in the northeast department of Santa Cruz, Bolivia, at about 61.82º W to 60.23º W and from 13.45º S to 15.10º S (CIA 2007) (Figure 1.1). At 1,523,446 ha, PNNKM is one of the largest and most undisturbed parks in the Amazon basin (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). It is a listed World Heritage Site, one of the most biologically diverse areas of the world , and it contains some of the largest, most intact, and important habitats for conservation of terrestrial biodiversity globally (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). No other protected area in the Amazon contains the diversity of habitat types found in the park: Amazonian evergreen rainforests, palm forests, cerrado, swamps, savannahs, gallery forests, and semi-deciduous dry forests (IUCN 2000).

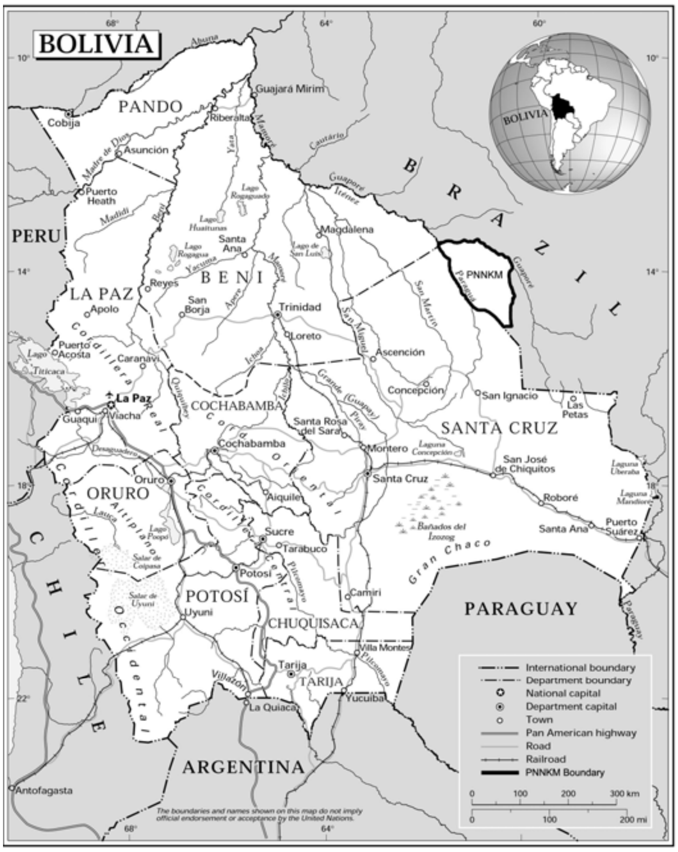

Figure 1.1. Noel Kempff Mercado National Park, Bolivia (United Nations, 1995, with park overlay by A. Lipman).

PNNKM is located on the southern fringe of the Amazon drainage, with rivers forming ninety percent of its boundary. The Paraguá River forms its western border, draining northward to the Iténez River (Guaporé in Brazil), which forms the park's northeastern border and Bolivia's border with Brazil. The Paraguá, a river navigable by small craft, borders Bolivian indigenous communities. The Iténez is a larger order river navigable year round by larger craft, mostly originating from Brazil. These easily accessible river borders make the park especially vulnerable to human activities, both from within Bolivia, as well as from the Brazilian side, which is outside the control of the Bolivian National Park system. Average annual precipitation is between 1,400 and 1,500 mm, with maximum precipitation in January and February, with means of 194 and 196 mm, and the driest month in July, with only 18 mm of precipitation (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). This pattern corresponds with river levels being lowest from July through December. This coincides with the *Podocnemis* nesting season, which is dependent on low water levels to expose beaches necessary for nesting activities.

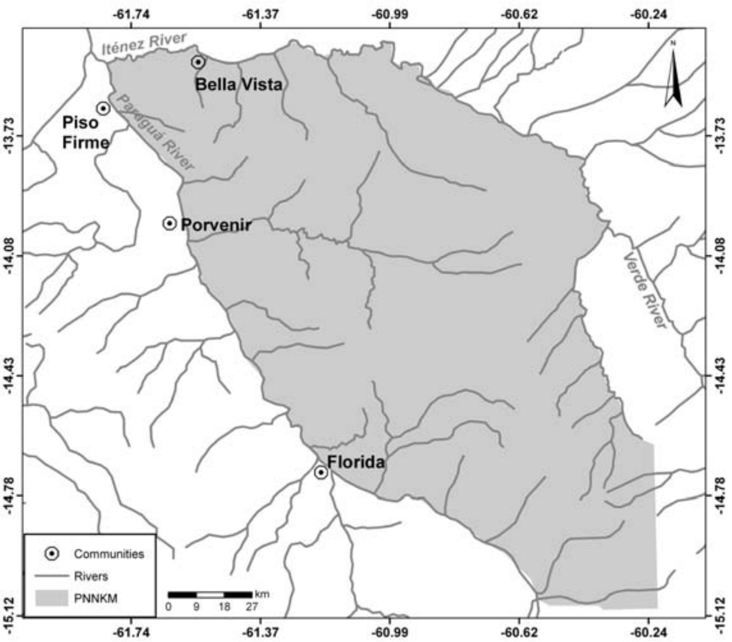

Figure 1.2. Noel Kempff Mercado National Park with participating local communities. Map by Marcia Snyder.

Project Need

As described, the geography of PNNKM (easily accessible river borders) makes the park especially vulnerable to human activities and increasing development pressures, especially those originating from the Brazilian side of the Iténez River. Complicating this, although the park is an internationally recognized center of biodiversity, its ecology remains largely understudied due to a historic lack of funding and scientific expertise to support research and conservation in Bolivia. For these reasons, park management has not had the resources to create or implement management plans that target specific species, in spite of the presence of many endangered species in the park, and Bolivian law, which requires management plans for all wildlife species used by human populations. There have been no previous studies related to *Podocnemis* population integrity in PNNKM, and there have been no documented efforts at creating an organized plan for their conservation in Bolivia.

With this dissertation, I address this situation, by targeting *Podocnemis* species, which are PNNKM administration's first priority for a species-specific conservation plan. At the request of all local stakeholders, institution of this plan will be an international collaborative effort to promote local and science-based conservation. The knowledge acquired through this project, and presented here, will enable intelligent planning for conservation of the species in PNNKM. It could also be relevant to other turtle conservation projects throughout Bolivia and the tropics in general.

This project was initiated to mediate what the collaborators (I, PNNKM administration, and local communities) perceive to be an imminent threat to local and global biodiversity: the unregulated use of, and thus decline in, freshwater turtle resources. It was initiated as a response to the observed decline of *Podocnemis* turtles (sentiment that turtles are decreased in abundance today in comparison with memories of the past), by local people who depend on them for subsistence purposes (Conway 2004; personal communication with local resource managers 2003; Conway-Gómez 2007). In the summer of 2003, when I was visiting the park office in Santa Cruz de la Sierra, I was approached by the directors of PNNKM and local community members, to see if, as a scientist, I would be interested in collaborating on a community-based *Podocnemis* conservation project they wished to institute. Local resource managers wanted to conduct ecological research to assess the status of (and threats to) populations of both *Podocnemis* species in PNNKM, which could then inform management actions necessary to local conservation of the species. If the species are shown to be in decline in PNNKM, they expressed their desire for scientific collaboration in creating a locally-based management plan. This dissertation thus directly addresses the expressed local conservation needs and wildlife management goals, of stakeholders in PNNKM, a Bolivian nationally protected area.

This dissertation also addresses (see Chapter Two) a need relevant to turtle conservation efforts worldwide: that turtle conservation projects are often not based on scientific understanding of specific turtle life histories and threats, and have thus been largely ineffective at maintaining turtle populations. Throughout every phase of this project I have used ecological study as a tool that directly informs recommendations for local management. I also address the problem that many conservation efforts in subsistence-based regions fail because they do not address the needs and rights of local people, such as the right to food (Conway 2004; Conway-Gómez 2007). The project I present here is not just community-based; it was community-initiated. Its objective is two-fold: to generate favorable conditions for turtle conservation and recuperation, while addressing the subsistence needs of local human populations.

My objective in this dissertation is to present a local institution-building program that uses ecological study at the local level to conserve natural resources that people depend on. I aim to demonstrate that conservation of these endangered species can fulfill the needs of local people as well as the goals of PNNKM administration, which is to conserve the biodiversity and natural resources of Bolivia.

<u>Project Objectives, Questions, and Hypotheses</u>

General Objective

To conserve and manage viable populations of *P. unifilis* and *P. expansa* within and near PNNKM, in conjunction with the rights and livelihoods of local ribereño (riverside) human communities.

Specific Objectives

1. To increase scientific knowledge of *Podocnemis* populations within and near PNNKM, so that an effective conservation strategy for these species can be implemented. By collecting scientific data specifically relevant to local *Podocnemis* conservation, I directly address the described need for a science-based turtle conservation strategy in PNNKM.
2. To strengthen the capacity of local residents and park officials in the management, research, and conservation of *Podocnemis* resources. This addresses the discussed need for a locally-based conservation strategy in the targeted region, in which I believe success of the conservation goal depends on the ability of local resource managers to conduct all aspects of project planning and implementation.
3. To create and implement a long-term management plan for *Podocnemis* conservation that will be based in local management, informed by ecological research, and mitigate the decline of *Podocnemis* species in and near PNNKM.

Questions and Hypotheses

In direct response to the objectives listed above, this dissertation tests and answers the following two questions:

1. Are populations of *P. unifilis* and *P. expansa* affected by human activities in and near PNNKM? This was addressed by testing the following hypothesis:

H_1: Direct human use of turtles by local communities (i.e., hunting, egg gathering) has negatively affected *Podocnemis* populations in and near PNNKM.

I also posed a second hypothesis, which I did not directly test in this dissertation, but which I addressed and recommend be tested in future project-related research: (H_2: Human land use practices (e.g., cattle ranching, agriculture, logging, tourism), resulting in changes to habitat and river and stream hydrology, have negatively affected *Podocnemis* populations in and near PNNKM).

2. How can baseline population information be used to formulate species management and monitoring plans with both national park and local community engagement?

Project Methodology

I outline project methodology as corresponding to the three specific objectives I discussed above.

1. To increase scientific knowledge of *Podocnemis* populations within and near PNNKM, so that an effective conservation strategy for these species can be implemented.

To address the first question, I implemented two years (2005-2006) of ecological study of *Podocnemis* population integrity in PNNKM and possible negative human impacts, as well as any potentially positive stewardship efforts (e.g., guarding of nesting beaches). I analyzed both small-scale/direct (i.e., local consumption) and large-scale/indirect (e.g., land use) human pressures on *Podocnemis* turtles in PNNKM. In addition to small-scale factors in species decline, a large-scale or landscape level analysis offers a valuable perspective from which to consider interactions of human and natural systems and the resulting impacts on natural systems (Forman & Godron 1986).

To test null hypothesis I, research involved the following:

a. Nesting studies to obtain reproductive population data.

b. Local interviews to obtain human consumption (turtle mortality) data.

c. Local interviews to obtain temporal and spatial patterns of turtle populations and their consumption.

To address null hypothesis II, research involved the following:

d. Local interviews to obtain temporal and spatial patterns of turtle populations and human land use and river movement.

e. Analysis of current and historic riverine habitat to determine possible human land-use effects on turtles.

2. To strengthen the capacity of local residents and park officials in the management, research, and conservation of *Podocnemis* resources.

In order to create and implement a true community-based conservation plan, part of the project focused on local capacity building; this included community-level training, technology transfer, and information exchange. This consisted of regularly working with park guards and the hiring and training of local residents. Through these efforts, PNNKM personnel and community members are developing the tools necessary to conserve their natural resources and livelihoods into the future.

3. To create and implement a long-term management plan for *Podocnemis* conservation in and near PNNKM.

Creation of this plan will be a collaborative process in which all the efforts of project research, planning, implementation, and evaluation are shared and discussed among all stakeholders. It will meet the following agreed upon requirements:

a. be based in local community management.

b. be supported by collaborative alliances.

c. be informed by the results of scientific research.

d. generate favorable conditions in the natural habitat for species' recuperation.

e. promote a more sustainable use of the species.

f. address the subsistence needs of local human populations.

g. involve long-term ecological monitoring of the species.

h. include regular evaluation of the strategy that will inform its renovation.

The project goal is, through active involvement of local people, to implement a National Park management plan that successfully conserves endangered species, addresses the subsistence needs of local human populations, and is sustainable in the long-term.

Chapter Organization

The dissertation is organized as a thorough presentation of the project to date. It includes project background and need; review of the relevant literature; methodology and results of ecological research; and results of the on-site capacity building and education programs. It concludes with a framework for the Management Plan and recommendations for future efforts.

In Chapter Two I review the literature relevant to the project- both research and conservation oriented. I present the literature relating to the global turtle decline problem, life history and decline of *Podocnemis* turtles, and relevant turtle conservation methodology. Chapters Three through Five are written as separate manuscripts for publication. Chapter Three is a short paper that presents the general research and conservation project. Chapters Four and Five present the results of three related research projects that address the two questions and analyze both small (e.g., human consumption) and large spatial (e.g., human land use) factors in local *Podocnemis* decline. Results answer the two questions outlined above; in doing so they provide the scientific basis for the Management Plan.

Chapter Three, titled "Locally-based conservation of *Podocnemis* river turtles in Noel Kempff Mercado National Park, Bolivia," summarizes the three phases of the ongoing conservation project. The first phase is a social/economic study of *Podocnemis* use in PNNKM, by Kristen Conway (2004). The second phase is the dissertation research presented here, and the third phase includes future plans of action. The paper draws conclusions relevant to broader conservation applications in subsistence-based regions.

Chapter Four, titled "Effects of human activity on nesting of *Podocnemis* turtles in Noel Kempff Mercado National Park, Bolivia," presents a study of local turtle nesting populations (nesting females and eggs) to obtain reproductive and mortality data. The study compares nesting data among six nesting sites, three on the Iténez/Guaporé River and three on the Paraguá River. The three nesting sites on each river are impacted by human turtle hunters and egg gatherers, at three different levels of intensity. I present these levels of human exploitation as three "treatments" of human impact, described as follows: (1) nesting sites that are close to human communities and subjected to direct intense exploitation by humans, (2) nesting sites that are far enough from human communities that people do not travel to hunt turtles or eggs, and (3) nesting sites that are accessible to human communities, but protected by beach guards from human use.

Findings demonstrate direct negative human effects on abundance of nesting female populations and nest survivability, caused by high rates of human exploitation of female turtles and their eggs. Findings also demonstrate indirect negative human effects on turtle nesting, caused by tourism, motor boat traffic, and grazing cattle. As well, I document animal predation and inundation of nesting beaches as additional causes of low survivability.

Chapter Five, titled "Community derived knowledge of *Podocnemis* turtles: their history, threats, and management needs in Noel Kempff Mercado National Park, Bolivia," presents two studies conducted through interviews with local residents. Both studies are PNNKM-initiated programs I helped design and implement. The first study was conducted by local students, to obtain local human use data in the communities of Bella Vista, Porvenir, and Piso Firme. It is part of an educational program instituted by the project. Results document high rates of use of both species and their eggs in all neighboring human communities, with a few families being the primary sources of turtle mortality in the larger communities. The second study was conducted by local citizens, in interviews with local residents (from the communities of Bella Vista, Porvenir, Piso Firme, and Florida), who queried temporal and spatial patterns of turtle populations and opinions and ideas related to turtle management. Interviews document a decline in both species over time, noticed by the majority of local inhabitants. As well, they document increasing development of riparian corridors, most noticeable on the Brazilian side of the Iténez/Guaporé River, widespread local concern that turtles are disappearing, support for the project, and ideas for management options and sustainable use of turtles.

Chapter Six, titled "Framework for a community based *Podocnemis* Management Plan in Noel Kempff Mercado National Park, Bolivia," outlines the backbone for the PNNKM *Podocnemis* Management Plan. The Management Plan was solicited by both PNNKM administration and local indigenous authorities; thus, the information presented here will directly inform the plan that will be implemented this year 2008, in PNNKM and neighboring communities. The sections correspond to those required by the Bolivian Ministry of Rural Farming Development and Environment (Ministerio de Desarrollo Rural Agropecuario y Medio Ambiente), in *Management Plans for Fauna* (Museo de Historia Natural Noel Kempff Mercado 2006). These include: "Background and project justification," "Project collaborators," "General and specific objectives," "Project area," "Social context," "Capacity building and education," "Ecological diagnostic," "Management actions and sustainable use," "Monitoring plan," "Documentation and evaluation," "Economic aspects," and finally, my recommendations for future action. Lastly, Chapter Seven summarizes the dissertation with a discussion of overall conclusions and broader applications.

References Cited

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Berkes, F. 2007. Community-based conservation in a globalized world. Proceedings of the National Academy of Sciences **104**:15188-15193.

Brechin, S. R., P. R. Wilshusen, C. L. Fortwangler, and P. C. West. 2002. Beyond the square wheel: Toward a more comprehensive understanding of biodiversity conservation as social and political process. Society and Natural Resources **15**:41-64.

Brosius, J. P., and D. Russell. 2003. Conservation from above: An anthropological perspective on transboundary protected areas and ecoregional planning. Journal of Sustainable Forestry **17**:39-65.

Brosius, J. P., A. L. Tsing, and C. Zerner. 1998. Representing communities: Histories and politics of community-based natural resource management. Society and Natural Resources **11**:157-168.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

CIA. 2007. The World Factbook.

Conway-Gómez, K. M. 2007. Effects of human settlements on abundance of *Podocnemis unifilis* and *P. expansa* turtles in northeastern Bolivia. Chelonian Conservation & Biology **6**:199-205.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Costanza, R. 1993. Developing ecological research that is relevant for achieving sustainability. Ecological Applications **3**:579-581.

Ehrlich, P. R., and G. C. Daily. 1993. Science and the management of natural resources. Ecological Applications **3**:558-560.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Food and Agriculture Organization. 1988. Las tortugas del río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Areas Silvestres **Año 3**:23-29.

Forman, R. T. T., and M. Godron 1986. Landscape Ecology. John Wiley & Sons, New York.

Fuentes, E. R. 1993. Scientific research and sustainable development. Ecological Applications **3**:576-577.

Fundación Amigos de la Naturaleza (FAN), and The Nature Conservancy (TNC). 1996. Plan de Manejo: Parque Nacional Noel Kempff Mercado, Bolivia in M. d. D. S. y. M. Ambiente, and D. N. d. C. d. l. Biodiversidad, editors, Santa Cruz, Bolivia.

Groom, M. J., G. K. Meffe, and C. R. Carroll 2006. Principles of Conservation Biology. Sinauer Associates, Inc., Sunderland, Massachusetts.

Hindery, D. L. 1997. A history of tropical deforestation in the Bolivian Amazon. Geography. University of California Los Angeles, Los Angeles.

Horwich, R. H., and J. Lyon. 2007. Community conservation: Practitioner's answer to critics. Oryx **41**:376-385.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Page 23. Intergovernmental Panel on Climate Change.

IUCN. 2000. World Heritage Nomination- IUCN Technical Evaluation, Noel Kempff Mercado National Park (Bolivia).

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Kaimowitz, D., G. Thiele, and P. Pacheco. 1999. The effects of structural adjustment on deforestation and forest degradation in lowland Bolivia. World Development **27**:505-520.

Laurance, W. F. 1998. A crisis in the making: Responses of Amazonian forests to land use and climate change. Trends in Ecology & Evolution **13**:411-415.

Meyer, J. L., and G. S. Helfman. 1993. The ecological basis of sustainability. Ecological Applications **3**:569-571.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Mittermeier, R. A., C. G. Mittermeier, T. M. Brooks, J. D. Pilgrim, W. R. Konstant, G. A. B. da Fonseca, and C. Kormos. 2003. Wilderness and biodiversity conservation. Proceedings of the National Academy of Sciences of the United States of America **100**:10309-10313.

Mooney, H. A., and O. E. Sala. 1993. Science and sustainable use. Ecological Applications **3**:564-566.

Museo de Historia Natural Noel Kempff Mercado. 2006. Lineamientos para la preparación y presentación de Planes de Manejo de Fauna Silvestre. Page 14 in Ministerio de Desarrollo Rural Agropecuario y Medio Ambiente, editor, La Paz, Bolivia.

Newmark, W. D., and J. L. Hough. 2000. Conserving wildlife in Africa: Integrated conservation and development projects and beyond. BioScience **50**:585-592.

Oates, J. F. 1999. Myth and Reality in the Rain Forest. University of California Press, Berkeley, Los Angeles, London.

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J. 1972. La Problematica de la Tortuga Arrau. Pages 4-10 in Ministerio de Agricultura y Cria, Dirección de Recursos Naturales Renovables, and Republica de Venezuela, editors.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Policansky, D. 1993. Uncertainty, knowledge, and resource management. Ecological Applications **3**:583-584.

Rubenstein, D. I. 1993. Science and the pursuit of a sustainable world. Ecological Applications **3**:585-587.

Salwasser, H. 1993. Sustainability needs more than better science. Ecological Applications **3**:587-589.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Terborgh, J. 2000. The fate of tropical forests: A matter of stewardship. Conservation Biology **14**:1358-1361.

Terborgh, J., C. van Schaik, L. Davenport, and M. Rao, editors. 2002. Making Parks Work: Strategies for Preserving Tropical Nature. Island Press, Washington, Covelo, London.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington DC.

U.S. Fish & Wildlife Service. October 5, 2007. USFWS Threatened and Endangered Species System (TESS).

Western, D. 2000. Conservation in a human-dominated world. Issues in Science and Technology **Spring 2000**:12.

Wilshusen, P. R., S. R. Brechin, C. L. Fortwangler, and P. C. West. 2002. Reinventing a square wheel: Critique of a resurgent "protection paradigm" in international biodiversity conservation. Society and Natural Resources **15**:17-40.

CHAPTER 2

LITERATURE REVIEW AND BACKGROUND

Turtle Decline: A global concern

This dissertation addresses a specific threat to local and global biodiversity: decline in freshwater turtle populations. This decline has been reported locally, in PNNKM, and it has been documented worldwide by the Turtle Conservation Fund (TCF), a partnership of the IUCN, Conservation International, and over 20 conservation organizations worldwide (TCF 2002). The TCF Global Action Plan (2002) describes a "global turtle survival crisis" and contends that “without (such) concerted conservation action many of the world’s turtles (and tortoises) will become extinct within the next few decades...”

Especially worrisome are the effects that freshwater turtle declines could have worldwide, in natural systems, as turtles are said to serve as keystone species in the ecosystems in which they are found (Turtle Conservation Fund 2002; Moll & Moll 2004). Turtles are large and often abundant in freshwater systems, where they might be the dominant vertebrate in total biomass (Bury 1979). Single standing crop biomass estimates of turtles are some of the highest for vertebrates in aquatic systems, and might be exceeded only by some fishes (Iverson 1982). Research documenting turtles’ high biomass contribution, and their inclusion at every level in aquatic food webs (predators, herbivores, and scavengers), suggests the important roles they play in nutrient cycling and energy flow (Thompson 1993; review in: Moll & Moll 2000; Moll & Moll 2004). Turtles are also important seed dispersers in riverine forests (Moll & Moll 2000; review in Conway 2004) and important sources of food for other animals, especially turtle eggs and hatchlings (Bury 1979; review in Moll &

Moll 2000). Because turtles are considered important biodiversity components of the ecosystems they inhabit, their extinction could cause ecosystems to degrade in ways still incompletely understood (Turtle Conservation Fund 2002; Moll & Moll 2004).

The root of the turtle decline problem lies in turtles' unique life history that has evolved over more than 250 million years (Hugall et al. 2007), and their relatively recent (last million years) interactions with humans. Important life history traits include delayed sexual maturity, high mortality in the first phases of life, long adult life-span with low mortality, iteroparity, large clutch size, and lack of reproductive senescence for many species. The hard carapace, which is an obvious trait that largely defines turtles as a group, protects adult turtles from non-human predators, except those that have powerful crushing jaw, such as crocodilians. While these traits were adaptive in the non-human world, contributing to turtles' success over their long history, they now make turtles poorly adapted to the human dominated world, and thus vulnerable to increasing human induced pressures (Burke et al. 1994; Frazer 2000; Turtle Conservation Fund 2002).

Human pressures in effect reverse the natural selective regime on turtles (i.e., add a cause of mortality to adult stages that had not existed before) increasing the mortality rates of adult turtles (Frazer 2000). As well, human pressures increase the mortality of early turtle life stages (i.e., eggs) by increasing predation on eggs in a manner that is continuous and unrelenting. The following pressures are documented to be causing worldwide decline in freshwater turtle populations: (1) loss and alteration of habitat (e.g., deforestation, agriculture, timber extraction, rural and urban development); (2) use by humans, especially exploitation as a protein food source of nesting females and their eggs; and to a lesser extent (3) disease (Smith 1975, 1979; Alho 1985; Johns 1987; Food and Agriculture Organization 1988; Fachín Terán 1994; Thorbjarnarson et al. 1997; Escalona & Fa 1998; Klemens 2000; Bodie 2001; Turtle Conservation Fund 2002).

Because freshwater turtles live in habitats that throughout history have attracted humans for their water supply, agricultural base, food resources, and transportation, they are especially susceptible to human pressures (Moll & Moll 2000; Moll & Moll 2004). Increasingly, riverine habitats are becoming more inhabited and developed: river banks are developed; rivers are dammed; freshwater is polluted; and hydrologic regimes and geomorphology are altered. All these changes negatively affect turtle populations (reviewed in: Moll & Moll 2000; Moll & Moll 2004). River turtles are especially susceptible to changes in hydrology, because, many species' reproductive habits adapted to patterns of fluctuations in river levels. They are dependent upon lowering water levels exposing nesting beaches in the dry season and early flooding or failure of beaches to become exposed interrupts reproduction (reviewed in Moll & Moll 2004).

In addition to this susceptibility, and because of their large biomass and ease of collection, turtles were targeted as a protein-rich food by the very earliest humans (Kuchling 1999; review in Moll & Moll 2004). Nesting turtles and their eggs are especially easy targets for humans. Female turtles are easily collected live in large numbers, when they are visible and not mobile, nesting on sandy beaches (see Figure 2.1). They are simply flipped onto their backs, then collected at leisure.

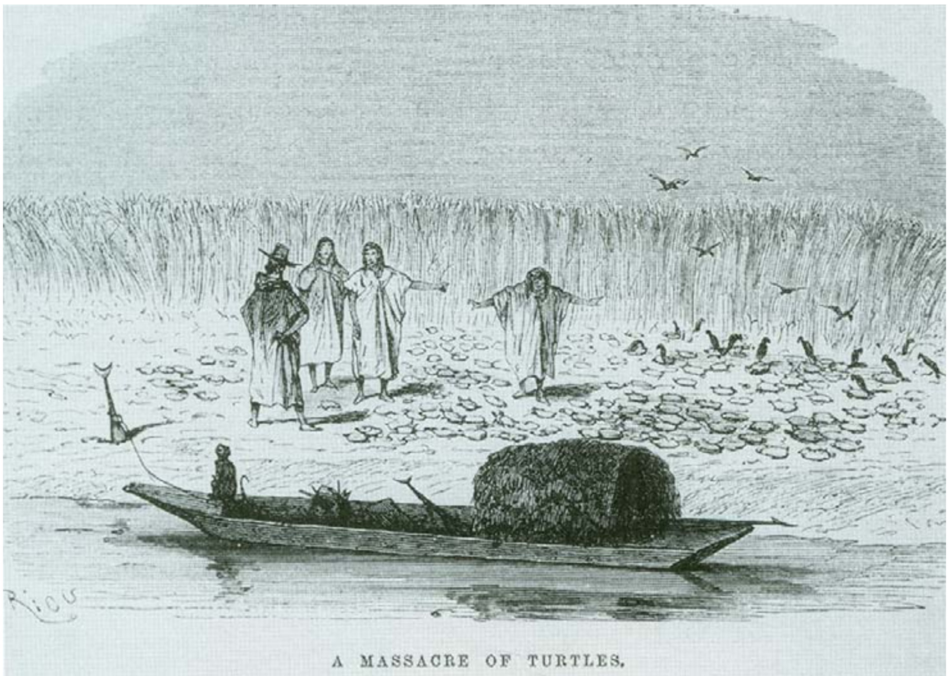

Figure 2.1. A Massacre of Turtles From St. Cricq, 1874 (Moll & Moll 2004).

Eggs are easily dug up, found by tracing (very visible) turtle tracks, or later spotted as (slightly) mounded nests, with a stick or the heel of the foot to detect the nest cavity air pocket (Ojasti 1996; personal observation). Turtles bear the additional risk of being easy to transport (stacked in boats) (see Figure 2.2), with little need for space and food, and can be maintained for months before they are eaten (Thorbjarnarson et al. 2000; personal observation). While traditional hunter-gatherer societies, such as the Australian aborigines, did not appear to deplete turtle populations through harvest (Kuchling 1999), when subsistence hunting pressures increase because of human population growth or socio-economic changes, turtle populations are put at risk of extinction (Klemens & Thorbjarnarson 1995; Kuchling 1999; Thorbjarnarson et al. 2000).

Figure 2.2. Live *Podocnemis unifilis* specimen being transported in PNNKM.

Klemens (2000) asserted that the decline in freshwater turtles is likely more widespread than the amphibian decline phenomenon, because due to the long generation time of turtles, negative effects take longer to create crises apparent to human observation. Especially problematic is the fact that human activities target breeding females and their offspring. An effect of this is that although many current turtle populations appear to be stable in abundance, they can in fact be described as "living-dead," meaning they have no to little recruitment from the earlier life stages and are composed of aged adults that are not being replaced in the population (Gibbs & Amato 2000; Klemens 2000; Moll & Moll 2004). When aged turtles finally die off, turtle populations can seem to disappear quite suddenly.

Compounding the problems discussed here, turtle conservation projects appear to be largely ineffective at maintaining turtle populations; because, they are often not based on scientific analysis or an understanding of turtle’s unique life histories (Gibbs & Amato 2000; Klemens 2000; McDougal 2000; Meylan & Ehrenfel 2000; Moll & Moll 2000; Seigel & Dodd 2000). There is thus an urgent and recognized need for scientists to become involved in turtle conservation. My goal is to help create a scientifically informed plan for turtle conservation in PNNKM and the surrounding indigenous communities. I have collected baseline data, examining the integrity of local turtle populations and their threats. These data, combined with an understanding of the species' life histories, will inform the community-based national park turtle conservation plan (see Chapter Six).

***Podocnemis* Turtles: Life history and decline**

Podocnemis expansa (Schweigger 1812) and *P. unifilis* (Troschel 1848) belong to the family Podocnemidae, which contains three genera of turtles that describe a total of eight extant species. All eight species are found in northern South America, except one species (*Erymnochelys madagascariensis*) that is found only in Madagascar (World Chelonian Trust 2003). All species are freshwater turtles that live in river and lake habitats; they are avid swimmers with flat shells (Pough et al. 2003). Most species in the family are herbivores, although many can display omnivorous eating habits, and the young of most turtles can be carnivorous (Cole & Link 1972).

The genus *Podocnemis* is the most ancient turtle genus existing today, and at one time it was the most widespread (Pritchard 1979a). Including *P. unifilis* and *P. expansa*, there are six species in the genus *Podocnemis*. Other species include: *P. erythrocephala* (red-headed river turtle), found in Colombia, Venezuela, and Brazil; *P. lewyana* (Magdalena river turtle), found in Colombia and Venezuela; *P. sextuberculata* (six-tubercled river turtle), found throughout the Amazon drainages of northern Brazil, northeastern Peru, and southeastern Colombia; and *P. vogli* (Savannah side-necked turtle), found in Venezuela and Colombia (Ernst et al. 1997).

Geography and Habitat

Podocnemis expansa and *P. unifilis* are found throughout the Amazon and Orinoco Basins. *Podocnemis unifilis*, the smaller of the two species, is distributed throughout the Orinoco basin of the Guianas, Venezuela, and Colombia, and the Amazon basin in Colombia, eastern Ecuador, northeastern Peru, northern Bolivia, southern Venezuela, and Brazil (Ernst et al. 1997). *Podocnemis expansa* is distributed in the Orinoco basin in Guyana and Venezuela and in the Amazon basin in Colombia, eastern Ecuador, northeastern Peru, northern Bolivia, Venezuela, and Brazil; occasionally it is found on the island of Trinidad (Pritchard 1979a; Food and Agriculture Organization 1988; Iverson 1992; Ernst et al. 1997). Historical accounts suggest that original populations of *P. expansa* were very abundant, perhaps numbering in the millions; information for *P. unifilis* is more scarce, but some accounts show it as having been less abundant than *P. expansa*, although common in more remote rivers (reviewed in Ojasti 1996).

Both species live in the slow moving waters of big rivers that have changes in their seasonal water levels. During the wet season, they are also found in flooded forests, swamps, and lagoons. *Podocnemis expansa* is found mostly in large rivers and their tributaries (blackwater and whitewater) (Ernst et al. 1997); while *P. unifilis* may also be found further upstream, in smaller, swifter rivers (Ernst & Barbour 1989), lakes, flood-plain pools, and oxbows (Ernst et al. 1997). *Podocnemis unifilis* are regular baskers in the dry season (personal observation; Ojasti 1996); while *P. expansa* females bask only for several weeks before nesting (Ernst & Barbour 1989; Ojasti 1996; Conway 2004).

Biology

Podocnemis expansa is one of the world's largest freshwater turtles, with maximum female size recorded at a carapace length of 80-107 cm (Vanzolini 1977; Pritchard 1979a;

Freiberg 1982; Ernst & Barbour 1989; Ojasti 1996; Moll & Moll 2004) and a maximum weight of 46-90.6+ kg (Pritchard 1979a; Ojasti 1996; Alderton 1998). *Podocnemis unifilis* is smaller, with maximum female carapace length at 45-68 cm (Pritchard 1979b; Freiberg 1982; Ernst & Barbour 1989; Fachín Terán 1992) and maximum weight at 11.2-11.6 kg (Fachín Terán 1992; Ojasti 1996; Fachín Terán & Vogt 2004). Like most river turtles, both species display sexual size dimorphism- females are much larger than males (Moll & Moll 2000). Maximum age of either species is unknown.

Like all *Podocnemis* turtles, both species are mainly herbivorous, but will take some animal food, especially in captivity and in the hatchling phase (Moll & Moll 2004). Both species eat plants, fruits, flowers, roots, plants, seeds, insects, mollusks, freshwater sponge, eggs, and animal remains (Freiberg 1982; Ernst & Barbour 1989; Fachín Terán et al. 1995; Ojasti 1996; Bruno Coca 1999; Moll & Moll 2004). Fachin Terán et al. (1995) reported that *P. unifilis* eats mostly fruits and seeds (at 39% of total food volume) and supplements with plant material (including roots, stems, leaves, and unidentified plant material at 50.2%), algae (0.3%), fish (0.95%), and insects (0.0005%). Both species exhibit neustophagia, a feeding mechanism in which particulate matter is swallowed from the water surface (Belkin & Gans 1968; Rhodin et al. 1981; Ernst et al. 1997).

Reproduction

Podocnemis expansa reaches reproductive age between five and 17 years (Ojasti 1971; Food and Agriculture Organization 1988; Ojasti 1996; Soini et al. 1997; Hernández & Espín 2006). I could not find estimates for *P. unifilis*. Both species nest at night, rarely during the day. Nesting occurs during the dry season, on sandy beaches that emerge as river levels drop, with *P. unifilis* emerging to nest about a month before *P. expansa* (Ojasti 1996; personal observation). Nesting timing varies by geography, and is dependent on hydrologic regimes; in PNNKM the nesting period is roughly August through October. *Podocnemis expansa* females have nesting habits similar to sea turtles: they gather from many miles of river, waiting 10-15 days offshore (Alho & Pádua 1982), to nest under cover of night on large, high, sandy beaches, in large synchronous groups, termed "arribadas" (Pritchard 1979a; Ojasti 1996; Thorbjarnarson et al. 2000; Moll & Moll 2004). Females have nested historically in widespread and massive seasonal migrations of hundreds of thousands of females (Ojasti 1967). In contrast, *P. unifilis* females are less particular about nesting sites; they will nest on beaches of various sizes, heights, and substrates, and they are mostly solitary nesters (Foote 1978; Food and Agriculture Organization 1988; Ernst & Barbour 1989; Ojasti 1996; Moll & Moll 2004).

It is generally agreed that *P. expansa* females lay no more than one nest per year, but estimates range from once a year (Ojasti 1971; Alho & Pádua 1982; Pritchard & Trebbau 1984; reviewed in: Kuchling 1999; Moll & Moll 2004) to once every 2-4 (or "multiple") years (Pritchard 1979a; Ernst & Barbour 1989; Alderton 1998; Kuchling 1999; reviewed in Moll & Moll 2004). Estimations for *P. unifilis* range from one (Thorbjarnarson et al. 1993; Kuchling 1999; Moll & Moll 2004) to more than one nest per year (Ernst & Barbour 1989; Soini 1994; reviewed in Ojasti 1996). Ojasti (1996) stated there is no clear proof of *P. unifilis* laying more than one nest per year.

Estimations for clutch size of *Podocnemis expansa* females range from 26-200 eggs (Ojasti 1972; Mittermeier 1978; Freiberg 1982; Ernst & Barbour 1989; Soini et al. 1997; Alderton 1998; Kuchling 1999; Vanzolini 2003), and hatchlings emerge from the nest in 42-80 days (Mittermeier 1978; Ewert 1979; Freiberg 1982; Food and Agriculture Organization 1988; Ernst & Barbour 1989; Soini et al. 1997; Alderton 1998; Kuchling 1999; Vanzolini 2003). *Podocnemis expansa* hatchlings hatch in at least two waves per clutch. About 60% of the clutch hatches in the first wave, digs to a level about 20 cm below the surface, and waits for the second wave that hatches about three days later (Alho & Pádua 1982). Hatchlings leave the nest together at night, usually waiting for rainy nights at the beginning of the rainy reason, when river levels begin to rise (months vary according to region) (Alho & Pádua 1982; pers. obs. 2005-2006).

Podocnemis unifilis females lay 7-60 eggs per clutch (Foote 1978; Pritchard 1979a; Food and Agriculture Organization 1988; Soini et al. 1997; Kuchling 1999), and hatchlings emerge from the nest in 51-159 days (Food and Agriculture Organization 1988; Soini 1994; Kuchling 1999). Soini (1994) reported that *P. unifilis* eggs incubate for 55-70 days, after which hatchlings break the egg and remain in the broken shell for 2-7 days. They remain a few days to five weeks, a few centimeters below the surface, before exiting the nest all at once, at night, and usually during or after rain. It is this time, waiting in the nest after hatching, which explains the large difference in days documented before hatchling emergence. Sometimes they leave the nest in 2-3 waves over a four week period (Soini 1994).

Like most sexually dimorphic turtle species, under natural conditions both *Podocnemis* species exhibit the TSDIa pattern of temperature-dependent sex determination (TSD), in which relatively low temperatures produce males and higher temperatures produce females (Moll & Moll 2004). *Podocnemis expansa* exhibit TSDII (cool temperatures produce females; intermediate temperatures produce males; and warmer temperatures produce females) under lab conditions, but in natural conditions, where cool temperatures are usually lethal, *P. expansa* exhibits the TSDIa pattern (Valenzuela 2001). *Podocnemis expansa* displays the highest pivotal temperature for TSD, 32.6º C, of any species yet examined (Valenzuela 2001); while, *P. unifilis* has a documented pivotal temperature between 31º C and 32º C (Remor de Souza & Vogt 1994).

Valenzuela (2001) discussed the importance of size structure in *P. expansa* populations. Larger females dig deeper cooler nests, contributing more males to the population than smaller females that dig shallower, warmer nests. *Podocnemis expansa* has a short and specific thermosensitive period during days 29 to 30 of incubation (Valenzuela et al. 1997; review in Moll & Moll 2004), and *P. unifilis* has a long thermosensitive period, extending from a little before the seventeenth day of incubation to the forty-ninth day of incubation (Remor de Souza & Vogt 1994).

Mortality

Types and causes of mortality of turtle eggs include: embryonic and in-shell hatchling mortality; destruction of nests by later nesting turtles; flooding and excessive humidity in nests compacting sand and prohibiting hatchling escape; and animal predators (reviewed in Ojasti 1996). Vanzolini (2003) reviewed studies of egg mortality in both species. An analysis of 15 nesting events in *P. expansa* reported hatching successes from 20% to 93%. An analysis of three hatching events of *P. unifilis* found hatching successes from 78% to 97%. Mittermeier (1978) estimated that only 5% of hatchlings survive the first few hours of life. Generally, survival of freshwater turtles in the egg and hatchling phases are low. Published estimates documented 99% or greater mortality during the first and second years of life, with estimates by turtle experts of 1 turtle in 1,000 to 10,000 surviving to adult phases (Frazer et al. 1990; Moll & Moll 2004).

Causes of natural mortality of *Podocnemis* hatchlings and juveniles include predation on sandy beaches and in water by mammals, birds, crocodilians, and fish (Fachín Terán 1994; Ojasti 1996). Adult turtles of both species have naturally low mortality- usually limited to isolation and drying of habitat, falling in gullies and landing on back, etc. (Ojasti 1972); however, predation by jaguars (*Panthera onca*) of nesting females has been witnessed even in large turtles (Emmons 1989; Fachín Terán 1994; personal observation). Additionally, I have second-hand accounts of black caimans (*Melanosuchus niger*) eating adult turtles (which species of *Podocnemis* is unclear) in the Rio Napo drainage of Ecuador (Ron Carroll, pers. obs., 2008).

Role in the Ecosystem

Like other large species of river turtles, *Podocnemis* turtles are important components of the ecosystems in which they are found. They are important contributors to river system biomass, and, through their feeding, they likely play an important role in nutrient cycling (Food and Agriculture Organization 1988; Fachín Terán 1994; Soini 1994; Kuchling 1999). As discussed above, turtle eggs and hatchlings are important food sources for mammals, birds, lizards, crocodilians, and fish (Bury 1979; Food and Agriculture Organization 1988), and adult turtles are an important food source for jaguars (Emmons 1989; Conway 2004). Another important well-documented role played by *Podocnemis* turtles is in dispersing seeds in flooded Amazonian forests (Ojasti 1971; Fachín Terán 1992; Bruno Coca 1999; Moll & Moll 2000; review in Conway 2004).

Migration

In the Rio Trombetas river, in the Amazon, post-nesting *P. expansa* females, studied with radio-telemetry, traveled up to 45 km in just two days, before their signals were lost (Vogt cited in Moll & Moll 2004). In the Orinoco basin, radio-tagged *P. expansa* females traveled 100 km upstream and a few hundred kilometers downstream from their nesting sites, and they traveled laterally up connecting tributaries (Ojasti 1967). Genetic studies of *P. expansa* in the Araguai and Tapajós river systems in Brazil detected within-system gene flow up to 275 km, with little evidence of gene flow between the two river systems, which are about 2400 km apart (Sites et al. 1999). Bock et al. (2001) found significant differences in allele frequency between turtle populations in Peru and Brazil, but they also found significant differences between turtles nesting on beaches only 80 km apart, in the Brazilian Amazon. They concluded that either females do not migrate far from their nesting beaches, or they travel far but always return to the same nesting beach (recommending further research on the subject). Genetic studies of *P. expansa* by Pearse et al. (2006) found differentiation at both nuclear and mitochondrial loci at the river basin level (between populations of different river basins), but not within populations in a given basin. This lack of differentiation among turtles at different nesting beaches within the same basin supports the hypothesis that *P. expansa* do not home to specific nesting beaches; however, they do have some degree of natal-river fidelity or other behavior that maintains genetic differentiation between populations of different rivers, even those that are geographically close (Pearse et al. 2006). I found no studies tracking the movement of males of either species. K. Buhlmann (pers. comm. 2008) suggested that the mating of wide-ranging male turtles, with female turtles that return to the same nesting beaches, might explain the lack of genetic differentiation between different nesting turtle populations.

Movement of *P. unifilis* is not well studied, but seems to be more limited than it is in *P. expansa*. Initial radio telemetry studies by Bock et al. (1998) found limited movement of *P. unifilis* females from their nesting sites. Genetic studies detected as much genetic differentiation between populations 60 km apart as between populations hundreds of kilometers apart (Bock et al. 2001), supporting the supposition that *P. unifilis* do not move far from their nesting sites.

Decline

Decline in *P. expansa* and *P. unifilis* is strongly related to their riverine habitat, as throughout the history of tropical South America people have been attracted to live near rivers, which provide an abundant water supply, food resources, agricultural foundation and transportation (review in Conway 2004). Decline in both species, documented since the sixteenth century throughout the extent of their range, is attributed to the over-exploitation of turtles (mostly breeding females extracted from nesting beaches) and their eggs by humans, for food and oil, with some negative effects caused by river flooding of nest sites and human development (e.g., deforestation, agriculture, timber extraction, and rural and urban development- which cause physical alterations of rivers and floodplains and increased inputs of sediments and toxins) (Ojasti & Rutkis 1965; Ojasti 1971; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Food and Agriculture Organization 1988; Fachín Terán 1994; Ergueta & de Morales 1996; Cantarelli 1997; Thorbjarnarson et al. 1997; Escalona & Fa 1998; Conway 2004).

Both species have long been important sources of protein for Indians of the Amazon and Orinoco basins, who collected large quantities of turtles and their eggs before European contact (Ojasti & Rutkis 1965; Ojasti 1971, 1972; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Food and Agriculture Organization 1988; Fachín Terán 1994; Klemens & Thorbjarnarson 1995; Cantarelli 1997; Licata & Elguezabal 1997; Thorbjarnarson et al. 1997; Escalona & Fa 1998; Moll & Moll 2000; Turtle Conservation Fund 2002; Orellana 2004). Widespread use of turtles probably dates from the earliest humans in these areas, and was documented in the first written and drawn records of the region, by early naturalist explorers such as von Humboldt (1819) and Bates (1863), who described in detail extensive use of the species (reviewed in: Conway 2004; Moll & Moll 2004). This use first focused on the larger *P. expansa*, but with depletion of this species, use shifted to smaller species, such as *P. unifilis* (Mittermeier 1975; Smith 1979; Alho 1985; Thorbjarnarson et al. 1997; Thorbjarnarson et al. 2000).

Not only were eggs, hatchlings, and adult turtles used widely as food sources by indigenous groups, but oil extracted from turtle eggs was used in creams and paints, for cooking, and for lighting (reviewed in Thorbjarnarson et al. 2000). The great abundance of the species, combined with their defenselessness (i.e., non-biting), easy collection, and transportability, makes *Podocnemis* spp. prime targets for the human food gatherer. Additionally, because one adult female *P. expansa* can feed up to 30 people, makes turtles the choice meat for all festive occasions (pers. obs.). The hunting of turtles was thus a large part of life for pre-European human groups, and they developed many methods for their collection. In addition to collection on nesting beaches, Indians hunted turtles with bows and arrows, nets, hooks on lines, and by deep diving (reviewed in Conway 2004). Turtles were so important to many Amazonian tribes that they were incorporated into their ceramics and tribal mythology (Ojasti 1972; Smith 1975).

Despite the extensive use of the species by pre-European indigenous groups, it did not appear to not have impacted the species, as very large populations were reported by early explorers. Certain conditions that existed historically worked to maintain large populations of the species: human populations were small and widely dispersed, they consisted mainly of hunter/gather groups with poorly developed market economies, and some cultures had ideologies that protected and conserved turtles (Smith 1975; Moll & Moll 2004). However, very intensive use of the species was still documented by early explorers. In the 1500s and 1600s, various European Amazonian expeditions reported seeing indigenous villages holding up to 4000 live turtles in corrals, and collected eggs “piled in heaps up to 20 ft high” (reviewed in Moll & Moll 2004). Captive turtles were kept for slaughter in the rainy season, when fish and other animals are hard to find; hence, turtles were a staple in indigenous diets

(Moll & Moll 2004). In spite of this extensive use, Alexander von Humboldt (1819, 1852) estimated in 1799 that more than one million *P. expansa* females were nesting annually in the lower Orinoco River alone (cited in Mittermeier 1975).

However, with the arrival of Europeans to tropical South America the tremendous increase in exploitation became too much for turtle populations. Early Jesuits became fond of turtle meat, and turtle oil (derived from both turtles and eggs) came to be especially appreciated, as a fuel for lamps, by other missionaries and early Spanish and Portuguese traders. Turtle oil was an especially fine grade, burning long and nearly smokeless; the highest grade oil was made from boiling fresh turtle fat (reviewed in Moll & Moll 2004). As Indians learned to exchange turtle products for metal goods, countless turtles were butchered (see Figure 2.3) (Smith 1975, 1979; Thorbjarnarson et al. 2000). Portuguese exploiters began to make annual expeditions, in Amazonian Brazil, to collect turtles as they finished nesting, and some beaches were even designated royal beaches to supply stationed militia (Moll & Moll 2004). In the mid-nineteenth century, the naturalist Henry Walter Bates (1876) estimated that 48 million eggs of *P. expansa* were extracted from the Upper Amazon alone (Pritchard 1979a), the equivalent of the reproductive output of 400,000 to 600,000 nesting females (Mittermeier 1978; Thorbjarnarson et al. 2000).

Figure 2.3. Manufacture of oil from *P. expansa* turtles' eggs by the Conibo Indians in Peru (St. Cricq, 1874) (Moll & Moll 2004).

Commercial harvests of eggs were fruitful until the mid-nineteenth century, when even as late as the 1850s, nesting aggregations of many thousands of *P. expansa* impeded river traffic on the Madeira River (reviewed in Moll & Moll 2004). However, finally, after 300 years of intense pressure, since the arrival of Europeans, both species of *Podocnemis* were seriously overexploited, and the huge numbers of turtles and eggs extracted were never to be regained (Smith 1975; review in Moll & Moll 2004). Pritchard (1979a) asserted that this exploitation "virtually eliminated" *P. expansa* from the entire Upper Amazon area of Brazil. Smith (Ojasti 1971; Smith 1975; Mittermeier 1978; Smith 1979; Johns 1987) stated that the introduction of kerosene and vegetable oil in the last half of the nineteenth century may have saved turtles from extinction. An example of continuing severe decline in *P. expansa* is documented by Ojasti (1996): as of 1996 the entire Brazilian Amazon population had only 28,000 females on 54 nesting beaches, compared to 34,000 nests counted in 1963 on the main nesting beach. Decline in these species demonstrates that human pressure can bring even very populous species to the brink of extinction, and in a relatively short period of time.

Due to this over-exploitation and consequent serious decline, both species are listed internationally, and nationally in many countries, as endangered. Both species are listed in the IUCN Red List of Threatened Species: *Podocnemis expansa* is listed as LR/cd (1994, out of date) (Lower Risk/Conservation Dependent), and *P. unifilis* as VU A1acd (Vulnerable) (1994, out of date) (Species Survival Commission 2008). Both species are listed on Appendix II of the Convention on International Trade in Endangered Species (CITES) (CITES Secretariat 2008), and they are rated "1," highest priority in the Tortoise and Freshwater Turtle Specialist Group Action Plan Rating (APR), which indicates that both species are "known threatened species in need of specific conservation measures" (Tortoise and Freshwater Turtle Specialist Group 1991).

Both species are protected by the U.S. Endangered Species Act (ESA) and classified as "Endangered" by the U.S. Fish & Wildlife Service (2007). Brazilian law protects both species; it prohibits the hunting of any wildlife in its territory for sale nationally or internationally (Article 1 Law 5,197 January 3, 1967 and Article 29 of Law 9,605 February 12, 1998) (Conway 2004; U.S. Fish & Wildlife Service 2007). Finally, both species are protected under the following Bolivian national laws, which prohibit hunting and trade in all wildlife: supreme decrees 21774 (26/11/1987), 22641 (8/11/1990), and 16605 (20/6/1979).

Despite the widespread recognition of the declining status of *Podocnemis* turtles, use of the species remains a yearlong way of life and part of local culture in river communities throughout much of South America (Smith 1975). *Podocnemis* turtles have always been, and continue to be, a favorite food of Amazonians (Johns 1987). The meat is highly regarded for its rich flavor and as an aphrodisiac (Johns 1987; personal observation). Additionally, an adult female *P. expansa* can provide up to 12 kg of high quality meat that can feed a family for several days (Mittermeier 1978; Conway 2004). As a protein source, turtle meat contains 85 to 88% protein, compared to 43 to 70% for domestic meats (e.g., chicken, pig, beef) (Cantarelli 1997). At least ten traditional dishes are made from turtle meat, and all parts of the turtle are used (Alho 1985). Turtle shells are used as containers for washing and cooking; they are used in artwork and made into trinkets and jewelry to sell to tourists (see Figure 2.4). Because of this wide and historic use, it is impossible and perhaps undesirable to curtail subsistence hunting completely (Smith 1979).

Figure 2.4. Children in PNNKM displaying artwork on a *P. expansa* carapace.

Although commercial exploitation can not be maintained at earlier levels, it still has a place in South America. Generally, due to their larger size, only females of both species are marketed commercially; while, males and juveniles are used locally. However, due to over-exploitation, there has been a growing use of juveniles (Mittermeier 1978). Turtle eggs are now a minor trade compared to the past; however, the oil is still used in cosmetics, soaps, creams, and ointments. Due to their low numbers, *Podocnemis* turtles and their eggs are now an expensive delicacy in many urban areas, and their illegal exploitation has become socially important for urban upper classes and economically important for rural lower classes (Johns 1987). In Brazil, market price for one *P. expansa* female has ranged from $80 to $150, depending on size (as of 1999), a price that outcompetes domestic meats (Alho 1985; reviewed in Conway 2004). Hatchlings of both species have also been sold in the pet trade; especially in the 1960s and 1970s, when hatchlings of both species were exported in large numbers to the U.S. (Mittermeier 1978). This use continues to some degree today in South American markets (pers. comm. with colleagues in Bolivia, 2005-2006).

As discussed above, in addition to human use, human land use (including agricultural development that destroys fertile floodplains and dams that permanently flood turtle nesting beaches) is documented as an important cause of worldwide decline in freshwater turtles (Mittermeier 1978; Bodie 2001). Bodie (2001) recommends a minimum 150 m riparian zone for maintenance of healthy turtle populations. Habitat loss is a growing threat to *Podocnemis* species. R. Carroll (pers. comm., 2004) suggested that declines in *Podocnemis* spp. in Ecuador are related to upstream land degradation that causes changes in the hydrology of rivers that affect the location and stability of *Podocnemis* nesting beaches.

Decline in PNNKM

Within PNNKM, *Podocnemis* populations are especially susceptible to threats from nearby human riverine communities. Like other Amazonian peoples, residents local to PNNKM have a strong cultural predisposition to use turtle products and state preference for turtle meat over all domestic meats, claiming it has more nutritional value (Conway 2004). Additionally, for many families, purchasing or raising adequate amounts of alternative protein sources (e.g., beef, chicken, pork) is currently beyond their means. Even the widespread raising of chickens has proven unsuccessful in these areas, due to problems with disease, need for infrastructure to raise and guard against stealing of chickens, and finally, access to obtaining of chickens (in areas that can be quite remote) (pers. obs. with community members and PNNKM administration, 2005-2006).

Because the park's borders are formed by two navigable rivers, the Paraguá and the Iténez (Bolivia's eastern border with Brazil), there is virtually open access to turtle and egg extraction in the park (see Figure 2.5). Although both species are theoretically protected by both Bolivian and Brazilian legislation, a historic lack of financial and infrastructure support for conservation and enforcement in this largely frontier area allows for their continued and unmonitored use.

Exploitation in PNNKM includes subsistence use by local Bolivian indigenous and colonist communities, as well as commercial sale by local Bolivians to nearby rural and urban centers and consumption and sale by rural and urban Brazilians (Conway 2004; personal observation 2005-2006). In and near PNNKM, exploitation includes the sending of turtles to other indigenous communities, to larger colonist communities such as Remanso and Cafetal, and to the urban centers of San Ignacio de Velasco and Santa Cruz de la Sierra (pers. obs. and communication with local people 2005-2007).

Bolivian law does not allow commercial exploitation of the species; however, it does allow subsistence use of the species by local indigenous communities. Unfortunately, the line between use for subsistence and commerce is often difficult to define, as many families engage in both, and trading and sale of turtles within subsistence-based communities is difficult to differentiate from sale outside the community (pers. comm. with PNNKM park guards, 2005-2006). Additionally, as in most tropical countries, conservation problems result at least partly from the fact that national and regional conservation goals are often countered by local people who depend on natural resources for their livelihoods. In PNNKM, this has been especially true, where local people see enforcement of *Podocnemis* protection laws as directly countering their right to sustenance (pers. comm. with K. Conway and local families, 2005-2006). Additionally, because most park guards are also community members, they are usually not willing to stop exploitation of turtles, especially when the regulations are loosely defined and hunters are close relations (pers. obs. and communication with park guards).

These combined conditions have likely led to the repeated observations, by local Bolivians who depend on turtles for subsistence, that *Podocnemis* populations are declining in and near PNNKM. This observed population decline by local people, reported to local PNNKM authorities (G. Peña, PNNKM Director until 2005, pers. comm., 2003), was the impetus for this project. Concerned authorities and local citizens explained to me their desire to conserve declining local *Podocnemis* resources; with this initial conversation began the collaborative project I present here. Although local people have in the past not supported outside restrictions placed on turtle use, there has been considerable community support for the proposed community-based turtle management strategy in PNNKM. This is because the project specifically addresses the concerns of both local resource users and conservationists, that local *Podocnemis* spp., as both important food resources and biodiversity components, are in decline.

I hypothesized that direct human use of turtles in this region negatively affects their populations and that the impact of human use is compounded by the indirect effects of human development (e.g., agriculture, cattle ranching, timber harvesting, and tourism), especially originating from the Brazilian side of the Iténez/Guaporé River. Deforestation on the Brazilian side of PNNKM is exaggerated, often completely destroying vegetation up to the river's edge (Figure 2.5). My goal was to test this hypothesis and use experimental results as the basis for long term and local management of the species. Within the local context of this conservation issue, I believe that only cross-sectoral collaborations that address both national and local interests are likely to promote successful conservation. The collaborative plan outlined here uses low cost and culturally appropriate methods that can be continued by local resource managers.

Figure 2.5. Aerial photo of the Green River, border between PNNKM (Bolivia) and Brazil, taken by Rolvis Pérez.

Turtle Conservation and Management: *Podocnemis* and relevant species

Here I present a literature review of past and current work related to turtle conservation methodology and theory. There is a scarcity of information related to conservation efforts specific to *Podocnemis* turtles, in comparison to the large number of articles related to conservation of other turtle species. Therefore, in addition to *Podocnemis* specific information, I include all turtle conservation research that could be relevant to conservation of *Podocnemis* turtles. Because many chelonians exhibit similar life histories and strategies, order-wide generalizations about conservation and management techniques (especially within distinct groups, such as freshwater turtles) are often possible.

There are many differing efforts reported worldwide that are attempting to mitigate declining turtle populations. All conservation efforts can be summarized under one of two headings: (1) ex situ, or manipulative techniques and (2) in situ, or non-manipulative techniques (Moll & Moll 2000; Seigel & Dodd 2000; Moll & Moll 2004). Ex situ techniques require the removal of animals or their eggs from the natural habitat (Moll & Moll 2000), depend on human manipulation of natural conditions, and often necessitate costly infrastructure and technologies. Examples are egg hatcheries, headstarting, captive breeding, and translocation of eggs. In contrast, in situ methods protect animals and their habitat or improve habitat (Moll & Moll 2000); examples include habitat protection, nest protection and/or nesting sanctuaries (often involving nest patrols), sweeping of nest sites to erase evidence of turtle tracks, and legal, eco-tourism, and educational efforts.

There is a prominent discussion in the literature, among chelonian experts, that refers to ex-situ techniques as "half-way technologies," meaning that they have often been based on poor science, and have rarely demonstrated success in boosting turtle populations (Frazer 1997; Klemens 2000; Moll & Moll 2000; Seigel & Dodd 2000; Moll & Moll 2004). It is widely asserted that these technologies are often no more than quick fixes, and that science has shown many possible dangers to natural turtle populations when they are manipulated by humans; therefore, many turtle experts recommend they be regarded as temporary measures and not substitute long-term approaches to turtle conservation based on research and understanding of turtle life histories and the threats they face (Frazer 1997; Klemens 2000; Moll & Moll 2000; Seigel & Dodd 2000; Moll & Moll 2004). Frazer (1997) stresses that ex-situ technologies are only short-term fixes, and they should be used only as a last resort. The Tortoise and Freshwater Turtle Specialist Group (1989) recommends in situ techniques as preferred for conserving chelonian populations.

Following is a summary of relevant experiences from global turtle conservation programs. I begin with in situ techniques and end with ex situ techniques.

Tourism

Vieitas et al. (1997) described a tourist program, implemented by the Brazilian Sea Turtle Conservation Programme (TAMAR), established in 1980 to protect and re-establish natural life cycles for sea turtles in Brazil. The program is based on local involvement by coastal communities; it provides jobs and generates alternative sources of income for local people, who work as guides and staff the nature center. A mini-guides program was created that trained children in turtle biology, conservation, and working as intern guides for tourists. Children were paid stipends in their work as interns, which provided an extra source of income for families. They were taught new skills, enhancing their awareness of their environment, families, and communities. The program was given excellent ratings by tourists, and it garnered the support of local communities, who came to appreciate turtles as a source of tourism income, thus becoming promoters of turtle conservation.

Although this type of tourism-based project appears promising, it is questionable if it could be implemented in PNNKM. PNNIKM is largely inaccessible, being far from urban centers and any developed rural areas; therefore, tourism as a major source of income is still limited, and access to tourists is limited to a few areas in the park that are far from turtle nesting areas. Also, although tourism is growing in some areas of the park, it is difficult to assess the impacts that large influxes of tourists could have on local people and economies. Furthermore, tourist travel on the rivers can disrupt turtle nesting activity (see Chapter Four), and would have to be limited to daytime.

Campbell and Smith (2006) reported the success of a volunteer tourism project working with sea turtles, at Tortuguero, Costa Rica. They reviewed the specific draw that volunteer tourists have towards sea turtles, more than any other single species. Tourists paid to act as research assistants, helping collect data on local projects. Large organizations, such as Earthwatch, use funds paid by such tourists to help support local conservation projects. This type of project could have more promise in PNNKM, where ongoing monitoring could be supported by such funds. *Podocnemis expansa*, as large river turtles with similar life histories to sea turtles, could easily have a similar draw to people interested in working with sea turtles.

Protection of Nesting Beaches

Ideally, protection schemes for river turtles would create large reserves that include all aspects of their habitat, including foraging grounds. However, because these areas can be immense for species that travel long distances, and conservation funding to protect turtles is often scarce, Moll and Moll (2004) recommended that protection schemes focus on guarding nesting beaches, where most human exploitation targets female turtles and their nests. In agreement, beach protection schemes are recommended by the Food and Agriculture Organization of the United Nations (1988). Protection schemes can include nest site patrols, as well as sweeping of nest sites to erase traces of turtle nesting activity. In addition to protecting against human activities that threaten and disturb nesting turtles, protection schemes often aim to protect nests against natural (animal) predation that poses threats to turtle reproductive success.

Moll and Moll (2004) reviewed nest protection programs, in Belize, the United States, India, and Malaysia, that reported increased survival of nests and eggs in a variety of turtle spp. Ross et al. (1989) reviewed a nest protection project at Rancho Nuevo reserve, which is part of Mexico's Kemp's Ridley (*Lepidochelys kempii*) conservation program. The project, involved patrolling by Mexican military to prevent poachers from collecting eggs, and was described as playing a critical role in reducing levels of poaching. Troeng and Rankin (2005) reported long term research that shows an increasing nesting trend in green sea turtles (*Chelonia mydas*) at Tortuguero, Costa Rica, which they attribute to protection of nesting beaches, which allows for increased natural hatchling, combined with conservation practices that lower adult and juvenile mortality.

Related to *Podocnemis* species, Moll and Moll (2004) discussed nest protection schemes in Brazil, run by the Brazilian Institute of the Environment and Natural Resources (Insituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) (IBAMA), that protect *Podocnemis* spp. in more than 115 protected areas. Smith (1975) argued that instead of prosecuting people for collecting turtles, governments should set aside remaining turtle nesting beaches as protected reserves. Ojasti and Rutkis (1965) discussed another benefit to keeping people off of nesting beaches: *P. expansa* turtles scared from beaches by human presence can take more than two weeks to return, which can be enough time to offset nesting so that nests become vulnerable to rising river levels.

A *P. unifilis* research program on the Iténez River in Bolivia experimentally compared treatments of nest guarding, nest protection (by cages, from predators), and translocation of eggs to safer locations (Caballero Guerrero 1996). All three treatments displayed higher survival of both eggs and nests than did the control group; although, translocation of eggs involved some increased rates of mortality. Caballero Guerrero concluded that because the prohibition of sales of turtles in rural areas is ineffective at promoting conservation, at the very least, nesting females should be protected. Experimental results showed that the guarding of nests, which is the cheapest of the three options, might be sufficient for protection of nest sites.

There are various problems with focusing on protecting nesting beaches from human gatherers. One is their dependence on enforcement. A report from the Trombetas and

Tapajós Rivers in Brazil described poachers outnumbering guards from Brazil's State Institute of Forestry (IBDF) (now part of IBAMA), because the institution lacked funds to station enough guards for patrols (Johns 1987). Additionally, Bock et al. (2001) recommended that projects that focus on only one or a few nesting beaches might not be protecting overall local genetic diversity of regional populations. However, given the low spatial genetic diversity of *P. expansa* within rivers, this might not be important in this species. Lastly, Johns (1987) discussed the problem that even if beaches are patrolled, turtles are still caught in rivers. I have witnessed all of these problems in PNNKM, where deployment of park guards is especially lacking.

Because animal predators may cause high mortality of turtle nests, many conservation projects protect nests from animal predators. Moll and Moll (2004) reviewed various animal removal schemes in the U.S., and concluded that while they lower predation on eggs, as soon as programs are stopped, predation returns to pre-program levels. Other downsides of these efforts are that they are costly, often remove animals that are also protected in reserves, and are often unpopular with the public.

Instead of predator removal, physically protecting nests from predators is another method for nest protection. Moll and Moll (2004) reviewed various projects that successfully raised survival of turtle nests: using wire to protect nests, translocation of nests (see Egg Translocation and Hatcheries), and the sweeping of nests, which not only hides nests from humans, but also from sight-oriented animal predators. I have witnessed another method practiced by community members in PNNKM: nests are covered with additional sand, which seems to effectively deter smell-oriented predators such as lizards. One concern I have with this method is the possible changing of nest temperatures due to the relative change in nest depth. In general, protecting turtle eggs from natural predators could raise the concern that other animals are being deprived of necessary food sources; however, the necessity to protect these endangered species makes this a relatively minor concern (K. Buhlmann, pers. comm. 2008). I believe that protecting turtle nests from animal predation could be an effective management action to boost recovering hatchling populations, in PNNKM.

Although exploitation of turtle nests by animal predators can cause high incidences of mortality, rates cannot be compared to the intensive and non-relenting pressure of exploitation by humans. The focus of protection schemes must therefore be to protect nesting populations from human exploitation. Protection from animal predators can add additional benefits. Because the research I conducted (see Chapter 3) demonstrates that in PNNKM most turtles collected are nesting females, I believe that protecting nesting turtles and nests from human (and animal) predation would have a large and positive impact on turtle populations there. This will be true only if local communities are involved to supplement enforcement and protection schemes.

Egg Translocation and Hatcheries

Egg translocation and hatchery programs are some of the most widely used ex situ techniques (Moll & Moll 2004). They are implemented in areas where threats to nests, including human predation, animal predation, erosion, and flooding, are deemed unavoidable. Threats are mitigated by moving eggs to higher and/or protected areas. Moll & Moll (2004) reviewed various egg hatchery programs, including programs for the river terrapin (*Batagur baska*) and leatherback sea turtle *(Dermochelys coriacea)* in Malaysia. They concluded that programs have not documented success, as female turtles show no signs of increasing; however, due to long life spans and the fact that the young are not marked before release, it is difficult to evaluate success. One problem documented in the leatherback program is a large number of infertile eggs, which resulted from hatchery techniques that over-produced females

(Chan & Liew 1996). Additionally, because pressures on adult turtles were so great, adult mortality could not be mitigated by even slightly better hatchling recruitment.

Garcia et al. (2003) presented a nine-year intensive beach management program for Olive Ridley sea turtles (*Lepidochelys olivacea*) in Mexico that included patrolling of beaches and removing eggs to a central hatchery. The program was part of a larger conservation strategy, in which mortality factors at other life stages were also addressed. The experimental beach was protected against poaching at two access points: every three hours new nests were sighted and transported to the enclosed hatchery, where they were placed nests protected by wire mesh. The temperature of all nests (in situ and hatchery) was measured twice a day. Upon hatching, hatchlings were released immediately onto the beach to find their way to sea. Results compared data from nests removed from the experimental beach to control beaches and to the nests (50% of total) that were left on site. The study concluded that beach management effectively reduced nest losses caused by poaching and other factors, such as beach erosion and predators. Nest loss from poaching, predation, and erosion was eliminated, compared to loss of on average 44% of in situ nests, which were patrolled. Additionally, the nest reburial technique had few negative effects on sex ratios and hatching success. Hatching success of in situ nests was 66%, and that of hatchery nests was 59%. Sex ratios were estimated from nest temperatures and also by randomly sampling 20 hatchlings from each nest for sex determination in the laboratory using the techniques of Humanson (1979) and Merchant-Larios et al. (1989). Garcia et al. explained that reasons other hatcheries have exhibited changes in sex determination is because many enclosed hatcheries are shaded. They did not present evidence for increase in numbers of nesting turtles; nine years is probably too soon for return of released hatchlings.

Ojasti & Rutkis (1965) report an experimental *P. expansa* program at Playa del Medio, in the Orinoco basin of Venezuela. Nests threatened with flooding were opened, and live hatchlings were collected, transported by boat, and released close to shore in areas deemed "safer" (i.e., with fewer predator fish and with vegetation that could be used for natural cover). The authors conclude that results of hatchling survival would have to wait 10 years, when marked hatchlings might return to nest. Other egg translocation and hatchery programs report what are potentially benefits to *Podocnemis* spp., such as increased egg and initial hatchling survival (IBAMA 1989; Paez *et al.* 1995; Paez & Bock 1997; Soares 1995; Vogt 1997).

However, despite the many successful reviews, there is little documented success in these schemes (proof that nesting populations are augmented). Additionally, there are various problems documented with turtle hatcheries. Changes in hatchling physiology can result from altered hydric conditions, especially in turtles (such as *Podocnemis* spp.) with flexible-shelled eggs (Ojasti & Rutkis 1965; Moll & Moll 2004). Embryos in eggs under favorable water conditions are shown to grow faster and larger, better utilize calcium from the shell, better metabolize their energy reserves, and have greater hatching success (Packard et al. 1981; Morris et al. 1983; Packard et al. 1983; Packard et al. 1988; Filoramo & Janzen 2002). Additionally, hatchlings from eggs incubated on wetter substrates are shown to be faster swimmers and runners than those incubated on drier substrates, probably due to increased respiratory ability (Miller et al. 1987).

Changed thermal conditions in the nest can very obviously affect hatchling development, especially in species whose sex is temperature dependent: artificial nests dug too deep could produce all males, while shallow nests could produce all females. This changing of natural sex ratios could have unknown consequences in the population. Thermal conditions in the nest can alter not only sex ratios, but also size: Remor de Souza and Vogt (1994) report that *P. unifilis* eggs are larger from warmer nests. And, in general, the moving of eggs results in lowered hatchling success (by 20 to 70%) (Mortimer 1988, cited in Moll &

Moll 2004), and the turning of eggs has adverse effects on hatchability (Alderton 1998). Klemens (2000) asserted that the least (physiological) damage to eggs occurs when they are transplanted within 24 hours of laying; while Mortimer (1999) recommends eggs be moved within two hours of laying.

Headstarting

Headstarting is the ex situ technique of keeping young turtles in captivity, for varying periods of time after hatching, so as to allow them to grow to a sufficient size that (in theory) will expose them to less predation risk when released to the wild. Headstarting projects can involve collection of hatchlings as they leave the natural nest, or they can be combined with hatchery or captive rearing programs. Turtles can be kept for short periods of time, as with *P. expansa* hatchlings kept for two weeks to a month by IBAMA in Brazil, or they can be kept for long periods of time, as with river and painted terrapins, which are kept from one to 10 years in conjunction with the described hatchery projects in Malaysia (reviewed in Moll & Moll 2004). Headstarting projects are very popular and widespread globally; they are also quite controversial and have many opponents. One reason for this is the fact that most headstart projects have not proven success; in other words, it is not known if released turtles integrate in the reproducing population to boost abundance levels (Moll & Moll 2004).

Alho (1985) was an early supporter of headstarting and outlined reasons for the idea he proposed, which is a combined headstarting and commercial captive rearing program in Brazil (see Commercial Captive Rearing below). Cantarelli (1997) reports that IBAMA’s National Center for the Amazonian Chelonia (CENAQUA) strategies have allowed for the recovery of wild *P. expansa* populations. These strategies are described as a combined approach of guarding nest beaches, translocation of eggs to areas where they won't be flooded, and the management of headstarted hatchlings, kept for 15 days until carapaces harden, when they are then released to areas with fewer predators. Cantarelli asserted that the project provided for a 25% increase in eggs laid per year, in the years 1979 to 1991.

Hernández and Espín (2006) report initial success of a *P. expansa* conservation program in the Orinoco Basin of Venezuela, which included nine years of release of headstarted hatchlings. Captures at the end of this time showed high recruitment in the population (high proportion in juvenile age classes), compared to *P. unifilis*, which was not part of the program and showed little recruitment (majority adult turtles). Knothe (1996) describes a *P. unifilis* headstart program, initiated in the Beni, Bolivia in 1991, and concludes that while the fate of the released hatchlings is unknown, increased juvenile basking counts in the region could be the result of the headstarting program.

The headstart program of Kemp's Ridley sea turtle, at Padre Island in Texas, the Gulf of Mexico, is the only one to document that headstarted turtles have augmented breeding populations (Moll & Moll 2004). Ross et al. (1989) describe this project, from 1978-1988, in which experimental attempts were made to establish a new nesting site at Padre Island. The program aimed to increase the number of hatchlings that survived the first hazardous year, by raising them in captivity. Turtle eggs were collected and transported in Styrofoam containers to the beach at Padre Island. To encourage imprinting, hatchlings were placed in the sand and allowed to enter the sea after hatching from eggs. They were then re-collected and raised in captivity for a year, where they were tagged and finally released off Padre Island. Good distribution data was acquired from tagged turtles. Survivors moved long distances to appropriate destinations and exhibited normal growth rates. However, it was found that headstarted turtles represented 26% of all strandings between 1985-1986. Ross et al. (1989) conclude that either the headstarted turtles were a large percentage of the overall juvenile population or they were more likely to strand than turtles that were not headstarted (i.e., not tagged).

Shaver (2005) reports the return of headstarted and imprinted turtles to Padre Island: of 171 nesting turtles found in Texas since 1985 (of which only 89 turtles were analyzed for tags), 24 nests were conclusively linked to those of headstarted turtles. The population there has been steadily rising after the period 1985 to 1994, when no more than one turtle was found nesting per year (Shaver 2005). This study demonstrates for the first time in the literature that headstarted turtles can become part of the future nesting population.

Despite what could be argued a conservation success story, the fact remains that this is the only documented return of headstarted hatchlings to nesting beaches. Controversy surrounding headstarting programs is additionally fueled by other negative effects on headstarted turtles in the literature. Pilcher & Enderby (1997) document negative effects of hatcheries on hatchlings in a study of green sea turtles. They report that hatchlings kept for prolonged periods often crawl around, burning limited energy reserves: laboratory experiments demonstrate swimming speed decreased by 12% with only six hours of retention in the hatchery. They also document a varied swimming style with prolonged retention: hatchlings demonstrated a dog-paddle swimming style, as opposed to the more efficient "powerstroke," after only several hours of retention. They conclude that these changes likely hinder offshore migration and survival rates. Bock et al. (2001) also warn that holding hatchling turtles in captivity may disrupt key behavioral processes that are necessary for early migratory processes after reproduction.

Snyder et al. (1996) discussed the well documented risks of transference to wild populations of genetic, disease, and behavior problems, including changes in foraging, predator avoidance, and social behavior in headstarted turtles. Moll and Moll (2004) review over 13 articles that report the variety of diseases found in captive turtle populations (both in captive rearing and headstarting projects): mycotic pneumonia, herpes virus infections, chlamydiosis, and the coccidial parasite *Caryospora cheloniae* in sea turtle populations; and a "profusion" of viral, bacterial, mycotic, and protozoan caused diseases in captive freshwater turtle populations. Jacobson (1993) reports a virulent upper respiratory mycoplasma disease in wild desert tortoises (*Xerobates agassizii*) and gopher tortoises (*Gopherus polyphemus*) traced from captive individuals released to the wild. Boede and Hernández (2004) report a study of diseases in turtles from two farms at a Venezuelan captive breeding program. They document the following in neonates (1-42 days): congenital anomalies, omphalitis, neonatal death, mycotic dermatitis, and septicemia. They document the following in hatchlings and juveniles (6 weeks to 3 years): metabolic bone disease, vitamin A deficiency, and gout; and in adults (7+ years): erosive and descarnative lesions of the carapace and claws. Finally, they report mortality rates in neonates, hatchlings, and juveniles from 1.54% to 60.50% and morbidity rates of 100% in adults.

Frazer (1992) discussed other negative effects of headstart programs: that while turtles are in captivity, other organisms and animals are being deprived of the function hatchlings play in the ecosystem. He argues that headstarting does not address the causes of population decline, but merely treats the symptoms. The IUCN (1989) and Snyder et al. (1996) recommend that captive breeding projects only be used as an extreme measure when existing habitat is destroyed or the remnant population is entirely devastated. Bock et al. (2001) recommend that hatchlings not be released far from natal beaches, until more genetic studies are performed. Lastly, it is widely argued that in addition to the potential problems headstarting poses, it is an expensive and unproven method for turtle conservation (Pritchard 1979a; Mortimer 1988; Snyder et al. 1996; Moll & Moll 2004).

Commercial Captive Rearing

Commercial rearing of turtles, as an alternative to wild harvesting, is discussed globally and specific to *Podocnemis* spp. as an economically viable means to counteract threats to wild populations (reviewed in: Moll & Moll 2000; Moll & Moll 2004). Turtle farming involves closed captive-breeding systems; whereas, turtle ranching involves periodic incorporation of eggs and/or breeders from the wild (Moll & Moll 2000). Moll and Moll (2000; 2004) discussed the most successful captive rearing projects as the ranching/farming of red-eared sliders and painted turtles in the U.S. for the pet trade, and the raising of Chinese softshell turtles for food, throughout eastern and southeastern Asia, and even Brazil. Moll and Moll (2004) cite the success of this program in Taiwan, in supplying an alternative to wild populations, where almost all turtles and eggs eaten are those raised in captivity. They state they have no knowledge of successful programs involving river turtles; although, they are often proposed.

The production of *Podocnemis* species is widely discussed in the literature. It has a historical basis, as aboriginal populations raised *P. expansa* in pens for year round use: Orellana's expedition down the Amazon River in 1542 documented a village with more than a thousand turtles in flooded enclosures (Smith 1975). A century later, Acuña reported that almost every village in the Amazon and Orinoco basins had at least a hundred turtles penned (Smith 1975). Smith reports having visited Amazonian families that still maintain *P. expansa* in captivity. Similarly, turtle pens are still regularly seen along the Rio Cuyabeno in Ecuador (R. Carroll, pers. comm., 2007).

Smith (1975) asserted that turtles fare well in captivity, but that overcrowding and inadequate nesting depress breeding rates, and that a lowering of water levels is shown to be a necessary stimulus to reproduction. However, he argues that with careful management of water levels, *P. expansa* shows potential for commercial production. (It is unclear whether these turtles were actually observed to mate and nest in captivity). Smith (1975) outlined low-cost production that could be carried out on a large scale, as practiced by missionaries on the Ucayali in the 1860s, or in the backyards of urban folk, like one family in Belem that feeds their 2,000 turtles from garden weeds and kitchen scraps. He states that *P. expansa* requires 8 years to attain a marketable 50 pounds; however, I am sure this is largely dependent on food supply. Additionally, Smith asserted that turtle production is ecologically less destructive than cattle ranching; in that, cattle ranching in the Amazon can sustain production at only about 50 pounds per acre per year, while a managed turtle pond could provide 22,000 pounds (1975, 1979).

Alho (1985) describes an idea for a combined headstarting/rearing program. He states, as a biological basis for the program, that naturally less than 20% of hatchlings return to nesting beaches as adults, but that high juvenile survivorship could be obtained through an 8 year management program. He describes a program in which every year new batches of hatchlings would be taken to tanks and small lakes, with 20% immediately released and 10% more released annually into the wild. He asserted that each year added in captivity should produce turtles with a higher survival probability against predators, and that, after 8 years the remaining turtles could be marketed. He argues that *Podocnemis* turtles are easy to rear, due to their low mortality, show good annual growth, and reach maturity at 7 to 8 years in captivity, which is earlier than in the wild.

In this way there could be a continual supply of turtles both for harvest and input into the wild. He recommends regulation by IBDF (now IBAMA) to avoid abuse, stating that conservation of natural adult turtle populations requires their complete protection and prevention of interference with reproductive activities. He argues that harvest of captive-reared turtles every year would stimulate support for conservation by local people, who he estimates could make net profits of up to US$ 10,000 per cycle (based on 1985 prices and beginning with 5000 hatchlings and sale of 1500 adult turtles after eight years).

Mittermeier (1975, 1978) also discussed the captive raising of *Podocnemis* species. He states that *P. unifilis* is the hardiest species in captivity, but that both species are easy and inexpensive to raise. Because their diet can consist of plant matter, scraps of produce, fish remains, and slaughterhouse leftovers, he describes programs as taking much less effort than raising tapir or beef. And, he asserted, because turtles are ectotherms, they require less energy than mammals, which translates to less food required than for mammals of similar size. Lastly he asserted, because turtles have few specialized habitat or behavioral requirements, they can be kept in large cement tanks, ponds, or natural or man-made lakes, and at much higher densities than cattle.

In further support of these projects, Cantarelli (1997) discussed the possibility for commercial propagation of *Podocnemis* spp., asserting that, given an equal amount of space, turtles could produce 100 times more meat than cattle, although they will require large amounts of food to be transported to ponds. Ranching projects, managed by IBAMA in Brazil, are reported to slow the harvest of wild *Podocnemis* turtles (Vogt 1995).

There is discussion in the literature that captive rearing projects might not be viable options for turtle conservation. Some researchers in Brazil report that commercial captive rearing of *Podocnemis* spp. is not economically viable, due to their delayed reproduction and production costs (Food and Agriculture Organization 1988). Johns (1987) also questions the viability of commercial rearing of *Podocnemis* species, due to their delayed reproduction and slow growth rates, in comparison to domesticated animals. R. Vogt (pers. comm., 2004) says that these projects have high production costs that are largely unsustainable for rural people. Klemens (2000), in his summary of turtle conservation projects, asserted that no case studies have evaluated the success of harvest programs. Finally, local Bolivians stated that captive-raised turtles they tasted in Brazil have a “putrid taste” that is not desirable (pers. obs. with residents of Piso Firme and Bella Vista, 2008).

Sustainable Egg Exploitation

The sustainable exploitation of turtle eggs is a management option that has mostly been attempted in sea turtles. The best documented project is an Olive Ridley sustainable egg harvesting project, run by a community cooperative in Ostional Costa Rica (Almengor et al. 1993; Campbell 1998; Campbell et al. 2007). The project is based on an understanding of the turtles' biology: because females nest in stages of synchronized groups, termed 'arribadas' (similar to the nesting strategy of *P. expansa*), eggs laid by the first groups are often crushed by later nesting groups. The idea is that local communities can harvest early egg crops, whose use and sale is managed through a certification process, while having little or no impact on hatchling populations. Campbell et al. (2007) report broad economic benefits for participating community members, which result in support for turtle conservation. They also report convincing results (with recommendations for continuing monitoring) that there are no negative impacts on turtle populations, with steady and possibly increasing nesting populations of female turtles, of up to 130,000 turtles per arribada, after 20 years project implementation.

Hope (2002) analyzes three Olive Ridley egg harvesting projects in Costa Rica and Nicaragua. He recommends the legalizing of community marketing cartels, based on seasonally permitted extraction of eggs, as a method to improve resource management, increase egg profit margins, and to clearly identify the origin of eggs for consumers. He recommends these projects as a sustainable means to provide sources of income to local impoverished people. Caputo et al. (2005) document an effort towards sustainable use of *P. unifilis* eggs in Ecuador. They analyze both the biological and socio-economic basis for the project. They argue that egg collection by indigenous people can be sustainable; this is based on data that demonstrate a loss of natural nests to flooding events as high as 61.3%, with human use of nests at only 28.2% of all nests. They thus argue that if human egg collectors collect only those nests that would naturally be lost to flooding, there should be no negative effect on numbers of hatchlings entering the population. Lastly, Caputo et al. (2005) document success in the technical ability of local people to implement monitoring and research programs, as well as community-wide support for the research and conservation project.

Sustainable egg harvesting projects could be relevant to management of *P. expansa*, which has similar nesting habits to sea turtles; however, in PNNKM, where there are extremely low nesting numbers of *P. expansa* (see Chapter Four), harvesting could not be based on the same theory involving arribada nesting. Sustainable egg harvesting could be more suitable for *P. unifilis* nests in PNNKM, based on the same theory as the project outlined by Caputo et al., in Ecuador. This would of course depend on human harvesting pressure being low enough to be satisfied by use of only naturally vulnerable nests. I have discussed this as a possible management option with local authorities and community members; all are in favor of trying to include such a scheme in our plan.

Exploitation of Turtles

Due to the fact that exploitation of *Podocnemis* turtles is so widespread, and embedded in local cultures, a consideration of sustainable exploitation schemes is essential to any discussion of the species' conservation. Campbell (2002) states that although the notion of sustainable use is now central to contemporary conservation policy, as seen in projects supported by the major wildlife conservation organizations, long-lived animals with slow reproductive rates pose special challenges for use. Campbell interviewed 38 marine turtle conservation experts (anonymous); her results reveal a variety of positions: seven experts said that harvesting of adult turtles poses difficulties; six said that adults can be harvested; five said they cannot be harvested; 20 said sustainable egg harvesting is possible; and five said that egg harvesting is questionable and/or difficult. Long generation time and delayed sexual maturity were listed by 20 experts as being limitations for sustainable turtle use regimes. Nine experts said that either ranching or farming is doable, but five were opposed. Nineteen experts said that due to uncertainty, non-use should be prescribed; nine said that with uncertainties, experimentation with use should proceed; and three said they would rather not see use, but that uncertainty was not the reason. Thorbjarnarson et al. (1997) argue that in most areas *Podocnemis* recovery will require reductions in exploitation, but that one potential management option is to permit subsistence use while eliminating commercial utilization. However, they admit that this distinction is often blurred, that control could be difficult, and that it would require enforcement by communities.

Studies performed by Congdon et al. (1993, 1994) provide a strong basis for a conservation theory of freshwater turtles that is built on an understanding that turtle life history traits make them especially vulnerable to increased mortality in the large juvenile and adult stages. Congdon et al. demonstrate that long-lived animals cannot withstand increased mortality pressure in the adult stage; extrapolations in populations of freshwater turtles show that a modest harvest pressure of 10% per year, for 15 years, may result in a 50% reduction in population size. Following from this, they asserted that perhaps the idea of sustainable exploitation of turtles should be discarded, that turtle biology cannot withstand continuous exploitation of adult turtles.

In agreement, Heppell (1998) reports analyses of life tables from several turtle populations. Her work emphasizes stage elasticity where elasticity is the proportional contribution of fecundity or annual survival to the population growth rate. She reports that elasticities for most freshwater turtles were very similar; high adult survival elasticity and low fecundity elasticity suggest that reduction in mortality of adults is likely to stabilize declining populations. She concludes that turtle life histories make them especially prone to overexploitation in the adult stage. She stresses that, while the harvesting of eggs and juveniles adds to the cumulative negative impact of human activities on turtle populations, and captive rearing programs might be able to help "boost" recovering populations, turtle populations will recuperate only if the principle source of decline has been reduced (i.e., mortality in adult stages). In response to the idea that use of adult turtles can be mitigated by increasing survival of eggs and hatchlings, Heppell & Crowder (Heppell 1998; Heppell & Crowder 1998) asserted that for late maturing species, an increase in juvenile cohort size does not necessarily increase population growth, and that the establishment of healthy adult stocks, through decreases in adult mortality, should be the conservation goal for these populations.

These studies support the theory that any conservation plan for long-lived turtles must have the objective of lowering the rate of exploitation of adult turtles. They support the idea that sustainable use of turtles would be difficult to achieve, but that a sustainable use of eggs might be realistic. I will thus aim to curtail use of adult turtles; although, I know local communities will not support a no-use policy. Johns (1987) asserted that while commercial exploitation should be curtailed, subsistence use is impossible to curtail. My aim therefore will be to over time lower human use levels to a small percentage of the adult turtle population.

Community-Based Conservation

Although both *Podocnemis* species are ‘protected’ by national and international endangered species legislation, regulation cannot limit exploitation in an area as large and sparsely habited as the Amazon basin. Johns (1987) discussed the problem with governmental agencies, such as Brazil’s IBDF, that lack funds and manpower necessary to enforce protective legislation. Ojasti (1972) describes governmental protection in Venezuela as having afforded some lessening of over-exploitation of turtle populations, but not enough to allow for recuperation.

Adding to this problem, because Amazonian communities are still highly dependent on turtles for subsistence and commercial purposes, local communities often do not back governmental enforcement and fight against turtle protection schemes (Ojasti & Rutkis 1965). Throughout their range, it is widely recognized that successful conservation of *Podocnemis* species will have to depend on involvement of and management by local people; through involvement in management local communities can develop proprietary attitudes towards turtles; otherwise, they simply do not back enforcement (Ojasti & Rutkis 1965; Ojasti 1972; Alho 1985; Johns 1987; Caballero Guerrero 1996; Thorbjarnarson et al. 1997). This requires that communities be given some control of turtle resources. Thorbjarnarson et al. (1997) recommend the implementation of pilot programs to test community-based conservation, including mechanisms to control widespread illegal commercialization and monitoring the effects of human utilization on wild turtle populations.

Fachín Terán (2005) reports the success of *Podocnemis* conservation projects in Brazil that involve local communities. He reports that community involvement gives support to political enforcement, lowers the cost of implementing conservation legislation, and garners the support of local people. Townsend et al. (2005) report the success of a conservation and monitoring program, of both *Podocnemis* species, implemented by Cofán Indians in Ecuador. Conservation efforts include the voluntary banning of hunting turtles and sustainable restricted use of turtle eggs. Community members benefited through employment in research and monitoring program and a payment plan for collection of hatchlings for a headstart program. Monitoring programs demonstrate positive effects (increasing turtle and nesting abundance) of these management programs on local turtles. Success of this program demonstrates the potential for low cost local management of sustainable turtle populations, and for the Cofán involved in the project it was the basis for their acquisition of territorial rights and creation of an Indigenous managed wildlife reserve.

With *Podocnemis* population abundance declining throughout most of South America, it is apparent that protective legislation alone cannot eliminate a strong tradition of use, especially in a country such as Bolivia, which lacks the enforcement resources of neighboring Brazil. I am convinced that community-based conservation efforts are essential to the conservation of these species in Bolivia, and other subsistence-based regions of the turtles' range.

Conservation in PNNKM

There has been one project in PNNKM that has focused on conservation of *Podocnemis* turtles. It is a seven year nest beach protection and headstarting project (of both species of *Podocnemis)* on six nesting beaches in PNNKM: four on the Iténez River and two on the Paraguá River. The project was initiated by park guards, the local municipal government of San Ignacio de Velasco, and local community members. The project has not involved ecological research, data collection, or monitoring of activities. People involved in these efforts report a level of success in guarding nesting turtles and their nests against human predation, especially on nesting beaches of the Iténez River (pers. obs. 2006-2006). I see the nest beach protection activities as worthwhile measures that could be expanded upon. Most importantly, these effort demonstrate the interest local people have in mitigating what they observe to be declining turtle populations.

The results or consequences of headstarting activities are unknown. Local people support these activities and feel they are helping conserve turtle populations; however, many people have also expressed concern that hatchling turtles are experiencing high mortality rates (pers. comm. with community members in Bella Vista, 2005-2006). I see the headstarting project as ineffective, poorly planned, and implemented, for the following reasons: (1) hatchling turtles are collected along great distances of the Iténez River, and then two months later they are released in one location; (2) there is no consideration of or ability to screen for possible disease transference among hatchlings, kept in crowded conditions in small pools, and to wild turtle populations; (3) there is no consideration of or ability to research the negative effects of headstarting activities on turtle behavior and survival; and (4) hatchling turtles are released under non-natural conditions, into bays, instead of on sandy nesting beaches.

The precursor to my research is dissertation research conducted in PNNKM by K. Conway, in 1999 and 2000-2001, which collected socio-economic data, related to turtle use in local communities, and baseline indices of turtle abundance through basking counts (Conway 2004). Conway compared number of turtles and turtle size among sites at different proximities to human communities, along the Paraguá and Iténez Rivers. Both number of turtles and turtle size were negatively correlated with proximity to human communities (Conway 2004). Therefore, hunting likely has an impact on abundance of turtles in PNNKM, with the caveat that basking counts are indices of abundance that can be confounded by turtle behavior and avoidance of humans (i.e., counts are confounded by subordinate turtles not getting a spot to bask, which causes them to be under counted, and turtles slipping into the water before they can be counted (R. Carroll & S. Schweiter, pers. comm., 2008). A similar study was performed in Bolivia's Estación Biológica del Beni, where basking counts of *P. unifilis* are shown to be negatively correlated to proximity to human settlements (Quiroga Vera 2000).

Analyses of data from interviews in local communities revealed that a low level of market integration and household wealth, subsistence-based livelihood, and indigenous origin were correlated with a higher level of exploitation of turtles (Conway 2004). This relationship suggests that the poorest and more subsistence-based households are most likely to be involved in turtle harvest, sale, and consumption. The people most dependent on turtles, due to their economic status, have the least access to alternative sources of meat protein.

Lastly, as a basis for the national park/community based project I describe, there is a history of such collaborative projects in PNNKM. PNNKM management and members from the communities of Bella Vista, Florida, Piso Firme, Porvenir, and Cachuela together agreed upon and set the current borders of PNNKM. PNNKM management assisted residents of Piso Firme and Bella Vista in acquiring title to their land. And finally, a PNNKM fisheries management plan was developed through collaboration with the communities of Piso Firme, Porvenir, Bella Vista, and Florida (through the indigenous authority- Comunidades Indígenas del Bajo Paraguá (CIBAPA)), PNNKM management, and the municipal government of San Ignacio de Velasco.

References Cited

Alderton, D. 1998. Turtles & Tortoises of the World. Blandford, London.

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Alho, C. J. R., and L. F. M. Pádua. 1982. Reproductive parameters and nesting behavior of the Amazon turtle *Podocnemis expansa* (Testudinata: Pelomedusidae) in Brazil. Canadian Journal of Zoology **60**:97-103.

Almengor, M. A., C. L. Mo, and E. Vargas M. 1993. Preliminary evaluation of Olive Ridley egg commerce from Ostional Wildlife Refuge, Costa Rica. Marine Turtle Newsletter **63**:11-13.

Bates, H. W. 1863. The Naturalist on the River Amazon. John Murray, London.

Belkin, D. A., and C. Gans. 1968. An unusual chelonian feeding niche. Ecology **49**:768-769.

Bock, B. C., V. P. Paez, and N. F. Perez B. 1998. Preliminary radiotelemetry study of the movements of female *Podocnemis unifilis* turtles in the Caqueta River, Amazonas, Colombia. Actual. Biol. **20**:29-36.

Bock, B. C., V. P. Páez, and M. M. White. 2001. Genetic population structure of two threatened South American river turtle species, *Podocnemis expansa* and *Podocnemis unifilis*. Chelonian Conservation and Biology **4**:47-52.

Bodie, J. R. 2001. Stream and riparian management for freshwater turtles. Journal of Environmental Management **62**:443-455.

Boede, E. O., and O. Hernández. 2004. Diseases in arrau sideneck turtle, *Podocnemis expansa*, kept in Venezuelan farms. Revista Científica **14**:395-403.

Bruno Coca, F. 1999. Diversidad alimenticia en dos especies de tortugas acuaticas: *Podocnemis expansa* y *Podocnemis unifilis*, en la cuenca del Río Iténez; Parque "Noel Kempff Mercado". Page 69. Facultad de Ciencias Agrícolas. Universidad Autonoma "Gabriel Rene Moreno", Santa Cruz de la Sierra, Bolivia.

Burke, V. J., N. B. Frazer, and J. W. Gibbons. 1994. Conservation of turtles: The chelonian dilemma in B. A. Schroeder, and B. E. Witherington, editors. Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation. NOAA, Jekyll Island, Georgia.

Bury, R. B. 1979. Population ecology of freshwater turtles. Pages 571-602 in M. Harless, and H. Morlock, editors. Turtles: Perspectives and Research. John Wiley & Sons, New York.

Caballero Guerrero, J. 1996. Comparación de cuatro tratamientos de manejo para la protección de la peta de agua (*Podocnemis unifilis)*, Troschel 1840, y estimación de la supervivencia de las crías en las playas del Río Iténez. Page 82. Facultad de Ciencias Agrícolas. Universidad Autonoma "Gabriel Rene Moreno", Santa Cruz de la Sierra, Bolivia.

Campbell, L. M. 1998. Use them or lose them? Conservation and the consumptive use of marine turtle eggs at Ostional, Costa Rica. Environmental Conservation **25**:305-319.

Campbell, L. M. 2002. Science and sustainable use: views of marine turtle conservation experts. Ecological Applications **12**:1229-1246.

Campbell, L. M., B. J. Haalboom, and J. Trow. 2007. Sustainablity of community-based conservation: sea turtle egg harvesting in Ostional (Cost Rica) ten years later. Environmental Conservation **34**:122-131.

Campbell, L. M., and C. Smith. 2006. What makes them pay? Values of volunteer tourists working for sea turtle conservation. Environmental Management **38**:84-98.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Caputo, F. P., D. Canestrelli, and L. Boitani. 2005. Conserving the terecay (*Podocnemis unifilis,* Testudines: Pelomedusidae) through a community-based sustainable harvest of its eggs. Biological Conservation **126**:84-92.

Chan, E. H., and H. C. Liew. 1996. Decline of the leatherback population in Terengganu, Malyasia 1956-1995. Chelonian Conservation & Biology **2**:196-203.

CITES Secretariat. 2008. Convention on International Trade in Endangered Species of Wild Fauna and Flora: Species database. CITES Secretariat, Geneva, Switzerland.

Cole, M., and B. Link. 1972. *Podocnemis* in captivity. International Turtle & Tortoise Society **6**:12-14.

Congdon, J. D., A. E. Dunham, and R. C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of blanding's turtles (*Emydoidea blandingii*): Implications for conservation and management of long-lived organisms. Conservation Biology **7**:826-833.

Congdon, J. D., A. E. Dunham, and R. C. Van Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): Implications for conservation and management of long-lived organisms. American Zoologist **34**:397-408.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Emmons, L. H. 1989. Jaguar predation on chelonians. Journal of Herpetology **23**:311-314.

Ergueta, P., and C. de Morales. 1996. Libro Rojo de los Vertebrados de Bolivia. International Union for the Conservation of Nature, Gland, Switzerland.

Ernst, C. H., R. G. M. Altenburg, and R. W. Barbour. 1997. Turtles of the World. ETI World Biodiversity Database.

Ernst, C. H., and R. W. Barbour 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Ewert, M. A. 1979. The embryo and its egg: Development and natural history. Pages 333-413 in M. Harless, and H. Morlock, editors. Turtles: Perspectives and Research. John Wiley & Sons, New York.

Fachín Terán, A. 1992. Desove y uso de playas para nidificación de taricaya (*Podocnemis unifilis*) en el Río Samiria, Loreto-Perú. Boletin de Lima **79**:65-75.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Fachín Terán, A. 2005. Participacao com unitaria na preservacao de praias para reproducao de quelonios na reserva de desenvolvimento sustentavel mamiraua, Amazonas, Brasil. Pages 19-30. Uakari.

Fachín Terán, A., and R. C. Vogt. 2004. Estrutura populacional, tamanho e razão sexual de *Podocnemis unifilis* (Testudeines, Podconemididae) no Rio Guaporé (RO), norte do Brasil. Phyllomedusa **3**:29-42.

Fachín Terán, A., R. C. Vogt, and M. d. F. Soares Gómez. 1995. Food habits of an assemblage of five species of turltes in the Rio Guapore, Rondonia, Brazil. Journal of Herpetology **29**:536-547.

Filoramo, N. I., and F. J. Janzen. 2002. An experimental study of the influence of embryonic water availability, body Size, and clutch on survivorship of neonatal red-eared sliders, *Trachemys scripta elegans*. Herpetologica **58**:67-74.

Food and Agriculture Organization. 1988. Las tortugas del río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Areas Silvestres **Año 3**:23-29.

Foote, R. W. 1978. Nesting of *Podocnemis unifilis* (Testudines: Pelomedusidae) in the Colombian Amazon. Herpetologica **34**:333-339.

Frazer, N. B. 1992. Sea turtle conservation and halfway technology. Conservation Biology **6**:179-184.

Frazer, N. B. 1997. Turtle conservation and halfway technology: What is the problem? Pages 422-425 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase.

Frazer, N. B. 2000. Foreword. Pages xi-xiv in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Frazer, N. B., J. W. Gibbons, and J. L. Greene. 1990. Life tables of a slider turtle population. Pages 183-200 in J. W. Gibbons, editor. Life History and Ecology of the Slider Turtle. Smithsonian Institution Press, Washington, D.C. .

Freiberg, M. 1982. Turtles of South America. TFH Publications, Neptune, NJ.

García, A., G. Ceballos, and R. Adaya. 2003. Intensive beach management as an improved sea turtle conservation strategy in Mexico. Biological Conservation **11**:253-261.

Gibbs, J. P., and G. D. Amato. 2000. Genetics and demography in turtle conservation. Pages 207-217 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Heppell, S. S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia **1998**:367-375.

Heppell, S. S., and L. B. Crowder. 1998. Prognostic evaluation of enhancement programs using population models and life histrory analysis. Bulletin of Marine Science **62**:495-507.

Hernández, O., and R. Espín. 2006. Effects of reinforcement on the arrau turtle (*Podocnemis expansa*) population in the Middle Orinoco, Venezuela. Interciencia **31**:424-430.

Hope, R. A. 2002. Wildlife harvesting, conservation and poverty: the economics of olive ridley egg exploitation. Environmental Conservation **29**:375-384.

Hugall, A. F., R. Foster, and M. S. Y. Lee. 2007. Calibration choice, rate smoothing, and the pattern of tetrapod diversification according to the long nuclear gene RAG-1. Systematic Biology **56**:543-563.

IUCN (International Union for Conservation of Nature and Natural Resources) 1989. Tortoises and freshwater turtles: An action plan for their conservation. International Union for Conservation of Nature and Natural Resources, Species Survival Commission, Tortoise and Freshwater Turtle Specialist Group, Gland, Switzerland.

Iverson, J. B. 1982. Biomass in turtle populations: A neglected subject. Oecologia **55**:1432-1939.

Iverson, J. B. 1992. A Revised Checklist with Distribution Maps of the Turtles of the World. J. P. Iverson Publishing, Richmond.

Jacobson, E. R. 1993. Implications of infectious diseases for captive propagatioin and introduction programs of threatened and endangered species. Journal of Zoo and Wildlife Medicine **24**:245-255.

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Klemens, M. W. 2000. From information to action: Developing more effective strategies to conserve turtles. Pages 239-258 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Klemens, M. W., and J. B. Thorbjarnarson. 1995. Reptiles as a food resource. Biodiversity and Conservation **4**:281-298.

Knothe, H. 1996. Manejo de la tortuga *Podocnemis unifilis* en la estación biologíca del Beni, Proyecto Quelonios 1991-1995. Estación Biológica del Beni, Santa Cruz de la Sierra, Bolivia.

Kuchling, G. 1999. The Reproductive Biology of the Chelonia. Springer-Verlag, New York.

Licata, L., and X. Elguezabal. 1997. Management plan for the giant Amazonian turtle, *Podocnemis expansa*, in De La Tortuga Arrau Wildlife Refuge, Orinoco River, Venezuela. Pages 171-173 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

McDougal, J. 2000. Conservation of tortoises and terrestrial turtles. Pages 180-206 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Meylan, A. B., and D. Ehrenfel. 2000. Conservation of marine turtles. Pages 96-125 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Miller, K., G. C. Packard, and M. J. Packard. 1987. Hydric conditions during incubation influence locomotor performance of hatchling snapping turtles. Journal of Experimental Biology **127**:401-412.

Mittermeier, R. A. 1975. A turtle in every pot: a valuable South American resource going to waste. Pages 9-14. Animal Kingdom.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Moll, D., and E. O. Moll 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press, Oxford.

Moll, E. O., and D. Moll. 2000. Conservation of river turtles. Pages 126-155 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Morris, K. A., G. C. Packard, T. J. Boardman, G. L. Paukstis, and M. J. Packard. 1983. Effect of the hydric environment on growth of embryonic snapping turtles (*Chelydra serpentina*). Herpetologica **39**:272-285.

Mortimer, J. A. 1988. Management options for sea turtles: Re-evaluating priorities. Florida Defenders of the Environment **25**:1-4.

Mortimer, J. A. 1999. Reducing threats to eggs and hatchlings: Hatcheries. Pages 175-178 in K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, and M. donnelly, editors. Research and Management Techniques for the Conservation of Sea Turtles. ICUN/SSC Marine Turtle Specialist Group, Washington DC.

Ojasti, J. 1967. Consideraciones sobre la ecologia y conservación de la tortuga *Podocnemis expansa* (Chelonia, Pelomedusidae). Pages 201-206. Atas do Simposia sobre a Biota Amazónia

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J. 1972. La Problematica de la Tortuga Arrau. Pages 4-10 in Ministerio de Agricultura y Cria, Dirección de Recursos Naturales Renovables, and Republica de Venezuela, editors.

Ojasti, J. 1996. Wildlife utilization in Latin America: Current situation and prospects for sustainable management (FAO conservation guide - 25) in F. a. A. O. o. t. U. N.-. FAO, editor, Rome.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Orellana, C. 2004. Turtles released into the Orinoco. Frontiers in Ecology and the Environment **2**:231.

Packard, G. C., M. J. Packard, and T. J. Boardman. 1981. Patterns of possible significance of water exchange by flexible-shelled eggs of painted turtles (*Chrysemys picta*). Physiological Zoology **54**:165-178.

Packard, G. C., M. J. Packard, T. J. Boardman, K. A. Morris, and R. D. Shuman. 1983. Influence of water exchanges by flexible-shelled eggs of painted turtles *Chrysemys picta* on metabolism and growth of embryos. Physiological Zoology **56**:217-230.

Packard, G. C., M. J. Packard, K. Miller, and T. J. Boardman. 1988. Effects of termperature and moisture during incubation on carcass composition of hatchling snapping turtles (*Chelydra serpentina*). Journal of Comparative Physiology B **158**:117-125.

Pearse, D. E., A. D. Arndt, N. Valenzuela, B. A. Miller, V. H. Cantarelli, and J. W. Sites, Jr. 2006. Estimating population structure under nonequilibrium conditions in a conservation context: Continent-wide population genetics of the giant Amazon river turtle, *Podocnemis expansa* (Chelonia; Podocnemididae) Molecular Ecology **15**:985-1006.

Pough, F. H., R. M. Andrews, J. E. Cadle, M. L. Crump, A. H. Savitzky, and K. D. Wells 2003. Herpetology. Pearson Prentice Hall, Upper Saddle River, NJ.

Pritchard, P. C. H. 1979a. Encyclopedia of Turtles. T.F.H. Publications, Neptune, NJ.

Pritchard, P. C. H. 1979b. Taxonomy, evolution, and zoogeography. Pages 1-42 in M. Harless, and H. Morlock, editors. Turtles: Perspectives and Research. John Wiley & Sons, New York.

Pritchard, P. C. H., and P. Trebbau 1984. The Turtles of Venezuela. Society for the Study of Amphibians and Reptiles.

Quiroga Vera, P. G. 2000. Abundancia y estructura poblacional en función de la intervención humana y las preferencias de nidificación de *Podocnemis unifilis* en el Río Maniqui. Page 58. Facultad de Ciencias y Technología. Universidad Mayor de San Simón, Cochabamba, Bolivia.

Remor de Souza, R., and R. C. Vogt. 1994. Incubation temperature influences sex and hatchling size in the neotropical turtle *Podocnemis unifilis*. Journal of Herpetology **28**:453-464.

Rhodin, A. G. J., F. Medem, and R. A. Mittermeier. 1981. The occurrence of neustophagia among *Podocnemis* turtles. British Journal of Herpetology **6**:175-176.

Ross, J. P., S. Beavers, D. Mundell, and M. Airth-Kindree. 1989. The Status of Kemp's Ridley. Pages 34-40. Center for Marine Conservation.

Schweigger, A. F. 1812. Prodromus monographiae Cheloniorum auctore Schweigger. Arch Naturwissu Math **1**:406-458.

Seigel, R. A., and C. K. Dodd, Jr. 2000. Manipulation of turtle populations for conservation: Halfway technologies or viable options? Pages 218-238 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Shaver, D. J. 2005. Kemp's ridley sea turtle nesting increasing in Texas. Pages 391-397 in D. Harmon, editor. People, Places, and Parks: Proceedings of the 2005 George Wright Society Conference on Parks, Protected Areas, and Cultural Sites. The George Wright Society, Hancock, Michigan.

Sites, J. W., Jr., N. N. FitzSimmons, N. J. Da Silva, Jr., and V. H. Cantarelli. 1999. Conservation genetics of the giant Amazon river turtle (*Podocnemis expansa*; Pelomedusidae) - Inferences from two classes of molecular markers. Chelonian Conservation and Biology **3**:454-463.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Snyder, N. F. R., S. R. Derrickson, S. R. Beissinger, J. W. Wiley, T. B. Smith, W. D. Toone, and B. Miller. 1996. Limitations of captive breeding in endangered species recovery. Conservation Biology **10**:338-348.

Soini, P. 1994. Ecología reproductiva de la taricaya (*Podocnemis unifilis*) en el Río Pacaya, Perú. Folia Amazonica **6**:111-134.

Soini, P., V. Pulido, A. Brack Egg, and K. Thelen 1997. Biologia y Manejo de la Tortuga *Podocnemis expansa* (Testudines, Pelomedusidae). Secretaria Pro Tempore, Caracas, Venezuelaq.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Thompson, M. B. 1993. Hypothetical considerations of the biomass of chelid tortoises in the River Murray and the possible influences of predation by introduced foxes. Pages 219-224 in L. D, and D. Ayers, editors. Herpetology in Australia-a Diverse Discipline. Royal Zoological Society of New South Wales, Mosman.

Thorbjarnarson, J. B., C. J. Lagueux, D. Bolze, M. W. Klemens, and A. B. Meylan. 2000. Human use of turtles: A worldwide perspective. Pages 33-84 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1993. Nesting of *Podocnemis unifilis* in the Capanaparo River, Venezuela. Journal of Herpetology **27**:344-347.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Tortoise and Freshwater Turtle Specialist Group 1991. Tortoises and Freshwater Turtles: An Action Plan for Their Conservation. The World Conservation Union, Broadview, Illinois.

Townsend, W. R., R. Borman A, E. Yiyoguaje, and L. Mendua. 2005. Cofán indians' monitoring of freshwater turtles in Zábalo, Ecuador. Biodiversity and Conservation **14**:2743-2755.

Troeng, S., and E. Rankin. 2005. Long-term conservation efforts contribute to positive green turtle *Chelonia mydas* nesting trend at Tortuguero, Costa Rica. Biological Conservation **121**:111-116.

Troschel, F. H. 1848. Amphibien in R. Schomburgk, editor. Versuch einer Zusammenstellung der Faunaund Flora von Britisch-Guiana.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington DC.

U.S. Fish & Wildlife Service. 2007. USFWS Threatened and Endangered Species System (TESS).

Valenzuela, N. 2001. Constant, shift, and natural temperature effects on sex determination in *Podocnemis expansa* turtles. Ecology **82**:3010-3024.

Valenzuela, N., R. Botero, and E. Martínez. 1997. Field study of sex determination in *Podocnemis expansa* from Colombian Amazonia. Herpetologica **53**:390-398.

Vanzolini, P. E. 1977. A brief biometrical note on the reproductive biology of some South American *Podocnemis* (Testudines, Pelomedusidae). Papéis Avulsos de Zoologia **31**:79-102.

Vanzolini, P. E. 2003. On clutch size and hatching suceess of the South American turtles *Podocnemis expansa* (Schweigger, 1812) and *P. unifilis* Troschel, 1848 (Testudines, Podocnemididae). Annals of the Brazilian Academy of Sciences **75**:415-430.

Vogt, R. C. 1995. Brazilian freshwater turtles, to eat or not to eat? Save them by eating them? in B. Devaux, editor. International Congress of Chelonian Conservation, SOPTOM (Station d'observation et de protection des tortues des maures), Gonfaron, France.

Von Humboldt, A. 1819. Relation Historique du Voyage aux Régions Équinoxiales du Nouveau Continet, Fait en 1799-1804. Maze, Paris.

Von Humboldt, A. 1852. Personal Narrative of Travels to the Equinoctial REgions of America 1799-1804. H. G. Bohn, London.

World Chelonian Trust. 2003. The complete chelonian taxonomy list.

CHAPTER 3

LOCALLY-BASED CONSERVATION OF *PODOCNEMIS* RIVER TURTLES IN NOEL KEMPFF MERCADO NATIONAL PARK, BOLIVIA[1]

[1] Lipman, A. J., K. Conway-Gómez, and Saucedo Mendía L. Submitted to Conservation Biology, 3/19/2008.

Abstract

The decline of river turtles, documented throughout tropical South America, has caught the attention of local indigenous communities and the administration of Noel Kempff Mercado National Park, in eastern Bolivia. Local resource managers initiated a collaborative conservation program, focused on the yellow-spotted Amazon river turtle (*Podocnemis unifilis)* and the giant South American river turtle (*P. expansa)*, to mitigate potential loss of these species. The project is locally-managed and based on academic studies; its goal is to conserve a natural resource that is important to local people and the biodiversity of the region. The first two phases of the project focused on collection and analysis of ecological and social data related to local turtle abundance, reproduction, human use, and other threats. Results demonstrated that negative impacts on local turtle populations are caused by direct exploitation by humans, and that human movement and land use potentially have negative impacts on turtle populations. High turtle mortality rates are also documented to result from nest beach inundation and animal predation. The third phase of the project will focus on creating and implementing a locally-based management plan that will preserve viable turtle populations, while striving for a sustainable subsistence use of the species.

Key Words: *Podocnemis expansa*; *Podocnemis unifilis*; river turtles; turtle conservation; Bolivia; local conservation; community-based conservation

Introduction

We present an innovative conservation project in Noel Kempff Mercado National Park (PNNKM), a World Heritage Site in the Bolivian Amazon, that focuses on management of rapidly declining South American river turtles (*Podocnemis* spp.), in conjunction with the rights and livelihoods of human communities. Our general goal is to conserve and manage viable populations of the species within and near PNNKM, on the Iténez (Guaporé in Brazil) and Paraguá Rivers. We plan to achieve this goal by strengthening the ability of local institutions to conserve the natural resources on which people depend. The project was initiated by local citizens and resource managers concerned about the decline of this subsistence resource, and it is supported by collaborative alliances that ensure its scientific integrity and long-term sustainability. Collaborators include indigenous communities of the Bajo Paraguá, PNNKM administration, Bolivia's Servicio Nacional de Áreas Protegidas (SERNAP), and the University of Georgia, U.S.A., with some involvement by the Bolivian NGO Fundación Amigos de la Naturaleza.

Conservation Need: Defined by local livelihoods and science

The project is based on the knowledge, gained from ecological study, of potential extirpation of the species if current practices continue. It is based in local management, with the understanding that locally-chosen livelihood alternatives pose a greater probability of success. We believe that locally-based management of natural resources, by the human populations that depend on them, is not only a more equitable option in conservation planning, it is likely the only management scheme that can be effective in areas where monetary and professional (e.g., scientific, enforcement) resources are scarce. Most importantly, local management allows people a sense of proprietorship, and thus responsibility, towards the natural resources on which they depend. Lastly, but integral to our program, throughout every phase of the project ecological study is used as a tool to directly inform management. This is in response to the failure of turtle conservation projects worldwide to maintain stable populations, because they have been based on poor understanding of turtles´ unique life histories and rigorous scientific study (Gibbs & Amato 2000; Klemens 2000; McDougal 2000; Meylan & Ehrenfel 2000; Moll & Moll 2000; Seigel & Dodd 2000). We hope to demonstrate that science-based, community-managed conservation of these endangered species can fulfill the goals of local people as well as of PNNKM administration, by conserving the biodiversity and natural resources of Bolivia.

The project's wildlife conservation foci are the yellow-spotted Amazon river turtle (*Podocnemis unifilis)* and the giant South American river turtle (*P. expansa),* found throughout the Amazon and Orinoco river basins. The species have regionally important cultural and economic value and are considered keystone species in their habitats (Turtle Conservation Fund 2002). Both species, once ubiquitous throughout their ranges, are listed in the IUCN Red List of Threatened Species (Species Survival Commission 2008) and classified as 'Endangered' by the U.S. Fish & Wildlife Service (2007). Hunting pressure is documented as the basis for their decline, as breeding females and their eggs are principal sources of protein for local people, and human land use that affects turtle habitat (especially through disruption of riverine nesting activities) is documented as a secondary threat (Ojasti & Rutkis 1965; Ojasti 1971; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Oficina Regional de la F. A. O. para América Latina y el Caribe 1988; Fachín Terán 1994; Ergueta & de Morales 1996; Cantarelli 1997; Thorbjarnarson et al. 1997; Escalona & Fa 1998; Conway 2004).

Science Based Community Planning

Phase I

The first phase of the project included collection of initial socio-economic data and baseline turtle abundance counts in 1999 and 2000-2001 (Conway 2004; Conway-Gómez 2007; Conway-Gómez 2008). These first studies were initiated to address biological concerns for species survivorship and to achieve a better understanding of human-environment interactions, particularly in light of local sentiment that turtles are decreased in abundance today (in comparison with memories of the past). The geographic context of the project was also a major driver in the initiation of the project. The region lies within a major tropical wilderness area – the Upper Amazonia/Guyana Shield - one of the three most pristine terrestrial ecoregions in the world, exhibiting a high degree of species endemism (Cincotta et al. 2000). The ecoregion concept, for conservation prioritization, is considered complementary to the biodiversity hotspot concept proposed by Myers in 1988 (Turtle Conservation Fund 2002; Myers 2003). The high endemism of terrestrial vertebrates in this region, coupled with human population density threats and the dependence of people on wildlife hunted for consumption, prioritize this area for proactive conservation efforts (Klemens 1997; Gibbs & Amato 2000; Moll & Moll 2000). Specifically, *Podocnemis* turtles are found largely within the Upper Amazonia/Guyana Shield major tropical wilderness area, suggesting them as potential focal species for conservation (Mittermeier et al. 2003).

Due to the project's goal of community-based conservation, investigation in the first phase sought to clarify human social and economic systems as they pertain to *Podocnemis* consumption. Findings from the first phase indicate that there are significant differences between communities in hectares of land cultivated and time dedicated to turtle hunting, which suggests differential pressure on turtles amongst economic groups. More market-integrated communities have a higher average area of land under cultivation and a lower average of hours per week dedicated to turtle hunting. This finding will have implications for the support of and search for alternative food or income sources.

Phase II

The second phase of the project consisted of two years (2005-2006) of ecological and oral history research that provide knowledge of local turtle reproductive populations, changes in local turtle abundance over time, and threats to the same (Chapter 4). We analyzed both small and large-scale factors affecting *Podocnemis* decline: human consumption of turtles and human land use effects, as well as any potentially positive stewardship effects (e.g., guarding of nesting beaches). The program included four separate activities: (1) study of turtle nesting populations (nesting females and eggs) to obtain reproductive and mortality data; (2) interviews with local residents to query temporal and spatial patterns of turtle populations; (3) weekly interviews with local residents (conducted by students) to obtain human use data; and (4) study of riverine habitat to determine possible human land-use effects on turtles (Chapters 4 & 5).

Findings demonstrate direct negative human effects on abundance of nesting female populations and nest survivability, caused by high rates of exploitation of female turtles and their eggs (reaching 100% on some beaches). Findings also demonstrate indirect negative human effects on turtle nesting caused by tourism, motor boat traffic, and grazing cattle. Animal predation and early inundation of nesting beaches were sources of mortality (both reaching 100%) on some beaches. Local interviews documented a decline in both turtle species over time, noticed by the most local inhabitants. Human use studies documented high rates of use of both species and their eggs in all neighboring human communities, with a few families being the primary sources of turtle mortality in the larger communities. Land use studies detected increasing development within riparian corridors that was most noticeable on the Brazilian side of the Iténez River, where land use is predominantly cattle ranching and large lodges for hunting and fishing tourists. Deforestation for these land use activities could cause changes in river hydrology that affect nesting beaches, but further research is needed to test this relationship.

The second phase of the project also focused on capacity building of local resource managers and local conservation education programs. Capacity building involved the training of five park guards and 14 community members, who were hired as research assistants in ecological and social research. Training was realized through workshops and working together on-site in project planning, data collection, data analysis, and management planning over the two-year period. The human use study was also part of an environmental/ecology course initiated in three local schools that involved teaching students (4^{th} to 8^{th} grade) about scientific research and conservation theory. Students (accompanied by researchers) conducted all interviews with local families related to the consumption of turtles in their communities. They collected valuable data and presented their results to the communities and PNNKM administration. These presentations were followed by discussions among adults concerned with numbers of turtles being collected.

We found this process of child education combined with informal discussion with adults to work well in garnering local support and interest in project investigation, and ultimately conservation. These discussions supplemented village level meetings that informed communities of the project's progress and the importance of turtle conservation. Lastly, we conducted interviews of all local families related to peoples' opinions of the project and the future Management Plan. We documented widespread local concern that turtles are disappearing, almost 100% support and belief in the necessity of the project, and many ideas for regulating turtle use in a sustainable manner. This information will be essential to creation of the community-based Species Management Plan.

Phase III

Work in the third phase will continue previous programs, analyze and compare data from the first and second phases, present results in community and PNNKM planning meetings, and work towards conservation management of the species. Specific objective and activities will be: (1) Continue ecological study of *Podocnemis* populations and threats to them in the long-term, including landscape-wide effects of human land use; (2) Continue capacity building of local resource managers in species research and conservation (until local managers can independently run all project activities); (3) Continue education of local students in research and conservation; (4) Create and implement a long-term, scientifically-informed, and community-based Species Management Plan; and (5) Search for alternatives or changes to turtle hunting behavior. In this phase we will also further examine differences in livelihoods between and within communities, such as time and area dedicated to subsistence cultivation, and potential relationships with turtle consumption. It is anticipated that this analysis of variance in local livelihoods will clarify the social and economic characteristics affecting turtle consumption and thus turtle abundance and species' survival. Armed with such livelihood pattern information, communities may make informed management decisions for the future of their turtle resources. For example, communities may identify the need for alternative food and income sources within specific sectors of the community that rely completely on turtle hunting for survival.

The end goal of the third phase is creation and implementation of the locally-based Species Management and Conservation Plan, which will be based on long-term ecological monitoring that advises ongoing reevaluation and updating of the plan. Research findings will be presented to communities along with projection scenarios. This information will be discussed among community members, researchers, and PNNKM staff to develop a plan that strikes a balance between communities' rights to govern their natural resources and by extension their livelihoods, and maintenance of healthy turtle populations, based on scientifically-rigorous data.

Conservation Applications

This project directly addresses an important threat to global biodiversity – dramatic worldwide decline in freshwater turtle populations (Turtle Conservation Fund 2002) – as well as local wildlife management goals in PNNKM, a nationally protected area with internationally recognized biodiversity value. It also addresses the cause for failure of many conservation efforts in subsistence-based regions, which do not address the needs and rights of local people, such as the right to food. This project directly addresses the needs of local people, as it was initiated by local citizens, to conserve their *Podocnemis* food resources. The project thus benefits not only *Podocnemis* populations, but also it addresses the subsistence needs of local human populations. The current PNNKM Management Plan, produced by PNNKM administration and FAN, allows for subsistence use of *Podocnemis* turtles and their eggs. Subsistence use is defined as local consumption. Our goal is to define and regulate use of turtles, based on results of data, related to the abundance of turtles and nest success, that have been discussed in planning meetings.

We report what has thus far been a successful effort in collaborative conservation planning (local people, scientists, and park management) in the tropics, which has been realized through necessity: only by working together could effective conservation be implemented. The expected products of this project are the *Podocnemis*, based on ecological research conducted by local residents, and the improved capacity of local resource managers to support and implement the plan in the long-term. Through local implementation, the project also creates local jobs in ecological research, supports local environmental education, and works to build a local understanding of the vulnerability and decline of *Podocnemis* turtles, and factors contributing to this decline. Project success will also raise the value of this protected area in the eyes of local people.

We present a practical conservation strategy– one that is locally-based, supported by local government, and requires only minimal and short-term outside support – that could be relevant to other subsistence based regions – where lack of conservation funding allows for unmonitored use, and thus destruction, of natural resources.

References Cited

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Cincotta, R. P., J. Wisnewski, and R. Engelman. 2000. Human population in the biodiversity hotspots. Nature **404**:990-992.

Conway-Gómez, K. 2008. Market integration, perceived wealth and household consumption of turtles (*Podocnemis* spp.) in eastern lowland Bolivia. Journal of Latin American Geography **7**:85-103.

Conway-Gómez, K. M. 2007. Effects of human settlements on abundance of *Podocnemis unifilis* and *P. expansa* turtles in northeastern Bolivia. Chelonian Conservation & Biology **6**:199-205.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Ergueta, P., and C. de Morales. 1996. Libro Rojo de los Vertebrados de Bolivia. International Union for the Conservation of Nature, Gland, Switzerland.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Gibbs, J. P., and G. D. Amato. 2000. Genetics and demography in turtle conservation. Pages 207-217 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Klemens, M. W. 1997. A New Paradigm for Conservation. Pages xv-xvii, New York.

Klemens, M. W. 2000. From information to action: Developing more effective strategies to conserve turtles. Pages 239-258 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

McDougal, J. 2000. Conservation of tortoises and terrestrial turtles. Pages 180-206 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Meylan, A. B., and D. Ehrenfel. 2000. Conservation of marine turtles. Pages 96-125 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Mittermeier, R. A., C. G. Mittermeier, T. M. Brooks, J. D. Pilgrim, W. R. Konstant, G. A. B. da Fonseca, and C. Kormos. 2003. Wilderness and biodiversity conservation. Proceedings of the National Academy of Sciences of the United States of America **100**:10309-10313.

Moll, E. O., and D. Moll. 2000. Conservation of river turtles. Pages 126-155 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Myers, N. 2003. Biodiversity Hotspots Revisited. Bioscience **53**:916-917.

Oficina Regional de la F. A. O. para América Latina y el Caribe. 1988. Las Tortugas de Río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Aréas Silvestres **3**:23-29.

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Seigel, R. A., and C. K. Dodd, Jr. 2000. Manipulation of turtle populations for conservation: Halfway technologies or viable options? Pages 218-238 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington, D.C.

U.S. Fish & Wildlife Service. 2007. USFWS Threatened and Endangered Species System (TESS).

CHAPTER 4

THE EFFECTS OF HUMAN ACTIVITY ON NESTING OF *PODOCNEMIS* TURTLES IN NOEL KEMPFF MERCADO NATIONAL PARK, BOLIVIA[1]

[1] Lipman, A. J. and L. Saucedo Mendía. To be submitted to Chelonian Conservation & Biology.

Abstract

The research presented here provides the scientific basis for an innovative conservation project in Noel Kempff Mercado National Park (PNNKM), a World Heritage Site in Bolivia, with an eastern border shared with Brazil, that focuses on two declining species of South American river turtles: *Podocnemis unifilis* (yellow-spotted Amazon river turtle, locally "tracayá") and *P. expansa* (giant South American river turtle, locally "tataruga"). These rapidly declining river turtles have regionally important biodiversity, cultural and economic value. Research addresses the following questions posed by local citizens and resource managers, who have observed that populations of both species are declining in PNNKM (compared to their memories of the past): Are local turtle populations declining, and if so, are they negatively affected by human activities? We posed two hypotheses: (H_1) direct human exploitation of turtles is negatively affecting local *Podocnemis* populations, and (H_2) indirect human activities (e.g., land use, tourism, movement) pose secondary negative effects. We tested H_1 through nesting studies that compared five indices of population viability (reproductive variables) between nesting sites under three different levels of human use (low, high, and protected). Reproductive variables compared were: (1) number of nests per beach; (2) size of nesting females; (3) hatchling size; (4) nest survival; and (5) hatchling survival. We also documented all observed threats (human and non-human) to nesting populations. Results demonstrated that all tested variables showed negative impacts at sites under heavy use by humans; thus H_1 was supported. In addition to direct human use of turtles, we documented indirect human threats to local turtles: trampling by cattle, human movement on the river, and tourism activities. Additional causes of high mortality at nest sites included predation of eggs by animals and early season nest inundation. We did not directly test our second hypothesis, but we documented

potential habitat-related threats to local turtles (e.g., high nest disturbance by inundation, high levels of animal predation, high levels of human river traffic that impedes turtle nesting, high levels of deforestation on the Brazilian side of the park).

Key Words: *Podocnemis expansa*, *Podocnemis unifilis*, turtle nesting, sustainable use, turtle reproduction, turtle conservation, river turtle, Bolivia, tropical conservation

Introduction

We present research that provides the scientific basis for an innovative conservation project, in Noel Kempff Mercado National Park (PNNKM), Bolivia, managed by local communities and park management, that focuses on two declining species of South American river turtles: *Podocnemis unifilis* (yellow-spotted Amazon river turtle, locally “tracayá”) and *P. expansa* (giant South American river turtle, locally “tataruga”). These turtles have regionally important cultural and economic value (Conway 2004), and, according to the Turtle Conservation Fund (2002), often serve as keystone species in their habitats. Our project is a locally initiated collaboration of indigenous communities, PNNKM administration, and scientists at the University of Georgia. It was developed in response to the observed decline of both turtle species in PNNKM, by local people who depend on them for subsistence purposes. As such, this work directly addresses local wildlife management goals in PNNKM, as well as the livelihood needs of subsistence-based indigenous human communities.

Target Species

Podocnemis expansa and *P. unifilis* were once ubiquitous throughout the Amazon and Orinoco river basins; they are now listed in the IUCN Red List of Threatened Species (Species Survival Commission 2008), in Appendix II of the Convention on International Trade in Endangered Species (CITES) (CITES Secretariat 2008), and rated “1,” highest priority in the Tortoise and Freshwater Turtle Specialist Group Action Plan Rating (APR) (Tortoise and Freshwater Turtle Specialist Group 1991). Hunting pressure is documented as the basis for their decline, as breeding females and their eggs are principal sources of protein for local people, and they have been over-exploited for sale in commercial markets, beginning with the arrival of

Europeans to the region (Ojasti 1971, 1972; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Food and Agriculture Organization 1988; Ergueta & de Morales 1996; Cantarelli 1997; Licata & Elguezabal 1997; Moll & Moll 2000; Turtle Conservation Fund 2002). Human land use (e.g., cattle ranching, agriculture, dams) that affects turtle habitat is a secondary threat (Ojasti & Rutkis 1965; Food and Agriculture Organization 1988; Fachín Terán 1994; Thorbjarnarson et al. 1997; Escalona & Fa 1998).

Local Conservation Need

Like most Amazonian peoples, residents near PNNKM have a strong cultural legacy of using turtle products and commonly state their preference for turtle meat over all domestic meats, claiming it has more nutritional value (Conway 2004). During the nesting season, turtles currently and historically have provided a reliable and readily available source of protein for subsistence-based Amazonian riverine people (Kuchling 1999; review in Moll & Moll 2004; personal observation 2005 to 2006). They are readily available because nesting turtles and their eggs are easy targets for humans. Non-mobile nesting females are easily sighted on open beaches and collected live in large numbers. Eggs are easily dug up, found by tracing obvious turtle tracks, or they are spotted later as mounded nests (Ojasti 1996; Lipman, pers. obs.). Turtles bear the additional risk of being easy to transport (stacked in boats) with little need for space and food, and they can be maintained live for months before they are eaten (Thorbjarnarson et al. 2000; Lipman, pers. obs.).

Podocnemis populations within PNNKM are especially vulnerable to threats from neighboring riverine communities, because PNNKM's borders are formed by two navigable rivers (the Paraguá and the Iténez) that provide virtually open access to turtle hunting and egg gathering in the park (Figure 4.1.2). Both species are protected by Bolivian and Brazilian laws; however, a historic lack of financial and infrastructure support for conservation and enforcement in this largely frontier area allows for their continued and unmonitored use. Bolivian law defines commercial exploitation of the species as illegal, but it allows for subsistence use of the species that is poorly defined (PNNKM administration, pers. comm. 2003).

In addition to direct human use, increasing levels of human land use (e.g., cattle ranching, agriculture, intensive tourism) pose potential threats to local *Podocnemis* populations, especially along the Brazilian side of the Iténez River, across and upstream the river from PNNKM. Changes in riverine habitat, combined with increased levels of human activity, could translate to large scale changes that affect turtle habitat, food sources, and nesting requirements. Despite the fact that PNNKM is an internationally recognized center of biodiversity, none of these potential threats have been previously studied, and previous studies on *Podocnemis* population integrity in PNNKM have been conducted.

The impetus for this project came from local citizens and resource managers, concerned by what they perceived to be declining turtle populations, in and near PNNKM. Their objective was to conduct ecological research to assess the status of (and threats to) local populations of both species, that could inform management and conservation actions directly. The research we present thus addresses a local and larger need, relevant to turtle conservation efforts worldwide: that turtle conservation projects are often not based on scientific understanding of specific turtle life histories and threats, and have been largely ineffective at maintaining turtle populations (Gibbs & Amato 2000; Klemens 2000; McDougal 2000; Meylan & Ehrenfel 2000; Moll & Moll 2000; Seigel & Dodd 2000). We present ecological study as a tool to inform recommendations for local management directly.

Project Objectives

The general objective of the conservation project is to conserve and manage viable populations of *P. unifilis* and *P. expansa* within and near PNNKM, in conjunction with the rights and livelihoods of local ribereño (riverside) human communities.

We hypothesized that direct human use of turtles has negatively affected *Podocnemis* populations within and near PNNKM, and that this impact has been compounded by the indirect effects of intensive land use (e.g., agriculture, cattle ranching, timber harvesting, tourism) along the park border in Brazil. The objective of our research was to test this hypothesis and use the results to inform management actions directed towards recuperation and conservation of the species. Our research examined the status of local *Podocnemis* populations and the fundamental causes of their reported population decline, as well as any potentially positive stewardship efforts (e.g., guarding of nesting beaches). We looked at both small-scale (consumption) and large-scale (land use leading to change in stream flow dynamics) factors of potential human impacts.

Research Questions and Hypotheses

The two specific questions addressed by this study were:

1. Are populations of *P. unifilis* and *P. expansa* affected by human activities in and near PNNKM? This was addressed by testing the following research hypothesis:

H_1: Direct human use of turtles by local communities (i.e., hunting, egg gathering) has negatively affected *Podocnemis* populations in and near PNNKM.

We also posed a second hypothesis, which we did not test directly in this study, but which we addressed and recommend be tested directly in future project-related research:

H_2: Human land use practices (e.g., cattle ranching, agriculture, logging, tourism), resulting in changes to habitat and river and stream hydrology, have negatively affected *Podocnemis* populations in and near PNNKM.

2. How can baseline population information be used to formulate species management and monitoring plans with both national park and local community engagement?

Methods

Study Area

The project is located in a subsistence-based region of the Amazonian tropics, in and near PNNKM, in the northeast department of Santa Cruz, Bolivia, on the border of Brazil, at about 61.82º W to 60.23º W and from 13.45º S to 15.10º S (CIA 2007) (Figure 4.1.1). PNNKM is located on the southern fringe of the Amazon drainage, with rivers forming ninety percent of its boundary. At 1,523,446 ha, it is one of the largest and most undisturbed parks in the Amazon basin (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). It is a World Heritage Site, one of the most biologically diverse areas of the world, and contains some of the largest, most intact, and important habitats for conservation of terrestrial biodiversity globally (FAN & TNC 1996).

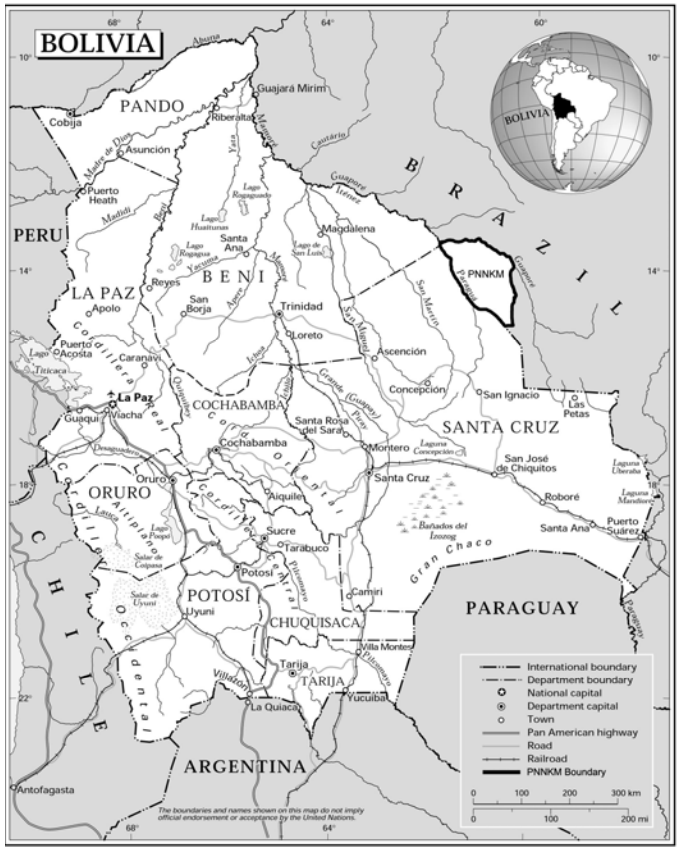

Figure 4.1.1. Noel Kempff Mercado National Park, Santa Cruz, Bolivia (United Nations, 1995, with park overlay by A. Lipman).

The study was conducted on the Paraguá and Iténez (Guaporé in Brazil) rivers (Figure 4.1.2). The Paraguá River forms the park’s western border, draining northward to the Iténez River (Guaporé in Brazil), which forms the park's northeastern border and Bolivia's border with Brazil. The Paraguá is a smaller order river that borders Bolivian indigenous communities; it is not well traveled, as it is navigable only by small craft. The Iténez is a larger order river that is highly traveled because it is navigable year round by large craft, mostly originating from Brazil. *Podocnemis unifilis* nests on both rivers, but *P. expansa* only nests on the Iténez River (pers. obs. and communication with local people). This nesting behavior is due to the larger body size of *P. expansa* and the fact that the Paraguá River is a smaller order river.

Research Design

Our first research goal was to test our first research hypothesis, through testing of the null hypothesis:

> H_{01}: There is no difference between *Podocnemis* populations directly exploited by humans (i.e., hunting, egg gathering) and *Podocnemis* populations not exploited by humans, in and near PNNKM.

We did this by evaluating and comparing indices of population viability among *Podocnemis* populations exposed to different levels of human exploitation, in and near PNNKM. We chose reproductive variables as the best approximation of population viability for several reasons: (1) abundance estimates based on mark recapture studies face significant logistical problems with live aquatic turtles that weigh up to 90.6 kg (Pritchard 1979; Alderton 1998); (2) abundance estimates based on basking counts are not a reliable method for estimating entire turtle populations, especially in areas where turtles demonstrate avoidance of all human activity; (3) counts of nesting females give a useful index for turtle population size, (4) reproductive studies allow us to analyze and project future viability of turtle populations, and (4) direct human use of both species is largely directed at (and thus affects) breeding females and their eggs (K. Buhlmann & W. Gibbons, pers. comm., Savannah River Ecology Lab 2004),.

We evaluated and compared five variables that are indices of reproductive fitness: (1) number of nests created per beach; (2) size of nesting females (measured by track width, as an estimator for carapace length), which is a rough indicator of age class (Moll 1990; Zweifel 1989); (3) size of hatchling turtles (carapace length), which might be an indicator of offspring viability (ability to survive animal predation attempts); (4) rates of nest survival and disturbance;

and (5) rates of hatchling survival. The testing of H_{01} involved the testing of five specific null hypotheses:

h_{01}: There is no difference in number of nests created per beach among *Podocnemis* populations subjected to different levels of human impact.

h_{02}: There is no difference in size of nesting females among *Podocnemis* populations subjected to different levels of human impact.

h_{03}: There is no difference in size of hatchling turtles among *Podocnemis* populations subjected to different levels of human impact.

h_{04}: There is no difference in rates of nest survival or disturbance among *Podocnemis* populations subjected to different levels of human impact.

h_{05}: There is no difference in rates of hatchling survival among *Podocnemis* populations subjected to different levels of human impact.

We chose two variables to describe the level of human use on turtle populations: (1) river (i.e., two rivers, the Paraguá and Iténez, that have different levels of human activity) and (2) level of human impact (HI) (high, low, or protected) on the river. The three levels of human impact were defined as follows: (1) nesting sites designated as "high" were close to human communities and subjected to direct intense exploitation by humans, (2) nesting sites designated as "low" were far enough from human communities that people do not travel to hunt turtles or eggs, and (3) nesting sites designated as "protected" were accessible to human communities, but protected by beach guards from human use.

We hypothesized that if all turtle reproductive variables among sites were equal (i.e., h_{01} through h_{05} are supported), then H_{01} could be rejected, and the conclusion that direct human use of turtles negatively impacts turtles local to PNNKM would not be supported by this study.

However, if h_{01} through h_{05} are rejected (i.e., significant differences are found among all variables), then H_{01} will be refuted. Quantification of human impact on turtle populations could then be accomplished through cross analysis of nesting, mortality, and oral history data.

We conducted the study as two repetitions over two turtle nesting seasons, in the years 2005 and 2006. Timing corresponded to the dry season in PNNKM, which begins in August with turtle nesting events, after river levels have dropped to expose sandy turtle nesting beaches, and ends by the end of December, with turtle hatching events, when river levels begin to rise. The study was conducted at six sites throughout PNNKM: three locations on the Paraguá River and three locations on the Iténez River (Figure 4.1.2). Each of the three sites on each river represented the three different treatments of beaches (i.e., high, low, or protected HI).

On the Paraguá River, three sites corresponded to the three HI treatments as follows: (1) two beaches at Puerto Alegre, near the community of Porvenir, (2) four beaches at Corte Oli, between the communities of Porvenir and Piso Firme, and (3) two beaches at Los Ciervos, between the communities of Porvenir and Florida (Figure 4.1.2; Table 4.1.1). On the Iténez River, three sites corresponded to the three HI treatments as follows: (1) three beaches (Siringuera, Gaviota, and Boliviana) near the community of Bella Vista, (2) four beaches (Bahía Preta, Mescla, Bahía Grande, and Bahía Grande a la vuelta) downstream from Bella Vista, and (3) two beaches further upstream, near the Verde River (Figure 4.1.2; Table 4.1.1). Each of the six sites consists of at least one beach intensively studied and one to three neighboring beaches studied less intensively, with a total of 17 beaches studied.

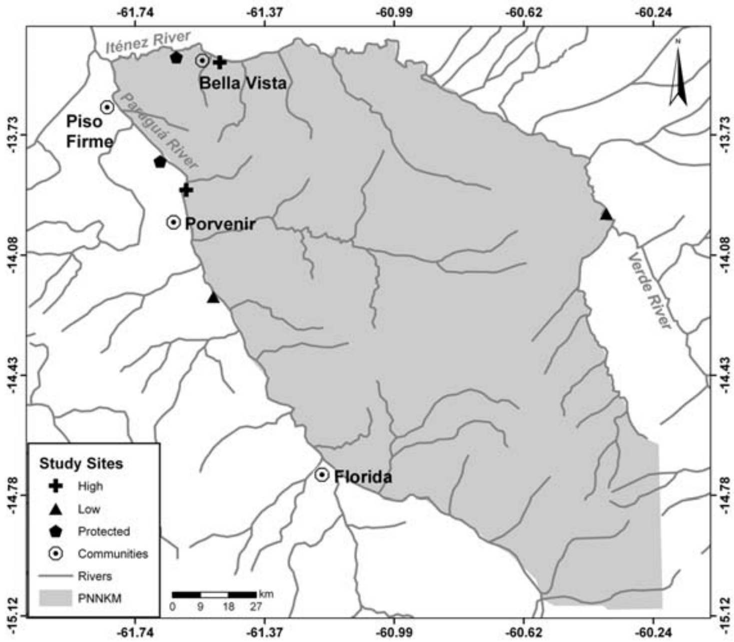

Figure 4.1.2. Turtle Nesting Study Sites, Noel Kempff Mercado National Park, Bolivia.

The unequal number of study beaches per site was due to the varying number of nesting beaches at each location. In choosing nesting sites for study, we first chose the largest nesting beach within each treatment area. We then chose all neighboring nesting beaches that could be studied daily, by the same researchers, given available transportation. This number ranged from one additional beach to four. On the Paraguá River, all nesting beaches were studied intensively; while, on the Iténez River only one beach was intensively studied at each site. This was due only to geographic restrictions: on the Paraguá River, nesting beaches were clumped together, so transportation between beaches was by canoe; however, beaches on the Iténez River were further apart and required a motor boat that disrupted turtle nesting activities at night.

At the beaches studied intensively, we initiated a study of female movement. Nesting females were marked with a permanent notch on the edge of the carapace. Sightings of marked turtles supplied information related to nest site fidelity and migration behavior (Harless &

Morlock 1979; Zweifel 1989). We used numbers of turtles marked and recaptured (from 2005 to 2006) to make rough estimates of turtle population sizes close to beaches of recapture.

Finally, although we did not directly test H_2, we planned to analyze all data collected for possible land use and habitat related effects.

Data Collection

All research activities were conducted every night of the turtle nesting season on the intensively studied beaches. Twelve local research assistants collected data each year; two men worked at each study site, living in rustic camping conditions, in the forest near the river's edge. Much care was taken so camping sites were hidden from the river, and far enough from nesting beaches to not disturb nesting sites. At night, travel to nesting beaches was conducted only on foot or by paddled canoe. Arrival at nesting sites was always from forested edge areas of beaches.

Visits to nesting beaches began nightly just after sundown, at 19:00. To avoid scaring turtles, assistants used light only when needed to identify and handle turtles and to record data; they worked by moonlight whenever possible. Turtles were extremely skittish to human presence, and researchers could not be present on the beaches continuously. We visited nesting beaches in 3-hour intervals throughout the night until sunrise: 19:00, 22:00, 01:00, 04:00, and 07:00.

Upon spotting a turtle, researchers waited to see if she nested, then they captured her as she was returning to the river. Turtles that did not nest were captured again, on their return to the river. After capture, turtles were marked, or if already marked, ID numbers were recorded. Each female received a unique number that corresponded to V-shaped notches filed on different scutes of the carapace edge. Files were disinfected between uses with 100% ethanol. We revised the marking methodology for *Podocnemis* turtles, from that used for other species of turtles (provided by Kurt Buhlmann 2004) (Figure 4.1.3). Each species was assigned a separate sets of numbers, and each turtle received a unique number within that set.

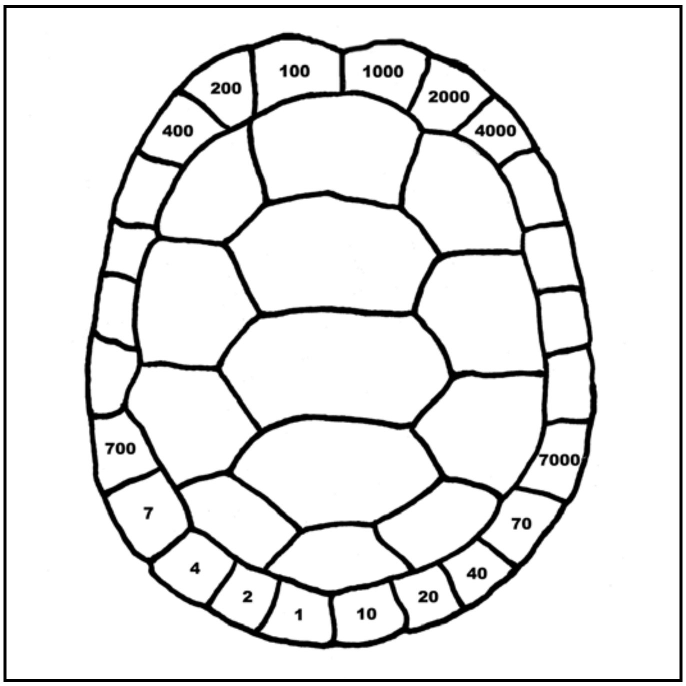

Figure 4.1.3. Marking method for *Podocnemis* turtles, PNNKM.

After marking turtles, the following data were recorded for each female caught: (1) location (beach, river); (2) time (date, hour); (3) species; (4) female identification number; (5) female carapace length (straight uncurved distance between head notch and tail, measured with tree calipers); (6) width of track left by each female; (7) any unique identifying characteristics of the turtle; (8) if the turtle laid eggs, dug a nest, or only walked on the beach; and (9) if the turtle created a nest: nest identification number. Track width was recorded for all nests, for use as an alternative measure of female size when nesting females were not caught. We duplicated methods described by Valenzuela (2001), who reported a significant positive correlation (r^2 = 0.96, n = 101, P < 0.00001); T. Escalona, unpublished data) between female carapace length and track width for *P. unifilis.* We measured the widest width (perpendicular to the direction of turtle movement) of the turtle track, between the outer edges of each foot, along the flattest area with the most visible track. Three separate widths were measured, and the largest measurement was recorded. Track widths were only recorded when they obviously corresponded to measured turtles or created nests.

We marked all nests with numbered stakes, so they could be monitored the entire season. On beaches close to human communities, we hid stakes beneath the surface of the sand (marked by twigs that appeared to be naturally placed), so that they were not visible to humans. In addition to specific nesting data, researchers recorded the following field observations every night: (1) rain and weather patterns; (2) human activity (e.g., presence on beaches, boat and human activity on the river); (3) presence of other animals (e.g., jaguars) on beaches; and (4) any other observations deemed relevant to turtle nesting.

Every morning researchers searched for nests that were missed during the night. They staked all additional nests and recorded, for each nest: (1) location (beach, river); (2) date created; (3) species; (4) nest number; and (5) track width. Any relevant observations were also recorded. Researchers traveled to additional beaches within their study sites, again staking all nests found and recording the same data. Lastly, researchers reviewed all nests daily and recorded losses of eggs or entire nests to animal predators, humans, or other causes (e.g., flooding, trampling by cattle) including: (1) nest number; (2) date of disturbance; (3) disturbance type; (4) number of eggs disturbed (if countable); and (5) if some eggs were left.

Nests that were only partially disturbed were left so that researchers could monitor them all season.

The second part of the study consisted of collecting hatching and nest data. Researchers reviewed nests daily, and when nests showed evidence of sand disturbance, a fine wire mesh was placed over the top of the nest, to keep hatchlings from escaping. A layer of sand was placed on top of the wire mesh to protect and hide hatchlings from the sun and animal predators. This allowed hatchlings to leave the nest but to remain shaded until they were collected. Hatchlings were collected as soon as possible after exiting from the nest (never more than an hour). After exiting, the following data were collected: (1) date of emergence; (2) number of live hatchlings emerged per nest; (3) up to 10 samples (depending on number of hatchlings available) of hatchling carapace length (straight uncurved length measured with small calipers); (4) number of dead hatchlings per nest; (5) number of unhatched eggs per nest; and (6) reason for unhatched eggs (e.g., inundation, predation, physical damage. As soon as hatchlings were counted and measured, they were replaced to the nest, where they naturally made their way to the river. At the end of the field season, all unhatched nests were excavated, and the number of unhatched eggs and the reason for their not hatching was recorded.

The last data collected were related to beach size. We walked the perimeters of all study beaches, at the lowest river level (in 2005), marking beach polygons with GPS units. Later we used GIS software to calculate beach areas. Finally, we recorded cursory measures for beach height (flat, part high, or high). "Flat" corresponded to beaches at the same level as the water; "part high" corresponded to beaches at the same level as the water that then sloped upwards to a higher point further from the water's edge; and "high" corresponded to beaches that immediately were raised from the water's edge (at least 1m above the water's edge).

Statistical Methods

We analyzed two replicate sets of data, collected in 2005 and 2006. We compared data among three treatments, where treatments were different categories of intensity of human visitation to beaches, to exploit turtles, from two different rivers. The human impact (HI) categories were high, low, and protected from human visitation. We constructed a 3 x2 unbalanced design (Table 4.1.1), three treatments vs. two rivers. We expected that *P. expansa* would be observed only on the Iténez River, but all 17 beaches were included in the analyses. Analyses were completed separately for each species. All analyses were completing using SAS statistical software and Microsoft Excel statistical software.

Table 4.1.1 Experimental (3 x 2) unbalanced design (HI x river). *denotes site for *P. expansa*. **denotes site measured only in 2005. Relative height of the beach in parentheses.

HI \ River	Paraguá	Iténez
High	Puerto Alegre Playa 1 (High) Puerto Alegre Playa 2 (High)	Siringuera* (Flat) Gaviota * (Flat) Bella Vista* (Flat)
Low	Los Ciervos Playa 2 (High) Los Ciervos Playa 1 (High)	Verde Playa 1* (Part High) Verde Playa 2 (Flat)
Protected	Corte Oli Playa 1 (Part High) Corte Oli Playa 2 (High) Corte Oli Playa 3** (High) Corte Oli Playa 4** (High)	Playa Mescla (Part High) Bahía Preta* (Flat) Bahía Grande* (High) Bahía Grande de la Vuelta (Part High)

The variables analyzed for difference between sites were: (1) number of nests per beach; (2) size of nesting females; (3) hatchling size; (4) nest survival; and (5) hatchling survival.

Number of Nests

If h_{01} were true, then the number of nests created should be randomly distributed with respect to level of human impact. If number of nests were not distributed randomly among blocks of human impact, we proposed that h_{01} would not be supported, and we would reject it.

The only differences between beaches, aside from the level of human impact, were: river, beach size, beach height, and beach substrate. The only characteristic for which we recorded quantitative measurements was beach size; all other characteristics were qualitative and thus more difficult to correlate to number of nests. We hypothesized that beach size would be correlated to number of nests, if no other factor was affecting number of nests. To test this, we performed a correlation analysis (SAS, PROC CORR) between total number of nests created per beach and beach size, to see if there was significant correlation ($P < 0.05$) between these two factors.

For both years we then calculated the number of nests that would be expected per beach, based on beach size as an explanatory variable for number of nests created. We estimated number of nests expected for each beach, by multiplying beach size with a factor, equal to the total number of nests on all beaches, divided by the total area of all beaches. We compared expected number of nests to observed number of nests, for all beaches, and we calculated simple binomial deviations, of observed number of nests from expected number of nests (i.e., more nests than expected or fewer nests than expected), for each beach. We calculated this binomial ratio (more nests than expected : fewer nests than expected) for all variables that describe differences between beaches: river, beach size, human impact (HI), beach height, and substrate.

We conducted chi square tests of independence (Microsoft Excel CHITEST) to test if these ratios can be described by random patterns, or if they are in fact described by the variables listed. We conducted these tests for all variables, for each year separately, and then for both years combined. We finally separated data by river systems, and once again conducted chi square tests on all variables, within each river.

Size of Nesting Females

To test h_{02} we proposed to compare the size of nesting females between sites at different levels of human impact. If female size were shown to be different between human impact sites, then we proposed that h_{02} would be false, and therefore rejected. To test the assumption that track width should represent the size of female turtles, we correlated (SAS PROC CORR) our measurements of female carapace length and track width. We used track width as the surrogate for female size, and tested its equality among treatments.

We performed a 2 sample T-test (SAS, PROC T-Test, the Satterthwaite Unequal Variance T-test) on the two data sets of 2005 and 2006, to determine year effect. We did this for each beach, and then with total data between years. We then combined data from both years and built various GLM models (SAS, PROC GLM), testing combinations of the following effects: human impact (HI), river, interaction of HI and river (HI*river), beach height, beach size, and year. The best model fit was that with the highest R^2 and lowest SBC (the smaller the better) values. All effects were tested to the 0.05 significant level. We then tested whether beaches in the same HI*river block had similar turtle sizes. We performed T-tests on track width for all pairs within the same block. Because results showed that turtle size within each block was the same (has low variance), we divided beaches into blocks, as opposed to testing beaches individually. We could thus effectively compare the effect of human use on average female turtle size.

Hatchling Size

To test h_{03} we proposed to compare the size of hatchlings between sites at different levels of human impact. If hatchling size were shown to be different between human impact sites, then we proposed that h_{03} would be false, and therefore rejected. We performed the same analyses on hatchling size as we did on female size (track width). We performed a two sample T-test to determine year effect between 2005 and 2006, for each beach and on combined data sets. We then built GLM models testing the following effects: human impact (HI), river, interaction of HI and river (HI*river), beach height, beach size, and year. We performed T-tests on hatchling size for all pairs of data within the same HI*river block. Again, because results suggested that data within blocks was similar (had low variance), we performed analyses between blocks, as opposed to testing effects on beaches individually.

Nest Survival/Disturbance

To test h_{04} we proposed to compare nest survival between sites at different levels of human impact. If nest survival were shown to be different between human impact sites, then we proposed that h_{04} would be false, and therefore rejected. Only summary statistics were performed on this data.

Hatchling Survival

To test h_{05} we proposed to compare hatchling survival between sites at different levels of human impact. If hatchling survival were shown to be different between human impact sites, then we proposed that h_{05} would be false, and therefore rejected. We performed a logistic analysis (SAS, PROC LOGISTIC) to explain the variation about the average rate of hatchling survival, due to the factors HI, river, and year, in nests where at least one egg had a live hatchling. The best model was chosen as that having the smallest AIC, SC, and -2 log L values. We tested interaction effects of river, HI, HI*river, and year. Predicted live hatchling probability was compared to observed survival percentages between blocks of each effect.

Results

In contrast to recommendations that nesting turtles can be approached, and that turtles can be handled while they are nesting (K. Buhlmann and R. Vogt, pers. comm., 2004), we found that both species in PNNKM avoided researchers by returning to the river, even stopping nesting activities to escape (pers. obs. 2005 to 2006). Additionally, we discovered (the first week of research, 2005) that after the presence of researchers on the beach, turtles waited a minimum of two hours to again resume nesting activities.

Summary Statistics

In 2005, 1113 incidences of *P. unifilis* turtles were observed (Table 4.2.1). Of these turtles, 1007 were observed to lay nests. Of these nests, 529 nests were completely lost to disturbance (eggs were all completely exploited or destroyed), and 256 nests were not evaluated due to a lack of research assistants (these were nests created on the secondary beaches on the Iténez River). Of the 1007 nests, only 222 were able to be analyzed for hatching data, at the end of the nesting season. In 2005, 32 incidences of *P. expansa* were observed. Of these turtles, 31 were observed to lay nests. Of these nests, eight were lost to disturbance, and five were not able to be evaluated. Of the 31 nests, only 17 were able to be analyzed for hatching data.

In 2006, 973 incidences of *P. unifilis* were observed, of which 903 created nests. Of these nests, 355 were lost to disturbance, and 06 were not analyzed. Of the 903 nests, 442 nests were analyzed for hatching data. In 2006, 92 incidences of *P. expansa* females were observed, of which 89 created nests. Of these nests, 65 nests were lost to disturbance, and two were not analyzed. Of the 89 nests, 22 nests were analyzed for hatching data.

In summary, over 2005 and 2006, more female *P. unifilis* turtles were observed than *P. expansa*. The extremely small sample sizes of *P. expansa* turtles and nests made it statistically impossible to test the H_{01} for this species. Therefore, all analyses of reproductive variables were conducted on *P. unifilis* data, while we provide only summary statistics for *P. expansa*. Additional statistics acquired through research, which were not compared among sites, include: average clutch sizes for each species (27 eggs/nest for *P. unifilis* and 139 eggs/nest for *P. expansa*) and average incubation time for each species (76.05 days for *P. unifilis* and 62.55 days for *P. expansa*), over 2005 and 2006.

Table 4.2.1. Summary of turtles, nests, eggs, and hatchlings evaluated, 2005 & 2006.

	Year	2005		2006	
	Species	***P. unifilis***	***P. expansa***	***P. unifilis***	***P. expansa***
Summary of Female Turtles	Number of beaches with turtles	17	6	15	6
	Total events (nests and turtles handled)	1113	32	973	92
	Number of turtles handled	303	12	317	15
	Number of turtles handled that didn't nest	106	1	70	3
Summary of Nests	Number of nests	1007	31	903	89
	Average nests / beach	59.2	5.2	60.2	14.83
	Nests completely lost to disturbance	529	8	355	65
	Nests from which data was not acquired	256	5	106	2
	Nests not disturbed	185	6	402	15
Summary of Eggs	Nests evaluated after hatching	222	17	442	22
	Total eggs from evaluated nests	5923	1991	11752	3438
	Average number of eggs / nest	26.7	117.1	26.6	156.3
	Median of eggs / nest	29	108	27	171
	Nests with at least one live hatchling	187	6	400	15
	Total live hatchlings	4284	494	8675	685
	Average number of live hatchlings / nest (if live hatchlings > 0)	22.9	82.3	21.7	45.7
	Median of live hatchlings / nest (if live hatchlings > 0)	24	89.5	24	53
Summary of Hatchling Turtles	Nests with incubation time data available	150	6	317	14
	Average incubation time (days)	76.6	68.7	75.5	56.4
	Nests with hatchling carapace length data available	161	6	323	4
	Average hatchling carapace length (cm)	39.7	44.8	39.9	48.8

Number of Nests

Of a total of 1007 *P. unifilis* nests created in 2005, and 903 nests created in 2006, most nests were created at protected sites, and the least number of nests were created at high impact sites (Table 4.3.1). Total numbers of nests created per beach varied widely by beach (Appendix A).

Table 4.3.1 Total number of nests created per site, by river and level of human impact, 2005 & 2006.

	P. unifilis	*P. expansa*
2005	**Number of Nests**	
Iténez	**441**	**31**
High	104	15
Low	139	7
Protected	198	9
Paraguá	**566**	-
High	248	-
Low	128	-
Protected	190	-
TOTAL	**1007**	**31**
2006	**Number of Nests**	
Iténez	**474**	**89**
High	56	20
Low	199	0
Protected	219	69
Paraguá	**429**	-
High	69	-
Low	78	-
Protected	282	-
TOTAL	**903**	**89**

Correlation analyses detected no correlation between number of nests per beach and size of beach. Correlation for 2005 data had $r^2 = 0.0036$ (16 df, $P = 0.82$), and correlation for 2006 data had $r^2 = 0.006$ (14 df, $P = 0.78$). We created contingency tables for each year (Appendix A), where expected numbers of nests were calculated from beach size corrected factors. For 2005 this factor was 32.54 nests/ha (1007 nests/80.948 ha), and for 2006 this factor was 74.01 nests/ha (903 nests/30.727 ha).

Chi square analyses of independence performed on data demonstrate that river, beach height, and beach substrate were significant factors in describing number of nests observed per beach (Figure 4.3.1). River was the most significant variable when years were combined ($P = 0.001$) and when data was calculated separately each year ($P < 0.03$): on the Paraguá River there were generally more nests than expected per beach, and on the Iténez River there were generally fewer nests than expected per beach. Beach height and beach substrate were significant variables when years were combined (P = 0.03 and P = 0.006, respectively): more nests were found on high or partially high beaches, compared to low beaches, and more nests were found on beaches with sand and vegetation, than on pure sandy beaches. However, beach height was not significant (P < 0.15) when data was separated by years, and beach substrate was not significant in 2005 (P = 0.06). Human impact was not significant (P > 0.6) when years were combined or analyzed separately.

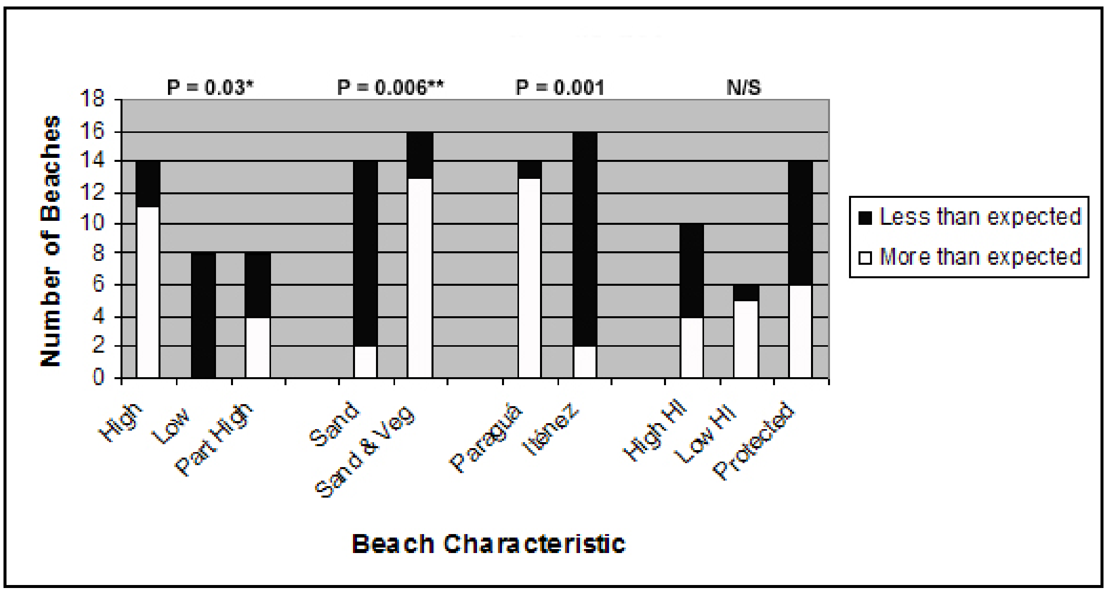

Figure 4.3.1. Ratio of beaches with more or less nests than expected, *P. unifilis*, 2005 & 2006. Significant P-values (P < 0.05) shown for chi-square test of independence. *not significant when separated by years. **not significant in 2005.

Results demonstrate that all beaches on the Iténez River had fewer nests than expected, with the exception of Verde 1 (a low HI beach), both years (Appendix A), and all beaches on the

Paraguá River had more nests than expected, with the exception of San Lorenzo 2 (a low HI beach) in 2005. Due to the strength of river in this analysis, we performed the same analysis on data sets separated by river, but with years combined. Results of this analysis demonstrate that all variables tested (beach height, beach substrate, and HI) were significant ($P < 0.05$) in describing number of nests on the Iténez River, but they were not significant ($P = 0.12$) in describing number of nests on the Paraguá River (Table 4.3.2). Beach height and beach substrate could not be tested on the Paraguá River, due to the homogeneity of these variables on that river (Appendix A).

Table 4.3.2. P-values for chi-square tests of independence when data from rivers were separated, 2005 & 2006 combined.

	Iténez	**Paraguá**
Beach height	0.04	-
Beach substrate	0.02	-
HI	0.03	0.12

Size of Nesting Females

Due to the difficulty of catching live nesting turtles, we were not able to measure the carapace length of all nesting turtles. However, for almost every nest created we have measurements of track width. We measured a total of 623 *P. unifilis* turtles for carapace length, in 2005 and 2006 combined. We measured almost twice as many track widths (1205), which corresponded to turtles measured and nests created (Table 4.4.1). The carapace lengths we measured ranged from 26.3 to 48.3 cm, with an average of 38.4 cm. The track widths we measured ranged from 14.0 to 44.0 cm, with an average width of 27.8 cm. We measured a total of only 28 *P. expansa* females, with carapace lengths that ranged from 28.0 to 75.0 cm, with an average length of 52.1. Small sample size makes comparison of track widths irrelevant.

Table 4.4.1. Summary statistics for all female turtles and track widths measured, 2005 & 2006 combined.

	P. unifilis	***P. expansa***
Total turtles measured	623	28
Total tracks measured	1205	107
Average carapace length (cm)	38.4	62.0
Range carapace length (cm)	26.3 to 48.3	50.0 to 72.0
Average track width (cm)	27.8	52.1
Range track width (cm)	14.0 to 44.0	28.0 to 75.0

The correlation between female track width and carapace length of *P. unifilis* (data from 2005 and 2006 combined) was significantly positive (n= 623, R = 0.369, P < 0..0001) (Figure 4.4.1). We thus used track width, for which we had a larger sample size than carapace length, to test h_{02}.

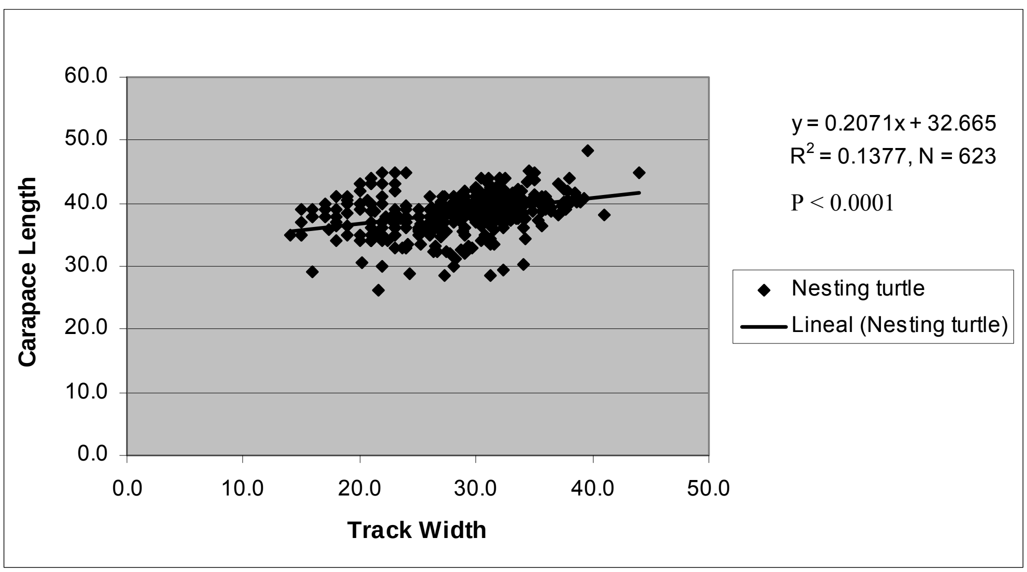

Figure 4.4.1. Regression of *P. unifilis* female carapace length to female track width, 2005 & 2006.

For the two sample T-test we performed on track width, to determine year effect between the data sets 2005 and 2006, we calculated a significant year effect of $P < 0.0001$ (Appendix B). On average the female turtles were 1.247 larger in 2006 than they were in 2005. However, this test does not control for beach effect, and when we separated out by beach, only five beaches show a significant year effect (to the 0.05 level). For this reason we decided to combine data from both years to build various GLM models. In the GLM models we built, with data combined from both years, all effects were significant at the 0.05 level, except for beach height and beach size (Appendix B). The best GLM model (3b) had an R^2 value of 0.437, with the smallest SBC (the smaller the better) at 6651.76.

The final model we used was: $\textit{Track width} = \mu + HI_i + river_j + HI{*}river_{ij} + year_k$, where i = High, Low, Prot; j = Iténez, Paraguá; k = 2005, 2006. The model includes the following effects: HI, river, HI*river, and year, which suggests that all have significant effects on female size. The year effect was consistent with the T-test on the combined data. T-tests performed on track width for all pairs within the same HI*river block showed only one pair of beaches with significant difference (Verde 1 and Verde 2), all others did not. As discussed above, Verde 2 was the only beach that does not have direct access to the river, as such it consistently was shown to display different variables than the rest. Results suggest that turtle size within each block was the same, we thus divided beaches into six blocks, as opposed to testing beach effects individually.

All effects tested were significant at $P < 0.0001$ (Appendix B), with *P. unifilis* females being significantly larger in the Iténez River than in the Paraguá River, and smallest on beaches with high human impact (effect dependent on river). In the Iténez River, turtles were the same size on protected beaches and beaches with low human impact; however, on the Paraguá River, turtles were larger on beaches with low human impact than on protected beaches (Tables 4.4.2 & 4.4.3). Lastly, after controlling for all other effects, track widths in 2006 were on average 0.95cm larger than those in 2005. This result was smaller than that given by the T-test, which was mostly due to level of human impact and river, but it was still significant due to the large sample size.

Table 4.4.2. Average track widths by HI*river, 2005 & 2006.

River / HI	Iténez	Paraguá
High	29.82 cm	23.49 cm
Low	32.63 cm	29.36 cm
Protected	32.87 cm	26.10 cm

Table 4.4.3. Deviations for final track width model, by HI*river, 2005 & 2006.

River / HI	Iténez	Paraguá
High	+3.72 cm	-2.61 cm
Low	+6.53 cm	+3.26 cm
Protected	+6.77 cm	0.00

Using the block for river Paraguá and HI = protected as the baseline, at an average mean track width of 26.10cm, all deviations between the six blocks are presented (Table 4.4.3). Track widths at high impact beaches, on the Iténez and Paraguá, 29.82 and 23.49 cm respectively, were smaller on average than at the low impact beaches, which were 32.63 and 29.36 respectively (Table 4.4.2). Averages for protected beaches were different on each river: 26.10 cm on the

Paraguá, which was smaller than the low impact beach but larger than the high impact beach, and 32.87cm on the Iténez, which was almost the same but a little larger than the low impact beach, which was significantly larger than the high impact beach (Table 4.4.2). The effects of HI and river were not additive, and deviations by river were dependent upon interaction of other variables.

Finally, errors for individual measurements were quite high, evident by the fact that R^2 for the final model was only 0.437; however, due to large sample sizes (n = 1205 nests), with good representation in all six blocks, statistically significant results were found.

Hatchling Size

There were 544 nests (2005 and 2006) for which we had *P. unifilis* hatchling carapace lengths, which over both years, averaged 39.8 mm. Average carapace length of *P. expansa* hatchlings was larger, at 46.8 mm (calculated from only 10 nests). To test h_{03}, we calculated average carapace lengths of *P. unifilis* hatchlings for all 544 nests (from up to 10 randomly chosen hatchlings per nest). We used these averaged carapace lengths, from each nest, as the response variable. Out of 15 total beaches, only six pairs could be tested for the year effect (T-test); this was due to loss of nests and lack of data on certain beaches, either year. No significant year effect was found at the 0.05 level (Appendix C).

For this reason, data was combined from both years to build various GLM models to test all other possible effects (Appendix C). The best model was Model 2b (R^2 0.406 and SBC 825.23), which includes HI, river, and HI*river. The following factors were tested: HI, river, year, beach height, beach size, track width, HI*river. Models that included track width had fewer observations because there were only 375 observations which included measurements of both female track width and hatchling carapace length. For this reason these models could not be directly compared to Model 2b. However, track width by itself was not significant, and the sample size of about 70% of the total was reliable in concluding that female turtle size does not significantly correlate to hatchling size. Because height was not a balanced variable, with a highly skewed distribution, it was better not included in the model. Year was not included in the final model, which was consistent with the non significant T-test. The final model used was: $Carapace\ length = \mu + HI_i + river_j + HI{*}river_{ij}$, where i = High, Low, Prot; j = Iténez, Paraguá.

As with track width, T-tests were performed to test effects of beaches within the six blocks. Only 3 pair wise comparisons were possible, and none were significant. For this reason, again, there was no need to test beaches separately. Data was combined, and effects were tested within blocks. All effects tested were significant ($P < 0.0001$, except river at .02) (Appendix C). Overall, hatchlings in the Paraguá River were similar in size, but those on low impact beaches were largest. However, hatchlings on the Iténez River varied much more: those on high impact beaches were smallest, and those on protected beaches were the largest.

Again, the average carapace length for the block HI=protected, river=Paraguá, 38.98 cm, was used as the baseline to display mean hatchling carapace lengths (Table 4.5.1). The mean carapace lengths on the Paraguá River were almost equal at high, low, and protected treatments, with 38.98, 39.09 and 39.89 on average, respectively. However, on the Iténez River, the hatchlings' carapace lengths at the low and protected beaches were significantly larger at 41.17 and 42.2cm on average, respectively; while they were significantly smaller at the high impact beach (36.3 cm).

Table 4.5.1. Average hatchling carapace lengths by HI*river, 2005 & 2006

River / HI	Iténez	Paraguá
High	36.30 mm	39.09 mm
Low	41.17 mm	39.89 mm
Protected	42.20 mm	38.98 mm

Table 4.5.2. Deviations table for final hatchling carapace length model, by HI*river, 2005 & 2006.

River / HI	Iténez	Paraguá
High	-2.68 mm	+0.11 mm
Low	+2.19 mm	+0.91 mm
Protected	+3.22 mm	0.00

Lastly, it should be noted that the results of this section could be biased, as from the original 1910 nests created, the sample n=543 nests analyzed in this study was not a random sample of all nests created. Because only viable nests that were studied were part of this sample, and nests most affected by disturbance were lost to the study, attributing variation in hatchling carapace length to various combinations of HI*river should be investigated.

Nest Survival/Disturbance

In our reporting, we defined all disturbances as those that caused 100% mortality of eggs in the nest, and we define no disturbance as events when at least one viable hatchling emerged from the nest. In 2005, only 185 (18.4%) nests, out of 1007 total *P. unifilis* nests, were not disturbed. (Table 4.6.1). The main disturbance type to affect all nests (over all sites) was animal predation (37.0%), and the second most important disturbance type was inundation (9.8%). For *P. expansa*, only six nests (19.4%), out of 31 total nests, were not disturbed. The main disturbance type for all nests was inundation (41.9%), and the second most important disturbance type was animal predation (16.1%).

Table 4.6.1. Frequency distribution of disturbance type, 2005.

	P. unifilis		***P. expansa***	
	Nests affected by disturbance	**Disturbed nests with eggs to evaluate**	**Nests affected by disturbance**	**Disturbed nests with eggs to evaluate**
Animal	373 (37.0%)	4	5 (16.1%)	1
Cattle	65 (6.5%)	0	0 (0%)	-
Human	72 (7.1%)	1	3 (9.7%)	0
Inundation	99 (9.8%)	34	13 (41.9%)	10
None	185 (18.4%)	182	6 (19.4%)	6
Data missing	213 (21.2%)	1	4 (12.4%)	0
Total	1007 (100%)	222	31 (100%)	17

In 2006, 396 *P. unifilis* nests (43.9%), out of 903 total nests, were not disturbed (Table 4.6.2). The main disturbance type for all nests was animal predation (23.0%), and the second most important disturbance was inundation (15.8%). For *P. expansa*, 15 nests (16.9%), out of 89 total nests, were not disturbed. The main disturbance type for all nests was inundation (60.7%), and the second most important disturbance was human predation (20.2%). The most important disturbance types for each species was the same both years, except that human predation replaces animal predation as the second largest disturbance type for *P. expansa* in 2006.

Ratios of disturbed to non-disturbed nests were similar for *P. expansa*, both years. However, for *P. unifilis*, there were many more non-disturbed nests in 2006 than in 2005 (43.9%

to 18.4%). However, the 2005 data was biased, due to the fact that 21.2% of the nests were not revisited to collect hatching data ("Data missing" in Table 4.6.1). If many of these nests were in fact undisturbed, then the two years might have had more similar disturbance rates.

Table 4.6.2. Frequency distribution of disturbance type, 2006.

	P. unifilis		***P. expansa***	
	Nests affected by disturbance	**Disturbed nests with eggs to evaluate**	**Nests affected by disturbance**	**Disturbed nests with eggs to evaluate**
Animal	208 (23.0%)	4	0 (0%)	-
Cattle	2 (0.2%)	0	0 (0%)	-
Human	70 (7.8%)	0	18 (20.2%)	0
Inundation	143 (15.8%)	55	54 (60.7%)	7
None	396 (43.9%)	383	15 (16.9%)	15
Data missing	84 (9.3%)	0	2 (2.2%)	0
Total	903 (100%)	442	89 (100%)	22

Disturbance type highly varies within treatments by level of human impact. In the year 2005, *P. unifili*s nests vary widely between blocks of human impact (Table 4.6.3; Figure 4.6.1). Beaches were mostly disturbed by animal predation, and less so by inundation. However, numbers of nests lost to human exploitation and trampling by cattle, combined, represent large losses on the high human impact beaches, and the highest loss at the high impact beaches on the Iténez River. There was virtually no loss to these disturbances at low human impact and protected sites. Overall, protected beaches have the most non-disturbed nests. Lastly, while inundation was overall lowest on high impact beaches (across all sites), this could be too low a number, as nests were always lost to animals and humans before they have a chance to be lost to inundation at the end of the season. Additionally, for this year there were a large number of nests not revisited, due to lack of resources.

Disturbance type varies between levels of human impact; it also widely varies between rivers, especially for some types of disturbance (Table 4.6.3; Figure 4.6.1). Losses to animal predation were generally much higher on the Paraguá River than on the Iténez River; cattle disturbance was only present on the Paraguá River, and human disturbance was higher on the Iténez River. Inundation effects varied between rivers.

Table 4.6.3. Disturbance type of *P. unifilis* nests, by HI*river (Iténez / Paraguá), 2005.

HI	Animal		Cattle		Human		Inundation		None		Unknown		Total
	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	
High	8 / 115	123	0 / 65	65	39 / 30	69	13 / 0	13	10 / 29	39	34 / 9	43	352
Low	12 / 127	139	0 / 0	0	2 / 0	2	42 / 1	43	42 / 0	42	41 / 0	41	267
Protected	50 / 61	111	0 / 0	0	1 / 0	1	3 / 40	43	15 / 89	104	129 / 0	129	388
Total	70 / 303	373	0 / 65	65	42 / 30	72	58 / 41	99	67 / 18	185	204 / 9	213	1007

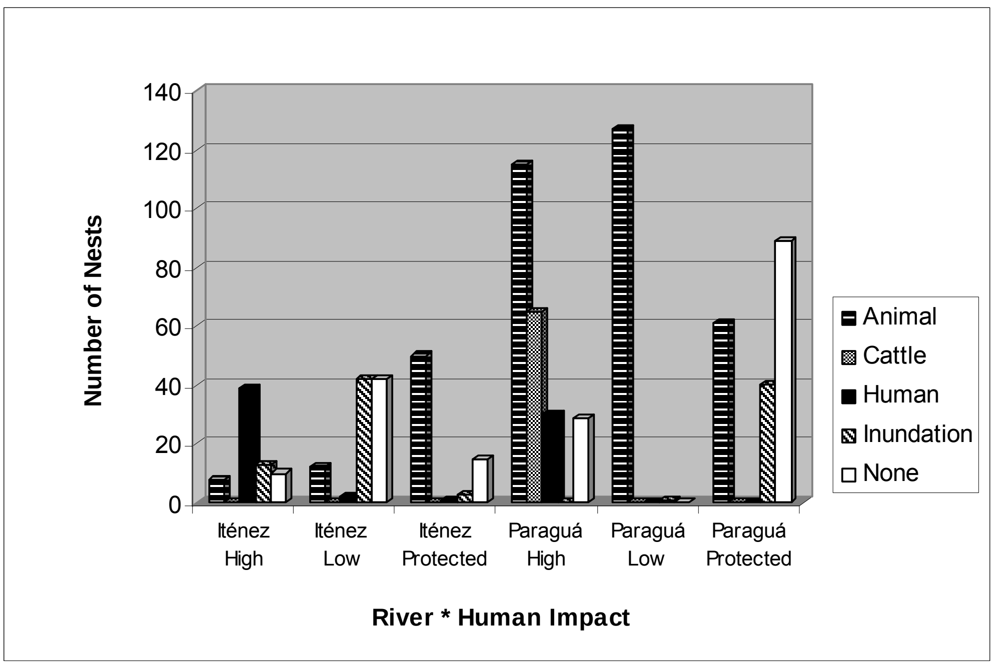

Figure 4.6.1. Disturbance type of *P. unifilis* nests by HI*river, 2005.

Because *P. expansa* was observed only on the Iténez River, we can only analyze disturbance effects between blocks of human impact level, not river (Table 4.6.4; Figure 4.6.2). In 2005, disturbance due to inundation was the highest disturbance, across all sites. However, similar to *P. unifilis* nests, nests of *P. expansa* have the highest levels of human disturbance at high impact beaches, with no human disturbance at protected beaches. Cattle was not a disturbance factor for *P. expansa*, but animal predation was present on all beaches, while highest on high impact beaches.

Table 4.6.4. Disturbance type of *P. expansa* nests, by HI, 2005.

	Animal	**Cattle**	**Human**	**Inundation**	**None**	**Unknown**	**Total**
High	3	0	2	6	2	2	15
Low	1	0	1	5	0	0	7
Protected	1	0	0	2	4	2	9
Total	5	0	3	13	6	4	31

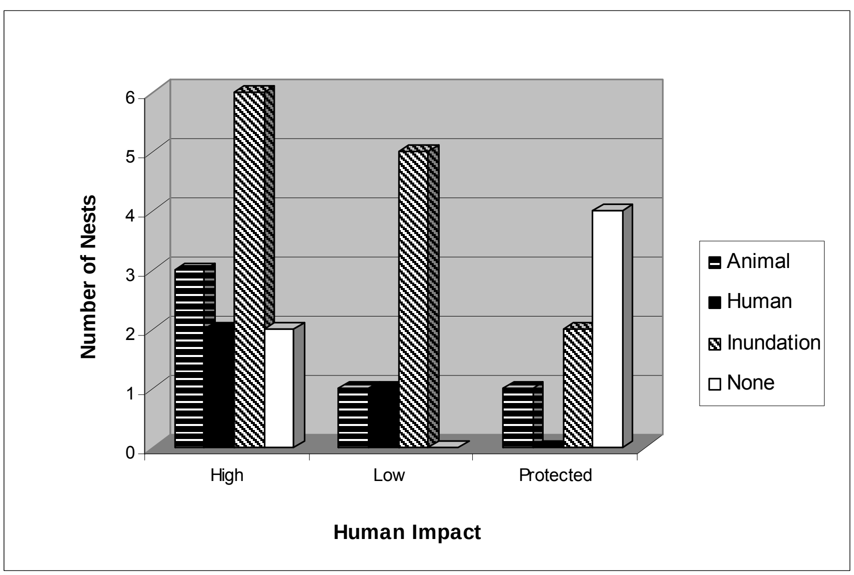

Figure 4.6.2. Disturbance type of *P. expansa* nests by HI, 2005.

In 2006, disturbance ratios were again different than 2005, when analyzed between site blocks (Table 4.6.5; Figure 4.6.3). Disturbance of *Podocnemis unifilis* nests in 2006 shows the highest levels of undisturbed nests on protected or low impact beaches. Animal predation was generally much lower than in 2005, and unlike 2005, in 2006 it was always highest on protected beaches and lowest on high impact beaches. Again, lower rates of animal predation on high impact beaches might be lowered by high human predation rates, because human disturbance often occurs before animal disturbance. In 2006, human exploitation was the most important disturbance at high impact sites, while, again, it was not a factor at other beaches. Cattle were not an important disturbance type this year. Inundation was a more important factor in 2006, on all beaches, and again, it was highest on low impact and protected beaches (which could be a factor of coming after human disturbance at high impact sites). Differences between rivers were not as pronounced this year; although total animal disturbance remains higher on the Paraguá, and total inundation disturbance remains highest on the Iténez (Table 4.6.5; Figure 4.6.3).

Table 4.6.5. Disturbance type of *P. unifilis* nests, by HI*river (Iténez / Paraguá), 2005.

HI	Animal		Cattle		Human		Inundation		None		Unknown		Total
	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	Iten/Par	Total	
High	3 / 19	22	0 / 2	2	34 / 35	69	19 / 0	19	0 / 13	13	0 / 0	0	125
Low	4 / 51	55	0 / 0	0	0 / 1	1	56 / 1	57	139 / 25	164	0 / 0	0	277
Protected	67 / 64	131	0 / 0	0	0 / 0	0	38 / 29	67	32 / 187	219	75 / 9	84	501
Total	78 / 143	208	0 / 2	2	36 / 36	70	169 / 86	143	187 / 166	396	204 / 9	84	903

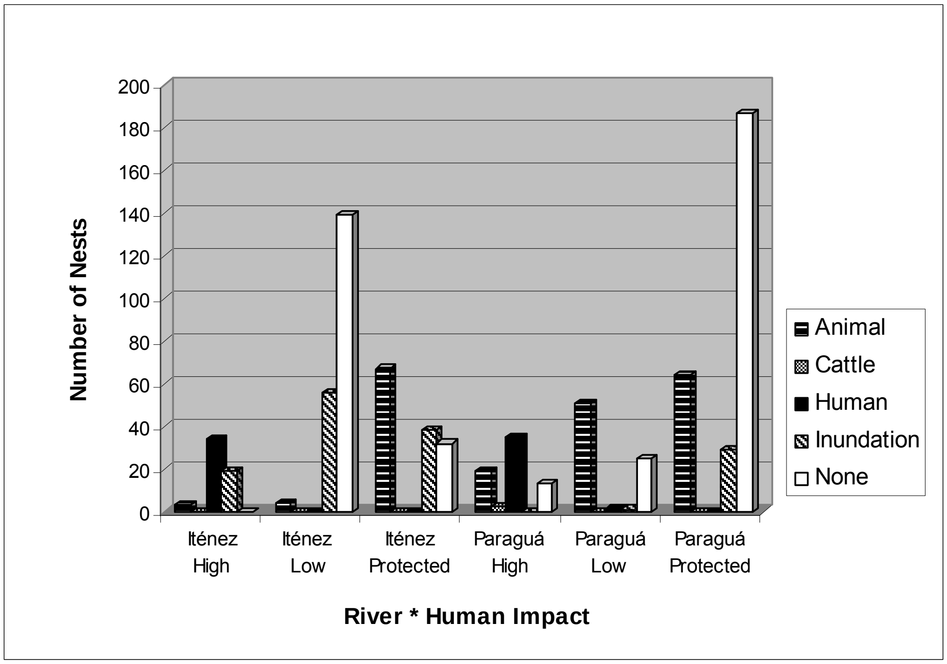

Figure 4.6.3. Disturbance type of *P. unifilis* nests by HI*river, 2006.

Lastly, disturbance of *P. expansa* nests was different in 2006 than it was in 2005, mostly due to extremely low nesting rates at some sites for the species this year (Table 4.6.6; Figure 4.6.4). There were no nests created in low impact areas this year. Additionally, all nests were disturbed, except for 15, at the protected site. All other reviewed nests were disturbed by either humans or later, inundation.

Table 4.6.6. Disturbance type of *P. expansa* nests, by HI, 2006.

	Animal	Cattle	Human	Inundation	None	Unknown	Total
High	0	0	13	7	0	0	20
Low	0	0	0	0	0	0	0
Protect	0	0	5	47	15	2	69
Total	0	0	18	52	15	2	89

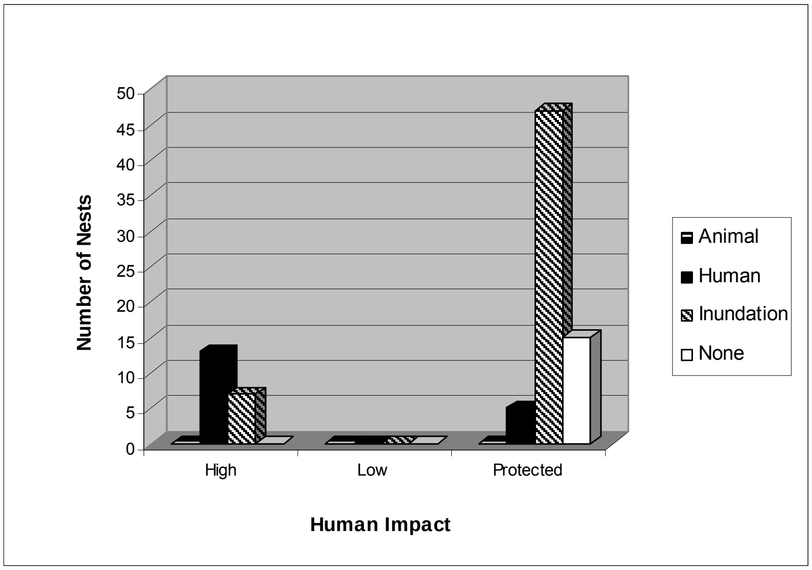

Figure 4.6.4. Disturbance type of *P. expansa* nests by HI, 2006.

By evaluating the total data, added over both years and across all sites, we found that for *P. unifilis* the most importance nest disturbance types are: Animal > Inundation > Human. For *P. expansa*, the most importance disturbance types are: Inundation > Animal/Human (animal in 2005, human in 2006). We also found, over both years and across all sites, that for *P. unifilis*, nest disturbance is highest at high HI sites and lowest at protected HI sites. For *P. expansa*, nest disturbance is lowest at protected HI sites.

Hatchling survival

In 2005, for *P. unifilis* we evaluated a total of 222 nests, of which only 184 had live hatched eggs. Of a total of 5959 counted eggs, only 4284 (71.9%) had live hatchlings (Table 4.7.1). For *P. expansa*, there were a total of 17 evaluated nests, of which only six had live hatchlings. Of a total of 1991 eggs counted, only 494 (24.8%) had live hatchlings. These percentages include only the nests we were able to examine. They do not include the 526 nests that were completely lost to disturbances, as well as random data losses from various nests. To calculate a more correct distribution, we used mean clutch size over both years to estimate the number of eggs we know were lost to these disturbances. For *P. unifilis*, this was 27 eggs per nest. The number of additional estimated eggs lost was 15,264, which changes the distribution to 16,865 dead eggs (77.2% of total), with only 22.5% live hatchlings (Table 4.7.1). For *P. expansa,* we estimated additional eggs lost from the eight nests lost to disturbance. With an average clutch size of 139, this estimates an additional 1,112 eggs lost, which changes the distribution to 2,600 dead eggs (83.8%), and only 15.9% live hatchlings.

Table 4.7.1. Frequency distribution for egg survival, 2005. *estimated quantity from mean clutch size.

Number of Eggs	***P. unifilis* (evaluated eggs only)**	***P. unifilis* (evaluated + estimated)**	***P. expansa* (evaluated eggs only)**	***P. expansa* (evaluated + estimated)**
Live Hatchlings	4284 (71.7%)	4284 + 627* = 4911 (22.5%)	494 (24.8%)	494 (15.9%)
Dead Eggs	1601 (27.0%)	1601 + 15264* = 16865 (77.2%)	1488 (74.7%)	1488 + 1112 = 2600 (83.8%)
Dead Hatchlings	74 (1.2%)	74 (0.3%)	9 (0.5%)	9 (0.3%)
Total	5923 (100%)	21850 (100%)	1991 (100%)	3103 (100%)

For 2005, hatchling survival for *P. unifilis* was different between treatments of human impact and river (Table 4.7.2 & Figure 4.7.1). The lowest survival over all sites was 0% at the low human impact site on the Paraguá River. However, this was completely explained by loss to animal predation. The highest survival over all sites was on the Paraguá River, at 41% at the protected site. The highest survival on the Iténez River was 36% at the low impact site, and the lowest survival was 9% at the high impact site. Overall survival for 2005, on the Iténez River was 26%, while overall survival on the Paraguá River was 21%.

Table 4.7.2. Hatchling survival by HI*river, *P. unifilis,* 2005.

HI*river	Number of Live Hatchlings	Number of Bad Eggs	Number of Dead Hatchlings	No Data	Total Eggs With Data	Survival
Iténez High	151	1570	0	352	1721	9%
Iténez Protected	340	733	0	4320	1073	32%
Iténez Low	875	1488	73	1107	2436	36%
Paraguá High	830	5644	1	405	6475	13%
Paraguá Protected	2715	3974	0	0	6689	41%
Paraguá Low	0	3456	0	0	3456	0%
Total	4911	16865	74	6184	21850	22%

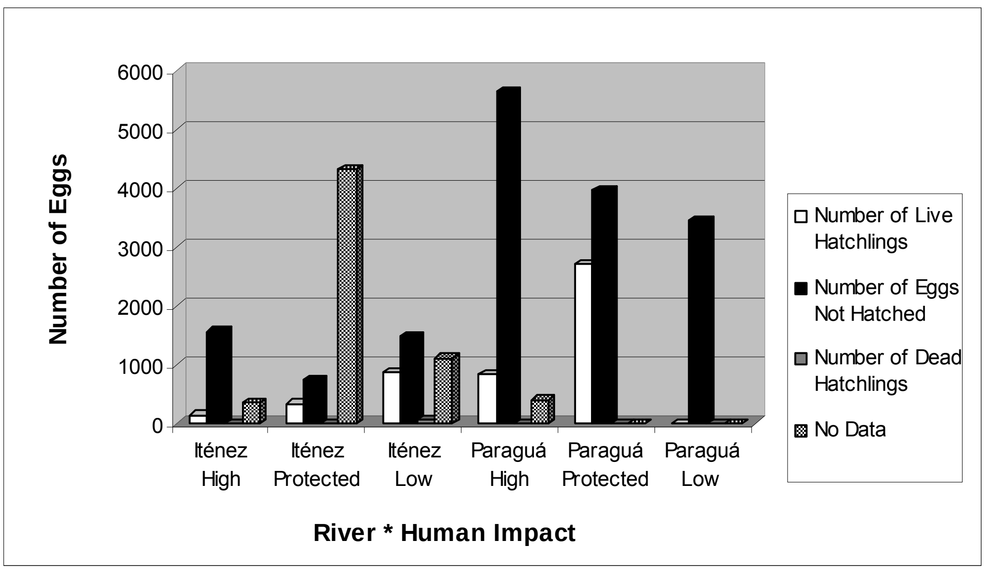

Figure 4.7.1. Hatchling survival by HI*river, *P. unifili*s, 2005.

In 2006, for *P. unifilis*, we evaluated a total of 442 nests, of which only 385 had live hatched eggs. Of a total of 11,752 eggs counted, only 8.675 (73.8%) had live hatchlings (Table 4.7.3). For *P. expansa*, there were a total of 22 nests reviewed; only 15 had live hatchlings. Of

3,438 eggs counted, only 685 (19.9%) had live hatchlings. Again, for P. *unifilis* we estimated the additional eggs lost in the 355 nests lost to disturbance (plus random nests with no data): 9,940 eggs lost, which changes the distribution to 12,988 (59.2%) dead eggs, and 40.7% live hatchlings. For *P. expansa* we estimated the additional eggs lost for the 65 nests lost to disturbance; this adds an additional 9,035 dead eggs, changing the distribution to 11,549 (92.6%) dead eggs, with only 5.49% live hatchlings (Table 4.7.3). With the estimated distributions, the live hatchling rate for *P. unifilis* increased almost 20% from 2005 to 2006, but dropped about 10% in *P. expansa*. Because data for additional nests were lost each year, due to human error and lack of resources to collect all data (Tables 4.7.2, 4.7.4, 4.7.5), these numbers are at best estimations of the real distribution. Actual numbers might show increases in live hatchlings as well as dead eggs.

Table 4.7.3. Frequency distribution for egg survival, 2006. *estimated quantity from mean clutch size.

Number of Eggs	*P. unifilis* (evaluated eggs only)	*P. unifilis* (evaluated + estimated)	*P. expansa* (evaluated eggs only)	*P. expansa* (evaluated + estimated)
Live Hatchlings	8675 (73.8%)	8675 + 275* = 8950 (40.7%)	685 (19.9%)	685 (5.49%)
Dead Eggs	3048 (25.9%)	3048 + 9940* = 12988 (59.2%)	2514 (73.1%)	2514 + 9035 = 11549 (92.6%)
Dead Hatchling	29 (0.2%)	29 (0.1%)	239 (7.0%)	239 (1.91%)
Total	11752 (100%)	21967 (100%)	3438 (100%)	12473 (100%)

For 2006, hatchling survival for *P. unifilis* was again different between treatments of human impact and river (Table 4.7.4 & Figure 4.7.2), but the distribution was different from 2005. The lowest survival over all sites was 0% at the high human impact site on the Iténez River, and highest survival over all sites was 64% at the low impact site on the Iténez River. The highest survival on the Paraguá River was 54,% again at the protected site. However, this year lowest survival on the Paraguá was 13% at the high human impact site. Lowest survival on both rivers this year corresponds to high human impact sites. Overall survival on the Iténez for 2006 was 39%, while overall survival on the Paraguá was 42%. This was opposite 2005, where survival was higher on the Iténez. Overall, survival was higher for 2006 than for 2005.

Table 4.7.4. Hatchling survival by HI*river, *P. unifilis,* 2006.

HI*river	Number of Live Hatchlings	Number of Eggs Not Hatched	Number of Dead Hatchlings	No Data	Total Eggs With Data	Survival
Iténez High	0	1516	0	0	1516	0%
Iténez Protected	660	2986	11	2295	3657	18%
Iténez Low	3595	1993	18	0	5606	64%
Paraguá High	250	1606	0	0	1856	13%
Paraguá Protected	3905	3300	0	81	7205	54%
Paraguá Low	540	1587	0	0	2127	25%
Total	8950	12988	29	2376	21967	41%

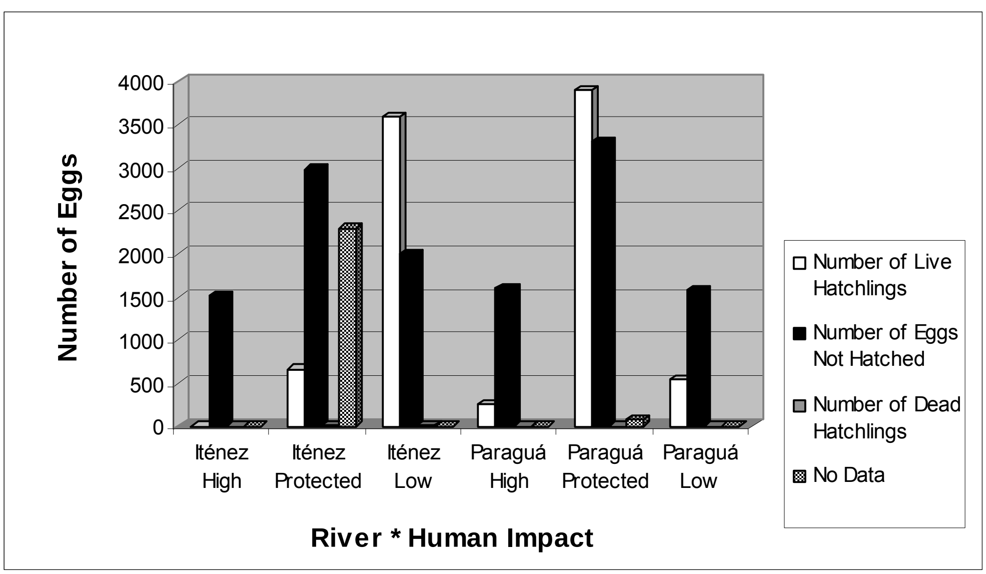

Figure 4.7.2. Hatchling survival by HI*river, *P. unifilis*, 2006.

Hatchling survival distributions were also different for *P. expansa* between treatments and years (Table 4.7.5 & Figure 4.7.3). Lowest survival rates for 2005 occur at the low human impact site on, while highest survival occurs at the protected site. In 2006, there was no occurrence of *P. expansa* nesting on the low impact site, and the only site with non-zero survival was at the protected site. Both years the protected site has highest survival rates. Average survival across both years was 13.2%.

Table 4.7.5. Hatchling survival by HI*year, *P. expansa,* 2005 & 2006.

HI*year	Number of Live Hatchlings	Number of Eggs Not Hatched	Number of Dead Hatchlings	No Data	Total Eggs With Data	Survival
High 2005	134	1630	0	278	1764	8%
Protected 2005	360	349	0	417	709	51%
Low 2005	0	621	9	0	630	0%
High 2006	0	2657	0	0	2657	0%
Protected 2006	685	8892	239	278	9816	7%
Low 2006	0	0	0	0	0	N/A
Total	1179	14149	248	973	15576	8%

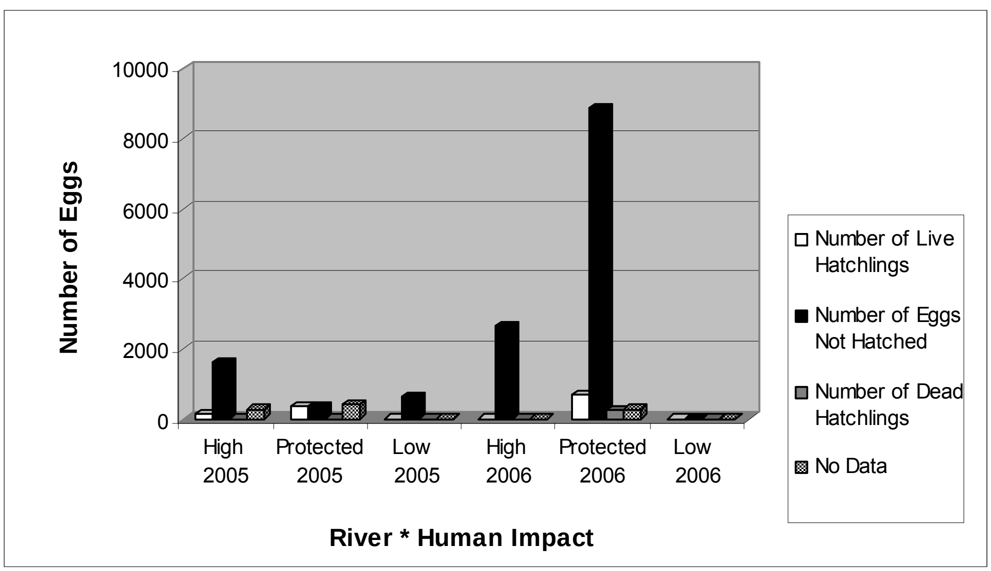

Figure 4.7.3. Hatchling survival by HI*river, *P. expansa,* 2005 & 2006.

We used a logistic model to describe the relationship between human impact and river on the probability of an egg hatching. Due to the lack of live hatchling observations for *P. expansa,* especially in certain blocks, we only did this analysis for *P. unifilis*. We tried to analyze data from each year separately, but the best model we could build was a saturated model. For that reason, we decided to analyze data from both years together.

Table 4.7.6. Summary of sample size for live hatchling model, 2005 & 2006.

	Total	Failed Nests	Normal Nests	Super Nests
Nests With Eggs	664	77	569	18
Live Hatchlings	12959	0	12752	207
Total Eggs	17675	2390	15063	222
P (Live Hatchling)	0.733	0	0.847	0.932

There were a total of 1,910 nests observed for *P. unifilis*, of which we had data for only 664. In these nests, there were 17,675 eggs observed, producing 12,959 live hatchlings, at a survival rate of 73.3% (Table 4.7.3). Because this total was composed of all nests we evaluated, some of these nests included those (77) with a 100% failure rate, or those which produced zero live hatchlings, which we term "failed nests." The nests evaluated also included 18 of what we term "super nests," or those for which only live hatchlings were recorded, but data for failed eggs was missing. We thus restricted the analysis to only those nests (569) for which at least one live hatchling was produced, and for which data for live hatchlings, dead hatchlings, and dead eggs were all recorded. Of these nests a total of 15,063 eggs were observed, with 12,752 producing live hatchlings, at a 84.7% chance of survival.

We produced a logistic analysis to explain the variation about this average rate of hatching, due to the factors HI, river, and year. We tried four models (Appendix D). All the variables were significant, with the best model number 4, having the smallest AIC, SC and -2 log

L values. The final model we used was: $Ln\ P/Q = \mu + HI_i + river_j + HI_i{*}river_j + year_k$, where P is the probability of a live hatching (Q = 1- P), where there was at least one egg hatched per nest. μ is the mean effect in logit scale, HI is effect of HI, river is the effect of river; year is the effect of year; i=High, Low, Protected; j= Iténez, Paraguá; k=2005, 2006. The baseline is nests in the protected Paraguá block of beaches, for the year 2006. Results show interaction between HI and river (Appendix D). Eggs in nests on the high impact and protected beaches of the Paraguá had better survival than the same beaches on the Iténez; however, the low impact beaches on the Iténez did better than the same beaches on the Paraguá (P < 0.0001) (Tables 4.7.7 & 4.7.8; Appendix D). There was slightly better survival in 2006 than 2005 (P < 0.0001) (Table 4.7.7; Appendix D).

Table 4.7.7. Average percent survival per nest, of observed live hatchlings, 2005 & 2006.

HI	River			
	Paraguá		Iténez	
	2005	2006	2005	2006
High	830/967 = 0.858	217/284 = 0.764	127/174 = 0.730	0/0
Low	0/0	399/555 = 0.719	875/1031 = 0.849	3515/3812 = 0.922
Protected	2088/2609 = 0.800	3838/4529 = 0.8474	340/444 = 0.770	523/658 = 0.795

Table 4.7.8. Average percent survival per nest, of observed live hatchlings, 2005 & 2006 combined.

	Paraguá	Iténez
High	0.84	0.73
Low	0.72	0.91
Protected	0.83	0.78

The assumptions made with the logistic regression model may be questionable, as there appeared to be occasional strong nest effects, even for nests on the same beach, in the same year.

This introduced excess variability in the model. For this reason, the model used here approximated the mean well, but it underestimated the spread, because of individual random nest effects that couldn't be modeled well. Additionally, by not using the eggs from the failed nests, we greatly reduced variability, but there still remained unexplained factors.

Turtle Movement

Of 303 *P. unifilis* and 12 *P. expansa* turtles marked in 2005, we recorded the return of only 14 marked *P. unifilis* females and one marked *P. expansa* in 2006 (Table 4.8.1). Of these returns, all but four turtles returned to the same beach they were marked. However, none of the four turtles caught on a different beach the second year were observed to nest on different beaches. All recorded return nesting incidences document the turtle nesting on the same beach in both years (Table 4.8.2). We marked an additional 317 *P. unifilis* and 15 *P. expansa* females in 2006.

Table 4.8.1. Summary of turtles marked and recaptured, 2005 & 2006.

	P. unifilis	***P. expansa***
Turtles marked 2005	303	12
Marked return 2006	14	1
Turtles marked 2006	317	15

Table 4.8.2. Turtles marked in 2005 and recaptured in 2006.

Species	ID Number	Location Turtle Marked 2005	Activity	Location Recapture 2006	Activity
P. unifilis	3019	Playa Preta	Nested	Playa Preta	Nested
P. unifilis	3015	Playa Preta	Nested	Playa Preta	Nested
P. unifilis	3002	Playa Preta	Walked	Playa Preta	Nested
P. unifilis	3004	Playa Preta	Walked	Playa Preta	Nested
P. unifilis	3013	Playa Preta	Walked	Playa Preta	Nested
P. unifilis	4020	Verde 1	Walked	Verde 1	Nested
P. unifilis	4016	Verde 1	Nested	Verde 1	Nested
P. unifilis	4010	Verde 1	Nested	Verde 1	Nested
P. unifilis	712	Puerto Alegre 2	Nested	San Lorenzo 1	Dug
P. unifilis	38	San Lorenzo 1	Walked	San Lorenzo 1	Nested
P. unifilis	28	San Lorenzo 1	Walked	San Lorenzo 1	Walked
P. unifilis	30	San Lorenzo 1	Walked	Puerto Alegre 2	Nested
P. unifilis	72	San Lorenzo 1	Walked	Puerto Alegre 2	Nested
P. unifilis	60	San Lorenzo 2	Walked	Puerto Alegre 2	Dug
P. expansa	1002	Playa Preta	Nested	Playa Preta	Nested

Human Movement

According to comments recorded by researchers, if a boat was parked nearby a nesting beach, or if there was much movement on the river, turtles did not nest that night. We documented that on nights with much boat traffic, turtles do not approach nesting beaches to nest. We also documented a general high level of boat movement on the Iténez River, even in areas far from human communities, and much higher than on the Paraguá River.

Discussion

Historical accounts suggest that across its range, original populations of *P. expansa* were very abundant, perhaps numbering in the millions; information for *P. unifilis* is more scarce, but some accounts show it as having been less abundant than *P. expansa* (reviewed in Ojasti 1996). *Podocnemis expansa* always nests at night on large, high, sandy beaches, in large synchronous groups, termed “arribadas” (Pritchard 1979; Ojasti 1996; Thorbjarnarson et al. 2000; Moll &

Moll 2004). Females have nested historically in widespread and massive seasonal migrations of hundreds of thousands (Ojasti 1967). In contrast, *P. unifilis* females are less particular about nesting sites; they will nest on beaches of various sizes, heights, and substrates, and they are mostly solitary nesters (Foote 1978; Food and Agriculture Organization 1988; Ernst & Barbour 1989; Ojasti 1996; Moll & Moll 2004).

That we observed so few *P. expansa* nesting, especially compared to numbers of *P. unifilis* nesting, and that all the *P. expansa* females we observed were nesting individually, was likely the result of a severe local population decline of the species. Because *P. expansa* has more requirements for nesting, it is possible that the nesting beaches we chose were not favored *P. expansa* nesting beaches. However, we did examine a few large, high beaches, on which females only nested singularly. Additionally, we know that *P. expansa* currently nests in large numbers (up to 1,000 on single beaches) further upstream on the Iténez River, on beaches protected by Brazilian conservation programs (Vogt, pers. comm. 2004), and it historically nested in much greater numbers in PNNKM (pers. comm. with local people, 2005 to 2006). Because documented nesting behavior was so different from the usual documented nesting behavior of the species, and considering local accounts of large numbers of the species nesting on single nights (hundreds on single beaches), we believe that the species must have declined significantly in and near PNNKM.

Number of Nests

Differing numbers of *P. unifilis* nests per beach across our study sites were not explained by random effects. The number of nests and beach size were not correlated, but number of nests was affected by the river in which the beach occurred; smaller effects of substrate, height, and level of human impact on number of nests were detected. Beaches on the Iténez show a strong tendency to have fewer *P. unifilis* nests per beach than would be predicted by their size. The only beach on the Iténez River that had more nests than expected was Verde 1, which was the only low impact beach on the Iténez entered in the analysis, both years. Results suggest that the Iténez river has smaller than expected nesting populations of turtles, and that a low level of human impact somewhat mitigates this negative effect.

The fact that most small beaches were found on the Paraguá River, and most large beaches were found on the Iténez river, might also explain the difference in number of nests per area. However, because Verde 1 was not the smallest beach on the Iténez, but it was the only beach on the Iténez River where more nests were observed than expected in both years, we concluded that there were negative river and human effects that explain lower numbers of nests observed on certain beaches.

The importance of sand substrate as a predictor of low number of nests was likely correlated with the fact that sandy beaches were mostly found on the Iténez River, while none were found on the Paraguá River. Most literature documents *P. expansa* as a nester on large sandy beaches. There is thus no reason to believe that a sandy substrate would be a factor in low nesting abundance for the species, especially because it correlates almost exactly with river. Beach height was also a significant factor in number of nests, when combined as a multi-year effect. Low height could be a factor in low nesting numbers, because beach height directly affects nest susceptibility to early inundation by rising rivers. However, this factor was also confounded in the analysis, because all low beaches were found on the Iténez River. However, while all low beaches had fewer nests than expected, because some high and partially high beaches also had fewer nests than expected, beach height was not the strongest predictor for number of nests.

Because we found differences in numbers of nests among sites at different levels of human impact on the Iténez River, our data did not support h_{01}; we therefore reject it. The most important conclusions of this study are that the Iténez River was the strongest predictor of low numbers of nests, and that low levels of human impact on this river might mitigate negative human effects.

The difference observed between rivers could be explained by negative human effects on the Iténez River. The Paraguá River is a smaller order river that is not easily navigable in the dry nesting season, and only accessed by relatively small indigenous Bolivian communities. In comparison, the Iténez River is a larger order river easily navigable year round by larger boats. It is on the border of Brazil, and thus sees a lot of human activity originating from Brazil; also, larger Brazilian towns are located on the river, in addition to Bolivian indigenous communities. We conclude that human activity on the Iténez River might be affecting numbers of nesting turtles, especially on beaches close to human communities. Results support the idea that smaller rivers are important for the species, and could be managed as refuge areas. Results suggest that high levels of human impact on the Iténez river have negative effects on turtle nesting populations. We recommend management actions that mitigate the impact of human travel and exploitation of turtles on this river.

Size of Nesting Females

Correlation analysis on female carapace length and corresponding track widths detected very strong correlation between the two measurements, supporting the idea that track width is a reliable estimator of female size, which is especially helpful in being able to study turtles without having to catch them. Catching turtles is a time-consuming and difficult process, especially where turtles are wary of human presence. Additionally, catching turtles causes disruption of natural nesting activities, and measuring tracks is a good, non-invasive method of studying their reproductive activities.

Conclusions we draw from this study are that human impact, river, and the interaction of human impact with river are strong predictors for female size. On average, turtles were larger in 2006 than in 2005. However, because this effect was not seen on most beaches, we did not explore it further. Nesting females were significantly larger in the Iténez River than in the Paraguá River. This finding is difficult to interpret, as it could be due to some negative human effects on the Paraguá River, or it could be due to other differences between the rivers, for example that the Paraguá is a smaller order river than the Iténez. Future research could explore the differences seen in turtles between these two rivers.

Effects of human impact on female size were variable, and dependent on river. Difference in female size was almost twice as large, between low and high impact sites, on the Paraguá River as on the Iténez River. The smaller difference in size on the Iténez river could be indicative of less effect of high human impact, or less benefit conferred by low impact beaches. Combined with results from the analysis of number of nests per beach, which suggested negative effects on the Iténez River, we might conclude that less benefit was conferred by low impact beaches on this river. However, definite conclusions cannot be made. Another result was that on the Iténez River, protected beaches and low impact beaches had close to the same size turtles; whereas, on the Paraguá River, larger turtles were observed on low impact beaches more frequently than on protected beaches. Our results suggest that protection conferred a benefit to turtle populations on both rivers, but that distance from human communities added an additional benefit on the Paraguá River. Therefore, the use of protected beaches by turtles should be emphasized in the Management Plan.

Because we found that female size was related to the level of human impact, on both rivers, our data did not support h_{02}; we therefore reject it. The most important finding in this analysis was that, depending on the river, female turtle size was always smallest on beaches with high human impact. Thus, a high level of human impact did have negative effects on nesting female size, and protected beaches could mitigate this effect.

An additional finding of this study is that the turtles we observed were smaller than turtles of the same species reported in the literature. For *P. unifilis*, we observed turtles at an average size of 38.4 cm and a size range of 26.3-48.3 cm, compared to an average size of 38-52 cm (Ojasti 1996) and maximum sizes of 45-69 cm (Pritchard 1979; Freiberg 1982; Ernst & Barbour 1989) reported in the literature. For *P. expansa*, we observed turtles at an average size of 62.0 cm and a size range of 50.0-72.0 cm, compared to an average size of 50-87.5 cm (Pritchard 1979; Ojasti 1996; Alderton 1998) and maximum sizes of 80-107cm (Pritchard 1979; Freiberg 1982; Ernst & Barbour 1989; Ojasti 1996) reported in the literature. The turtles we observed in PNNKM are at the lower limits of reported average sizes and maximum sizes. The largest *P. expansa* turtles we observed do not even enter the maximum size ranges reported in the literature.

The fact that female turtles in PNNKM are generally small suggests over-exploitation of the species in the region. Female size can be related to female age or nutritional levels in the habitat. However, the fact that field sites are on the same river leads us to hypothesize that the small female sizes we observed are related to turtle age, which has been influenced by human exploitation (K. Buhlmann, pers. comm. 2008). Differences in nutritional quality likely vary little between high impact and protected sites, as they are near to each other, and both are close to human communities. Because we observed significant differences between high impact and protected sites, in turtle size, it is likely that human impact is affecting turtle size in PNNKM.

Large numbers of female turtles are likely being extracted from nesting beaches early in their lives, which has a negative effect on turtle populations by killing off the oldest life stages. This conclusion is supported by our finding that female turtles are even smaller in areas with high levels of human impact. Humans selectively hunt larger turtles if given a choice (pers. obs. 2005-2006), and larger (most likely older) turtles in a population have had more time to be killed by humans. Thus, smaller turtles in areas of high human impact could be indicative of long-term exploitation leading to population decline in these long-lived animals. Overall, this suggests that humans have had a negative impact on nesting populations (Kurt Buhlmann, pers. comm., 2004).

Hatchling Size

We detected an effect of human impact, river, and interaction of human impact and river on hatchling size. However, effects were different on each river. On the Iténez River, the largest hatchlings were on protected beaches, and the smallest were on high impact beaches. On the Paraguá, the largest hatchlings were on low impact beaches, and the smallest were on protected beaches. Size of hatchlings was not correlated with female size. In general, high impact level was a predictor of smaller hatchling size, when compared to low impact beaches. The effect of protected beaches was opposite on both rivers, implying that protected sites predicted large hatchling size on the Iténez, but small hatchling size on the Paraguá. Whether this is indicative of a negative effect (or failure) of protection schemes on the Paraguá River was difficult to assess, especially because other variables (such as female size) were positively correlated to protected sites on both rivers.

In conclusion, because we found that hatchling size was related to the level of human impact, on both rivers, our data did not support h_{03}; we therefore reject it. Because larger hatchling size may indicate a higher probability of survival, smaller hatchling sizes at high human impact sites could demonstrate another negative effect of high levels of human impact on nesting populations. While hatchling size was not related to size of the mother, smaller size might be attributed to higher energy costs and stress levels to female turtles that mate and live in areas of high human impact, before nesting. However, further research is needed to investigate reasons for this finding.

Nest Survival/Disturbance

We found high levels of disturbance in nests of both species in both years of the study, where total disturbance to nests was always higher than incidences of no disturbance. However, the degree of each disturbance type varied by year, by river, and by level of human impact. We found that generally, for *P. unifilis,* animal predation and inundation were the two most important types of nest disturbance, respectively. For *P. expansa*, inundation and then human and animal were the most important disturbance types. Because *P. unifilis* nests are much shallower than *P. expansa* nests, *P. unifilis* nests were more vulnerable to predators, while deep *P. expansa* nests were more vulnerable to rising river levels. The results of this study suggest that due to differences in nesting characteristics, management actions must focus on different threats for each species.

In 2006, animal predation became less important to both turtle species, especially to *P. expansa*, where it became irrelevant, and inundation became more important to both species. However, it is important to note that because inundation is a threat that occurs only later in the season, it is possible that percent loss to inundation fluctuates in reverse to ratios of animal and human threats. For example, if animal and human disturbance is high, there are fewer nests left vulnerable to inundation, later in the season. Finally, our results across only two years demonstrate that non-human disturbances fluctuate by year, and might not always be important sources of mortality. Further research is needed to determine if variations are cyclic.

In addition to differences in non-human disturbances between years, we see differences in direct and indirect human effects. For *P. expansa* nests, there was an increase in human exploitation from 2005 to 2006, and, only in 2005, we document disturbance caused by trampling of nests by cattle on the Paraguá River. Previously, we did not know that cattle wandered to nesting beaches, disturbing turtle nests. These results show that human effects also differ in their importance by year. Further research is needed to evaluate long-term effects.

Important disturbances and their management implications are most clearly understood when they are analyzed according to level of human impact. Most importantly, human exploitation and cattle were only important factors on high impact sites, where they were the most important disturbances. It is highly probable that other disturbances would be higher at these sites, if human disturbances were lower (this because humans often gather eggs early in the season, before they are prone to other disturbances). For *P. unifilis,* both years, overall survival was highest on protected and low impact beaches, and for *P. expansa* overall survival was highest on protected beaches. Results support the idea that both low impact and protected beaches offer refuge to turtles against human exploiters, and indirect impacts of human land use. We thus recommend the use of protected beaches as refuge from nest disturbance.

Lastly, we evaluated which disturbances were more important on each river. Animal predation was higher on the Paraguá both years; disturbance by cattle was only a factor on the Paraguá; and inundation, while a factor on both rivers, was higher on the Paraguá. Human disturbance was a factor on both rivers, close to human communities. This shows us that management options on each river should have different focuses.

In conclusion, because we found that nest disturbance was related to the level of human impact, on both rivers, our data did not support h_{04}; we therefore reject it.

Hatchling Survival

Hatchling survival estimates were low – less than 50% of total eggs created. Survival rates for *P. unifilis* hatchlings varied by year, and among treatments, with the greatest survival estimate being 40.7%. Lower overall survival rates for 2005 were mostly explained by especially high rates of animal predation, as well as trampling by cattle, but both effects varied between years. Survival rates differed between rivers and years, suggesting that due to changing disturbances, neither river had a significant effect on hatchling survival. Generally, except the incidence of especially high animal predation in 2005 on the Paraguá River, we found that high human impact sites had the lowest hatchling survival rates on each river. Hence, disturbance caused by humans did negatively affect hatchling survival. Differences were detected between rivers related to where highest hatchling survival rates were found: On the Iténez River, hatchling survival was greatest at low impact sites across both years, while on the Paraguá, hatchling survival was always highest at protected areas. Low human impact appeared to be a predictor for higher hatchling mortality, but only in the absence of other disturbances (here mainly animal predation). Protected sites show advantages for hatchling survival at all sites.

Hatchling survival rates for *P. expansa* were extremely low across all sites except one, the protected site in 2006. At all other sites disturbance was too high for the species to have any reproductive success. Regeneration prospects for *P. expansa* seem to be exceptionally poor in our study area given the low number of nests for the species.

In our logistic model we found that year, HI, river, and HI*river were all factors affecting hatchling survival from viable nests, but that effects were different on each river. Because we found that hatchling survival was related to the level of human impact, on both rivers, our data did not support h_{05}; we therefore reject it. On the Paraguá, low impact beaches had lower survival rates, whereas, on the Iténez they had the highest. However, a general conclusion about the effect of human impact on hatchling viability in viable nests cannot be made. We can only say that high human impact predicted low hatchling survival in viable nests on the Iténez River. However, it was clear that overall nest survival (including completely destroyed nests and still viable nests) differed according to block, with human disturbance being much higher in high impact areas, thus lowering overall nest viability.

Turtle Movement

Due to the small numbers of turtles recaptured in 2006, we were not able to draw many conclusions. The return of all nesting turtles to the same beach does support nest site fidelity of the species; however, some turtles were caught on different beaches, which demonstrates movement of turtles to different beaches, on which they might be nesting. A larger percentage of recapture of *P. expansa* turtles, compared to *P. unifilis* turtles recaptured, suggests a smaller population for this species. This agrees with our other observations (i.e., number of turtles captured and nests created) that local *P. expansa* populations are much smaller than *P. unifilis* populations. Further study is needed in this area, and more recaptures of turtles in the future will provide more information, related to abundance of nesting populations, nest site fidelity, and turtle migration.

Human Movement

The cumulative effect of river traffic over a prolonged period during the nesting season could cause turtles to lay eggs later in the season, which might affect nest vulnerability to rising river levels. Additionally, locals recount that starting in the year 2005, rain levels have increased greatly in the region. This could also be affecting nest vulnerability to inundation. As well, changing hydrology of the region could be caused by large levels of deforestation on the Brazilian side of the river. Further research is needed to test all these hypotheses.

Conclusions

The five null hypotheses we tested were rejected because definite differences in turtle population viability were consistently found among sites at different levels of human impact. Of all the variables tested among study blocks, all except for hatchling survival, in already viable nests, were shown to be negatively at high human impact sites. Therefore, we reject H_{01} and conclude that direct human use of turtle resources has negatively impacted their populations in PNNKM. Negative effects that could be attributed to human impact are smaller nesting populations, smaller nesting turtles, smaller hatchlings, and lower nest and hatchling survival rates.

While results discussed here support the hypothesis that proximity to human communities has negative effects on turtle reproductive populations, direct causes of these observations have not been tested. However, we propose reasons for these negative effects on local populations. The most important is likely direct human overexploitation of the species (turtles and eggs), which has already been widely documented in the literature as the cause of decline in the species. It is thus reasonable to conclude that the negative effects documented here, in turtle nesting populations in PNNKM that are close to human communities, are caused by the same human activity documented as the cause of the species´ decline throughout its range, namely human exploitation.

Causes of mortality to turtle nests that do not include direct human exploitation can also be high sources of mortality to nests. The largest of these are animal predation and early inundation of nests at the end of the season, before hatchlings can leave the nests. We do not know if mortality due to these two disturbances is occurring at historic and natural rates, or if it is a changed occurrence from the past. If they are changed occurrences, we can only propose hypotheses for the causes. Changed rates in animal predation could be caused by natural or human influences in the landscape. Loss to flooding might be due to higher and early onset of rising river levels, or it could be due to eggs being created later in the local nesting season (both of these theories correspond to information collected in local interviews). Causes of changing hydrology could include natural climatic variation, or indirect human impacts, such as changes to the landscape caused by high levels of deforestation, especially on the Brazilian side of the Iténez River. Changes in numbers of nests vulnerable to flooding could also be due to changes in timing of turtle nesting behavior, caused by increased human activity on the river, especially at night, and mostly originating from Brazilian tourism activities.

Due to initial results, we propose further research, which would be related to the possible indirect negative impacts on *Podocnemis* populations of human river activities (e.g., tourism, commercial boating, fishing), as well as possible indirect impacts on turtle reproductive activities caused by human land use (e.g., agriculture, cattle ranching, development) and possible climatic change.

In general, results of our research provide good information related to local turtle populations and their threats. We provide strong evidence that local populations are in need of management efforts to mitigate local decline of the species, especially focusing on *P. expansa*, which appears to be rare locally, compared to historic numbers recounted by local people. Additionally, we documented small female sizes of both species of turtles, compared to all reports in the literature, which suggests that viability of *Podocnemis* populations in PNNKM is poor, compared to other regions. This supports our conclusion that local *Podocnemis* populations are in decline due to unsustainable harvests of turtles by local human residents. We documented various negative effects on local reproductive populations of turtles that are in close proximity to human settlements where people hunt turtles and their eggs. Five indices for turtle reproductive viability showed negative effects correlated to high levels of human impact. Due to all these negative effects we have observed in local turtle populations, we strongly recommend that restrictions be placed on the harvest of nesting female turtles.

Results suggest areas of focus for conservation measures, which will differ by river, and by treatment block. For example, management efforts should concentrate on human use of the species at high impact sites, while efforts to protect against animal predation and inundation effects might be the focus at other sites. Results support the use of protected beaches in the region, as most indices for population/reproductive viability were higher at protected sites than at the high human impact sites. Results of this study will be combined with results from other interview based studies, which were conducted at the same time as this research, related to local human use of turtles, as well as to oral histories related to temporal and spatial changes in local turtle populations throughout time (Chapter 5). All information will be presented in local planning meetings and will inform the community-based species Management Plan we are collaborating with in PNNKM.

The knowledge acquired through this project, and presented here, will enable intelligent planning for conservation of the species in PNNKM. It will provide the base for the next phase of the project, which will involve the continuation of all research described here, as part of a long-term ecological monitoring program of turtle populations. In the future, multi-year data sets will allow us to compare nesting populations and their threats through time. Monitoring will also be used to evaluate the effects of future management tools, implemented over time.

Our results could be relevant to other turtle conservation projects in Bolivia and the tropics in general. This project is a good example of how long term conservation planning can incorporate both scientific study and management at the local level. We present a collaborative process, begun in 2003, in which PNNKM personnel and community members are developing the tools necessary to manage conservation of their natural resources. The training effort, which was a large part of the research presented here, has been very effective. The community members involved in research are highly capable of implementing project methodology and supervising research efforts independently. All researchers showed a strong interest in the work, and almost all wish to continue the work in the long-term.

This scientific study was part of a collaboration with the Bolivian National Park system and local indigenous communities. It was an integral part of a locally-based conservation effort that will ensure the scientific integrity of the greater conservation project.

References Cited

Alderton, D. 1998. Turtles & Tortoises of the World. Blandford, London.

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

CIA. 2007. The World Factbook.

CITES Secretariat. 2008. Convention on International Trade in Endangered Species of Wild Fauna and Flora: Species database. CITES Secretariat, Geneva, Switzerland.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Ergueta, P., and C. de Morales. 1996. Libro Rojo de los Vertebrados de Bolivia. International Union for the Conservation of Nature, Gland, Switzerland.

Ernst, C. H., and R. W. Barbour 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Food and Agriculture Organization. 1988. Las tortugas del río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Areas Silvestres **Año 3**:23-29.

Foote, R. W. 1978. Nesting of *Podocnemis unifilis* (Testudines: Pelomedusidae) in the Colombian Amazon. Herpetologica **34**:333-339.

Freiberg, M. 1982. Turtles of South America. TFH Publications, Neptune, NJ.

Fundación Amigos de la Naturaleza (FAN), and The Nature Conservancy (TNC). 1996. Plan de Manejo: Parque Nacional Noel Kempff Mercado, Bolivia in M. d. D. S. y. M. Ambiente, and D. N. d. C. d. l. Biodiversidad, editors, Santa Cruz, Bolivia.

Gibbs, J. P., and G. D. Amato. 2000. Genetics and demography in turtle conservation. Pages 207-217 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Klemens, M. W. 2000. From information to action: Developing more effective strategies to conserve turtles. Pages 239-258 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Kuchling, G. 1999. The Reproductive Biology of the Chelonia. Springer-Verlag, New York.

Licata, L., and X. Elguezabal. 1997. Management plan for the giant Amazonian turtle, *Podocnemis expansa*, in De La Tortuga Arrau Wildlife Refuge, Orinoco River, Venezuela. Pages 171-173 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

McDougal, J. 2000. Conservation of tortoises and terrestrial turtles. Pages 180-206 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Meylan, A. B., and D. Ehrenfel. 2000. Conservation of marine turtles. Pages 96-125 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Moll, D., and E. O. Moll 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press, Oxford.

Moll, E. O., and D. Moll. 2000. Conservation of river turtles. Pages 126-155 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Ojasti, J. 1967. Consideraciones sobre la ecologia y conservación de la tortuga *Podocnemis expansa* (Chelonia, Pelomedusidae). Pages 201-206. Atas do Simposia sobre a Biota Amazónia

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J. 1972. La Problematica de la Tortuga Arrau. Pages 4-10 in Ministerio de Agricultura y Cria, Dirección de Recursos Naturales Renovables, and Republica de Venezuela, editors.

Ojasti, J. 1996. Wildlife utilization in Latin America: Current situation and prospects for sustainable management (FAO conservation guide - 25) in F. a. A. O. o. t. U. N.-. FAO, editor, Rome.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Pritchard, P. C. H. 1979. Encyclopedia of Turtles. T.F.H. Publications, Neptune, NJ.

Seigel, R. A., and C. K. Dodd, Jr. 2000. Manipulation of turtle populations for conservation: Halfway technologies or viable options? Pages 218-238 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Thorbjarnarson, J. B., C. J. Lagueux, D. Bolze, M. W. Klemens, and A. B. Meylan. 2000. Human use of turtles: A worldwide perspective. Pages 33-84 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Tortoise and Freshwater Turtle Specialist Group 1991. Tortoises and Freshwater Turtles: An Action Plan for Their Conservation. The World Conservation Union, Broadview, Illinois.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington DC.

Valenzuela, N. 2001. Maternal effects on life-history traits in the Amazonian giant river turtle *Podocnemis expansa*. Journal of Herpetology **35**:368-378.

Appendix A. Contingency charts for number of nests expected to number of nests observed.

Binomial distribution of observed vs. expected number of nests for *P. unifilis*, 2005. White denotes more than expected number of nests; grey denotes fewer than expected. Expected correction factor is 32.54.

Beach	River	Size (ha)	Human Impact (HI)	Beach Height	Substrate	Number of Nests	Expected Number of Nests
Bahía Grande	Iténez	6.487	protected	high	sand&veg	89	211
Gaviota	Iténez	3.941	high	low	sand	42	128
Preta	Iténez	2.913	protected	low	sand	36	95
Mescla	Iténez	2.902	protected	part high	sand	21	94
Bahía Grande de la V	Iténez	2.897	protected	part high	sand	52	94
Siringuera	Iténez	2.808	high	low	sand	29	91
Verde 2	Iténez	2.584	low	low	sand	41	84
Verde 1	Iténez	2.187	low	part high	sand	98	71
Boliviana	Iténez	1.159	high	low	sand	33	38
Puerto Alegre 2	Paraguá	0.813	high	high	sand&veg	143	26
Corte Oli 1	Paraguá	0.63	protected	part high	sand&veg	83	21
Corte Oli 2	Paraguá	0.527	protected	high	sand&veg	72	17
San Lorenzo 2	Paraguá	0.472	low	high	sand&veg	7	15
Puerto Alegre 1	Paraguá	0.269	high	high	sand&veg	105	9
San Lorenzo 1	Paraguá	0.208	low	high	sand&veg	121	7
Corte Oli 4	Paraguá	0.081	protected	high	sand&veg	13	3
Corte Oli 3	Paraguá	0.07	protected	high	sand&veg	22	2

Binomial distribution of observed vs. expected number of nests for *P. unifilis*, 2006. White denotes more than expected number of nests; grey denotes fewer than expected. Expected correction factor is 29.39.

Beach	River	Size (ha)	Human Impact (HI)	Beach Height	Substrate	Number of Nests	Expected Number of Nests
Bahía Grande	Iténez	6.487	protected	high	sand&veg	144	191
Gaviota	Iténez	3.941	high	low	sand	21	116
Preta	Iténez	2.913	protected	low	sand	17	86
Mescla	Iténez	2.902	protected	part high	sand	16	85
Bahía Grande de la V	Iténez	2.897	protected	part high	sand	42	85
Siringuera	Iténez	2.808	high	low	sand	18	83
Verde 2	Iténez	2.584	low	low	sand	14	76
Verde 1	Iténez	2.187	low	part high	sand	185	64
Boliviana	Iténez	1.159	high	low	sand	17	34
Puerto Alegre 2	Paraguá	0.813	high	high	sand&veg	59	24
Corte Oli 1	Paraguá	0.63	protected	part high	sand&veg	88	19
Corte Oli 2	Paraguá	0.527	protected	high	sand&veg	194	15
San Lorenzo 2	Paraguá	0.472	low	high	sand&veg	22	14
Puerto Alegre 1	Paraguá	0.269	high	high	sand&veg	10	8
San Lorenzo 1	Paraguá	0.208	low	high	sand&veg	56	6

Appendix B. Statistical charts for analysis of female track widths.

T-test for year effect for track width of 15 beach pairs, 2005 & 2006.

River	HI	Beach	2005		2006		Diff	T	P-value	Signifi-cance (α=0.05) *multiple component corrected
			Number of Observations	Average	Number of Observations	Average				
Iténez	High	SG	33	29.68	20	30.71	1.03	0.91	0.3703	
Iténez	High	GT	42	28.15	21	28.69	0.54	0.82	0.4175	
Iténez	High	BV	28	29.46	16	29.29	-0.18	-0.29	0.7759	
Iténez	Low	V1	122	31.70	173	31.90	0.21	0.50	0.6208	
Iténez	Low	V2	40	34.18	14	34.21	0.03	0.02	0.9827	
Iténez	Prot	BP	45	30.96	24	32.68	1.71	2.04	0.0464	
Iténez	Prot	PM	7	33.03	16	30.75	-2.28	-0.63	0.5500	
Iténez	Prot	BG	4	31.88	8	32.33	0.45	0.14	0.8963	
Iténez	Prot	BD	23	37.60	40	31.56	-6.04	-2.58	0.0159	
Paraguá	High	P1	29	22.41	13	24.29	1.88	1.39	0.1710	
Paraguá	High	P2	34	20.32	59	24.64	4.31	4.84	<.0001	*
Paraguá	Low	L1	54	28.91	43	28.23	-0.68	-1.63	0.1050	
Paraguá	Low	L2	6	33.17	7	28.29	-4.88	-1.64	0.1435	
Paraguá	Prot	C1	66	23.71	28	28.29	4.57	9.40	<.0001	*
Paraguá	Prot	C2	67	24.13	101	27.37	3.23	10.52	<.0001	*
Total			622	27.93	583	29.17	1.25	3.98	<.0001	*

GLM models of comparison of *P. unifilis* track width. "+" marked variables significant on 0.05 level in model.

Model	Variables	Model Df	Error Df	SSE	SBC	R Square
1a	HI+	2	1202	26798.36	7496.77	0.157
1b	river+	1	1203	21349.25	6941.82	0.328
1c	year+	1	1203	31371.04	7869.36	0.013
1d	height+	2	1202	21537.12	6970.03	0.322
1e	size+	1	1203	25086.45	7330.58	0.211
2a	HI+, river+	3	1201	18769.88	6645.69	0.409
2b	HI+, river+, HI*river+	5	1199	18161.95	6580.53	0.428
3a	HI+, river+, year+	4	1200	18528.45	6621.59	0.417
3b#	**HI+, river+, HI*river+, year+**	**6**	**1198**	**17893.63**	**6551.76**	**0.437**
3c	HI+, river+, HI*river+, height	7	1197	18134.00	6591.01	0.429
3d	HI+, river+, HI*river+, size	6	1198	18160.01	6587.37	0.429
4a	HI+, river+, HI*river+, year+, height	8	1196	17826.29	6556.86	0.439
4b	HI+, river+, HI*river+, year+, size	7	1197	17890.74	6558.46	0.437
4c	HI+, river+, HI*river+, height, size	8	1196	18130.70	6597.66	0.429
5a	HI+, river+, HI*river+, year+, height, size	9	1195	17821.28	6563.27	0.439

Appendix B (cont.)

Summary of the final model: Track width = $\mu + HI_i + river_j + HI*river_{ij} + year_k$, where i = High, Low, Prot; j = Iténez, Paraguá; k = 2005, 2006

The GLM Procedure

Dependent Variable: track_wid

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	13884.00225	2314.00038	154.93	<.0001
Error	1198	17893.63330	14.93625		
Corrected Total	1204	31777.63555			

R-Square	Coeff Var	Root MSE	track width Mean
0.436911	13.35744	3.864745	28.93328

Source	DF	Type III SS	Mean Square	F Value	Pr > F
HI	2	3008.524063	1504.262031	100.71	<.0001
River	1	7629.293937	7629.293937	510.79	<.0001
HI*River	2	634.820056	317.410028	21.25	<.0001
Year	1	268.321211	268.321211	17.96	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		26.09709496	0.26000510	100.37	<.0001
HI	High	-2.61308430	0.40440911	-6.46	<.0001
HI	Low	3.25824217	0.43402372	7.51	<.0001
HI	Prot	0.00000000	.	.	.
River	Iténez	6.77155571	0.37722352	17.95	<.0001
River	Paraguá	0.00000000	.	.	.
HI*River	High Iténez	-0.44369452	0.59090284	-0.75	0.4529
HI*River	High Paraguá	0.00000000	.	.	.
HI*River	Low Iténez	-3.50100422	0.56622982	-6.18	<.0001
HI*River	Low Paraguá	0.00000000	.	.	.
HI*River	Prot Iténez	0.00000000	.	.	.
HI*River	Prot Paraguá	0.00000000	.	.	.
Year	2006	0.95145141	0.22448120	4.24	<.0001
Year	2005	0.00000000	.	.	.

Appendix C. Statistical charts for analysis of hatchling carapace lengths.

T-test for year effect for hatchling carapace length of 15 beach pairs, 2005 & 2006. "*" denotes year effect significant at 0.05 level, blank denotes not significant at 0.05 level.

River	Hi	Beach	2005		2006		Diff	T	P-value
			Number of Observations	Average	Number of Observations	Average			
Iténez	High	SG	10	36.300	0				
Iténez	High	GT	0		0				
Iténez	High	BV	0		0				
Iténez	Low	V1	42	41.218	137	41.149	-0.069	-0.19	0.8503
Iténez	Low	V2	0		0				
Iténez	Prot	BP	15	42.178	3	42.293	0.115	0.10	0.9247
Iténez	Prot	PM	0		0				
Iténez	Prot	BG	0		0				
Iténez	Prot	BD	0		0				
Paraguá	High	P1	10	39.530	4	37.625	-1.905	-1.00	0.3837
Paraguá	High	P2	19	39.332	9	38.756	-0.576	-0.61	0.5522
Paraguá	Low	L1	0		11	39.201			
Paraguá	Low	L2	0		6	38.800			
Paraguá	Prot	C1	43	38.998	60	39.023	0.024	0.11	0.9164
Paraguá	Prot	C2	34	39.027	127	38.954	-0.073	-0.40	0.6900
Total			187	39.364	357	39.679	0.315	1.10	0.2715

GLM models of comparison of *P. unifilis* hatchling carapace length. "+" marked variables significant on 0.05 level in model.

Model	Variables	Model Df	Error Df	SSE	SBC	R Square
1a	HI+	2	541	1385.27	1035.85	0.267
1b	river+	1	542	1386.59	1030.59	0.266
1c	year	1	542	1884.91	1364.64	0.002
1d	height+	2	541	1358.65	1014.74	0.281
1e	size+	1	542	1447.04	1077.02	0.234
1f	track_wid+	1	373	1220.83	897.12	0.122
2a	HI+, river+	3	540	1319.26	989.03	0.302
2b#	**HI+, river+, HI*river+**	**5**	**538**	**1121.8**	**825.23**	**0.406**
3a	HI+, river+, year	4	539	1316.2	992.81	0.303
3b	HI+, river+, HI*river+, year	6	537	1120.54	830.30	0.407
3c	HI+, river, HI*river+, height	5	538	1121.8	825.23	0.406
3d	HI+, river, HI*river+, size	6	537	1121.79	831.52	0.406
3e	HI+, river+, HI*river+, track_wid	6	368	787.281	597.73	0.434
3f	HI+, river+, track_wid	4	370	949.593	726.47	0.317
4a	HI+, river, HI*river+, height, size	6	537	1121.79	831.52	0.406
4b	HI+, river, HI*river+, year, height	6	537	1120.54	830.30	0.407
5a	HI+, river+, height, size, track_wid	6	368	944.115	733.98	0.321
5b	HI+, river, HI*river+, year, height, track_wid	7	367	786.78	603.18	0.434
6a	HI+, river, HI*river+, year, height, size, track_wid	8	366	786.766	609.10	0.434

Appendix C (cont.)

Summary of the final model: carapace length = $\mu + HI_i + river_j + HI*river_{ij}$, where i = High, Low, Prot; j = Iténez, Paraguá.

```
                             The GLM Procedure
Dependent Variable: carapace length
                                       Sum of
 Source                     DF        Squares   Mean Square  F Value  Pr > F
 Model                       5     767.831047    153.566209    73.65  <.0001
 Error                     538    1121.803648      2.085137
 Corrected Total           543    1889.634695

          R-Square     Coeff Var      Root MSE        carapace Mean
          0.406338      3.628777      1.444000           39.79303

 Source                     DF     Type III SS   Mean Square   F Value   Pr > F
 HI                         2      211.9615777    105.9807889     50.83   <.0001
 river                      1       11.7489972     11.7489972      5.63   0.0180
 HI*river                   2      197.4522450     98.7261225     47.35   <.0001

                                                  Standard
Parameter                     Estimate              Error   t Value   Pr > |t|
Intercept                  38.97956835 B     0.08660538    450.08     <.0001
HI        High              0.11328880 B     0.23905357      0.47     0.6358
HI        Low               0.90572577 B     0.36077085      2.51     0.0123
HI        Prot              0.00000000 B      .               .        .
River     Iténez            3.21765388 B     0.35119999      9.16     <.0001
River     Paraguá           0.00000000 B      .               .        .
HI*River  High Iténez      -6.01051102 B     0.61765786     -9.73     <.0001
HI*River  High Paraguá      0.00000000 B      .               .        .
HI*River  Low Iténez       -1.93764073 B     0.50758778     -3.82     0.0002
HI*River  Low Paraguá       0.00000000 B      .               .        .
HI*River  Prot Iténez       0.00000000 B      .               .        .
```

Appendix D. Statistical charts for analysis of hatchling survival.

Logistic models comparison of *P. unifilis* live hatchlings.

Model	Variables	AIC	SC	-2 log L
1	HI, river	12804	12834	12796
2	HI, river, HI*river	12652	12697	12640
3	HI, river, year	12774	12812	12764
4#	**HI, river, HI*river, year**	**12614**	**12667**	**12600**

Summary of the final logistic regression model for live hatchling. Final model $Ln\ P/Q = \mu + HI_i + river_j + HI_i{*}river_j + year_k$, where P is the probability of a live hatching (Q = 1- P), μ is the mean effect in logit scale, i = High, Low, Protected; j = Iténez, Paraguá; k = 2005, 2006.

Type 3 Analysis of Effects

Effect	DF	Chi-Square	Pr > ChiSq
HI	2	1.2728	0.5292
RV	1	5.5013	0.0190
HI*RV	2	182.4822	<.0001
YR	1	40.9713	<.0001

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	1.4434	0.0383	1421.7074	<.0001
HI High	1	-0.00098	0.0694	0.0002	0.9888
HI Low	1	0.0386	0.0523	0.5443	0.4607
HI Prot	0	-0.03762			
RV Iténez	1	0.0903	0.0385	5.5013	0.0190
RV Paraguá	0	-0.0903			
HI*RV High	1	-0.3775	0.0662	32.5015	<.0001
HI*RV Low	1	0.6137	0.0492	155.8137	<.0001
HI*RV Prot	0	-0.2362			
YR 05	1	-0.1611	0.0252	40.9713	<.0001
YR 06	0	0.1611			

CHAPTER 5

COMMUNITY DERIVED KNOWLEDGE OF *PODOCNEMIS* TURTLES: THEIR HISTORY, THREATS, AND MANAGEMENT NEEDS IN NOEL KEMPFF MERCADO NATIONAL PARK, BOLIVIA[1]

[1] Lipman, A. J. and L. Saucedo Mendía. To be submitted to Conservation Biology.

Abstract

The research presented here provides community-derived social and oral history data relevant to an innovative conservation project in Noel Kempff Mercado National Park (PNNKM), a World Heritage Site in Bolivia, that focuses on two declining species of South American river turtles: *Podocnemis unifilis* (yellow-spotted Amazon river turtle, locally "tracayá") and *P. expansa* (giant South American river turtle, locally "tataruga"). These rapidly declining river turtles have regionally important biodiversity, cultural and economic value. Social research in local communities addresses questions posed by local citizens and resource managers, who have observed that populations of both species are declining in PNNKM (compared to their memories of the past): The fundamental question is, "Are local turtle populations declining, and if so, are they negatively affected by human activities? This study complements a parallel ecological study performed on effects of human activities to local turtle populations. Here we report on two social studies that consist of interviews in local human communities that use the turtles as a subsistence protein source. First we documented and quantified local human use of the species during the nesting season, through weekly interviews, conducted with the help of local students, as part of an educational program instituted by the project. Results documented high rates of use of both species and their eggs in all neighboring human communities, with a few families being the primary sources of turtle mortality in the larger communities. The second study involved interviews of local residents, regarding temporal and spatial patterns of turtle populations and their use, and opinions and ideas related to turtle management. Interviews documented a decline in both species over time, noticed by most local inhabitants. This study also found increasing development of riparian corridors, and express widespread local concern that turtles are disappearing, support for the project, and ideas for management options and sustainable use of turtles.

Key Words: *Podocnemis expansa*, *Podocnemis unifilis*, management plan, sustainable use, turtle conservation, subsistence use, social research, river turtle, Bolivia, tropical conservation

Introduction

We present the results of social research that provide baseline information relevant to the community-based *Podocnemis* conservation project in Noel Kempff Mercado National Park (PNNKM), a World Heritage Site in the Bolivian Amazon. The project is a collaboration of PNNKM administration, local indigenous communities of the Bajo Paraguá, and scientists at the University of Georgia; it was initiated as a response to the observed decline of *Podocnemis* turtles in and near PNNKM. The project's general goal is to conserve and manage viable populations of the species, within and near PNNKM, while responding to the livelihood needs of local human populations. Our goal was to produce a science and community-based approach to conservation that could produce credible stewardship of the species, while addressing human livelihood issues, such as peoples' rights to food. All interviews were conducted by local community members under the supervision of PNNKM local biologists.

The conservation project focuses on two declining species of South American river turtles: *Podocnemis unifilis* (yellow-spotted Amazon river turtle, locally "tracayá") and *P. expansa* (giant South American river turtle, locally "tataruga"). Both species are rapidly declining river turtles that have regionally important cultural and economic value (Conway 2004). They were once ubiquitous throughout the Amazon and Orinoco river basins, but they are now listed in the IUCN Red List of Threatened Species (Species Survival Commission 2008), in Appendix II of the Convention on International Trade in Endangered Species (CITES) (CITES Secretariat 2008), and rated "1," highest priority in the Tortoise and Freshwater Turtle Specialist Group Action Plan Rating (APR) (Tortoise and Freshwater Turtle Specialist Group 1991). Hunting pressure is documented as the basis for their decline, as breeding females and their eggs are principal sources of protein for local people, and they have been over-exploited for sale in commercial markets, beginning with the arrival of

Europeans to the region (Ojasti 1971, 1972; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Food and Agriculture Organization 1988; Ergueta & de Morales 1996; Cantarelli 1997; Moll & Moll 2000; Turtle Conservation Fund 2002). Human land use that affects turtle habitat is documented as a secondary threat (Ojasti & Rutkis 1965; Food and Agriculture Organization 1988; Fachín Terán 1994; Thorbjarnarson et al. 1997; Escalona & Fa 1998).

The conservation and social need for this project is well documented through ongoing ecological and social research work on-site (Chapters 4 & 5; Conway 2004; Conway-Gómez 2007; Conway-Gómez 2008). Ecological studies performed on site documented negative effects on local turtle populations that were correlated with close proximity to human communities that exploit turtles (Chapter 4; Conway 2004; Conway-Gómez 2007). The goal of this research directly responds to the documented link between species decline and human activities. Our research had three objectives: (1) to quantify and explore local human use of the species; and (2) to document local knowledge of the species and their use, especially change over time and space; and (3) to explore and document local values and ideas related to local conservation management of the species.

Social research, in the form of surveys and interviews that assess ecological knowledge in local communities, is recognized as a useful tool in building ecological knowledge bases, locally (Calheiros et al. 2000; Russell & Harshbarger 2003; Ozesmi & Ozesmi 2004; Fairweather et al. 2006). The knowledge that local people have, related to their environment, often surpasses that of outside scientists (Calheiros et al. 2000; Russell & Harshbarger 2003). Because there was no previous data collected in PNNKM, related to local human use of *Podocnemis* turtles, historic turtle populations, and changes in the species and their habitat over time, we conducted interview-based studies to query the knowledge bases of local people. Local people have a working knowledge of the natural history of the region that can help reconstruct the history of turtle populations in PNNKM. This knowledge will be most important in the assessment of changes in turtle populations, and their use, over time.

Methods

Study Area

This research was conducted simultaneous to the ecological research discussed above (Chapter 4). It was conducted in three local indigenous communities: Bella Vista (inside PNNKM), Piso Firme (across the river from PNNKM), and Porvenir (across the river from PNNKM) (Figure 5.1).

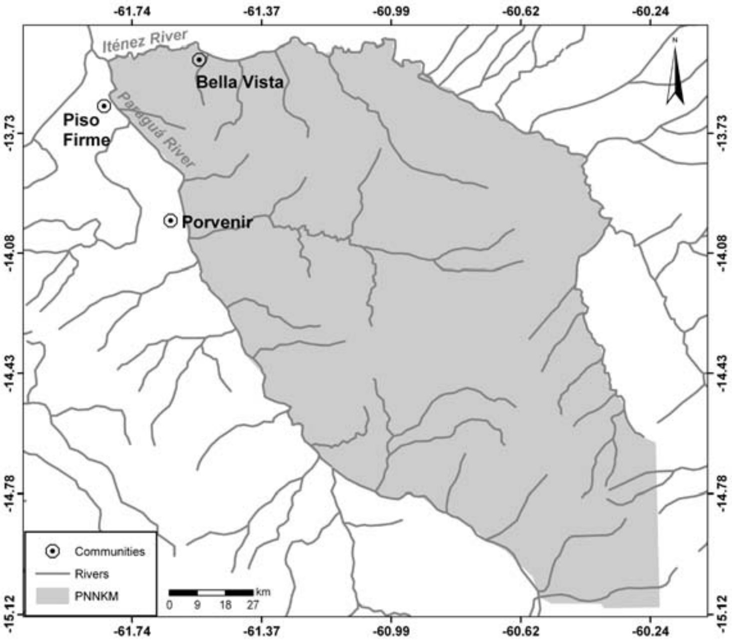

Figure 5.1. Map of study areas.

The research was conducted in 2005 and 2006, during the *Podocnemis* nesting seasons (August to December).

Methodology

The social research, in responding to our three objectives, was comprised of three separate studies: (1) research related to direct human use of the turtle species over two nesting seasons; (2) interviews documenting a local oral history of the species and its habitat over time and space; and (3) interviews documenting use patterns, views, opinions related to the general conservation project. All interviews were conducted by local community members, hired for the research project, who were trained in interview methods outlined in Russell and Harshbarger (2003). Although the responses people make to questions depends upon their own interpretations of past observations, a consensus of similar responses in the region might suggest actual past occurrences.

Human Use Study

In this study we researched direct use of turtles by local human populations. We conducted this study in two replications over two years (2005 and 2006). Because the highest levels of exploitation of these turtles occur during their nesting season, when females and their eggs are vulnerable to easy gathering (Chapter 2), and because of finite funding resources, we conducted the study throughout the turtle nesting season, August through the end of October. In 2005 we conducted the study in Bella Vista and Porvenir, and in 2006 we added the community of Piso Firme.

The study was part of an environmental education program we initiated in 2005. In collaboration with teachers in all communities, we conducted this investigation as a natural resource conservation course that included a semester long research project that students would conduct. All research was conducted by students, who were accompanied by hired community members trained in social research methods. We initiated this method of combining social research with an education initiative as a response to two observations: (1)

that historically, people local to PNNKM have not been willing to participate in interviews conducted as part of research, especially by outsiders (Conway, 2003, pers. comm.); and (2) the lack of, and general desire for, environmental curriculum in local schools (pers. comm. with local teachers and community members, 2003).

We decided that by responding to this local need, the social research we conducted would benefit local education, and people would be more willing to participate in interviews conducted by their children, as part of their education. The idea for this combined research/education initiative was widely supported by local leaders, teachers, and community members, as long as we promised not to divulge personal information (only community-wide information) recorded in the interviews. We worked with one school class in each community; either the oldest class (8^{th} grade) or the class with the most supportive teacher. In the community of Bella Vista, the smallest community, we worked with all the oldest students (4^{th} to 5^{th} grade, but up to 14 years old).

As part of the environmental curriculum, we taught a class in which we discussed with students the importance of turtles in their communities and in their native habitat. Then for two weeks, students were taught all the methodology for conducting their research. They practiced interviews on each other and adults, and they practiced measuring and reading turtle ID numbers on discarded turtle carapaces. As part of their curriculum we taught them the methods and reasoning behind the ecological research being conducted by local research assistants (reported in Chapter 4).

After their training, students conducted their research weekly, visiting all the families in their community. Before starting the research, we conducted a census of all communities, drew maps of all communities, and divided up the families among all the children. In Bella Vista, all the children visited all families together. In the two larger communities, families were divided among all participating students. At all times student interviews were conducted under the supervision of a trained community member.

Research questions were chosen to query all aspects of human use that would be relevant to the turtle Management Plan. This included questions related to the species, sex, and size of turtles collected, as well as sites and methods of extraction. Questions were phrased by community members, so as to be non-invasive to local people. Students recorded the date of the interview and then posed the questions to the adult present in the house. Questions included:

1. Number of people per household (adults and children)
2. Species of turtles/eggs collected in the past week.
3. Number of turtles/ eggs collected in the past week.
4. Date each turtle or eggs were collected.
5. Site of extraction for each turtle or eggs.
6. Sex of each turtle collected.
7. If the female turtles had eggs inside (if yes, quantity was recorded).
8. Carapace length of each turtle.
9. Method of extraction (line, harpoon, caught by hand).
10. If the turtle has an ID number (if yes, number was recorded).

Students collected their data in personal data books (Appendix A). They asked for the carapaces of all turtles collected. If the carapace was available, they measured the straight (not curved) carapace length of all turtles with tree calipers. Families were asked to keep all carapaces for study by the students.

After all data were collected, at the end of the nesting season, we held classes for the students, in which the students analyzed their data, through simple summations into the following categories: total number of female turtles collected, total number of male turtles collected, total number of each species collected, total number of turtles collected from each location, total number of eggs collected from each location, total number of eggs inside all females, total number of eggs collected by the community, total number of turtles collected by the community, and average number of turtles collected per family. We reanalyzed all data to check for errors made by students. Students then created large posters presenting their data and gave formal presentations in their communities, to community leaders, community members, and PNNKM administrators.

Oral History Study

This study was only conducted in 2006. We conducted interviews with local people, especially hunters and fishermen when they were available. Due to funding constraints, interviews were not conducted in all communities. They were conducted in the two largest communities near PNNKM: Porvenir and Piso Firme. Interviewers attempted to interview at least one adult per household. Additionally, an effort was made to interview the eldest members of the family, as they would have the most knowledge of change in the region over time. However, where older people were not available to interview, we interviewed younger adults. Where more than one adult was available to be interviewed in a family, all available adults were interviewed.

Interview questions were divided into two studies, one related to changes in turtle habitat and the second related to changes in turtle populations and their use by local people. Questions were created to query peoples' knowledge of local environmental changes, over time and space, that might be related to local viability of the species. We queried possible changes in climate and habitat that might affect turtle reproduction (e.g., related to turtle nesting beaches and river flooding), turtle nutrition (i.e., change in riparian vegetation), and other turtle habitat requirements (e.g., size of rivers, water quality). We also queried changes in human activity on and near the river that might affect turtle habitat and turtle reproductive activities.

In the second part of the study, related to changes in turtle populations and their use, we created questions that queried peoples' knowledge of changes in turtle abundance, through peoples' observations of turtles in the landscape, nesting, and through use in the community. Lastly, we queried peoples' thoughts on changes in use of the species in their communities. See Appendix B for specific questions asked.

Interviews Related to the Management Plan

Interviews conducted in this study queried local knowledge and opinions that would directly inform management actions to conserve the species. We created questions that queried local use patterns of turtle species (e.g., if people hunt turtles for subsistence or to sell, when people collect turtles, sizes of turtles collected, percentage of observed turtles collected) and local opinions related to the PNNKM turtle conservation project. We queried local concern and thoughts related to *Podocnemis* population decline in and near PNNKM, and we queried local opinion related to the future community-based Management Plan, and ideas for its creation and implementation. Specific questions are in Appendix C.

Results

Human Use Study

Most families in all communities participated in the study, even though it was explained that participation was voluntary. In 2005, the students visited 16 families in Bella Vista and 47 families in Porvenir. In 2006, the students visited 13 families in Bella Vista, 50 families in Porvenir, and 68 families in Piso Firme. All families participated in Bella Vista, both years. Only 1-2 families declined to participate in both Porvenir and Piso Firme.

Students successfully collected and analyzed data in their communities (Figure 5.2), and they presented results to the community and PNNKM administration (Figure 5.3). After listening to the children's presentation, many people commented that they were concerned with how many turtles are being collected. There was enthusiastic support for the students' presentation in all communities. It was discussed as an important educational achievement, as well as informative to the Management Plan.

Figure 5.2. Students measuring a *P. expansa* carapace in Bella Vista.

Figure 5.3. Students presenting project results to the community of Bella Vista.

There was a difference between use of turtles between years and among communities (Tables 5.1 & 5.2). Total numbers of turtles extracted (over the three month nesting period) in Bella Vista were 132 in 2005 and 92 in 2006; total eggs collected were 121 in 2005 and 350 in 2006. Total numbers of turtles extracted in Porvenir were 127 in 2005 and 260 in 2006; total eggs collected were 2800 in 2005 and 3540 in 2006. In Piso Firme, in 2006, the total number of turtles collected was 241, and the total number of eggs collected was 1975. Porvenir, as a community, collected the largest number of turtles and eggs over both years (Figures 5.4 & 5.5).

Table 5.1. Total results of *Podocnemis* human use studies, first week of August to last week of October, 2005.

	Bella Vista	Porvenir
***P. unifilis* Females**	111	98
***P. unifilis* Males**	8	29
***P. expansa* Females**	10	0
***P. expansa* Males**	3	0
Total Females	121	98
Total Males	11	29
Total *P. unifilis*	119	127
Total *P. expansa*	13	0
TOTAL Turtles	132	127
Total *P. unifilis* Females With Eggs	60	73
Total *P. expansa* Females With Eggs	3	0
***P. unifilis* Eggs From Females**	1197	1826
***P. expansa* Eggs From Females**	389	0
Total Eggs From Females	1586	1826
***P. unifilis* Eggs From Beach**	48	2800
***P. expansa* Eggs From Beach**	130	0
Total Eggs From Beach	121	2800
Number of Families	16	47
Average Turtles per Family	8.3	2.7
Range of Turtles per Family	0 to 50	0 to 8

Table 5.2. Total results of *Podocnemis* human use studies, first week of August to first week of November, 2006.

	Bella Vista	Porvenir	Piso Firme
***P. unifilis* Females**	49	204	114
***P. unifilis* Males**	7	56	29
***P. expansa* Females**	34	0	79
***P. expansa* Males**	2	0	19
Total Females	83	204	193
Total Males	9	56	48
Total *P. unifilis*	56	260	143
Total *P. expansa*	36	0	98
TOTAL Turtles	92	260	241
Total *P. unifilis* Females With Eggs	30	131	82
Total *P. expansa* Females With Eggs	6	0	9
***P. unifilis* Eggs From Females**	584	3632	2015
***P. expansa* Eggs From Females**	860	0	817
Total Eggs From Females	1444	3632	2832
***P. unifilis* Eggs From Beach**	350	3540	1818
***P. expansa* Eggs From Beach**	0	0	157
Total Eggs From Beach	350	3540	1975
Number of Families	13	50	68
Average Turtles per Family	7	5.2	3.5
Range of Turtles per Family	1 to 21	1 to 24	0 to 14

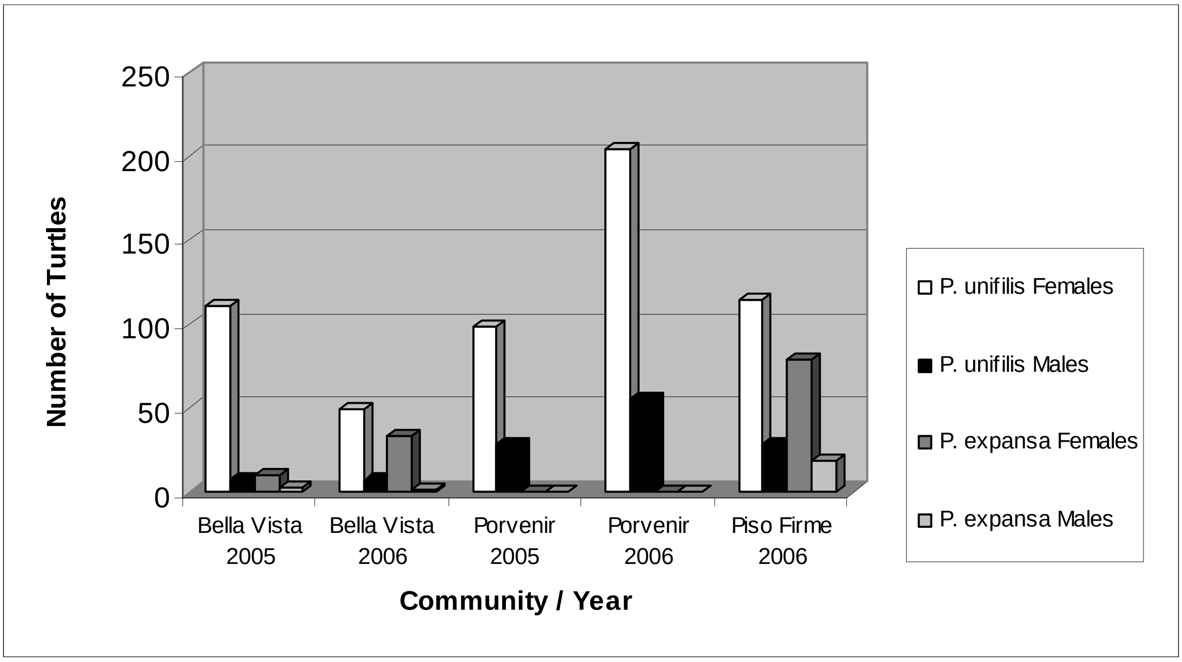

Figure 5.4. Total number of turtles collected, by species, community, and year, 2005 & 2006.

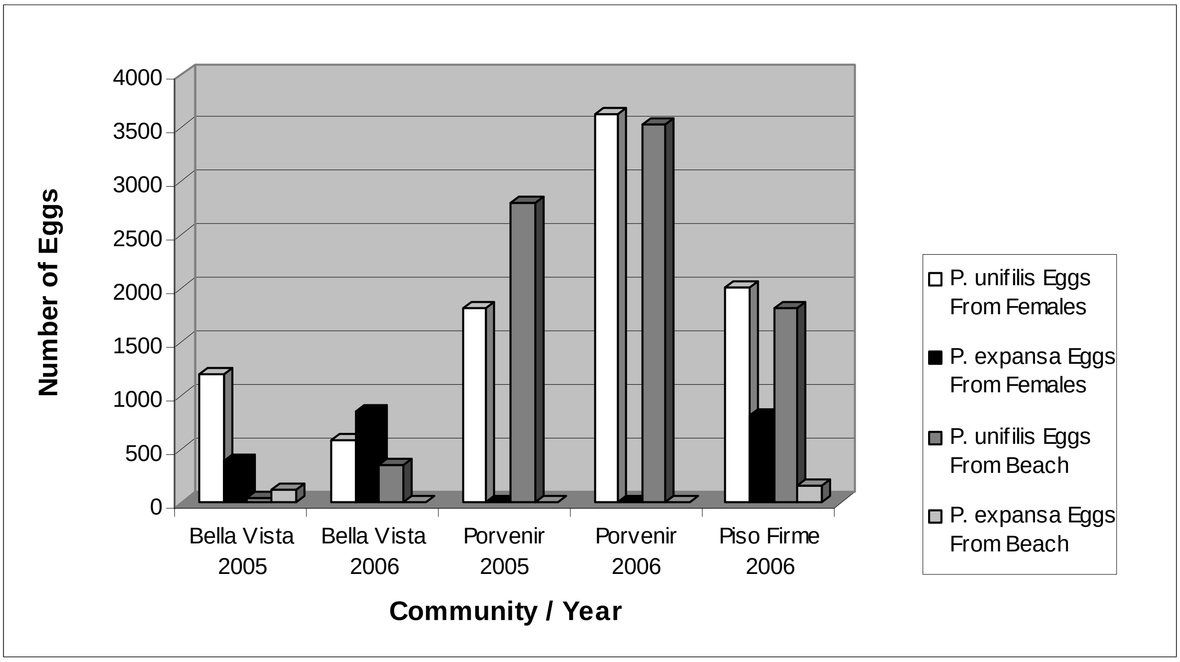

Figure 5.5. Total number of turtle eggs collected, by species, community, and year, 2005 & 2006.

A large difference in turtle use was observed among families, across all communities and within communities (Tables 5.1 & 5.2). In Bella Vista, an average of 8.3 turtles were collected per family in 2005, and an average of 7 turtles in 2006. The range of turtles collected per family was 0 to 50 turtles over the 3-mongh period (2005 and 2006). In Porvenir, an average of 2.7 turtles was collected per family in 2005, and an average of 5.2 turtles in 2006. The range of turtles collected range per family was 0 to 24 turtles over the 3-month period (2005 and 2006). In Piso Firme, an average of 3.5 turtles were collected per family in 2006, and the range of turtles collected per family was 0 to 14 turtles over the 3-month period. Bella Vista, although the smallest community, had the highest average use per family, the highest recorded use per family, and the widest range over both years.

Most turtles collected, over both years and in all communities, were females collected from nesting beaches (Tables 5.1 & 5.2; Figure 5.4). Male turtles were always a small percentage of total catch during the nesting season. However, larger numbers of males were collected in Porvenir and Piso Firme than in Bella Vista (Figure 5.4). More *P. unifilis* turtles than *P. expansa* turtles were caught in all communities, both years (Tables 5.1 & 5.2; Figure 5.4), although more *P. expansa* were caught in 2006 than in 2005.

In all communities, in both years, 43% to 74% of female turtles collected were collected before they were able to lay their nests (Figure 5.6). The two highest rates of female turtles collected with eggs inside were 74% in Porvenir in 2005 and 70% in Bella Vista in 2005 (Figure 5.6). The lowest rates were 43% in Bella Vista in 2006 and 47% in Piso Firme in 2006. Total numbers of eggs collected inside females, differed by community and year (Tables 5.1 & 5.2), and depended on numbers of female turtles caught. The lowest numbers of total eggs collected inside females were in Bella Vista, where 1586 eggs (1197 *P. unifilis* eggs and 389 *P. expansa* eggs) were counted in 2005, and 1444 eggs (584 *P. unifilis* eggs and 860 *P. expansa* eggs) were counted in 2006 (Tables 5.1 & 5.2; Figure 5.6). The largest number of eggs collected from inside females was in Porvenir, where 3632 eggs were collected (all *P. unifilis*) in 2006.

We compared numbers of eggs taken from females to those collected from nesting beaches. We found that numbers of eggs acquired from females can exceed numbers of eggs collected on beaches (Tables 5.1 & 5.2; Figure 5.5). In Bella Vista, in both years and for both species, more eggs were collected from females than from beaches. In Porvenir, results differed by year: in 2005 more eggs were collected from beaches than females (2800 to 1826), while in 2006 more eggs were collected from females than beaches (3632 to 3540). In Piso Firme, for both species, more eggs were collected from females than from beaches. Generally, for *P. unifilis*, large numbers of eggs were collected from females and from beaches, while for *P. expansa*, more eggs were collected from females (Figure 5.5). Generally, across both species, and both years, more eggs were collected from females than from beaches.

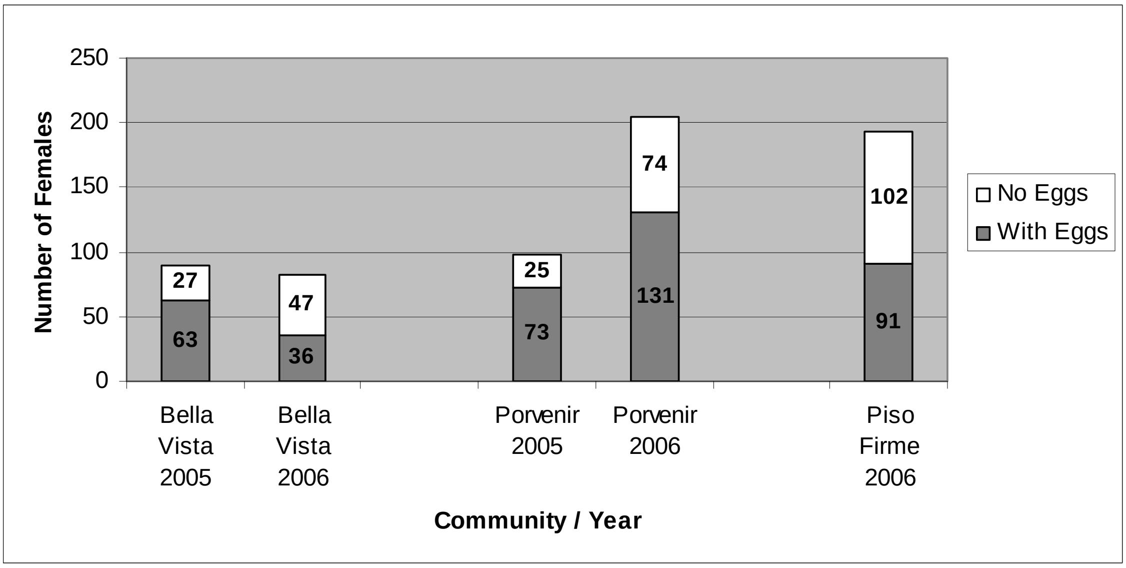

Figure 5.6. Ratio of female turtles (*P. unifilis* and *P. expansa*) collected without eggs to female turtles collected with eggs, by community, 2005 & 2006. Percent females with eggs shown.

Size of females collected was similar among communities and between years. For *P. unifilis*, average size was 35.0 to 35.7 cm, across all study sites and years (Table 5.3). For *P. expansa*, average size varied from 38.0 cm to 48.5 cm, with most variance within the community of Bella Vista, between years. Range of size of turtles collected was always large and had a larger variance among communities and between years than did average size (Table 5.3). For *P. unifilis,* overall range, across all sites and years, was 10.0 cm to 54.0 cm. For *P. expansa*, overall range was 10.0 cm to 73.3 cm. The smallest turtles (10 cm, both species) were collected in Porvenir and Piso Firme, but never in Bella Vista, where minimum size was 20.2 cm (*P. expansa*) and 21.5 (*P. unifilis*). Largest turtles (54.0 cm *P. unifilis,* 73.3 cm *P. expansa*) were also collected in Porvenir and Piso Firme, but never in Bella Vista, where maximum size was 45.0 cm for *P. unifilis* and 67.8 cm for *P. expansa*.

Table 5.3. Size of turtles collected by community.

	P. expansa			***P. unifilis***		
	Number of turtles measured	**Average Size Collected (cm)**	**Range of Size Collected (cm)**	**Number of turtles measured**	**Average Size Collected (cm)**	**Range of Size Collected (cm)**
Bella Vista 2005	9	38.0	20.2 to 60.0	42	35.6	21.5 to 45.0
Bella Vista 2006	19	48.5	27.1 to 67.8	41	35.7	24.1 to 42.1
Porvenir 2005	0	x	x	57	35.7	18.0 to 47.0
Porvenir 2006	0	x	x	182	35.0	10.0 to 54.0
Piso Firme 2006	71	39.7	10.0 to 73.3	85	35.7	17.0 to 49.2

Because collection sites of all turtles and eggs were determined, it was possible to geographically locate areas of highest pressure. These areas differed widely by community and by year (Table 5.4). Areas of highest pressure for turtle hunting were those visited by people from Porvenir and Piso Firme: Bahía Tichela (72 turtles taken in 2006) on the Paraguá River, and Estevón (49 turtles taken in 2006) on the Iténez River, respectively. Areas of highest pressure for egg collection were those visited by people from Porvenir: Bahía

Tichela (1071 eggs collected in 2006), Corte Oli (648 collected in 2006), and Playa Consuelo (508 collected in 2005), all on the Paraguá River.

Table 5.4. Number of turtles collected by location. Only largest numbers displayed (> 12 turtles per location and >33 eggs per location).

Location	Number of Turtles	Number of Eggs
Bella Vista 2005		
Debajo del Campo	14	0
Playa Siringuera	31	0
Playa Gaviota	23	33
Riosiño	27	0
Bella Vista 2006		
Estevón	12	0
Porvenir 2005		
Bahía de Miguel	35	345
Playa Consuelo	32	508
Porvenir 2006		
Bahía de Miguel	21	298
Bahía Pacusal	18	60
Campiña	15	197
Carmen	26	313
Consuelo	41	298
Corte Oli	28	648
San Lorenzo	13	410
Bahía Tichela	72	1071
Piso Firme 2006		
Aguazú	17	80
El Diablo	15	65
Estevón	49	285
San Juan	32	84

Further data collected in interviews was related to the method of capture of all turtles collected. Capture method differed widely by community, and according to sex of the turtle caught (Table 5.5 & Figure 5.7). Bella Vista was the only community that used yaticá (spear for hunting turtles) most of the time to collect female turtles. In Porvenir and Piso Firme, people mostly used camurín (a line with a hook and Styrofoam that floats, specially designed for hunting turtles) to hunt all turtles (male and female). After yaticá, people in Bella Vista also used camurín to hunt females and male turtles. For female turtles, in all communities, hand catching turtles was the next most common method, after camurín. Hand catching of male turtles was always rare. The only community that used guns to hunt turtles was Porvenir, where gun was the next most used method of hunting both female and male turtles, after hand catching of females and use of camurín for males. Use of nets and harpoons were mostly irrelevant in all communities.

Table 5.5. Method for capturing turtles by community and sex of turtle.

Capture Method	Bella Vista Female	Bella Vista Male	Porvenir Female	Porvenir Male	Piso Firme Female	Piso Firme Male
hand (a mano)	18	2	52	4	61	3
line with hook and Styrofoam (camurín)	42	15	169	43	99	41
spear (yaticá)	128	2	17	9	25	4
fishing line (anzuelo)	3				1	0
gun (tiro)			23	16		
net (malla)	1					
harpoon (harpón)	3					

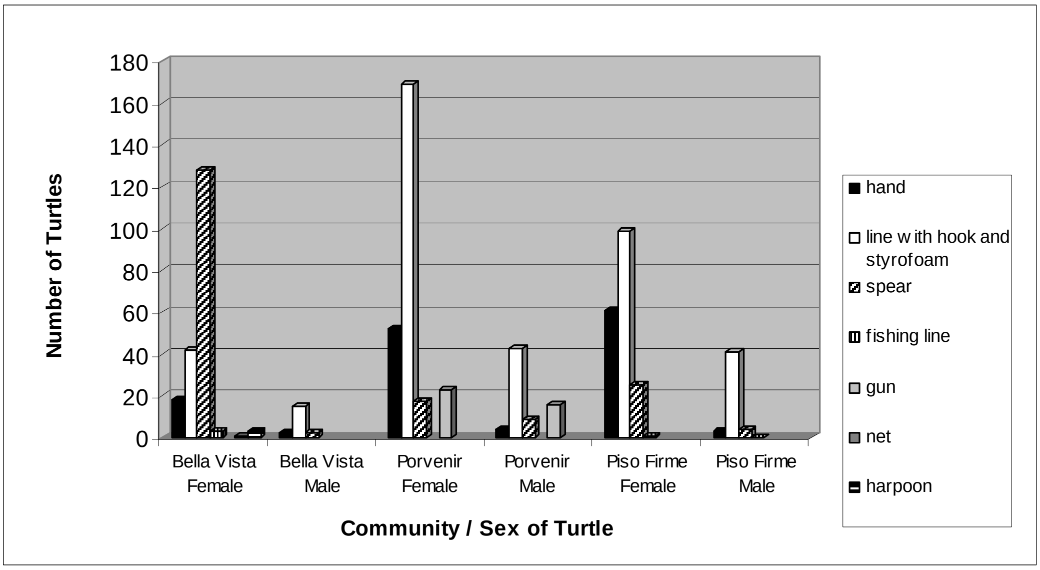

Figure 5.7. Method for capturing turtles by community and sex of turtle.

Lastly, we documented local trade and/or commercialization of turtles (Table 5.6). Most families in Bella Vista and Porvenir collected their own turtles for subsistence use. In

Bella Vista, only 13 turtles were reported to be acquired from people outside the immediate family (same house) in 2006. Interviewers were not told if these turtles were bought, traded, or given. In Porvenir, only in 2006, 13 turtles were acquired from people outside the immediate family (unknown whether bought), and 11 turtles were bought from other members of the community. In Piso Firme, we documented the largest number of turtles acquired outside the immediate family, at least 153 turtles (63% of all turtles consumed). It was unknown whether they were bought, traded, or given. Piso Firme showed a much higher rate of trading of turtles within the community than the other two communities.

Table 5.6. Ratio of turtles collected within family to turtles acquired from others.

	Turtles collected within family	**Turtles collected by other people**	**Turtles bought**
Bella Vista 2005	132	0	0
Bella Vista 2006	79	13	unknown
Porvenir 2005	127	0	0
Porvenir 2006	236	13	11
Piso Firme 2006	88	153	unknown

Oral History Study

Interviews Related to Turtle Habitat

In Porvenir, 80 people were interviewed, and in Piso Firme, 38 people were interviewed. In Porvenir, ages of the interviewees ranged from 26 to 80, with an average age of 44. In Piso Firme, ages ranged from 20 to 79, with an average age of 42. Some people did not wish to participate in interviews, so the results presented were only from that segment of the community that wished to participate in the study.

Additionally, many people did not answer all questions, and they did not answer all segments of each question. We left them out of the presentation for questions when they did not respond. For each of the 15 numbered questions asked, we reported “Yes” for change and “No” for no change, where this response was relevant. However, for segments of single questions, we report only answers of positive or negative change, as opposed to answers of “no change.” This is because for numbered questions the interviewers always recorded if there was a “change” or “no change” response; whereas, for segments of questions, the interviewers sometimes recorded “no change,” while they sometimes left the space blank. Because we could not determine if a blank space was the same as a “no change” response, we left these “no change” responses out of the analysis. In parentheses we report the consensus of responses to certain questions as “X to Y,” where X is the number of people (with similar responses) in the majority, and Y is the number of people (with similar responses) in the minority, who answered in direct disagreement to the people in the majority. Finally, responses to certain questions contradicted each other, and there was no majority conclusion. We reported these contradictions in Appendix D.

The first interviews conducted were related to changes in turtle habitat (Appendix D). Answers to most questions agreed between communities, but some were different between communities. Most people from Piso Firme did not answer the first four questions of the interview, saying they had no knowledge of these questions. For this reason, we reported only the answers from Porvenir (for the first five questions), where most people answered all questions.

Most people in Porvenir (71 to 8) responded “Yes” to physical changes in local rivers, over time. Due to the location of Porvenir, these changes were related to the Paraguá River. More people (26 to 10) said the river is narrower now than 10-30 years ago. Most people (27 to 11) said the river is shallower now than 10-30 years ago, and most people (39 to 15) said the river carries more sediment now than10-30 years ago. A large majority of people (42 to 2)) said there is less vegetation on the edges of the rivers now than 6-30 years ago.

Most people in Porvenir (54 to 28) responded “Yes” to changes in local beaches over time. Of these 54 people, 23 said locations of the beaches change over time, and 13 people said they are further from the community than they used to be. Most people (26 to 8) responded that beaches are smaller and lower now than in the past.

Most people in Porvenir (52 to 17) responded “No” to change in timing of flooding at beaches, over time. Most people in Porvenir (46 to 31) responded “No” to change in the height of flooding at beaches, over time. However, most people (17 to 6) said that flooding is higher now than 1-10 years ago. Eight people responded that flooding was higher in 2006 than before.

Responses to changes in climate varied between Porvenir and Piso Firme. In Porvenir, most people (44 to 29) responded “No” to changes in climate; while, in Piso Firme, most people (22 to 9) responded “Yes” to changes in climate. In each community, all positive responses (except one) were that it is warmer now than it was 3-30 years ago. Again, responses to changes in the rain varied by community. In Porvenir, more people (41 to 36) responded “No” to changes in rain; while, in Piso Firme, more people (17 to 14) responded “Yes” to changes in rain. In both communities, most positive responses (15) were that rains begin earlier now than before, compared to three that said rains begin later now. People who gave specific months of change responded that rains used to begin in January; whereas, now they begin August to November. In both communities, most positive responses (19 to 6)) were that there is more rain now than 1-30 years ago.

Responses to changes in forest fires again differed by community. In Porvenir, most people (45 to 32) responded “No” to changes in fire; while, in Piso Firme, 29 to 2 responded “Yes” to changes in fire. In Porvenir, most positive responses (15 to 10) were that there are less fires now than 2-30 years ago. However, in Piso Firme, most positive responses (27 to 2) were that there are more fires now than 2-20 years ago.

Peoples' responses to changes in human development on riverbanks again differed by community. In Porvenir, more people (55 to 47) responded "Yes" to change in development; while, in Piso Firme, the majority (29 to 2) responded "No" to changes in development. Most people who gave positive responses said that there is less deforestation now (15 to 8) than 12-20 years ago, less cattle now (19 to 12) than 16-25 years ago, and less agriculture now (22 to 8) than 10 to 30 years ago. Finally, most people (45 to 31 in Porvenir; 20 to 11 in Piso Firme) from both communities responded "Yes" to changes in human activity on the river. However, specific changes differed by community. In Porvenir, most people (20 to 4) said there is less fishing, fewer boats, and fewer tourists now than 10-30 years ago. However, in Piso Firme, everyone (16 to 0) said there is more fishing this year than before, and three people said there are more boats and tourists than before.

Interviews Related to Turtle Populations

The second set of interviews were specifically related to turtles (Appendix E). Because most people from Piso Firme did not answer questions in this section, we only report answers from Porvenir.

Most people (47 to 29) responded "Yes" to changes in turtle abundance. Most people (14 to 8) said there are less turtles than 3-30 years ago. Four people said turtles have moved further away. Most people (44 to 34) responded "No" to changes in size of turtles over time. Responses to changes in the number of turtles seen nesting were almost equal ("Yes" was 39 to 37). Of positive responses, most people (21 to 11) answered that there are more turtles now than before. People who responded that there are less turtles nesting than before gave longer responses, giving examples that previously they saw larger numbers of turtles nesting, but that now they rarely see more than 5-10 turtles on one beach.

Most people (69 to 8) answered “Yes” to changes in location of nesting sites: 32 people responded that sites are now further from the community than before. Most people (74 to 5) responded “No” to changes in months of nesting. People who gave positive responses all responded that nesting changed from beginning in early August to now beginning in late August to early September. Finally, responses were equally divided (25 “Yes” to 26 “No) in response to changes in use of turtles in the community. Responses were largely contradictory, but more people (12 to 10) said that fewer turtles are consumed now than 6-30 years ago.

Interviews Related to the Management Plan

The final results are related to local opinions that will inform the species Management Plan. People from both communities answered most questions, and results varied by community. Results, divided by community, were as follows.

Most people in Porvenir (48 to 29) said they were not worried about declining turtle populations. Responses were quite different in Piso Firme, where all 38 responded “Yes:” they were worried about declining turtle populations. Opinions about what is affecting turtle populations again varied by community. In Porvenir, most people (51) felt that animal predators affect turtle populations; other responses include: over hunting (37), fires/loss of vegetation (6), turtles leaving (4). In Piso Firme, most people (28) said that overhunting most affects turtle populations. Other responses included: fires/loss of vegetation (5), animal predators (4), and turtles leaving (2).

When asked about what could be done so that people can continue using turtles in the future, most people (35) in Porvenir answered hunting regulations; while, most people in Piso Firme (23) answered that a management plan needs to be created. Additional answers for Porvenir were to create a management plan and implement education (27), protect beaches

(20), protect nests (20), headstart hatchlings (16), protect nests from animals (9), research (2), and stop eating eggs (1). Additional answers for Piso Firme were to implement hunting regulations (4), protect beaches (3), protect nests (3), protect nests from animals (2), and prohibit fires (1).

When asked about the minimum size of turtles for consumption, answers between communities were similar: in Porvenir average size was 27 cm (range 15-40 cm); in Piso Firme average size was 30 cm (range 20-38 cm). When asked if people use turtles for subsistence or to sell, answers from both communities were similar. In Porvenir, 76 people answered subsistence, compared to one answer of “to sell;” in Piso Firme 36 people answered subsistence; compared to two answers of “to sell.” When asked what percentage of turtles and eggs are collected of those that are found, answers differed widely between communities. In Porvenir, the average percentage of turtles and eggs that people say they collect was 31% (range 2-80%); while, in Piso Firme, average percentage of turtles was 9% (range 2-95%), and average percentage of nests was 2% (range 0-10%). Both communities showed a wide range between people within the same community.

When people were asked if they collect turtles outside of the nesting season, only answers for Porvenir were recorded, due to human error. Most people in Porvenir (73 of 74) responded “Yes,” they do collect turtles outside the nesting season. Equal numbers of people (32) said it is more difficult outside the nesting season, as those (37) who said it is not more difficult. The percentage of males collected outside the nesting season averaged 41% (range 5-100%).

When people were asked if they would replace turtle meat with other meat if it were more available, most people in both communities responded “Yes:” 48 to 29 in Porvenir and 37 to 1 in Piso Firme. When people were asked if they think a turtle management plan is necessary, almost all people responded “Yes:” 74 to 3 in Porvenir, and 38 to 0 in Piso Firme.

When people were asked if they would personally be interested in creating and implementing the Plan, almost all people responded “Yes:” 77 to 3 in Porvenir and 38 to 0 in Piso Firme. Ideas that people had for the Management Plan were as follows. For Porvenir: regulations (56), protected beaches (11), education (6), nest protection (2), protection from animals (2), headstarting (2), and research (1). For Piso Firme: protected beaches (15), education (6), headstarting (17), and nest protection (1). Additionally, most people supported the idea of a sustainable egg use program (97 in Porvenir and 38 in Piso Firme, and 18 people in Porvenir were interesting in turtle ranching/farming (for consumption) projects.

Lastly, when people were asked if they would support regulations on consumption of turtles, everyone (78 from Porvenir, 38 from Piso Firme) supported restrictions placed on all people who are not members of their community. Everyone, except two people from Porvenir, also supported regulations for members of their own community. When people were asked what kind of regulations they would support, in Porvenir, 61 people supported size limits, 60 people supported limits on numbers of turtles collected, 29 people supported geographic limitations, and 13 people supported season restrictions. In Piso Firme, 17 people supported number restrictions, 10 people supported size limits, 9 people supported geographic limits, and four people supported season restrictions. Only one person, from Porvenir, did not support any kind of limits.

<u>Discussion</u>

Human Use Study

The methodology of this project was highly successful in three aspects: (1) the students were able to collect the important data presented here, thus supporting the study and conservation of turtles in their communities; (2) student education in both resource conservation and scientific research methodology was implemented in communities where they had previously never existed; and (3) the process of combining child education with ecological research worked well to garner local support for and participation in research surveys. The presentation of research results by students, combined with informal discussion of conservation subjects with adults at the presentations, worked well to inform communities of turtle conservation issues, as well as to garner support for the general project.

Data collected by the students demonstrated a strong use of *Podocnemis* turtles in all communities. We believe that data largely underestimated actual rates of turtle exploitation, because while some people answered accurately to consumption-related questions, for various reasons (including forgetfulness and fear of answering truthfully) many people under-reported their use of turtles. This problem was discussed by students and adults in the communities. In the future we plan to discuss this problem of under-reporting of turtle consumption in project surveys with local people in all communities. We hope that by helping people understand that survey results are necessary to inform the Management Plan, we will in the future acquire more accurate data. We use all numbers reported here as minimum estimations of local turtle use, keeping in mind, especially for management actions, that actual numbers could be much larger.

For the Management Plan, estimated numbers of turtles collected per community will help to define areas of focus for the Management Plan. For example, Porvenir had the highest reported rates of usage, while Bella Vista, although the smallest community, had the highest rates of use per family. These results are explained by Conway (Conway 2004; Conway-Gómez 2008), who reports socio-economic data that correlates higher poverty levels and less market integration with higher rates of turtle consumption. Bella Vista, due to its location inside PNNKM and only being accessible by river, is the most subsistence-based community, and it is most isolated from local markets. Porvenir, due its location on poorly accessible roads, is more isolated from local markets than is Piso Firme. Results demonstrate that socio-economic considerations are important in assessing communities' impacts on turtle populations. Isolated subsistence-based communities, like Bella Vista, can have a disproportionate effect on turtle populations, and must be the focus of management actions.

Another important finding, related to turtle use within communities, was that turtle use per family is one of the most important variables. We found that most families consumed few turtles, while some families consumed large numbers (up to 50) of turtles. We found that these few families act as suppliers to other families that do not hunt turtles. This was especially true in Piso Firme, where we found that most turtles were acquired by other people. This represents a community-level commercialization of the species. Management actions need to be directed towards specific members of the community who hunt the most turtles, especially those few who make a livelihood out of it. Possibly, if the livelihoods of a few families can be directed away from turtle hunting, through management actions and incentive programs (e.g., turtle limits per family, including these people in research activities, alternative meat and livelihood sources), this could have a large effect on turtle use within the community.

An additional important finding was, as we suspected, that during the nesting season most turtles collected were females. This was due to their easy collection on nesting beaches, which defines the turtle nesting season as "turtle season" in local communities. The nesting season is generally known to be the time for consuming turtles in local communities. The exploitation of nesting females by people has demonstrated negative effects on local turtle populations (Chapter 4). The objective of management actions must be to mitigate this negative effect by lowering human exploitation rates on nesting turtles.

The number of turtles we recorded to be hunted by local communities, which are likely low estimates of actual numbers, represent large portions of local turtle populations, especially reproductive populations. For example, we recorded, in 2006, that 369 *P. unifilis* females and 113 *P. expansa* females were harvested in PNNKM. These numbers were under-reported, and most importantly, they only represent the harvest of three local communities. There are many other local, and larger, communities that also exploit turtle resources in PNNKM; therefore, total harvest rates of the species in PNNKM must be much larger.

The number of *P. expansa* turtles (113) that we observed to be harvested in 2006 was larger than the total number (89) of *P. expansa* turtles we observed nesting at eight nesting beaches, the same year (Chapter 4). We have thus documented a level of harvest for this species that is not only not sustainable, it is larger than actual nesting populations we observed. The number of *P. unifilis* turtles harvested in 2006 (369) was smaller than the number of turtles we observed nesting at all sites (903), but it is still represents a large proportion of the nesting population. Because these species are long-lived animals, whose females potentially lay 25 or more nests in their lifetimes (K. Buhlmann, pers. comm. 2008), the large number of females that are being removed from local populations must be having tremendous effects on long-term population viability. These findings strongly support the need for management actions to limit take of these animals, especially of their nesting populations, and especially of *P. expansa* turtles.

We would like extend research to other times of the year, to document human use of turtles outside the nesting season. In Bella Vista, we found larger catches of female turtles than male turtles, more so than in the other communities. This was because Bella Vista has nesting beaches close to the community. This large take of female nesting turtles likely has a negative effect on reproductive populations. Again, we see that although Bella Vista is the smallest community, it might be having a disproportionately large effect on local turtle populations.

In addition to the hunting pressure placed on female turtles, the take of turtle eggs likely has negative effects on turtle reproductive success rates in the region. We found that not only were large numbers of eggs collected from beaches in all communities (likely under-reported, especially in Bella Vista), but even larger numbers of eggs could be collected from inside hunted females, in all communities, and of both species. These eggs constitute nests that were never created, and place additional pressures on nest survival.

Also, as expected, we found that more *P. unifilis* turtles were caught, compared to *P. expansa*. This agrees with our findings from nesting studies, that *P. unifilis* turtles well outnumber *P. expansa* in and near PNNKM (Chapter 4). Most people would collect *P. expansa,* as opposed to *P. unifilis*, if it were available, as the females are much larger and thus provide much more meat (Lipman, pers. obs., 2005-2006). In fact, when a large *P. expansa* female is caught, it is usually reason for a community feast (Lipman, pers. obs., 2005-2006). Our findings suggest, in agreement with results from the nesting studies, that local populations of *P. expansa* are extremely small. Management actions must be focused towards recuperation of this species.

Data related to the size of turtles shows us that people are consuming a wide range of turtle sizes, which includes young (small) females and smaller males. When we compare the range of sizes of turtles consumed to turtle sizes observed in our nesting studies (Chapter 4), we see that people are consuming the largest turtles. In fact, the largest *P. unifilis* turtle consumed (54.0 cm carapace length) was larger than the largest turtle observed nesting (48.3 cm). The average sizes of turtles consumed are smaller than those observed nesting because they include non-nesting, smaller turtles.

The sizes of turtles consumed give us limits to the sizes of turtles that will be consumed by people. We see that very small turtles were sometimes consumed, but that most people preferred medium to large turtles, as opposed to the smallest ones, which have little meat. However, due to the small sizes documented, we found that people often do eat small turtles. This means that they will readily eat male turtles where they were available. This has important management implications, because if people are willing to eat male turtles instead of female turtles, this would put less pressure on reproductive nesting populations. We recommend that management actions work to direct exploitation of turtles to smaller and male turtles.

Locations of high turtle use will be important for placing geographic limits on turtle exploitation within the project region. We found that certain areas were the preferred hunting grounds of certain communities. The Management Plan must then focus on these different areas for different communities. We also observed that residents of Porvenir only hunted turtles in the Paraguá River; whereas, residents of Piso Firme (which is also located on the Paraguá River, but near the Iténez River) hunted most of their turtles large distances up the Iténez River, even past the community of Bella Vista. Members of the community of Bella Vista also hunt only close to their community, on the Iténez River. Members of Piso Firme traveled the farthest, and even past other communities to hunt turtles. This is important information, especially if part of the Management Plan will designate use sites for specific communities.

Finally, we documented capture methods for different communities. This information is important, because, for example we see that while PNNKM fishing regulations outlaw the use of nets, turtles were rarely caught in nets. Also, restricting the use of guns would do little to protect turtles. Most turtles were caught by indigenous methods of catching, which all for the catch of single turtles at a time. Because turtles were mostly caught on nesting beaches, by hand, and by other single-handed local methods, we see that other management options will be needed.

Oral History Study

Interviews Related to Turtle Habitat

From this study we found some general consensus among people interviewed. There was some agreement that the Paraguá River is narrower, shallower, and contains more sediment now than before. There was also wide agreement that there is now less vegetation along the river. These changes in habitat could affect turtle movement, turtle food supplies, and turtle survival in general. Because turtles depend on riverine vegetation for their food (Chapter 2), the fact that there is less vegetation now than before could have caused negative effects to local turtle populations. The size of rivers also affects turtles, especially *P. expansa*, which prefer larger, free moving rivers (Chapter 2). While *P. expansa* have been sighted in the Paraguá River (pers. comm. with local people, Lipman, 2005-2006), they do not nest there (Chapter 4). However, if rivers are in fact becoming smaller, and more filled with sediment this could affect dispersal and movement of both species. This would suggest that clearing for new land use, called a secondary threat in earlier studies, may become a dominant threat.

Other conclusions from interviews were that beaches change location, that they have moved further from the community, and that they are smaller now than before. If this were true than it could affect turtle nesting patterns. This could then affect turtle consumption patterns within the communities, over time. For example, people from Piso Firme professed that there are no longer nesting beaches near their community, which is why they must travel further than people from other communities, to hunt turtles.

There was general consensus that river flooding has not changed greatly, but possibly, according to a number of people, rivers are flooding earlier, higher, and with more intensity than before. This is consistent with the notion that there is now increased sediment loading in local rivers. If this were true it could affect turtle nesting success in the region, as early flooding could cause early inundation of turtle nests, before they are ready to hatch. If it is true that timing of flooding has changed, this might explain the high rates of mortality caused by early nest inundation that we documented in 2005 and 2006 (Chapter 4).

There was general consensus that if there is climate change, it is a warming trend, and most people agreed that there are more fires near Piso Firme than before. Possible long-term change in climate is a large-scale landscape effect that we are most interested in exploring in the future. Especially because changes in climate (whether it be large-scale or localized) could affect river hydrology, and thus turtle nesting success. Possible changes in local climate might also be related to increasing fires in the area, and to development patterns along riverbanks. Increasing fires also clear vegetation, greatly decreasing the most important food source for the species.

Finally, results suggested that in Porvenir there was more human development, boats, and tourists about 20 years ago than today, and that in Piso Firme there is more fishing today than before. This finding likely describes a time of much growth for the community of Porvenir, about 20 years ago. In that time also, the Paraguá River was regularly cleared, so clear passage between communities was possible. However, it has been about 10 years since outside sources funded clearing of the river; since that time, the river has closed, and it is not possible to travel between communities by river. This fact likely protects turtles near the community of Porvenir from being exploited by members of other communities.

Interviews Related to Turtle Populations

General consensus in Porvenir suggests that turtles are less abundant than before, and that turtle nesting sites have moved further away from the community. This supports findings from our nesting study that there are negative effects on nesting turtle populations near human communities, which most likely result from human exploitation of the species

(Chapter 4). This finding also shows that most people believe that turtles are less abundant than before, and it helps garner support for the turtle conservation project.

A surprising finding was that most people responded that there are more turtles seen on nesting beaches than before. We doubt this is indicative of increasing turtle populations, but might be indicative of turtle movement from areas with more human activity, and concentrating in areas with less human activity. A final conclusion is that if turtle nesting time has changed, then according to a few people, it is starting later now than it was before (changed from the beginning of August to the end of August). If this is true, it might also help explain high mortality rates due to inundation of turtle nests, before they can hatch. More research is needed to explore possible changes in timing of turtle nesting activities, and possible effects of local climate and/or hydrologic changes, especially due to knowledge of high rates of nest mortality caused by flooding events.

Interviews Related to the Management Plan

Results of this study form a basis of local opinion related to the turtle conservation project, the Management Plan, and ideas for its creation. All responders in Piso Firme were concerned about declining turtle populations; responses in Porvenir were more varied. However, we documented here that most people were concerned by what they perceived to be declining turtle populations. Generally, people believed that animal predators and overhunting are affecting turtle populations. Other responses, such as fires, loss of vegetation, and out-migration of turtles, suggest important possible negative effects on local populations. These responses demonstrate that people recognize over-hunting as a problem that has direct effects on turtle populations. Indirect human effects of land use are important possible threats to turtles that should be explored further. All these threats should be addressed as part of the Management Plan.

In relation to use of turtles, almost 100% of responders professed to use turtles for subsistence only. Because subsistence use of turtles is allowed by Bolivian law, as opposed to commercial use of the species, it will be important to distinguish subsistence use from commercial use, in the Management Plan. Results of interviews demonstrate that most local use of the species is already in agreement with Bolivian law. Additionally, an important goal of the Management Plan will be to strive for a more sustainable use of the species. We were interested in what percentage of the population people are harvesting. People in Porvenir said they hunt a larger percentage of turtles and eggs, of the total populations, than people in Piso Firme. Because the Management Plan will likely include limits on numbers of turtles, a percentage take for the community will have to be decided upon. If responses were indicative of actual take, then management actions should focus on Porvenir, where use rates are the highest.

Further information related to use includes if the species are harvested outside the nesting season. We documented that almost all people continue to hunt turtles outside the nesting season, all year long, and that the percentage of males collected can be much higher than that taken during the nesting season. This information is important for possible seasonal limits that might be part of the Management Plan. We know that people can and do find turtles year-long, and that about half of these people responded that it is not difficult to find non-nesting turtles. We know that the turtles caught outside of the nesting season were a higher percentage of males and smaller turtles in general (probably non-reproductive turtles). The move towards use of turtles outside of the nesting season could be a realistic management action. It could fulfill local needs for turtles as a food source, while not disrupting turtle nesting events.

Finally, in regards to actual management options, we documented that most people would replace turtle meat with other meat, if it were more available. This was more so in

Piso Firme than Porvenir. While some people stated they prefer to eat turtle, most people eat turtle because there is currently no other meat source to replace it. We recommend that management planning focus on finding alternative protein sources for people that hunt turtles. In general, we documented that almost all responders believed a turtle management plan is necessary to conserve turtles, locally. As part of the Management Plan, most people supported regulations on turtle consumption for people outside the community, as well as for themselves.

Generally, we found some differences in responses between communities, which suggest that the community of Porvenir is more dependent on turtle resources than the community of Piso Firme. This is in agreement with socio-economic considerations discussed above that describe Porvenir as a more isolated community that is more dependent on hunting turtles for local livelihoods. We recommend that further social research be conducted in Porvenir, and additionally in Bella Vista, to investigate the livelihood needs and opinions of those people most dependent on turtles for their protein needs.

The information we present here is the first to document general agreement and consensus in the community-based Management Plan we propose to create and implement, as a collaboration of all local communities and PNNKM administration. Lastly, we documented peoples' ideas for actual management actions. The most popular included: hunting regulations (size, number, and geographic limits), protected beaches and nests, sustainable egg programs, headstarting projects, and ranching/farming projects. All of these ideas will be discussed in local management meetings that will decide the final content of the Management Plan.

Conclusions

We presented the results of social research, related to *Podocnemis* turtles and their use in local communities, that will be essential to creation of the community-based turtle Management Plan in PNNKM. All results will be presented at planning meetings, in 2008, in local communities and to PNNKM authorities. Information will be discussed, along with ecological findings from simultaneous nesting studies performed in 2005-2006. Both studies together documented heavy use of both species in all local communities, and significant negative effects on turtle populations close to human communities (Chapter 4). We have thus demonstrated the necessity of a long-term strategy for local conservation of the species.

Bolivian law prohibits commercial and sport use of the species; however, it allows for subsistence use of the species by local indigenous people. Because local people depend on the species as a protein source, and often lack alternative meat sources, the Management Plan created will need to address local livelihood needs, as well as conservation needs of the species. Additionally, due to the lack of effective conservation infrastructure in PNNKM (Chapter 2), the only turtle conservation measures sure to be implemented will be those supported by local people.

Most important to success of the Management Plan is that almost all people interviewed supported the conservation project, think it necessary, and wish to participate in its planning. Many ideas for management options were discussed and offered by local people. They could all be incorporated as part of the future Management Plan, but only discussion in planning meetings will determine what regulations and projects will enter into the final plan.

Information presented here (e.g., differential use of turtles between communities and families, peoples' preference for turtles of certain sizes, extraction sites, changes in turtle habitat, and threats to turtle populations) will be used to prioritize threats to the species, as well as targets for conservation. Conservation targets should include: heavily exploited seasons of turtle use (i.e., nesting season), the reproductive portion of the population (i.e., female turtles), species-specific concerns (e.g., low abundance of *P. expansa*), areas of especially high extraction, and certain families in the community (i.e., those that supply the rest of the community with turtles). Additionally, we documented the need for different approaches to management in each community. For example, we found that in Piso Firme there was more trading of turtles than in other communities; in Porvenir there were overall larger numbers of turtles extracted; and in Bella Vista a larger number of turtles were extracted per family. Because we found consumption of turtles to be an activity largely dependent on the lack of alternative protein sources, the Management Plan must include initiatives to explore viable alternatives to turtle hunting to support local livelihoods.

We conclude that the studies presented here provide valuable information for local conservation planning of two endangered species, in a tropical Amazonian country that is largely lacking of conservation support and infrastructure. Our research supported local environmental and science education in communities where such courses were entirely lacking. The students' involvement in project research and activities benefited not only their education, but it garnered support for the conservation project from the students' parents, and the community in general. The method of combining student education with social interviewing was highly successful. Interviewing people in communities can often be a difficult process, especially where people are reluctant to reveal private information related to use of known endangered species. Because local children performed interviews, people were willing to participate, and they were more supportive of the process in general.

Lastly, the community-based nature of the project was most assuredly the reason for the high degree of support by local people. All researchers were hired from local communities, for the ecological research as well as the social research presented here. People thus witnessed the benefit of the project in their own communities. Local capacity building, through local training, in direction and implementation of all research, enabled local people to manage the conservation project. Capacity building will continue as part of a long-term monitoring program. In the future, all research presented here will also continue as part of a long-term monitoring effort that will work to include more communities in the ongoing research.

Finally, we believe that the research methodologies, results, and local approach that we present here, could be relevant to conservation of turtles and other species in other subsistence-based tropical regions. Our work could be especially applicable to similar regions where funding and support for conservation are scarce. We present an integrative, low-cost, collaborative, and community- based framework for planning and implementing a conservation strategy based in science, but also addresses the livelihood needs of local people.

References Cited

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Calheiros, D. F., A. F. Seidl, and C. J. A. Ferreira. 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**:684-696.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

CITES Secretariat. 2008. Convention on International Trade in Endangered Species of Wild Fauna and Flora: Species database. CITES Secretariat, Geneva, Switzerland.

Conway-Gómez, K. 2008. Market integration, perceived wealth and household consumption of turtles (*Podocnemis* spp.) in eastern lowland Bolivia. Journal of Latin American Geography **7**:85-103.

Conway-Gómez, K. M. 2007. Effects of human settlements on abundance of *Podocnemis unifilis* and *P. expansa* turtles in northeastern Bolivia. Chelonian Conservation & Biology **6**:199-205.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Ergueta, P., and C. de Morales. 1996. Libro Rojo de los Vertebrados de Bolivia. International Union for the Conservation of Nature, Gland, Switzerland.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Fairweather, T. P., M. Hara, C. D. van der Lingen, J. Raakjaer, L. J. Shannon, G. G. Louw, P. Degnbol, and R. J. M. Crawford. 2006. A knowledge base for management of the capital-intensive fishery for small pelagic fish off South Africa. African Journal of Marine Science **28**:645-660.

Food and Agriculture Organization. 1988. Las tortugas del río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Areas Silvestres **Año 3**:23-29.

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Moll, E. O., and D. Moll. 2000. Conservation of river turtles. Pages 126-155 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J. 1972. La Problematica de la Tortuga Arrau. Pages 4-10 in Ministerio de Agricultura y Cria, Dirección de Recursos Naturales Renovables, and Republica de Venezuela, editors.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Ozesmi, U., and S. L. Ozesmi. 2004. Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. Ecological Modelling **176**:43-64.

Russell, D., and C. Harshbarger 2003. GroundWork for Community-Based Conservation. AltaMira Press, Walnut Creek, CA.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Tortoise and Freshwater Turtle Specialist Group 1991. Tortoises and Freshwater Turtles: An Action Plan for Their Conservation. The World Conservation Union, Broadview, Illinois.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington DC.

Appendix A. Student data sheets used in the human use study.

Community	
Researcher	
Family Name	
Number of Adults in House	
Number of Children in House	
Interview Date	

Turtle Species	Name of Collector	Date of Extraction	Site of Extraction	Female or Male	Carapace Length (cm)	Number of Eggs Inside Female	Method of Extraction	Turtle ID Number	Number of Eggs Collected

Appendix B. Interview questions used in the oral history study, in Spanish.

Investigador/a____

Comunidad____

Fecha de Entrevista____

Nombre y Apellidos____

Edad____

Por cuánto tiempo ha vivido en el área____

____

Investigación del Hábitat

Preguntar si han observado los siguientes cambios a través del tiempo en el área. Si han observado alguno, anotar una descripción del cambio, donde ocurrió y el año o los años en que ocurrieron.

1. Cambios en los ríos (localización, ancho, profundidad, sedimentación, color, y vegetación).
2. Cambios en las playas (localización, tamaño y altura).
3. Cambios en el tiempo (meses) de inundación de las playas.
4. Cambios en la altura de inundación de las playas.
5. Cambios en el clima.
6. Cambios en la lluvia (intensidad y meses de lluvia).
7. Cambios en los incendios.
8. Cambios en el desarrollo humano de las riberas del río (ej. agricultura, ganado, deforestación y construcción de casas).
9. Cambios en las actividades humanas en el río (ej. pesca, uso de lanchas y turismo).

Investigación de la Historia de las Tortugas y su Consumo Local

Preguntar si han observado los siguientes cambios en las poblaciones de Tracayá y Tartaruga a través del tiempo en el área. Si han observado alguno, anotar una descripción del cambio, la especie de tortuga, donde ocurrió y el año o los años en que ocurrieron.

1. Cambios en la abundancia (geográficos y temporadas) de poblaciones de las tortugas.
2. Cambios en el tamaño de las tortugas vistas y capturadas.
3. Cambios en el número de las tortugas poniendo huevos.
4. Cambios en los sitios de nidificación.
5. Cambios en los meses de nidificación.
6. Cambios en el uso de tortugas en la comunidad (número de tortugas, meses de uso, dificultad de encontrar, sitio y método de extracción).

Appendix B (cont). Interview questions used in the oral history study, translated to English.

Interviewer____

Community____

Interview Date____

Name of Interviewee____

Age____

How long s/he has lived in the area____

____

Research Related to Turtle Habitat

Ask if they have observed the following changes over time in the area. If they have observed one, record a description of the change, where it occurred, and the year or years in which it occurred.

1. Changes in the river (location, width, depth, sediment, color, and vegetation).
2. Changes in the beaches (location, size, and height).
3. Changes in the timing (months) of flooding of the beaches.
4. Changes in the height of flooding of the beaches.
5. Changes in the climate.
6. Changes in the rain (intensity and months of rain).
7. Changes in fires.
8. Changes in human development on the riverbanks (e.g., agriculture, cattle, deforestation, and construction of houses).
9. Changes in human activity on the river (e.g., fishing, boating, and tourism).

Research Related to Turtle Life History and Local Consumption

Ask if they have observed the following changes in populations of P. unifilis and P. expansa, over time, in the area. If they have observed one, record a description of the change, the species of turtle, where it occurred, and the year or years in which it occurred.

1. Changes in abundance (geography and time) of populations of the turtles.
2. Changes in the size of turtles seen and captured.
3. Changes in the number of turtles nesting.
4. Changes in the location of nesting sites.
5. Changes in the months of nesting.
6. Changes in the use of turtles in the community (number of turtles, months of their use, difficulty to hunt, site and method of extraction).

Appendix C. Questions used in interviews related to the Management Plan, in Spanish.

Investigación para la Planificación del Plan de Manejo

1. Si hay preocupaciones de disminución de las poblaciones de tortugas.
2. Opinión y/o valoración de lo que está afectando a las poblaciones de las tortugas.
3. Pensamientos de lo que se puede hacer para que puedan continuar usando tortugas en el futuro.
4. El tamaño mínimo de las tortugas para su aprovechamiento.
5. Si sacan para subsistencia o para la venta.
6. Que porcentaje sacan de tortugas y huevos que encuentran en las playas.
7. Si colectan afuera del tiempo de desove (incluye método de extracción, dificultad en encontrar, porcentaje de machos colectados, meses de colecta, tamaño de tortugas).
8. Si prefieren comer tortuga o si pudieran reemplazar la carne de tortuga con otra carne si hubiera más disponible.
9. Si piensan que un plan de manejo de tortugas será necesario para poder usar las tortugas en una manera sostenible.
10. Si tienen interés en hacer e implementar un plan de manejo de tortugas (que tendría base en las comunidades).
11. Si tienen interés en un plan de manejo, que ideas tienen para su realización e implementación?.
12. Si apoyarían a que se elaboren reglamentos y normas para el consumo de estas especies
    - -para comunarios?
    - -para personas que no son comunarios pero son del Bajo Paraguá?
    - -para personas afuera del Bajo Paraguá?
13. ¿Qué clase de límites serían apoyados? (ej. Límite en número de tortugas sacadas, límites geográficos, límites en el tiempo de caza, límite de tamaño).
14. Si tendrían interés en algunos métodos de manejo, por ejemplo en criar las tortugas en granjas para su uso comestible o en una reglamentación de uso de huevos que sería más sostenible.

Appendix C (cont.). Questions used in interviews related to the Management Plan, translated to English.

Research Related to the Management Plan

1. If there are worries that turtle populations are declining.
2. Opinions of what is affecting turtle populations.
3. Thoughts of what could be done so that people can continue to use turtles in the future.
4. The minimum size of a turtle for consumption.
5. If they use turtles for subsistence use or to sell.
6. What percentage of turtles and eggs to they take, out of what they find on the beach.
7. If they collect turtles outside of the nesting season (include method of extraction, difficulty to find, percent males, months collected, and turtle size).
8. If they prefer to eat turtle or if they could replace turtle meat with other meat if it were more available.
9. If they think that a turtle management plan will be necessary to be able to use turtles in a sustainable manner.
10. If they are interested in creating and implementing a turtle management plan (that would be based in the communities).
11. If they are interested in a management plan, what ideas do they have for its creation and implementation?
12. If they support rules and regulations for consumption of the species
    - for community members?
    - for people from other communities of the Bajo Paraguá?
    - for people outside the Bajo Paraguá?
13. What kind of limitations would they support? (E.g., limits in the number of turtles collected, geographic limits, limits in hunting time, size limits).
14. If they would be interested in other management methods, for example in farming or ranching turtles for consumption, or a regulated use of turtle eggs that would be more sustainable.

Appendix D. Answers to interview questions related to turtle habitat.

1. Changes in the river (location, width, depth, sediment, color, and vegetation).

	Yes	No	Location changed	River wider now	River narrower now	River deeper now	River shallower now	More sediment now	Less sediment now	More vegetation now	Less vegetation now
Porvenir	71	8	3	10	26 (10-30 yrs)	11	27 (10-30 yrs)	39 (10-30 yrs)	15	2 (15 yrs)	42 (6-30 yrs)
Piso Firme	3	0						1			2

2. Changes in the beaches (location, size, and height).

	Yes	No	Location of beaches changed	Location of beaches now further	More beaches now	Less beaches now	Beaches larger and taller now	Beaches smaller and lower now	General change in size
Porvenir	54	28	23	13	3	3	8	26	4
Piso Firme	3	0					1	1	

3. Changes in the timing (months) of flooding of the beaches.

	Yes	No	Flooding earlier now	More flooding now
Porvenir	17	52	5	4 (1-2 yrs)
Piso Firme	1	2	1	

4. Changes in the height of flooding of the beaches.

	Yes	No	Higher now	Lower now	Highest 2006
Porvenir	31	46	17 (1-10 yrs)	6	8
Piso Firme	3	0	2		

5. Changes in the climate.

	Yes	No	Hotter now	Colder now
Porvenir	29	44	24 (10-30 yrs)	1
Piso Firme	22	9	24 (3-20 yrs)	0

6. Changes in the rain (intensity and months of rain).

	Yes	No	Rains later now	Rains earlier now (before began jan, now begins aug)	More rain now	Less rain now
Porvenir	36	41	3	4	16 (1-30 yrs)	4
Piso Firme	17	14	0	11 (2006)	3	2

7. Changes in fires.

	Yes	No	More fires now	Less fires now
Porvenir	32	45	10 (2-30 yrs)	15 (3-20 yrs)
Piso Firme	29	2	27 (3-20 yrs)	2 (2 yrs)

8. Changes in human development on the riverbanks.

	Yes	No	More deforestation now	Less deforestation now	More cattle now	Less cattle now	More agriculture now	Less agriculture now
Porvenir	55	47	7	15 (12-20)	12	19 (16-25)	8 (15-30)	22 (10-30 yrs)
Piso Firme	2	29	1					

9. Changes in human activity on the river (e.g. fishing, boating, and tourism).

	Yes	No	More fishing now	Less fishing now	More people, hunters now	More boats, tourists now	Less boats, tourists now
Porvenir	45	31	4 (5-6 yrs)	17 (10-20 yrs)	3	4 (10-30 yrs)	20 (12-25 yrs)
Piso Firme	20	11	16 (2006)			3 (1-12 yrs)	

Appendix E. Answers to interview questions related to turtle populations.

1. Changes in abundance (geography and time) of populations of the turtles.

	Yes	No	Less turtles now than before	More turtles now than before	Turtles have moved away
Porvenir	47	29	10 (3-30 yrs)	8 (3-7 yrs)	4
Piso Firme	2	1			1

2. Changes in the size of turtles seen and captured.

	Yes	No	Turtles smaller now than before	Turtles larger now than before
Porvenir	34	44	13 (3-30 yrs)	12
Piso Firme	0	3		

3. Changes in the number of turtles nesting.

	Yes	No	Less turtles now than before	More turtles now than before
Porvenir	39	37	11 (3-30 yrs)	21 (1-20 yrs)
Piso Firme	3	0	3	21

4. Changes in the location of nesting sites.

	Yes	No	Sites have moved further away
Porvenir	69	8	32
Piso	1	2	

5. Changes in the months of nesting.

	Yes	No	Nesting changed from early August to late August/Sept.
Porvenir	5	74	5
Piso Firme	0	3	

6. Changes in the use of turtles in the community.

	Yes	No	Consume less than before	More difficult to find now	Not more difficult to find now	Consume more now than before
Porvenir	25	26	12 (6-30 yrs)	9	8	10 (2-3 yrs)
Piso Firme	1					

Appendix F. Answers to interview questions related to the Management Plan.

1. If there are worries that turtle populations are declining.

	Yes	No
Porvenir	29	48
Piso Firme	38	0

2. Opinions of what is affecting turtle populations.

	Overhunting	Animal predators	Fires / Loss of vegetation	Turtles leaving
Porvenir	37	51	6	4
Piso Firme	28	4	5	2

3. Thoughts of what could be done so that people can continue to use turtles in the future.

	Hunting regulations	Stop eating turtle eggs	Protected beaches	Protect nests	Protect nests from animals	Headstart hatchlings	Research	Management Plan / Education	Prohibit fires
Porvenir	35	1	20	20	9	16	2	27	
Piso Firme	4		3	3	2	2		23	1

4. The minimum size of a turtle for consumption.

	Average (cm)	Range (cm)
Porvenir	27	15 to 40
Piso Firme	30	20 to 38

5. If they use turtles for subsistence use or to sell.

	Subsistence	To sell
Porvenir	76	1
Piso Firme	36	2

6. What percentage of turtles and eggs to they take, out of what they find on the beach.

	Average Turtles	Range Turtles	Average Nests	Range Nests
Porvenir	31%	2% to 80%		
Piso Firme	9%	2% to 95%	2%	0% to 10%

7. If they collect turtles outside of the nesting season.

	Yes	No	Method	More difficult than nesting season	Not more difficult	% Males
Porvenir	73	1	camurin, yatica, tiro, anzuelo	32	37	5% to 100%, 41% ave.

8. If they prefer to eat turtle or if they could replace turtle meat with other meat if it were more available.

	Yes	No
Porvenir	48	29
Piso Firme	37	1

9. If they think that a turtle management plan will be necessary to be able to use turtles in a sustainable manner.

	Yes	No
Porvenir	74	3
Piso Firme	38	0

10. If they are interested in creating and implementing a turtle management plan (that would be based in the communities).

	Yes	No
Porvenir	77	3
Piso Firme	38	0

11. If they are interested in a management plan, what ideas do they have for its creation and implementation?

	Protected beaches	Protect nests	Protect from animals	Research	Regulations	Management Plan / Education	Not necessary	Headstart hatchlings	Community based
Porvenir	11	2	2	1	56	5	2	2	1
Piso Firme	15	1				6		17	

12. If they support rules and regulations for consumption of the species.

	Not for community members, but yes for other people.	Yes for community members, other communities, and outsiders
Porvenir	2	76
Piso Firme	0	38

13. What kind of limitations would they support?

	Protected Areas	Number of turtles	Season restrictions	Size limits	None
Porvenir	29	60	13	61	1
Piso Firme	9	17	4	10	0

14. If they would be interested in other management methods.

	Sustainable egg program	Turtle ranching / farming
Porvenir	97	18
Piso Firme	38	0

CHAPTER 6

FRAMEWORK FOR A COMMUNITY BASED *PODOCNEMIS* MANAGEMENT PLAN IN NOEL KEMPFF MERCADO NATIONAL PARK, BOLIVIA[1]

[1] Lipman, A. J. and L. Saucedo Mendía. Management Plan to be submitted to Noel Kempff Mercado National Park administration.

Preface

The framework outlined here will directly inform the final community-based *Podocnemis* Management Plan in Noel Kempff Mercado National Park (PNNKM), Bolivia. This chapter is organized according to sections required by the Bolivian Ministry of Rural Development, Agroforestry, and Environment (Ministerio de Desarrollo Rural, Agropecuario y Medio Ambiente), outlined in the government document "Requirements for the Preparation and Presentation of Wildlife Management Plans" (Lineamientos para la preparación y presentación de Planes de Manejo de Fauna Silvestre), relevant to all wildlife management plans presented in Bolivia. Many of the sections presented here will translate with little change to the final document; other sections, such as "Management Actions and Sustainable Use," will be revised according to decisions made on site by local resource managers and communities at local level planning meetings. The final Management Plan will be presented in Spanish to Bolivia's National Park Service (Servicio Nacional de Áreas Protegidas (SERNAP)) as administrators of PNNKM, by the end of 2008.

Summary / Resumen

The Management Plan outlined here is a community-based conservation collaboration in Noel Kempff Mercado National Park (PNNKM) that focuses on management of rapidly declining South American river turtles, *Podocnemis unifilis* (locally "tracayá") and *P. expansa* (locally "tataruga"), which have regionally important cultural and economic values, and that can act as keystone species in their habitats (Turtle Conservation Fund (2002). The general goal of the Plan is to conserve and manage viable populations of the species within and near PNNKM, on the Iténez

(Guaporé in Brazil) and Paraguá Rivers, while addressing the subsistence needs of local people.

This conservation effort was initiated in 2003, as a management collaboration between Noel Kempff Mercado National Park (PNNKM) and local indigenous communities of the Bajo Paraguá TCO (Tierra Comunitario de Origen). Scientists at the University of Georgia, Odum School of Ecology, also entered into the collaboration in 2003, as scientific advisors and consultants to the project. The initial and current goal of all collaborators is to define the conservation project by two prerequisites: (1) it must be locally-based and co-managed by local communities, and (2) it must be informed, throughout all phases, by ecological study.

The Management Plan describes a small-scale subsistence use of the turtle species, only by indigenous communities that are collaborators with the plan. Use of turtle species will be regulated by various limits placed on turtle exploitation, so taking is sustainable and allows for restoration and long-term viability of local populations. Regulations outlined here will begin implementation in 2009, as part of a collaborative management scheme that will include co-enforcement by PNNKM officials and local community authorities.

All planned management actions are informed by two years of ecological study, conducted in 2005 and 2006, which assessed the viability of local turtle populations and documented threats to the species. As well, the plan is informed by interviews, conducted in local communities, which queried and documented local sentiment related to turtle management, as well as ideas and opinions related to actual management schemes. The plan outlined here is thus in accordance with the PNNKM management, local indigenous authorities, ecological data, and general local sentiment, as documented in local interviews

Background and justification for using the resource / (Antecedentes y justificación del uso del recurso)

Similar experiences / Experiencias similares

We include examples from the literature of community-based turtle conservation projects that report success of locally-based initiatives. We also include positive and relevant examples of management methods included in the Management Plan.

Community-Based Conservation

Podocnemis conservation projects in Brazil have successfully involved local communities (Fachín Terán 2005). Community involvement supported political enforcement, lowered the cost of implementing conservation legislation, and garnered the support of local people.

A conservation and monitoring program for both *Podocnemis* species, has been successfully implemented by Cofán Indians in Ecuador (Townsend et al. 2005). Conservation efforts included voluntary banning of hunting turtles and sustainable restricted use of turtle eggs. Community members benefited through employment in the research and monitoring program and a payment plan for collection of hatchlings for a headstart program. The monitoring programs demonstrated positive effects (increasing turtle and nesting abundance) of these management programs on local turtles. Success of this program demonstrated the potential for low cost local management of sustainable turtle populations, and for the Cofán involved in the project it was the basis for their acquisition of territorial rights and creation of an Indigenous managed wildlife reserve.

Protection of Nesting Beaches

Protection schemes for river turtles would ideally create large reserves that include all aspects of their habitat, including foraging grounds. However, because these areas can be immense for species that travel long distances, and conservation funding to protect turtles is often scarce, Moll and Moll (2004) recommended that protection schemes focus on guarding nesting beaches where most human exploitation targets female turtles and their nests. Beach protection schemes were also recommended by the Food and Agriculture Organization of the United Nations (1988). Protection schemes include nest site patrols and sweeping of nest sites to erase traces of turtle nesting activity. In addition to protecting against human activities that threaten and disturb nesting turtles, protection schemes often aim to protect nests against natural (animal) predation that poses threats to turtle reproductive success.

Moll and Moll (2004) reviewed nest protection programs, in Belize, the United States, India, and Malaysia that report increased survival of nests and eggs in many turtle species. Ross et al. (1989) reviewed a nest protection project at Rancho Nuevo reserve, part of Mexico's Kemp's Ridley conservation program. The project involved patrolling by Mexican military to prevent poachers from collecting eggs. It played a critical role in reducing levels of poaching. Troeng and Rankin (2005) described long term research that detected an increasing nesting trend in green turtles at Tortuguero, Costa Rica, that was attributed to protection of nesting beaches. Protection allowed increased natural hatching, and conservation practices that lowered adult and juvenile mortality rates.

Moll and Moll (2004) discussed nest protection schemes in Brazil, run by the Brazilian Institute of the Environment and Natural Resources (Insituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) (IBAMA), that protected

Podocnemis species in more than 115 protected areas. Smith (1975) argued that instead of prosecuting people for collecting turtles, governments should set aside remaining turtle nesting beaches as protected reserves. Ojasti and Rutkis (1965) discussed another benefit to keeping people off of nesting beaches: *P. expansa* turtles avoid beaches disturbed by human presence, and it may be more than two weeks before they return after such disturbance. Such a delay may be enough time to offset nesting so nests become vulnerable to rising river levels.

A *P. unifilis* research program on the Iténez River in Bolivia experimentally compared treatments of nest guarding, nest protection (by cages, from predators), and translocation of eggs to safer locations (Caballero Guerrero 1996). All three treatments resulted in higher survival of both eggs and nests than did the control group, although translocation of eggs involved some increased rates of mortality. Caballero Guerrero concluded that because the prohibition of sales of turtles in rural areas is ineffective at promoting conservation, at the very least nesting females should be protected. Experimental results show that guarding of nests, which is the cheapest of the three options, might be sufficient for protection of nest sites.

Physically protecting nests from predators is another method of nest protection. Moll and Moll (2004) reviewed various projects that successfully increased the survival of turtle nests. Using wire to protect nests, translocation of nests (see Egg Translocation and Hatcheries), and the sweeping of nests to hide nests from humans and sight-oriented animal predators all increased the survival rates of nests.

In general, protecting turtle eggs from animal predators could raise the concern that other animals are being deprived of necessary food sources. And, although rates of predation on turtle nests, and specifically *Podocnemis* nests by animal predators can be high, this pressure cannot be compared to the intensive and unrelenting pressure of human exploitation.

Sustainable Exploitation of Turtles

Thorbjarnarson et al. (1997) argued that in most areas *Podocnemis* recovery will require reductions in exploitation, but that one potential management option is to permit subsistence use while eliminating commercial use. However, they admit that this distinction is often blurred, that control could be difficult, and that it would require enforcement by communities.

Studies performed by Congdon et al. (1993, 1994) provided a strong basis for a conservation theory of freshwater turtles that is built on an understanding that turtle life history traits make them especially vulnerable to increased mortality rates in the large juvenile and adult stages. Congdon et al. (1993, 1994) demonstrated that long-lived animals cannot withstand high mortality pressure in the adult stage. Extrapolation of population data of freshwater turtles found that a modest harvest pressure of 10% per year, for 15 years, may result in a 50% reduction in population size. From this estimate, they assert that the idea of sustainable exploitation of turtles likely should be discarded, and that population dynamics of turtles cannot withstand continuous exploitation of adults.

In agreement, Heppell (1998) provided life tables from several turtle populations. Her work emphasized stage elasticity where elasticity is the proportional contribution of fecundity or annual survival to the population growth rate. Elasticities for most freshwater turtles were very similar – high adult survival elasticity and low fecundity elasticity suggested that reduced mortality of adults would be likely to stabilize declining populations. She concluded that turtle life histories make them especially prone to overexploitation in the adult stage. She stressed that, while the harvesting of eggs and juveniles adds to the cumulative negative impact of human activities on turtle populations, and captive rearing programs might be able to help "boost" recovering populations, turtle populations will recuperate only if the principle source of decline has been reduced (i.e., mortality in adult stages). In response to the idea that use of adult turtles can be mitigated by increasing survival of eggs and hatchlings, Heppell & Crowder (Heppell 1998; Heppell & Crowder 1998) asserted that for late maturing species, an increase in juvenile cohort size did not necessarily increase population growth, and that the establishment of healthy adult stocks, through decreases in adult mortality, should be the conservation goal for these populations.

These studies support the theory that any conservation plan for long-lived turtles must have within it, the objective of lowering the rate of exploitation of adult turtles. Sustainable use of turtles would be difficult to achieve, but a sustainable use of eggs might be realistic. Our goal was to limit and regulate use of adult turtles to the smallest subsistence level possible, while completely eradicating commercialization of the species.

<u>Sustainable Egg Exploitation</u>

The sustainable exploitation of turtle eggs is a management option that has mostly been attempted for sea turtles. The best documented project is an Olive Ridley sustainable egg harvesting project, run by a community cooperative in Ostional, Costa Rica (Almengor et al. 1993; Campbell 1998; Campbell et al. 2007). The project is based on an understanding of the turtles' biology: because females nest in stages of synchronized groups, termed 'arribadas' (similar to the nesting strategy of *P. expansa*), eggs laid by the first groups are often crushed by later nesting groups. Local communities can harvest early egg crops, whose use and sale are managed through a certification process, while having little or no impact on hatchling populations. Campbell et al. (2007) report broad economic benefits for participating community members, resulting in support for turtle conservation. They also report convincing results (with recommendations for continued monitoring) that there are no negative impacts on turtle populations, with steady and possibly increasing nesting populations of female turtles, of up to 130,000 turtles per arribada, after 20 years of project implementation.

Hope (2002) analyzed three Olive Ridley egg harvesting projects in Costa Rica and Nicaragua. He recommended the legalizing of community marketing cartels, based on seasonally permitted extraction of eggs, as a method to improve resource management, increase egg profit margins, and to clearly identify the origin of eggs for consumers. These projects have been a sustainable means of providing sources of income to local impoverished people. Caputo et al. (2005) investigated sustainable use of *P. unifilis* eggs in Ecuador. They analyzed biological and socio-economic bases for the project. They argued that egg collection by indigenous people could be sustainable, based on findings of a 61.3% loss of natural nests to flooding events, and 28.2% of nests taken by humans. Thus, they argued that if human egg collectors collect only those nests that would be lost to flooding naturally, there should be no negative effect on numbers of hatchlings entering the population. Lastly, Caputo et al. (2005) documented success in the technical ability of local people to implement monitoring and research programs, as well as community-wide support for the research and conservation project.

Sustainable egg harvesting projects could be relevant to management of *P. expansa*, which has similar nesting habits to sea turtles; however, in PNNKM, where there are extremely low nesting numbers of *P. expansa*, harvesting cannot be based on the same theory involving arribada nesting. Instead, sustainable egg harvesting in PNNKM is more suitable for *P. unifilis* nests, based on the same theory as the project outlined by Caputo et al. (2005) in Ecuador. Harvesting of turtle eggs will, of course, depend on harvest rates low enough so only naturally vulnerable nests are targeted.

Relevant legislation / Marco legal relevante

Both turtle species are listed in the IUCN Red List of Threatened Species. *P. expansa* is listed as LR/cd (1994, out of date; Lower Risk/Conservation Dependent), and *P. unifilis* is listed as VU A1acd (Vulnerable; 1994, out of date; (Species Survival Commission 2008). Both species are listed on Appendix II of the Convention on International Trade in Endangered Species (CITES; (CITES Secretariat 2008), and they are rated “1,” highest priority in the Tortoise and Freshwater Turtle Specialist Group Action Plan Rating (APR), indicating that both species are “known threatened species in need of specific conservation measures” (Tortoise and Freshwater Turtle Specialist Group 1991). Brazilian law protects both species; it prohibits the hunting of any wildlife in its territory for sale nationally or internationally (Article 1 Law 5,197 January 3, 1967 and Article 29 of Law 9,605 February 12, 1998; (Conway 2004). Both species are protected under Bolivian national laws that prohibit hunting and trade of all wildlife: supreme decrees 21774 (26/11/1987), 22641 (8/11/1990), and 16605(20/6/1979).

The plan presented here will prohibit all commercialization and trade of the species, as is prohibited by international agreement and Bolivian law. The only use of wildlife considered legal in PNNKM, and by Bolivian law, is subsistence-based use by local indigenous peoples. Hence, the only use of *P. expansa* and *P. unifilis* proposed here is a small-scale subsistence-based harvest, applicable only to collaborating indigenous communities. All other use not defined in this document, or engaged in by people not members of the participating communities, will be considered illegal and not in agreement with the plan outlined here.

Justification / Justificación

Social benefits / Beneficios sociales

The conservation project outlined here addresses human needs specific to the geographic location in eastern Bolivia, representative of subsistence-based human needs throughout the tropics. The Management Plan is not only community-based, it was initiated by local people concerned by what they observed as *Podocnemis* population decline in and near PNNKM. Because local people historically and presently depend on turtles as a subsistence protein source, population decline in the species translates to decline in the local resource base. Local people thus have a direct livelihood stake in local turtle conservation, as well as in promoting a more sustainable use of the species. This local stake in *Podocnemis* turtles, in and near PNNKM, is the basis from which the community-based turtle Management Plan has been forged.

Social research conducted in the park queried local opinions related to *Podocnemis* turtles and their use, and documented general concern in local communities that turtle populations were declining (Chapter 5). It also documented majority opinion that community-managed regulations were needed to regulate hunting activities and to ensure that turtle resources do not disappear. Decline in turtle populations thus poses direct threats to local food resources that local people recognize. As such, conservation of turtle resources, and promotion of a more sustainable use of the species, will directly benefit local people, by protecting an important food resource.

In addition to direct social benefits gained through conservation of turtles, other benefits of the project include local capacity building and training in methods of ecological research and sustainable resource management (see Table 1 for yearly benefits). Local people have already benefited (20 local people hired 2005-2006), and will continue to benefit, through paid salaries made available in communities for work collecting data in long-term turtle monitoring studies.

Table 6.1. Project benefits in local communities per year.

Project Benefits	**Number**	**Hours Trained**	**Location**
Administrators trained	3	1 year	PNNKM
Park guards trained in ecological and social science research	1	8hr x 25day x 5mo = 1000hr	Porvenir
	1	1000hr	Bella Vista
	1	1000hr	Boca del Rio Verde
Community members hired and trained in ecological research	6	8hr x 25day x 5mo = 1000hr x 6 = 6000hr	Porvenir
	4	1000hr x 4 = 4000hr	Bella Vista
	2	1000hr x 2 = 2000hr	new site (to be determined)
	2	1000hr	Boca del Rio Verde
Community members hired and trained in social research	2	8hr x 25day x 2mo = 400hr	Piso Firme, Porvenir
Community-PNNKM workshops	1/month x 12 months x 7 communities x 2hr	168hr	All communities
Teaching of local school students	80	4hr/wk x 12 wk x 80 = 3840hr	All communities

An additional successful and well received benefit to local communities is the environmental education program instituted by the project in all local schools. Local students participate in social research studies that monitor use of turtles within their communities. Students are not only trained in resource management and environmental themes, but for the first time they are able to participate in actual research projects, in which they collect and analyze all data, then present results to their communities and PNNKM in formal settings.

Environmental benefits / Beneficios ambientales

This plan was initiated to mediate what the collaborators (PNNKM administration, and local communities) perceived to be an imminent threat to local and global biodiversity: the unregulated use of, and thus decline in, freshwater turtle resources. The Management Plan will not only protect turtle resources for local people (as described above), but it will enable PNNKM administration (SERNAP) to achieve its goals of conserving important biodiversity elements of the region, and Bolivia in general. Conservation of turtles is ensured through capacity building initiatives that train park employees in turtle-specific conservation management methods. Management goals outlined below will accomplish the first real effort to conserve these two endangered species and the ecosystems of which they are an integral part.

This plan outlines methods to conserve two endangered species that are not only important locally, but across all of tropical South America. Both species were once ubiquitous throughout the Amazon and Orinoco River basins, but, as described above, populations have declined across their entire range. Hunting pressure is the primary factor effecting their decline because breeding females and their eggs are principal sources of protein for local people (Ojasti 1971; Smith 1975; Mittermeier 1978; Smith 1979; Alho 1985; Johns 1987; Cantarelli 1997). Human land use that affects turtle habitat is a secondary threat (Ojasti & Rutkis 1965; Food and Agriculture Organization 1988; Fachín Terán 1994; Thorbjarnarson et al. 1997; Escalona & Fa 1998).

The plan outlined here, an organized effort to conserve two endangered species, is a direct response to the vulnerability of the species to mortality factors in PNNKM.

The geography of PNNKM (easily accessible river borders) makes the park especially vulnerable to human activities and increasing development pressures, especially those originating from the Brazilian side of the park. The park's borders are formed by two navigable rivers, the Paraguá and the Iténez (Bolivia's eastern border with Brazil), that provide virtually open access to turtle and egg extraction in the park. Although on paper both species are protected by both Bolivian and Brazilian legislation, a historic lack of financial and infrastructure support for conservation and enforcement in this largely frontier area allows for their continued and unmonitored use.

Exploitation in PNNKM includes subsistence use of turtles by local Bolivian indigenous and colonist communities, as well as commercial sale by local Bolivians to nearby rural and urban centers, and consumption and sale by rural and urban Brazilians (Conway 2004 and pers. obs. 2005-2006). Turtles captured in and near PNNKM, are sent to other indigenous communities, to larger colonist communities such as Remanso and Cafetal, and to the urban centers of San Ignacio de Velasco and Santa Cruz de la Sierra (pers. obs. and communication with local people 2005-2007).

Ecological and social research conducted in the first phase of the conservation project (2005 and 2006; Chapters 4 and 5) revealed definite negative effects of proximity to human communities on local turtle populations. The research also found extremely low abundance of nesting *P. expansa* throughout the park. The social research documented local peoples' perceptions of long-term decline of *Podocnemis* turtles in and near PNNKM. Hence, these guidelines directly address and attempt to mitigate the negative effects on local turtle populations of proximity to human settlement. Environmental benefits of the plan include reducing negative impacts on local turtle populations so this important environmental resource does not disappear.

This plan addresses a need relevant to turtle conservation efforts worldwide, namely, that turtle conservation projects are often not based on scientific understanding of specific turtle life histories and threats, and thus have been largely ineffective at maintaining turtle populations (Gibbs & Amato 2000; Klemens 2000; McDougal 2000; Meylan & Ehrenfel 2000; Moll & Moll 2000; Seigel & Dodd 2000). Throughout every phase of this project, we used ecological study as a tool to directly inform recommendations for management of local turtle populations.

Finally, through this collaborative project, quality of community life will be linked to protection of a nearby natural area and two species contained within. This linking of a protected area to local livelihood needs raises the value, and thus the effectiveness, of protected areas and conservation in the eyes of local people. A long-term benefit and goal of this project is that the groundwork will be laid for more intensive and broad-spectrum conservation and research efforts in PNNKM.

Economic and/or cultural benefits / Beneficios económicos y/o culturales

The outlined plan will directly benefit peoples' livelihoods through protection of a key subsistence-based food source. It protects an important aspect of local cultural identity as residents local to PNNKM have a strong cultural predisposition to use turtle products and state preference for turtle meat over all domestic meats, claiming it has more nutritional value (Conway 2004). *Podocnemis* turtles have always been, and continue to be, a favorite food of Amazonians (Johns 1987). The meat is highly regarded for its rich flavor and as an aphrodisiac (Johns 1987; pers. obs.). Additionally, an adult female *P. expansa* can provide up to 12 kg of high quality meat that can feed a family for several days (Mittermeier 1978; Conway 2004). As a protein source, turtle meat contains 85 to 88% protein, compared to 43 to 70% protein of domestic meats (e.g., chicken, pig, beef; (Cantarelli 1997).

At least ten traditional dishes are made from turtle meat, and all parts of the turtle are used (Alho 1985). Turtle shells are used as containers for washing and cooking, and they are used in artwork and made into trinkets and jewelry to sell to tourists (Figure 2.4). Conservation of turtle resources works not only to protect an important food source for local people, but also to protect a strong cultural tie that local people have with the natural environment.

Probability of success / Probabilidades de éxito

Because *Podocnemis* species are highly valued resources for riverine communities of indigenous people, the inclusion of local people in *Podocnemis* management projects is essential to project success (Alho 1985; Caballero Guerrero 1996; Conway 2004; Johns 1987; Ojasti 1972; Ojasti & Rutkis 1965; Thorbjarnarson *et al*. 1997). Often, and especially in tropical regions, conservation problems occur because national and regional conservation goals are countered by local people who depend on natural resources for their livelihoods. Our plan addresses this fact directly. It is locally-initiated and constructed, so it inherently addresses the needs and concerns of local people. Our Management Plan is relevant to local conditions because it was created by consensus from local communities. Thus, it faces little risk of being opposed by local resource users, and there is an increased probability that local people will help support and implement it.

Furthermore, although this plan is community based, it is supported by collaborative alliances (resource users, national park management, scientists, local non profit organizations, local municipal government) that ensure its scientific integrity and long-term sustainability. Responsibility is shared between communities and PNNKM administration, at all stages of project design and implementation, promoting a higher probability of success and long-term implementation.

Throughout all aspects of project planning, it has been a main goal of all stakeholders that the project outlined here be sustainable and implemented in the long-term. Through the Management Plan, collaborators strive to lay the groundwork for a long-term monitoring and conservation program for *Podocnemis* species in PNNKM. In 2008, we have submitted proposals to obtain funding from various local and international organizations, to be used in implementation of the plan, continued hiring and training of local residents in data collection, and for community engagement.

Prospects for project success are positive because PNNKM management has strong incentives to achieve the outlined conservation goals through their management work and financial contributions. Furthermore, both *Podocnemis* species have been listed as PNNKM's prioritized species of concern. As such, PNNKM management has pledged funds, personnel, and infrastructure to support the project in the long term. Additionally, the local municipality of San Ignacio de Velasco has communicated its interest in supporting the project in the near future, and the department of the Beni has expressed interest in collaborating with PNNKM to create, and possibly fund, larger scale projects for *Podocnemis* conservation in the region. The Fundación Noel Kempff Mercado (local non profit organization) has professed much interest in project collaboration, and is currently working with project directors to submit funding proposals to various organizations. Lastly, SELVA International, a non profit US-based organization, has pledged scientific support and help in securing long-term funding for implementation of the plan and ecological monitoring of the species.

Within the local context of this conservation issue, all project stakeholders agree that only cross-sector collaborations that address both national, local, scientific, and conservation interests are likely to promote successful conservation. The collaborative plan outlined here uses low cost and culturally appropriate methods that can be continued by local resource managers. Outside and local collaborations will ensure that the Management Plan is implemented properly, with a high probability of fulfilling its objectives.

Accreditation of ownership type / Acreditación del tipo de titularidad

Include here:

1. Letter from Jorge Alberto Landívar Cabruja, Director of Noel Kempff Mercado National Park

2. Legal documents of community land titles

General and specific objectives of the management plan / Objetivos generales y específicos del plan de manejo

General objectives / Objetivos generales

To conserve and manage viable populations of *Podocnemis unifilis* and *P. expansa* within and near PNNKM, in the long-term, and in conjunction with the rights and livelihoods of local ribereño (riverside) human communities.

Specific objectives / Objetivos específicos

1. Promote a more sustainable (subsistence) use of the species in local communities.
2. Generate favorable conditions in the natural habitat for recuperation and survival of the species.
3. Address the subsistence needs of local human populations, by investigating and promoting viable and socially-accepted alternatives to turtle hunting.

4. Strengthen the capacity of local residents and PNNKM employees in the management, research, and conservation of *Podocnemis* resources.
5. Implement long-term ecological monitoring of the species that will inform ongoing evaluations management schemes and project success.

<u>Project Area / Delimitación del área de manejo</u>

The specific location of this project, Noel Kempff Mercado National Park, is in the northeast department of Santa Cruz, Bolivia, at about 61.82º W to 60.23º W and from 13.45º S to 15.10º S (CIA 2007). At 1,523,446 ha, PNNKM is one of the largest and most undisturbed parks in the Amazon basin (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). It is a listed World Heritage Site, one of the most biologically diverse areas of the world , and it contains some of the largest, most intact, and important habitats for conservation of terrestrial biodiversity globally (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). No other protected area in the Amazon contains the diversity of habitat types found in the park: Amazonian evergreen rainforests, palm forests, cerrado, swamps, savannahs, gallery forests, and semi-deciduous dry forests (IUCN 2000).

PNNKM is located on the southern fringe of the Amazon drainage, with rivers forming ninety percent of its boundary. The Paraguá River forms its western border, draining northward to the Iténez River (Guaporé in Brazil), which forms the park's northeastern border and Bolivia's border with Brazil. The Paraguá, a river navigable by small craft, borders Bolivian indigenous communities. The Iténez is a larger order river navigable year round by larger craft, mostly originating from Brazil. These easily accessible river borders make the park especially vulnerable to human activities, both from Bolivia, as well as from Brazil, which is outside the control of the Bolivian

National Park system. Average annual precipitation is between 1,400 and 1,500 mm, with maximum precipitation in January and February, with means of 194 and 196 mm, and the driest month in July, with only 18 mm of precipitation (Fundación Amigos de la Naturaleza (FAN) & The Nature Conservancy (TNC) 1996). This pattern of precipitation corresponds with river levels being lowest from July through December, also the *Podocnemis* nesting season. Nesting by *Podocnemis* is dependent on low water levels to expose beaches necessary for nesting activities.

Social Context / Organización local y contexto social del manejo

Socioeconomic aspects of the involved population (production, health, education, basic services, etc. / Aspectos socioeconómicos de la población involucrada (producción, salud, educación, servicios básicos, etc.)

All involved communities are considered indigenous communities and have acquired land rights through Bolivia's designation, Territorios Comunitarios de Origen (TCO) of the Bajo Paraguá. Socioeconomic aspects differ between communities. Bella Vista is the only community inside PNNKM. It is also the smallest community (12-20 families, depending on year), and the only community that cannot be reached by land. Residents are mostly last survivors of what is now considered a culturally extinct indigenous group, the Guarasug´we, who migrated to the region from Paraguay, in the 16th century (Muñoz 2006). Since the year 1700 they are documented to have lived between the Iténez, Paraguá, and Paucerna rivers (Muñoz 2006). Residents engage mostly in subsistence-based livelihoods, with some selling of fish to local communities and Brazilian traders. Livelihoods are based almost entirely on fishing, turtle hunting, hunting, and agriculture of staple products such as yucca, rice, and plantains. There is some raising of chickens, ducks, and pigs by only a few families. Only two families own cows. In relation to basic services and health, Bella Vista mostly does not receive the benefits of any services, due to its isolated location. The only access the community has to health services is a doctor provided by the local municipality, who visits the community once every 1-3 months, for a few hours, and charges for medication. All other services are acquired, if possible, by a 5-20 hour trip upstream to the closest Brazilian town. Basic education is provided by the municipality (only K-5).

All other communities are more integrated with each other, and with Bolivian rural life, in general. Some communities have large numbers of family from the Guarasug´we indigenous group; however, most identify with the Chiquitana indigenous group that more recently has moved from further south to present locations. Piso Firme is the most integrated community, due relatively easy access to it by road in the dry season (there is a weekly bus to the cities of San Ignacio de Velasco and Santa Cruz de la Sierra; it is a 2 to 5-day trip one-way, along poor dirt roads). Porvenir and Florida are accessible by road, but because there is no regular traffic, and the roads can be quite impassable in the wet season, they can be quite isolated.

People in these communities also largely depend on subsistence-level production. Most people actively engage in fishing, turtle hunting, hunting, and staple agricultural activities. However, most also raise livestock, and many people raise cattle for market production. Involvement in local palmito and timber industries is also common. Health services are more accessible in these communities; Piso Firme has a resident doctor, and Porvenir has a resident nurse. Smaller communities access services at the larger communities. Education in these communities is more diverse, and it is offered K-8. Access to the cities is easier in these communities, thus this is importation and exportation of products between rural and urban areas.

Organizational management structure / Tipo de organización para el manejo

The management structure for implementation and enforcement of the plan will be shared between PNNKM administration and local indigenous communities. The exact nature of the structure of this agreement and collaboration will be formalized in local planning meetings.

Organizational strengthening / Fortalecimiento organizativo

Most importantly, this project emphasizes that active involvement and support by local communities will be essential to successful conservation and management of turtles. Through implementation of all field research, as well as participation in local conservation discussions and meetings, community members have been equal collaborators in this project since its inception. Moreover, due to hours spent working on the project, local people feel that the project is theirs, and they have expressed interest in assuring its long-term planning and continuation.

Through the described collaboration of local resource managers and users, PNNKM employees (park guards and directors) and local residents have implemented the first stages of this project. Many changes to project methodology were made through collaborative recommendations by both groups. The promotion of this collaborative partnership within PNNKM will continue to be a key project objective, as it is most important to the project's success and longevity.

Successful collaboration in project research and creation of the Management Plan supports the idea that in this tropical area, where resources (e.g., funding, enforcement) to support conservation are scarce, management of natural resources by the local human populations that depend on them is more effective than conservation imposed from afar. Most importantly, collaboration gives local people proprietorship, and thus responsibility towards, the natural resources upon which they depend. Working with national park authorities, local people are able to become part of a larger, national process that works to conserve the natural resource base of the country. Through this collaboration, the effectiveness of the national park and peoples´ abilities to successfully manage their livelihoods, are strengthened; they are joining forces to work towards a common goal.

Local actors, institutions, and/or scientists responsible for the plan / Actores locales, instituciones y/o técnicos responsable del plan

Communities of the Bajo Paraguá TCO (Territorios Comunitarios de Origen)

The Baja Paraguá TCO includes all indigenous communities local to PNNKM: Piso Firme, Porvenir, Florida, Bella Vista, and Cachuela. Local authorities of each community are mandated to govern (through the Bolivian government) community-titled land within their jurisdiction. Lisandro Saucedo Mendía, a member of the community of Porvenir, and previous park guard in PNNKM, is acting director of the project.

PNNKM Administration: Servicio Nacional de Areas Protegidas (SERNAP)

SERNAP, the Bolivian National Park Service, director of PNNKM, is a key project collaborator and will be involved in all aspects of project implementation. It is this department of the Bolivian federal government that gives official project approval (see attached letter of approval) and final evaluation. SERNAP will provide invaluable project support through park personnel, transportation to and within the park, use of park camps and infrastructure, and supplies throughout project duration. SERNAP has requested, and will be involved in, the training of park guards and community members that will ensure project duration. Personnel available for the project include Jorge Landívar Cabruja (PNNKM Director); Eloy Guayao Mano (Director of Protection), who has 12 years experience working on *P. unifilis* projects in the Pilón Lajas Reserve, Beni Department; and two park guards, Roger Montaño and Elio Justiniano, who will be stationed at Bella Vista and Boca del Rio Verde for project support and data collection.

University of Georgia (UGA), Odum School of Ecology

The Odum School of Ecology is an internationally respected center for ecological research worldwide. The Odum School is a center for long-term ecological research (LTER), and it is widely involved in tropical research and community-based conservation projects in Latin America. The project scientist is Alison Lipman, Ph.D. Ecologist, who has almost 10 years of experience managing endangered species and conservation projects (in the U.S. and Bolivia). Lipman initiated UGA's involvement in this project, in summer 2003. C. Ronald Carroll, Ph.D., professor and co-director of UGA´s River Basin Center, is actively involved in project oversight and direction through all stages of project implementation. Carroll has worked in Latin America since 1967, and he has been lead scientific advisor to the Maquipucuna Foundation (community-based conservation and sustainable agriculture organization in Ecuador) for almost 20 years. Key advisor to the project is Kurt Buhlmann, Ph.D., turtle expert at the University of Georgia’s Savannah River Ecology Laboratory. Buhlmann was recently Coordinator for Amphibian and Reptile Conservation programs within the Center for Applied Biodiversity Science (CABS) at Conservation International (CI) (and continues as a consultant), he helped create the Turtle Conservation Fund (TCF), and he is a Deputy Chair of the IUCN Tortoise and Freshwater Turtle Specialist Group.

Management consultation / Instancias de consulta y decisión para el manejo adecuado.

All technical consulting services will be provided by the scientists at UGA. Transfer of some of the ecological consulting will be to SELVA International, an ecological consulting non profit organization, headed by A. Lipman. Socio-economic and environmental geography consulting will be provided by K. Conway-Gómez, Ph.D., at California State Polytechnic University, Pomona.

Roles and responsibilities of all actors / Roles y responsabilidades de los actores

Local indigenous communities and PNNKM administration will be co-managers and the two responsible parties for implementation and enforcement of this plan. Exact responsibilities of each party are still to be defined. The responsibilities of the collaborating scientists are to act as scientific consultants to the project, ensuring the scientific integrity of all research and monitoring programs, as well as all management and conservation actions included in the plan. All parties are responsible for yearly evaluation of the plan.

Mechanisms for coordination with departmental, national and scientific authorities / Mecanismo de coordinación con oficinas departamentales, nacionales DGB-AP y Autoridad Científica.

All coordination with official Bolivian institutions will be through Jorge Landívar Cabruja, director of PNNKM, and authorities of all local communities. Coordination will be organized through the PNNKM Board of Directors (Comité Gestión).

Ecological diagnostic / Diagnóstico del recurso y bases ecológicos para el manejo propuesto

This section describes an ecological diagnostic of the species. It includes a literature review of the species, a study of local populations of the species, and a study of local exploitation of the species. Translations of chapter 2, 3, and 5 will be included.

The included chapters describe the life histories of both species and the constraints that these unique life histories put on exploitation of the species. The results of thorough analyses of freshwater turtle life history tables, which include traits such as long life, delayed sexual maturity, reproductive iteroparity, low mortality in adult stages, lack of reproductive senescence, and high mortality in early life stages, suggest that the species cannot withstand high levels of exploitation of adult turtles (Congdon et al. 1993, 1994; Heppell 1998; Heppell & Crowder 1998). These same life history traits make the managed exploitation of turtle eggs potentially more sustainable than the exploitation of adult turtles.

The results of nesting studies (Chapter 4) demonstrated that turtle populations in PNNKM are likely negative affected by direct human use of the species for consumption. Turtles in PNNKM were documented to be smaller at sites closer to human communities, as well they were smaller than average sizes documented in the scientific literature. Abundance levels of *P. expansa* were extremely low at all nesting sites, which suggests tremendous local decline in the species. Additional factors related to turtle reproductive viability were shown to be negatively affected by human use. These included number of nests created by turtles, size of viable hatchlings, and nest disturbance and survival. These results demonstrate the need to curtail human use of the species and implement management actions whose goal is conservation and recovery of the species.

The results here discussed and attached will inform management decisions that will define and set regulations for limited take by local communities. Descriptions of take will include numbers, age, and sex of each species to be harvested. Ecological justifications and explanations for the sustainability of all harvest actions decided upon will be included. Exact descriptions of turtles to be harvested are still to be decided in the planning process. Based on the supporting ecological data (Chapter 4), we recommend that the harvesting of *P. expansa* turtles and eggs be entirely prohibited, and that local harvest of *P. unifilis* be limited in numbers (per family and community), sex (limit on nesting females), size (preferred harvest of smaller, and male turtles), and location (critical nesting beaches to be determined should be protected).

Management Actions and Sustainable Use / Prácticas de cosecha y/o producción

Exact management actions that will be included in the Management Plan are still to be determined through the locally-based planning process, that will occur in 2008. Management actions must include the following:

Management practices / Prácticas de manejo

Management practices defined by the plan are still to be discussed and decided upon in local planning meetings. Results of project research (both ecological and social, Chapters 4 & 5) will inform these discussions, laying the scientific basis for the Management Plan as a whole. Local opinions related to the Management Plan, and peoples' ideas of actual management actions to be included in the plan have directly informed the management actions presented here. Ideas related to prohibitions and restrictions were documented in social studies that were based in local interviews (Chapter 5). Ideas that were agreed upon by the majority of responders are included here. Final agreements of what will be included in the Management Plan will be made by local community authorities and PNNKM administration, with evaluation and final input of collaborating scientists.

Results of the ecological and social research (representing the opinions and management ideas of local people) support recommendations of the following management actions:

a. Ceasing of all hunting and egg collecting of *P. expansa* turtles, at least for an initial agreed upon period of time.

b. Illegalization of all commercial sale in the species.

c. Limits to the total numbers of all turtles hunted and eggs collected.

d. Limits per family of total number of turtles hunted and eggs collected.

e. Geographic limits to turtle hunting and egg collection, especially through the designation and guarding of protected nesting beaches.

f. Seasonal limits in turtle hunting, specifically in the turtle nesting season.

g. Size limits on turtles hunted (i.e., limits on maximum size; change focus to smaller, male turtles).

h. Delimitation of turtle hunting and egg collection grounds for each community, with exploitation of turtles outside of these grounds not allowed.

i. Designation of illegal use of the species for all non-community members.

j. The physical protecting of nests from animal predators on designated beaches.

k. The restriction of burning and/or clearing of vegetation at the river's edge.

l. The restriction of human activity (e.g., camping, walking) on beaches at night during the nesting season.

m. The restriction of motor boat travel near nesting beaches, at night, during the nesting season.

n. Ceasing of local turtle headstarting projects and the translocation of turtle nests to other locations. These activities have many documented negative side effects to turtles and potential negative side effects to wild populations (Chapter 4). We therefore recommend: (i) the education of local people in the harm caused by these programs, (ii) training in methodology of more appropriate management schemes, and (iii) that all local efforts related to these actions be dismantled.

Management actions chosen to be part of the final plan will need to be detailed as to specific geographic locations, quotas, etc. For example, the specific beaches that will become protected reserves will be decided upon by all collaborators; however, they will need to be important, viable areas for nesting that are vulnerable to high levels of human exploitation. Additionally, seasonal hunting limits might designate all hunting during the nesting season as illegal, or it might define certain months or weeks as "protected" nesting periods for turtles. Geographic limitations will need to take into consideration the ecology and needs of the species, as well as different local communities. Final agreements will have to compromise the combined scientific, social, economic, and political agendas of all communities and PNNKM.

All research results will be used to identify and protect critical nesting beaches and to set goals for harvest rates. Based on possible management decisions, different projection scenarios will be created by project scientists. For example, for the best possible scenario for recuperation of the species we would recommend zero harvesting of adult turtles, with implementation of sustainable egg harvesting projects. Because local resource managers are unlikely to accept this management recommendation, we will make projections for local species conservation based on different levels of harvest, which will be based on species, numbers, sex, locations, and timing of harvest. These projections will be presented and discussed in local meetings, to identify reasonable and acceptable options for management.

Finally, adaptive management strategies will be implemented, so that the results of ecological monitoring will inform yearly updating of the plan.

Zones and specimens for harvesting./Zonas y especímenes a cosechar

Final zones and specimens for harvesting are yet to be finalized.

Strategies for use./ Estrategias de aprovechamiento

In addition to the management actions recommended above, which will be further defined before final creation of the Management Plan, the following use strategies are recommended by the authors, as well they are documented in the attached literature and supported by interviewed community members.

Most community members interviewed supported the idea of a sustainable use program for egg harvesting. This program is supported by documented success in similar projects (see “similar experiences” above), and the ecological evidence supports the theory behind it. High mortality rates of turtle nests, due to river flooding, suggest that many nests (those already vulnerable to flooding due to their low placement on beaches) could be harvested by humans with little impact on turtle populations. Vulnerable nests could be harvested, while less vulnerable nests could be protected. Local people support the idea behind this scheme, and it will likely enter into the final plan.

Limits on numbers and seasons extracted / Tasas de extracción y épocas de cosechas

Exact limits and numbers yet to be determined. Sustainable harvest levels will be determined by modeling the survivorship values of juvenile age classes and adults, female age at maturity, and expected longevity (in the absence of human predation).

Plan of activities and timetable / Plan de actividades y cronograma

To be determined.

Technical support / Apoyo técnico

Technical support will be provided by all collaborating institutions. Local communities will provide needed equipment and infrastructure (e.g., canoes, boats, housing and food for visiting scientists, teacher support in the educational program). As described below, PNNKM administration will provide not only personnel support, but all infrastructural and transportation support. Additionally, PNNKM administration will apply for further program support from SERNAP, as part of its yearly park budget. Local governments and non profit organizations have offered their support. Fundación Amigos de la Naturaleza offers transportation and technical support (e.g., computer and office equipment). The Fundación Noel Kempff Mercado has offered its support in securing long-term funding for the project. The local governments of the Prefectura of the Beni and the municipality of San Ignacio de Velasco have offered future support. Collaborating scientists, especially A. Lipman, offer technical and scientific support in all aspects of creation and implementation of the Plan.

Capacity building and applied research / Capacitación e investigación aplicada

Capacity building

Integral to development of this plan was the idea that long-term success would depend on the future ability of PNNKM management and local communities to direct and manage all aspects of project planning, implementation, and maintenance. A key project objective was to strengthen the capacity of local residents and park officials in the conservation of *Podocnemis* turtle resources. During 2005 and 2006, the project scientist, Alison Lipman, UGA ecologist, was actively involved in training local professionals (PNNKM administration, PNNKM park guards, and local community members) in turtle conservation methodology. Training was realized through working together on-site in project planning, data collection, data analysis, and the social aspects of management planning. This close working environment allowed for daily community-level training, technology transfer, and information exchange. Through the collaborative process that defines this plan, which began in 2003, PNNKM personnel and community members are developing the tools necessary to manage conservation of their natural resources.

Detailed capacity building efforts in PNNKM are as follows. Work in 2005 involved the training of 3 park guards, who are working full time with the project. One park guard, Lisandro Saucedo, who is also a community member of Porvenir, has been directing all research efforts on the west side of PNNKM (this includes all sites on the Paraguá River). All efforts in project direction have been collaborative with Mr. Saucedo, and he has been trained in all aspects of ecological research, planning, and project direction. Additionally, the two other park guards (one also a community member) have been trained in all aspects of project methodology and implementation. This training effort has been very effective; these men are highly capable of implementing project methodology and supervising research efforts independently. Throughout 2005 and 2006, we have trained all (23) park guards and park administrators in general understanding and support of project methodology and implementation. FAN and SERNAP administrators and park guards have all been actively involved in project support and have taken leading roles in community meetings.

Involvement and training at the community level has been highly successful. It has involved the hiring and training of 20 local residents (from Porvenir, Piso Firme, and Bella Vista). Most full-time hired research assistants were trained intensively in the methodology of ecological research, three were trained in social research. All workers demonstrated a strong interest in the work, and almost all of them wish to continue the work in the long-term. Capacity building and training programs will continue, as before, with the research programs described in the next sections.

Ecological research

Ecological research, as a long-term monitoring program of species viability in the habitat, will occur every year, during the turtle nesting season. Research methodology will be the same as that conducted during 2005 and 2006 (Chapters 4 & 5). Researchers will continue monitoring and analysis of turtle nesting activities, whose results give indices of turtle viability, especially in the reproductive population, which is the most vulnerable to the human activities that the Plan directly aims to curtail.

In addition to beaches studied previously, the monitoring program should include more beaches on the Iténez River that might be more appropriate beaches for the species *P. expansa*. An additional change to research methodology might include that the handling of live hatchling turtles will no longer be included in monitoring.

Nests can be evaluated effectively after hatchlings leave the nest, for mortality and survival rates. The goal of the monitoring program, as it will be a long-term effort, is to have the least amount of human impact on the species.

An additional study that will be added to the monitoring program is a study of human effects on the habitat landscape over time. This study will be conducted by A. Lipman and K. Conway-Gómez. It will evaluate aerial photography, remote sensing imaging, and other land-use related data in the area. The goal of the study will be to evaluate potential large-scale and indirect effects of human developmental activity on local turtle populations. Areas with the largest potential negative impact on the species (for example those most highly developed along the river, and thus lacking in vegetation food sources for turtles) will be identified and used to inform future changes in management actions, defined by the Plan. Results of these studies will be combined with the results of nesting data, to determine possible interactions of direct (consumption) with indirect (land use) human effects on the species. Such analyses might change priority areas considered for management actions. The Management Plan might also work to include actions that will help protect a viable habitat necessary to the species.

Social Research

The monitoring of local use of the species previously conducted (Chapter 5)) will be continued, with addition of the communities of Florida and Cachuela. Social research will continue as part of the environmental education program implemented in local schools. Other communities, outside the plan have demonstrated a desire to participate in this project. Therefore, the goal is to expand to the communities of Remanso and Cafetal, on the Iténez River, which will allow for the collection of more data across the region. Interviews will also continue, as described in Chapter 5, especially querying local opinions and ideas related to the Management Plan. We will also expand this study to include the communities of Bella Vista, Florida, Cachuela, Remanso, and Cafetal.

An additional focus of research will be the determination of possible alternative sources of protein that might, at least partially, replace use of turtle meat in the communities. Almost all local people interviewed said they would replace turtle meat with an alternative meat source, if it were more available. Thus, a new direction of social research will be to identify potential, relevant, and socially-accepted protein alternatives. This will include social analysis in local communities, as well as in-depth socio-economic and ecological analyses of the potential for success of various food products in the area.

Local knowledge for improvement of the plan / Conocimientos locales para el mejoramiento del manejo

Local knowledge is already largely informing this plan, through the input of many community members in its creation, as well as from ideas and information gained from interviews conducted. Local knowledge will continue to be an integral part of the Plan, and one of its key goals is to be updated according to new scientific and social input. The plan outlines social research (above) that works to gather more local knowledge, related to new ideas, and from additional local communities.

Monitoring Plan / Sistema de monitoreo

Monitoring and evaluation of the turtle conservation project will be conducted yearly, as an integral part of the project. Monitoring and evaluation of data produced by the monitoring program, will be a collaborative process that will include PNNKM administration, local communities, and collaborating scientists. This will include Lisandro Saucedo Mendía (project director), Jorge Landívar Cabruja (PNNKM Director), Eloy Guayao Mano (PNNKM Director of Protection), all local authorities, scientists from the University of Georgia (Alison Lipman, Ph.D. (responsible scientist), Ron Carroll, Ph.D., and Kurt Buhlmann, Ph.D.), and Kristen Conway-Gómez at California State Polytechnic University, Pomona.

Community members will also be key project evaluators, as the enforcement of conservation initiatives will largely depend on community self-regulation. Ongoing workshops will be conducted in all communities to discuss and evaluate project progress. The intent of these workshops will be to discuss ongoing possibilities for management options, project methodology, and evaluation. On-site evaluations, evaluating progress of field and community data collection, as well as workshop progress, will be written and submitted to Saucedo Mendía and Lipman by all project workers. Results will be shared amongst all stakeholders at planning workshops and community meetings. The goal of evaluation is that a continuous and cyclical sharing of all information, between all project collaborators, will inform an ongoing updating of project methodology, management actions, and resulting success. Success will be defined by two criteria: (1) protection and recuperation of viable turtle populations in the natural habitat and (2) community support and involvement in the project.

Final project evaluation will inform the adaptive management process on which this Management Plan will be based. Benchmarks for recuperation and conservation of the species, that will be evaluated through long-term ecological monitoring, will be set in planning meetings. Benchmarks for local species' viability will be evaluated annually, and if expectations are not reached or surpassed, more strict management actions will be formed and implemented.

Ecological Monitoring

The long-term ecological monitoring program, of both species of *Podocnemis* turtles in and near PNNKM, will begin with implementation of the Management Plan, and it will be dependent on the securing of funding. Monitoring will include ecological research of local turtle nesting populations and social research related to human use of the species. Comparison of nesting data across years will provide the scientific basis for evaluating success of the Management Plan. Indices for turtle reproductive viability will be evaluated and compared, among sites and across years. These indices include female turtle abundance, female turtle size, number of nests created per year, and survival and mortality rates of nests.

Negative changes in any of these indices will suggest a worsening of negative impacts of human exploitation of the species, and will thus call for a reevaluation and reformatting of the Management Plan. Our benchmarks for project success will be to document positive changes in the listed indices over time. Yearly evaluation of these indices that indicate a failure to reach our benchmarks will demonstrate a failure of implemented management practices, and will call for the implementation of stricter actions. This process of evaluation will be ongoing; its goal will be to make the plan more effective every year in its goal to conserve viable populations of the species, locally.

Social Monitoring

In addition to the ecological monitoring program, there will be a monitoring program simultaneously conducted in all participating communities (described above). Information collected in this program will allow for the evaluation of local support of the plan, and acceptance and adherence to actions outlined therein. Data will also allow for comparison of turtle use in the communities, across years. Information related to changes in the numbers, sex, size, and location extracted of turtles used will be essential to keeping the Management Plan updated and relevant to actual use within the communities. Likewise, peoples´ ideas and opinions related to regulations and projects defined by the Plan will be essential to keeping the plan relevant to the needs of local people.

Control

Enforcement of the Management Plan will be a collaborative effort between PNNKM and local indigenous authorities. This will include enforcement by PNNKM park guards within their jurisdiction inside the park, and the enforcement by the local indigenous authorities of each community. Bi-national agreements with Brazilian authorities are currently underway, so that the plan might also be enforced on the Brazilian side of the Iténez River. Exact methods for enforcement (e.g., penalties, collaborative dividing of enforcement duties) are still to be determined.

Questions

Project evaluation will always include answering of the following questions in planning meetings:

1. Do local stakeholders feel they have the knowledge, ability, and understanding of research methodology to continue the project into the indefinite future?

2. Are all actions outlined in the Plan agreed upon by all stakeholders?
3. Is the Management Plan being implemented within the timeframe designated?
4. Do the ecological data support long-term survival of local, viable turtle populations?
5. Is the project able to continue as a long-term research and conservation effort?
6. Does the Management Plan successfully address local resident livelihoods?
7. Are funding sources in place to ensure project continuation into the future?

Positive answers to these questions will describe project success. Negative answers will call for reevaluation of project methodology with all project collaborators.

Documentation and traceability of products / Documentación y trazabilidad de productos

Not applicable to this plan, which only outlines a non-commercial use of the species. Turtles will only be used for local subsistence needs, and thus should never leave the vicinity of PNNKM. Any exportation of turtle products should be confiscated, as will be outlined in management actions of the plan.

Economic Aspects / Aspectos económicos básicos del manejo

Costs / Costos

Costs associated with this plan are generally low, as it does not depend on the hiring or paying of any outside experts. Local people have already been through two years of intensive training, both at the leadership/management level and in research data collection. Ongoing scientific consultation will be supplied by outside collaborators at no local cost. Additionally, many costs, such as gasoline, transportation, infrastructure, personnel (in the form of park guards to assist in supervision of ecological monitoring and educational programs), and communication are provided by PNNKM.

Specific project costs that will need to be covered include the yearly salary of the project director (who is a local community member, paid at $400/month), seasonal pay to local researchers (all community members, paid at $150/month, for 5 months), and start up and ongoing research equipment costs (including camping equipment, research equipment, some boating equipment, computer, and office supplies). We estimate yearly costs of the project to be about $12,000. This number can vary according to the number of researchers that will be needed.

Benefits / Beneficios

As discussed above, the more general benefit of the Management Plan, which will be conservation of turtle resources as a subsistence based food source in local communities, will be shared by all community members who depend on this resource. Other benefits of the conservation project, such as employment and training opportunities, can only benefit a percentage of the population. However, community authorities make sure that those most needy in the community are given first chance at employment opportunities; as well, it is generally seen that opportunities are rotated by year, and equally represented among families. Educational benefits are to all children (usually the oldest class) who participate in the natural resource and research course.

Financial Support / Fuente de financiamientos

As described above, possible sources of local financial support include the Department of the Beni and SERNAP (through application of PNNKM administration to have the project added to the yearly Management Plan). Fundación Amigos de la Naturaleza (Bolivian conservation organization involved in PNNKM) has pledged some project support, at least in gasoline, transportation, computer equipment, and office supplies. Project directors are currently seeking financial support, with the help of the Noel Kempff Mercado Foundation and SELVA International. Other ideas for long-term collaboration with Kristen Conway-Gómez, could result in long-term funding of a research/education center near PNNKM that would collaborate in *Podocnemis* conservation and research efforts.

Quantity for commercialization / Cantidades a comercializar

Not relevant.

Markets for products o alternative commerce / Mercados para los productos o comercial alternativos

Not relevant.

Economic sustainability / Sostenibilidad económica

Sustainability of the long-term monitoring program, which will be necessary to monitor the species and success of management actions, depends on the acquiring of outside finances to support research costs. Due to the high profile and general interest in the project, we believe it should not be a problem to secure enough funding to at least support a minimal program of research and monitoring. One goal for funding is to acquire funding through volunteer recipient programs, where volunteers help with project research, in return for funds received to support local costs. This type of funding would work well at PNNKM, which as World Heritage Site, is a popular destination for tourists in tropical South America. As well, turtles are extremely charismatic species and, large turtles are known to attract visitors, especially to watch nesting events. The project would most likely be quite attractive to volunteers. A positive aspect of this type of funding is that it is generally long-term.

Other parts of the Management Plan, such as implementation and enforcement of specific management actions should not be dependent on outside funding. Methods of enforcement will involve agreements between PNNKM administration and indigenous authorities. These are both institutions that do not require further outside funding for their support in this plan. Documentation of people's support of this plan, supports the notion that as long as all collaborators continue in support of the plan, implementation of management actions should be continued.

Distribution of benefits / Distribución de los beneficios

Because the species will not enter the commercial market, this is irrelevant. Benefits of the project are already described above.

References Cited

Alho, C. J. R. 1985. Conservation and management strategies for commonly exploited Amazonian turtles. Biological Conservation **32**:291-298.

Almengor, M. A., C. L. Mo, and E. Vargas M. 1993. Preliminary evaluation of Olive Ridley egg commerce from Ostional Wildlife Refuge, Costa Rica. Marine Turtle Newsletter **63**:11-13.

Caballero Guerrero, J. 1996. Comparación de cuatro tratamientos de manejo para la protección de la peta de agua (*Podocnemis unifilis)*, Troschel 1840, y estimación de la supervivencia de las crías en las playas del Río Iténez. Page 82. Facultad de Ciencias Agrícolas. Universidad Autonoma "Gabriel Rene Moreno", Santa Cruz de la Sierra, Bolivia.

Campbell, L. M. 1998. Use them or lose them? Conservation and the consumptive use of marine turtle eggs at Ostional, Costa Rica. Environmental Conservation **25**:305-319.

Campbell, L. M., B. J. Haalboom, and J. Trow. 2007. Sustainability of community-based conservation: sea turtle egg harvesting in Ostional (Cost Rica) ten years later. Environmental Conservation **34**:122-131.

Cantarelli, V. H. 1997. The Amazon turtles- Conservation and management in Brazil. Pages 407-410 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles- An International Conference. New York Turtle and Tortoise Society and WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Caputo, F. P., D. Canestrelli, and L. Boitani. 2005. Conserving the terecay (*Podocnemis unifilis*, Testudines: Pelomedusidae) through a community-based sustainable harvest of its eggs. Biological Conservation **126**:84-92.

CIA. 2007. The World Factbook.

CITES Secretariat. 2008. Convention on International Trade in Endangered Species of Wild Fauna and Flora: Species database. CITES Secretariat, Geneva, Switzerland.

Congdon, J. D., A. E. Dunham, and R. C. Van Loben Sels. 1993. Delayed sexual maturity and demographics of blanding's turtles (*Emydoidea blandingii*): Implications for conservation and management of long-lived organisms. Conservation Biology **7**:826-833.

Congdon, J. D., A. E. Dunham, and R. C. Van Loben Sels. 1994. Demographics of common snapping turtles (*Chelydra serpentina*): Implications for conservation and management of long-lived organisms. American Zoologist **34**:397-408.

Conway, K. M. 2004. Human use of two species of river turtles (*Podocnemis* spp.) in lowland eastern Bolivia. Page 162. Geography. The University of Florida, Gainesville.

Escalona, T., and J. E. Fa. 1998. Survival of nests of the terecay turtle (*Podocnemis unifilis*) in the Nichare-Tawadu rivers, Venezuela. Journal of Zoology (London) **244**:303-312.

Fachín Terán, A. 1994. Depredacion de la taricaya *Podocnemis unifilis* en la Reserva Nacional Pacaya-Samiria, Loreto. Boletin de Lima **XVI**:417-423.

Fachín Terán, A. 2005. Participacao comunitaria na preservacao de praias para reproducao de quelonios na reserva de desenvolvimento sustentavel mamiraua, Amazonas, Brasil. Pages 19-30. Uakari.

Food and Agriculture Organization. 1988. Las tortugas del río: Proposiciones para la recuperación y el manejo de dos valiosas especies. Flora Fauna y Areas Silvestres **Año 3**:23-29.

Fundación Amigos de la Naturaleza (FAN), and The Nature Conservancy (TNC). 1996. Plan de Manejo: Parque Nacional Noel Kempff Mercado, Bolivia in M. d. D. S. y. M. Ambiente, and D. N. d. C. d. l. Biodiversidad, editors, Santa Cruz, Bolivia.

Gibbs, J. P., and G. D. Amato. 2000. Genetics and demography in turtle conservation. Pages 207-217 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Heppell, S. S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia **1998**:367-375.

Heppell, S. S., and L. B. Crowder. 1998. Prognostic evaluation of enhancement programs using population models and life history analysis. Bulletin of Marine Science **62**:495-507.

Hope, R. A. 2002. Wildlife harvesting, conservation and poverty: the economics of olive ridley egg exploitation. Environmental Conservation **29**:375-384.

IUCN. 2000. World Heritage Nomination- IUCN Technical Evaluation, Noel Kempff Mercado National Park (Bolivia).

Johns, A. D. 1987. Continuing problems for Amazon river turtles. Oryx **21**:25'28.

Klemens, M. W. 2000. From information to action: Developing more effective strategies to conserve turtles. Pages 239-258 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

McDougal, J. 2000. Conservation of tortoises and terrestrial turtles. Pages 180-206 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Meylan, A. B., and D. Ehrenfel. 2000. Conservation of marine turtles. Pages 96-125 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Mittermeier, R. A. 1978. South America's river turtles: Saving them by use. Oryx **14**:222-230.

Moll, D., and E. O. Moll 2004. The Ecology, Exploitation, and Conservation of River Turtles. Oxford University Press, Oxford.

Moll, E. O., and D. Moll. 2000. Conservation of river turtles. Pages 126-155 in M. W. Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Muñoz, A. 2006. Los Pueblos Vecinos al Parque Nacional "Noel Kempff Mercado". Editorial FAN, Santa Cruz de la Sierra, Bolivia.

Ojasti, J. 1971. Un recurso natural impropiamente utilizado: La tortuga arrau del Orinoco. Defensa de la Naturaleza **1**:3-9.

Ojasti, J., and E. Rutkis. 1965. Operacion tortuguillo: Un planteamiento para la conservacion de la tortuga del Orinoco. El Agricultor Venezolano **26**:32-37.

Ross, J. P., S. Beavers, D. Mundell, and M. Airth-Kindree. 1989. The Status of Kemp's Ridley. Pages 34-40. Center for Marine Conservation.

Seigel, R. A., and C. K. Dodd, Jr. 2000. Manipulation of turtle populations for conservation: Halfway technologies or viable options? Pages 218-238 in M. W.

Klemens, editor. Turtle Conservation. Smithsonian Institution Press, Washington and London.

Smith, N. J. H. 1975. Destructive exploitation of the South American river turtle. Chelonia **2**:3-9.

Smith, N. J. H. 1979. Aquatic turtles of Amazonia: An endangered resource. Biological Conservation **16**:165-176.

Species Survival Commission. 2008. 2007 IUCN Red List of Threatened Species. International Union for Conservation of Nature and Natural Resources.

Thorbjarnarson, J. B., N. Pérez, and T. Escalona. 1997. Biology and conservation of aquatic turtles in the Cinaruco-Capanaparo National Park, Venezuela. Pages 109-112 in J. V. Abbema, editor. Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles-An International Conference. New York Turtle and Tortoise Society and the WCS Turtle Recovery Program, State University of New York, Purchase, New York.

Tortoise and Freshwater Turtle Specialist Group 1991. Tortoises and Freshwater Turtles: An Action Plan for Their Conservation. The World Conservation Union, Broadview, Illinois.

Townsend, W. R., R. Borman A, E. Yiyoguaje, and L. Mendua. 2005. Cofán indians' monitoring of freshwater turtles in Zábalo, Ecuador. Biodiversity and Conservation **14**:2743-2755.

Troeng, S., and E. Rankin. 2005. Long-term conservation efforts contribute to positive green turtle *Chelonia mydas* nesting trend at Tortuguero, Costa Rica. Biological Conservation **121**:111-116.

Turtle Conservation Fund 2002. A Global Action Plan for Conservation of Tortoises and Freshwater Turtles: Strategy and Funding Prospectus 2002-2007. Conservation International and Chelonian Research Foundation, Washington DC.

CHAPTER 7

CONCLUSIONS

Conservation Issues

In this dissertation I have addressed three interconnected conservation issues: (1) a broad ecological and conservation issue– how to integrate a locally-based theory of conservation with a science-based theory of conservation; (2) decline in two endangered species that is part of a larger threat to global biodiversity – worldwide decline in freshwater turtle populations; and (3) a specific conservation need – decline in local turtle populations in and near PNNKM, in the Bolivian Amazon.

I conducted my dissertation research in response to a general need, in subsistence-based regions, for initiatives that are local and can address both the scientific and social realms of conservation problems. By collaborating on a project initiated by people from local communities, I addressed the problem that many conservation efforts in subsistence-based regions fail because they do not address the needs and rights of local people. The project I presented is not only community-based, it was community initiated, as an effort by local people to mitigate decline in a natural resource on which they depend. Because the project is locally managed, its conservation goal, which is to mitigate decline in local *Podocnemis* populations, inherently addresses the subsistence needs of local people.

I also addressed the need for a science-based conservation theory, especially at the local level of community-based management. I created a science-based strategy for this project, which throughout every phase uses ecological study as a tool that directly informs management actions. By focusing on a science-based conservation strategy, I addressed a need specific to turtle conservation efforts worldwide – that conservation efforts have been largely ineffective at maintaining turtle populations, because they are not based in scientific study or an understanding of turtles' unique life histories (discussed in Chapter 2).

I presented the results of a combined ecological and social research program that was designed specifically to inform conservation efforts of *Podocnemis* turtles in PNNKM. Results of the research are specific to the region of study, but they might also apply to *Podocnemis* and turtle conservation efforts in other regions. I documented and suggested specific conservation needs to the species that are defined by *Podocnemis* life history traits. I described two species that have specific management needs, constrained by the long-lived life histories unique to freshwater turtles.

Both species likely cannot withstand high rates of mortality (e.g., human exploitation) in their adult phases, but they might easier withstand sustainable harvest of their eggs. I recommended management actions specific to local populations of the species that might mitigate the negative effects of human exploitation of the species. I provided the framework for an adaptive long-term Management Plan, which will later be defined by local community planning efforts. The Plan will use long-term ecological monitoring to evaluate the effects of subsistence-based harvest and protection schemes on local populations of the species. Because the final Management Plan will likely include actions for a low-level subsistence-based harvest of the species, ecological monitoring will be necessary to evaluate negative and/or positive effects on local populations. Evaluation of monitoring data, with an understanding of species specific life history traits, will inform a yearly updating of the Plan, as necessary, to ensure protection of the species.

As a collaborative effort that focused on local capacity building, this project has ensured the ability of local resource managers and residents to conserve important natural resources. It addresses a specific conservation need, of local resource managers and local people, in PNNKM, Bolivia. Capacity building combined ecological research, conservation training, and education efforts, in the communities, to build a project that is integrative and based on an understanding of the species and ecological and social conditions. This effort built a strong foundation for support of local conservation in general, and it promoted a communal understanding of the decline of turtle resource and factors contributing to this decline.

Project Results

During the first phase of this science-based approach to conservation, ecological and social research projects were designed and implemented to inform conservation and management actions for the species. Research investigated the local status of the species and threats to local populations. Results strongly supported my initial hypothesis: that human activity in the region had negatively affected local turtle populations. Social research documented local sentiment that agreed with this conclusion. Combined results strongly supported the need for management actions in PNNKM to protect and allow for recuperation of the species.

Research results described negative effects on local turtle populations, the need for conservation actions, and specific information (e.g., geographic-specific threats to the species) that can be addressed in the Management Plan. Threats include direct human exploitation, other threats in the environment (e.g., animal predators), and possible indirect negative effects of other human activities in the region (e.g., deforestation, river traffic).

Another important result of project research was the documentation of local support for the project, and a general consensus that management actions will be necessary to conserve turtles and to ensure their sustainable use in the future. Research documented local opinions and ideas for turtle management, and it described peoples' specific ideas for management actions and sustainable use projects. These ideas will be invaluable to informing specific management options chosen in the plan.

Future Work

All research findings presented here will be presented in local planning meetings to communities and PNNKM authorities. Recommendations and projection scenarios for different management actions will also be presented. This information will be evaluated to develop a management plan that strikes a balance between subsistence-based communities' rights to govern their natural resources, and the maintenance of healthy turtle populations, based on long-term ecological study that monitors population viability. Management planning will focus on specific regulations for controlling use of the species, questions to be addressed in future research programs, and the identification of alternative food and income sources within communities, especially those sectors that rely completely on turtle hunting for survival.

Specific objectives and activities of the next phase of the project include: (1) Create and implement a long-term, scientifically-informed, and community-based Species Management Plan; (2) Continue ecological study of *Podocnemis* populations, their threats, and local consumption, in the long-term, in PNNKM and all local communities; (3) Continue social research of local impressions of turtle populations and opinions and ideas for the conservation project; (4) Implement research investigating possible climatic and human land use effects on the species; (5) Continue capacity building of local resource managers in species monitoring and conservation; (6) Continue education of local students in project research and conservation activities; and (7) Search for local alternatives to turtle hunting behavior.

Conclusion

The direct goal of the local institution-building program described here is the conservation of natural resources that people depend on. The direct application of the work I presented will be to inform the community-based *Podocnemis* Management Plan in PNNKM. I described a conservation strategy based on ecological research, conducted entirely by local residents, that works to improve the capacity of local resource managers to effectively conserve their natural resources. Locally-based management of natural resources, by the local human populations that depend on them, is not only a more equitable option in conservation planning, it is likely the only management scheme that can be effective in areas where monetary and professional (e.g., scientific, enforcement) resources are scarce. Just as important is the recognition that for community-based (or any) conservation initiatives to be effective, they must be based in ecological research that can clearly explain the conservation problem, inform management actions, and lastly, allow for evaluation of effectiveness of the program.

In conclusion, I report an effort in conservation planning, where local people, scientists, and national park management are working together to create a plan for conservation of an endangered resource. A national protected area strategy has been combined with local knowledge and science, to create a plan for conservation that will be strong on all fronts, and most importantly- to create a plan that will be implemented because it is supported locally. Drawing from the case study of *Podocnemis* turtle conservation in PNNKM, Bolivia, I present a practical conservation strategy – one that is locally-based, science-based, low-cost, supported by local government, and requires only minimal and short-term outside support. It is a strategy that could be relevant, not only to other turtle conservation projects in the region, but to other conservation projects in subsistence based regions, where lack of funding and support for conservation often causes people to unknowingly over-exploit the natural resources on which they depend.