The Impact of Subsistence Hunting by Tikunas on Game Species in Amacayacu National Park, Colombian Amazon

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ABSTRACT

Subsistence hunting has been identified as a global conservation issue not only for the stability of tropical ecosystems, but also for securing the long-term livelihood of local people. Little is known about the impact of subsistence hunting by indigenous people within protected areas and on indigenous land. This community-based research provides baseline information on the sustainability of hunting by two Tikuna indigenous communities overlapping Amacayacu National Park, Colombian Amazon. During 2005-2009, game species' densities and biomasses were determined using transect sampling methods, with 2,262 km of census effort, while simultaneously monitoring the hunting rate of game species. A total of 2,101 prey items were hunted, corresponding to 49 species of vertebrates. The sustainability of hunting was calculated for the 10 most hunted species using qualitative as well as quantitative approaches. The quantitative approach included four models: density/standing biomass model, the production model, the stock-recruitment model and the unified-harvest model. The results suggested that eight game species were overhunted. Furthermore, primate biomass was significantly higher in the Tikuna community where a hunting ban for woolly monkeys has been applied (Mocagua 398 kg/km^2; San Martin 199 kg/km^2). In addition, I present a case study on the illegal trade in night monkeys for biomedical research in the Brazil-Colombia-Peru tri-border area. The implications of subsistence hunting for harvest-sensitive game species are discussed considering their life history traits and ecological constraints. Bearing in mind the importance that wildlife has in local people's livelihoods, I present an ethnographic description of past and current hunting patterns by Tikunas in order to gain a better understanding of the factors underlying the current use of wildlife. Attempts to implement a management strategy for using natural resources in Amacayacu National Park had failed. This study highlights the importance of a multidisciplinary approach when designing management strategies. It also provides sustainable alternatives for the conservation of the overharvested species. Ultimately, the implementation of the proposed management strategy is only possible if local stakeholders are willing to take action. Thus, this study may be use as the baseline for its design.

To the memory of Alex, Jan, Nomy and Gordy

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LIST OF ABREVIATIONS AND ACRONYMS

ANP	Amacayacu National Park
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COAMA	Consolidation of the Colombian Amazon
COP	Colombian Pesos
Corpoamazonia	Corporación para el Desarrollo sostenible del Sur de la Amazonía Colombiana – Corporation for the Sustainable Development of the Southern Colombian Amazon
FAO	Food and Agriculture Organization of the United Nations
FARC	Fuerzas Armadas Revolucionarias de Colombia – Revolutionary Armed Forces of Colombia
FIDIC	Fundación Instituto de Inmunología de Colombia – Colombian Institute of Immunology
GPS	Global Positioning System
IDEAM	Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia – Colombian Institute of Hydrology, Meteorology and Environmental Studies
IGAC	Instituto Geográfico Agustín Codazzi – Agustín Codazzi Geographical Institute
IIAP	Instituto de Investigacions de la Amazonia Peruana (Research Institute of the Peruvian Amazon)
IIED	International Institute for Environment and Development
INCODER	Instituto Colombiano de Desarrollo Rural. Colombian Institute for Rural Development
IUCN	The International Union for Conservation of Nature
K	Carrying Capacity
M	Mean
MPH	Maximum Production Harvestable
MSY	Maximum Sustainable Yield
NGO	Non-Governmental Organisation
OBS	Ome Biological Station
OH	Observed Harvest

P	Production
PD	Perpendicular Distance
PNNA	Parque Nacional Natural Amacayacu – Amacayacu National Park
RAINFOR	Amazon Forest Inventory Network
SD	Standard Deviation
SINCHI	Instituto Amazónico de investigaciones científicas (Amazonian Institute for Scientific Research-Colombia)
SPSS	Statistical Package for the Social Sciences
TEK	Traditional Ecological Knowledge
TICOYA	Tikuna, Cocama and Yagua indigenous authorities
UAESPNN	Unidad Administrativa Especial del Sistema de Parques Nacionales Naturales de Colombia – Colombian Park System
UNDP	United Nations Development Programme
USD	United States Dollars
WWF	World Wildlife Fund

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1. INTRODUCTION

The Amazon is the largest continuous tropical forest on earth and one of the most intact tropical ecosystems owing to its lower rate of species extirpation [see Fragoso et al. 2004; Laurance 2006]. Nonetheless, Amazonian rainforests provide crucial resources for their human inhabitants, such as food, medicine, shelter, tools and income when those resources are commercialised [Laurance and Peres 2006; Naranjo et al. 2004; Robinson and Redford 1991a]. Currently, the harvest of wildlife for subsistence and commercial purposes represents one of the greatest threats for large vertebrates in the neotropics [Bodmer 1995a; 1995b; Laurance et al. 2006]. The present patterns of wildlife extraction have to be modified in order to prevent the extinction of sensitive species that owing to their ecological and biological constrains cannot supply an ongoing and increasing harvest [Bodmer et al. 1997; Robinson 2000; Robinson and Bodmer 1999; Zapata- Rios et al. 2009].

In addition, the selective removal of top predator and medium- and large-sized species can have catastrophic consequences for the structure of the ecosystems [Laurance et al. 2006; Laurance and Useche 2009; Peres 2000a; Wright 2003]. For instance, an implication of overhunting is that plant species that previously relied on large-bodied vertebrates as seed vectors may be poorly dispersed, thus causing an increased density-dependant seed or seedling mortality [Laurance et al. 2006; Peres and Palacios 2007; Terborgh and Nunez-Iturri 2006]. Such changes may alter plant community composition, causing a decline of animal-dispersed plants and compensatory increases in abiotically dispersed species [Jansen and Zuidema 2001; Laurance and Peres 2006]. Many large-seeded trees and liana species depend on large bodied primates such as woolly monkeys (*Lagothrix* spp.) and spider monkeys (*Ateles* spp.) for dispersal, as a number of these require passage throughout the primate gut to stimulate germination [Laurance et al. 2006; Stevenson 2000a; 2000b; 2002a; 2002b; Stevenson and Aldana 2008; Terborgh and Nunez-Iturri 2006].

On the other hand, the use and management of wildlife has to be improved in order to maintain viable faunal populations, as well as to guarantee the long term survival of indigenous people and their traditional diet [Silvius 2004; Townsend 2000]. However, until now the scale and success of management options have yet to demonstrate robust and replicable conservation results [Niesten and Rice 2006]. Alternative mechanisms have to be explored in order to mitigate the exploitation and development of tropical forests, thus providing governments and local stakeholders with direct benefits for conserving and maintaining biodiversity [Niesten and Rice 2006]. Furthermore, any management approach has to include a clear rational acknowledging the biological limitations of harvested species and an accurate socio-cultural and economic profile of the human population using the resources.

This study provides baseline information for the design of a management strategy for eight game species that have been severely decimated due to subsistence and commercial hunting by Tikuna indigenous people located near or inside the Amacayacu National Park (ANP). I use an interdisciplinary approach, including ecology and social anthropology. Additionally, I provide preliminary information on the feasibility of sustainable alternatives that might reduce economic dependence on extraction of resources. This baseline information will be presented to the Colombian Park System and the TICOYA Indigenous organisation (indigenous authority in the area).

1.1. Specific Aims

1.1.1 To estimate the density of primates and other large mammals in areas of ANP that overlap with the indigenous territories of Mocagua and San Martin Tikuna communities

2.1.1 To assess the abundance of important plant species for human use and wildlife consumption using a rapid plant assessment combining traditional ecological knowledge and scientific plant taxonomy

3.1.1 To quantify the harvest of wildlife through the use of participatory Methods

4.1.1 To assess the impact of subsistence hunting on harvest-sensitive vertebrate fauna, and to determine whether hunting is sustainable

5.1.1 To identify the socio-cultural and economic aspects influencing hunting by Tikunas

6.1.1 To quantify the illegal trade of night monkeys in the Brazil-Colombia-Peru tri-border area

7.1.1 To provide baseline information on the conservation status of the eight most preferred game species for the design of a management strategy currently being developed by the ANP and the indigenous communities

1.2 Structure of the Thesis

This thesis is divided into seven chapters. Chapters 1, 2 and 7 are presented in a conventional thesis structure, while the results chapters (3, 4, 5 and 6) are presented in the form of journal articles. I decided to combine those structures as this thesis covers a variety of topics that although related, have different rationales and methods.

Several authors have emphasised that despite the effects that subsistence hunting has on wildlife populations, there are other environmental factors that drastically affect the structure and primary productivity of most tropical forests [Laurance et al. 2006; 2008; Terborgh 1983b]. Thus, soil fertility, rainfall, forest type and structure, floristic composition, fruit production and distribution of keystone plant resources, are key determinants of vertebrate communities and should be taken into account when determining the sustainability of hunting [e.g. Defler 2004; Eeley and Lawes 1999; Kay et al. 1997; Peres 2000b; 2008; Peres and Janson 1999; Terborgh 1983a; 1985]. Chapter 2 on the study site provides a summary of the edaphic and rainfall characteristics in ANP. In addition, it includes a plant assessment carried out with Tikuna co investigators using a combination of Traditional Ecological Knowledge (TEK) and scientific/western plant taxonomy. Bearing in mind the importance that plant species have in local people's livelihoods and in resource availability for wildlife populations (Appendix I), this chapter provides a pictorial guide for Tikuna co-investigators and students (volunteers during the research) on the most important plant species (Appendix II). This guide is in Spanish as it is currently used as a learning resource at local level. This chapter also describes the human population and provides a summary of the current process of resources management by ANP and the Tikuna communities.

In order to provide reliable estimates of the sustainability of hunting, it is crucial to have baseline information on the ecology of wildlife populations at local level. In Chapter 3, I present densities and biomasses for the 15 most preferred game species. However, ecological information was only available for 10 game species. Annual harvest and annual production for these species was calculated in order to determine the sustainability of hunting. Hunting core areas for each indigenous community are also presented. I explore the implications of subsistence hunting on game species taking into account their life history traits and reproductive constraints (Appendix III). I also provide a glossary section with the definitions of technical terms and formulas that are not fully explained within the thesis (Appendix IV). In addition, I define terms that could be interpreted ambiguously (e.g. the use of the term community, when referring to humans or wildlife populations). I conclude this chapter by presenting a qualitative density comparison with other sites in the Amazon basin exposed to similar degrees of hunting and with comparable environmental characteristics.

In Tikuna culture, primates played an important role in their traditional diet; for example, the woolly monkey (*Lagothrix lagothricha*) was one of the most preferred species due to the taste of its meat and the skin was used for the elaboration of drums, specially made for traditional festivities [Parathian and Maldonado 2010]. Owing to their extremely low reproductive rates, woolly monkeys are one of the first species that can become locally extinct as a result of hunting [Defler 2004; Di Fiore and Campbell 2007; Mena et al. 2000; Peres 1990a; 1991]. In Chapter 4, I present a description of the primate assemblage in the overlapping territory between the two Tikuna communities and ANP. In addition, I provide a preliminary assessment of a hunting ban on woolly monkeys applied by one of the Tikuna communities as a locally-based management initiative, and its short term effects on woolly monkey populations.

Bearing in mind the relevance of anthropogenic factors affecting the use of resources when several actors are involved, in Chapter 5 I illustrate the sociocultural changes affecting the sustainability of hunting by Tikunas in ANP. In this chapter, I provide a qualitative analysis of hunting patters as well as current views of wildlife utilisation by 46 expert hunters. In addition, I present a summary of local people's description of the reproductive patterns and lifespan of their preferred game species. Qualitative data were obtained throughout the implementation of ethnographic methods such as interviews, participant observation and focus group (workshops). People's perceptions of wildlife are explored in order to gain a more complete understanding of human-wildlife interactions and to identify the inclination for sustainable resource management by local people.

Although some primate species naturally occur in small populations because of diverse constraints on abundance and distribution, other species' populations have been diminishing, owing to the anthropogenic effects of habitat disturbance, introduced species, and secondary extinctions [e.g. Cowlishaw and Dunbar 2000; Peres and Michalski 2006; Wright and Jernvall 1999]. Moreover, consumptive utilisation has a tremendous impact on primate populations, and has been driving several populations to extinction [e.g. Mittermier 1987; Peres 1990a; Stevenson and Aldana 2008; Stevenson et al. 2005]. The most common consumptive uses of primates are: subsistence hunting, the trading of live primates for biomedical research, trade in primate parts for medical purposes and ornamental uses, and the pet trade [Cowlishaw and Dunbar 2000; Held and Wolfle 1994; Maldonado et al. 2010; Smith 1978]. In Chapter 6 I present a case study of the illegal trade of night monkeys (*Aotus* spp.) in the Brazil-Colombia-Peru tri-border area. This chapter exposes the violation of, and the failure to adhere to, CITES international trade regulations. To conclude, I provide recommendations to restrain the illegal trade of night monkeys.

After numerous experiences of locally-based management strategies throughout tropical rainforests, there are several lessons which have proven that monitoring during the management strategy has to be continuous over time otherwise the strategy will fail [e.g. Garcia and Lescuyer 2008; Poulsen and Luanglath 2005; van Rijsoort and Jinfeng 2005]. A summary of the most common causes of failure are: i) the income resulting from monitoring and protecting biodiversity does not ensure an appropriate monetary return for local people [Fraser et al. 2006]; ii) the monitoring system does not provide clear guidelines for adaptive management at local level [Garcia and Lescuyer 2008];

iii) change of institutional agreements due to the transfer or the promotion of an official [Garcia and Lescuyer 2008; Ulloa et al. 2004]. In Chapter 7, I provide general conclusions and recommendations for the design of a management strategy addressing three management goals: species conservation, ecosystem health and human livelihoods. I conclude this chapter with the description of feasible economic alternatives that might be implemented at a local level, in order to decrease the commercialisation of natural resources as a way to obtain cash income.

1.3 Origin of this research

In 1998, when a juvenile male woolly monkey was confiscated from the illegal trade in the southern Colombian Amazon, I had the opportunity to return it into the wild. The *in-situ* rehabilitation process was carried out in Caparu Biological station, in Vaupes, middle Caqueta River, Colombia. The logistical support was offered by Dr. Sara Bennett and Professor Thomas R. Defler, who were the directors of the biological station at that time. The male woolly monkey was successfully integrated into a wild troop of woolly monkeys [Maldonado and Botero in press.]. One month after I left Caparu, the Colombian Guerrilla group FARC (Revolutionary Armed Forces of Colombia) invaded the station, burned books and research data from Defler and Bennett and threatened to kill Defler, who managed to escape.

As a result of the FARC's incursion in Caparu, the station was left without any human presence and I assumed the management of Caparu. I spent almost three years in Caparu rehabilitating monkeys and working alongside the local indigenous communities. Sara Bennett decided to stay in Colombia and went to ANP in 2001. The evident degradation of natural resources in ANP (in comparison with Caparu) made her decide to stay and implement a community-based project with Tikuna people living in and nearby ANP. The aim was to protect one of the most threatened bird species in the area, the wattled curassow (*Crax globulosa*). Bennett invited me to ANP and asked me if I would be interested in leading the assessment of primate populations in the area.

In 2003, I submitted a research project to the Tikuna communities and the ANP, which was approved. A research permit by the indigenous authorities and the Colombian Park System was granted. This participatory research project started in 2005 and the research team was composed of local hunters, volunteers and myself. In 2007, I decided to establish a local NGO in Leticia (capital of the Colombian Amazon). Entropika Foundation was formed by a group of people that had been working in the area for environmental organisations, the park system and indigenous organisations. Currently, Entropika Foundation has one of the most complete databases on wildlife densities in ANP and the Calderon basin area (buffer zone of ANP). Since February 2010 we have extended our research to the Peruvian side of the Amazon River to monitor the illegal trade of natural resources.

1.4 Wildlife Management in the Neotropics: An Overview

Several studies throughout the neotropics have measured the impact of subsistence hunting by indigenous people within their territory and protected areas using two resource management approaches: biological (wildlife conservation) and anthropological (local people's livelihoods) [e.g. Bodmer et al. 1997; Bodmer and Robinson 2004; Peres and Nascimento 2006; Silvius 2004; Townsend 2004]. The biological management approach aims to determine the sustainability of hunting based on Maximum Sustainable Yields (MSY) of game species. Thus, in order to obtain the MSY, it is critical to acquire detailed information on the ecological traits of wild populations of game species such as: reproductive productivity, life span, densities and biomasses (at sites with and without human intervention), hunting areas and source-sink dynamics (see Appendix IV), amongst others factors [e.g. Bennett and Robinson 2000; Bodmer 1990; 1994; 1995a; 1995b; Dillehay 1997; Gavin 2007; Mena et al. 2000; Novaro 2000; Peres and Dolman 2000; Peres and Palacios 2007; Redford 1987; Robinson 1993; 2001; Robinson and Bennett 2000; Robinson and Redford 1986b; 1991a; Siren et al. 2004; Smith 2005]. Nonetheless, most of the calculations provided by this approach do not fully address the importance that wildlife has on local people's lifestyle and livelihoods.

The anthropological/social management approach examines the subsistence of hunting by Amerindians looking at the socio-economic and cultural changes that modern indigenous cultures have had after contact with western economies, cultures and religions. Sedentarism, population growth, market involvement and the acculturation of hunting practices had been the most common factors affecting hunting presented by this perspective [Alvard 1993; 1995; Campos-Rozo 1987; 1996; Stearman 1984; 1990; 1995; Townsend 1996; Vickers 1994]. However, in most cases this approach does not include crucial information on local wildlife ecology, as densities and biomasses are obtained from published literature, leaving open questions about the accuracy of the definition of the sustainability of hunting.

Since the late 1970s the main goal of wildlife management was envisioned as "*maintaining hunted populations while allowing human hunting*" [Caughley 1977]; the accomplishment of this goal depends on several factors. Bennett and Robinson [2000] summarised those factors as: i) harvest must not exceed production; ii) the management goals should be clearly specified, and iii) the biological, social, and political conditions must be in place to allow effective management. Thus, management of resources might be in the national interest but may be incompatible with governmental, regional or local management agendas and economic interests. Therefore, wildlife management has become one of the most challenging and urgently needed conservation strategies. By the 1980s, several conservation organisations began to develop new strategies designed to turn local communities into allies of conservation with a special focus on those who live near or inside protected areas [e.g. Hutton and Dickson 2001; Niesten and Rice 2006; Weber et al. 2000; Zimmerman et al. 2001].

Different approaches were implemented such as: i) creation of low-intensity development around protected areas that could act as a barrier to colonisation; ii) involvement of local people in wildlife management in ways that gave them a tangible chance to preserve ecosystems around and inside protected areas and/or their territory; iii) sustainable development that merged income generation and conservation [Larson et al. 1996; Niesten and Rice 2006; Weber et al. 2000]. It has been clear that working with indigenous people involves complex issues that might be tackled, but long-term involvement from external stakeholders is crucial in order to monitor and follow up conservation strategies. In addition, it became apparent that management strategies implemented by outsiders without the active involvement of local people rapidly fail [Bodmer et al. 1994; Fragoso et al. 2000; Irvine 2000; Townsend 2000; Ulloa et al. 2004; Zimmerman et al. 2001].

1.5 Previous Case Studies in the Neotropics

In ANP a few short term studies provided preliminary information on hunting extraction by Mocagua and/or San Martin Tikuna communities [e.g. Arias and Castellanos 2000; Barrera et al. 2008; Campos-Rozo 1987; Gomez and Lozano 2000; Sanchez 2006; van Leijsen and Vleut 2005]. Below I review two examples of collaborative studies, where indigenous people and scientists designed and implemented a management strategy with a degree of success. The following cases are relevant to this study as socio-cultural, ecological and/or political conditions are similar.

1.5.1 Case study I: Emberás in Utría National Park, Colombia

The Emberá indigenous group has a human population of approximately 70,000 inhabitants. They are located along the main headwaters of the rivers that drain into the Colombian Pacific Ocean. Their indigenous territories overlap the Utría National Park [Ulloa et al. 1996; 2004]. The Emberá had a very strong relationship with their territory, where hunting and land cultivation were supervised by spiritual deities who advised their shaman or *Jaibaná* (who could be a man or women) how to use the land and wildlife. The survival of the Emberá in their territory is currently threatened by several impacts such as the catastrophic cultural changes in their society, followed by the depletion of wildlife, especially the white-lipped peccary (*Tayassu peccary*) and the local extinction of game species such as the Bairdi's tapir (*Tapirus bairdii*). In the Emberá mythology, the white-lipped peccary determines the abundance or scarcity of species and it is the main mediator between nature and the *Jaibaná*. During three periods of research (1990-1992; 1994-1996 and 1997 onwards), an interdisciplinary group assessed the way Emberá people use wildlife, and then aimed to implement a management strategy [Ulloa et al. 2004].

This participatory assessment involved important stakeholders such as representatives of three Emberá indigenous territories, representatives of the ministry of the environment (the Colombian Park System), one regional indigenous organisation (OREWA) and one Colombian NGO funded by international organisations. The selected management alternatives were based on indigenous knowledge and local needs, law environmental policies and baseline information on hunting pressure. However, this project did not include an assessment on wildlife populations. A comprehensive management strategy was defined, and implemented by a couple of Emberá villages, but owing to the unstable socio-political situation in the area, where illegal armed groups are in a dispute over the control of territories for coca (*Erythroxylum coca*) plantations, this management plan has not yet been implemented at a regional level [Campos-Rozo et al. 1996; Ulloa et al. 1996; 2004]. Nonetheless, this participatory assessment has been one of the most relevant examples in South America, where local people's needs and sociocultural contexts were the basis for the design of the management strategy, and monitoring is currently being applied.

1.5.2 Case study II: The Xavante of Rio das Mortes, Brazil

The Xavante indigenous group has a human population of approximately 9,000 inhabitants and their indigenous territory, Rio das Montes reserve, is located in the Mato Grosso state of Brazil and it has an area of 3300 km². During the late 1980s, after Xavante people noticed the decline of game populations in their land they contacted the WWF-Brazil for advice. From 1991 to 1993, Leeuwenberg [1994 in Leeuwenberg and Robinson 2000] collected baseline information on wildlife populations and its hunting impact by the Xavante. Following research during 1995-1997, Fragoso et al. [2000] designed a management plan for game species, based on the preliminary data obtained by Leeuwneberg and his study [Graham 2000; Silvius 2004]. Both studies indicated that five game species were threatened or vulnerable to overhunting: the giant anteater (*Myrmecophaga tridactyla*), the giant armadillo (*Priodontes maximus*), the marsh deer (*Blastocerus dichotomus*), the pampas deer (*Ozotoceros bezoarticus*) and the tapir (*Tapirus terrestris*). Moreover other game species such as the collared and the white-lipped peccary, the brocket deer, the paca and the black agouti presented stable populations and researchers did not identify any other threat for those species [Fragoso et al. 2000; Leeuwenberg and Robinson 2000].

The management plan designed by Fragoso et al. [2000] included an assessment of three forests located at different distances from the community, in order to test source-sink dynamics (see Appendix IV for definition). The rationale of this strategy is that if animals are abundant at distant areas from the human communities, animals may move into the hunted areas to provide a low but constant supply of game species. The management strategy suggested a hunting ban for the giant anteater and the giant armadillo until their populations recovered. For the rest of the overhunted species recommendations included hunting at distant forests until closer forests recovered, followed by a shift of hunting to those forests, to allow source-sink dynamics to maintain game populations. For the other game species with stable populations (e.g. collared peccary, brocket deer and smaller species) hunting was recommended to be maintained at current or higher levels in all of the three forests [Fragoso et al. 2000].

The Xavante management decision differed from the recommendations made by Fragoso and colleagues. Their management strategy was based more on designating wildlife refuges taking into account geographical boundaries, rather than in implementing hunting bans or restrictions for particular species. In an attempt to identify the basis of the Xavante's management plan, Silvius [2004] searched for historical data on past hunting preferences or number of harvested prey. Furthermore, Silvus concluded that changes in game populations, increasingly sedentary life and cultivation, and a recent reclamation of a traditional hunting culture, were the main factors influencing the Xavante's management decision. Therefore, the differences between the management recommendations of the biologists and the final Xavante choice are practical and biological rather than cultural [Silvius 2004]. Although a management plan has been formally signed between the Xavante and WWFBrazil, Silvius [2004] stated that if the initial analysis made by the biologists included, from the beginning, the approach implemented by Ulloa et al. [2004] with the Emberás in

Colombia, it would increase the coherence of the management strategy and facilitate decision making amongst stakeholders.

2. THE STUDY SITE

This chapter is divided into three main sections: a general description of the study area including aspects such as geographical location and climatic patterns (precipitation, temperature and annual levels of the Amazon River). I include an overview of the principal geological units of ANP and a description of soil types and vegetation, bearing in mind the importance that these environmental variables have on the total forest productivity. This section also includes the information provided by a rapid plant assessment which combines TEK and scientific plant taxonomy in order to identify important plant species for wildlife consumption and human use. The second section includes a broad description of the studied human population: the Tikuna ethnical group, Mocagua and San Martin indigenous communities. The third section presents an outline of the current context of resources management for the overlapping areas between the ANP, Mocagua and San Martin indigenous territories.

2.1 Amacayacu National Park

2.1.1 Geographic location, climate and soils

ANP was established in 1975 and it is the only protected area located in the extreme southern part of Colombia at 3º02'–3º47'S and 69º54'–70º25'W, in the municipality of Leticia, Amazonas Department. In 1928, Colombia and Peru signed the treaty Lozano-Salomon where it was conceded to Colombia a small portion of land, which corresponds to the only fraction of Colombian territory with access to the Amazon River [Zarate 2008]. This area is known as the Colombian trapezium (Trapecio Amazonico) and includes 116 km of the Amazon River. The creation of ANP was carried out bearing in mind the importance of the Colombia trapezium and its strategic geographical location, and the urgency for monitoring the illegal trade of natural resources carried out between the frontiers with Peru [PNNA 2006].

ANP covers 2,940 km² of rainforest and varies in elevation from 80 to 200 m (Fig. 2.1). Based on the records from the Vasquez Cobo and Puerto Nariño climatological stations between 1997 and 2007, the rain regime is unimodal-biseasonal with a multi-annual average precipitation of 3,270 mm and with a monthly average of 266 mm (IDEAM, unp. data) (Fig. 2.2). The lowest rainfall is registered in August, with an increase in September and then it increases considerably from January to April, the wettest month of the year [Rudas et al. 2005]. The level of the Amazon River reaches its maximum level in May (1,686 cm) and drops to its lowest level in September (445 cm) [IDEAM, unp. data] (Fig. 2.3). The average temperature is 26.2 ºC and the average relative humidity is over 86%. [Rudas 1996] describes that the evapotransportation does not fluctuate significantly during the year, and its relation with the precipitation regime makes a super humid, mega thermal climate without water deficiency.

The Amazon basin encompasses a vast depression between the Guyana Shield and the Brazilian Shield. As a result of the consolidation and folding of these shields, three arches were shaped: the Iquitos, Purus and Gurupa Arches [Daly and Prance 1989]. The fact that ANP is located between two of these areas of subsidence, which are considered to have kept several fractions of the Amazon basin isolated during marine transgressions, gives the study area particular geographical significance [Rudas et al. 2005]. The principal geological units of ANP are the Pebas formation, the Amazon formation and the Quaternary alluvial deposits [Herrera 1997]. The Pebas formation covers most of the park's area, distributed mainly at the north and south. It consists mainly of mud deposits with parallel planar stratification, with clay, sand and sandy-clay elements. The terrain is generally undulating and uniform.

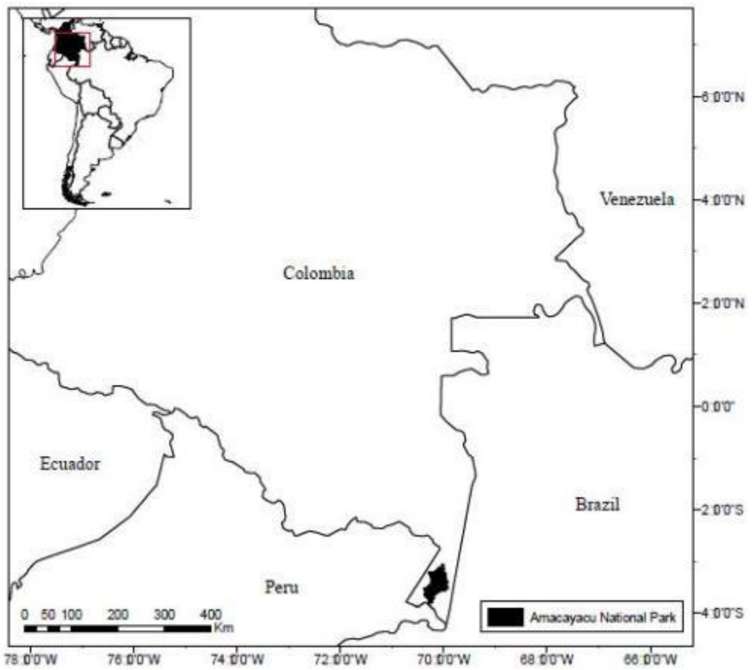

Figure 2.1 Location of the study site. Map of Colombia and ANP

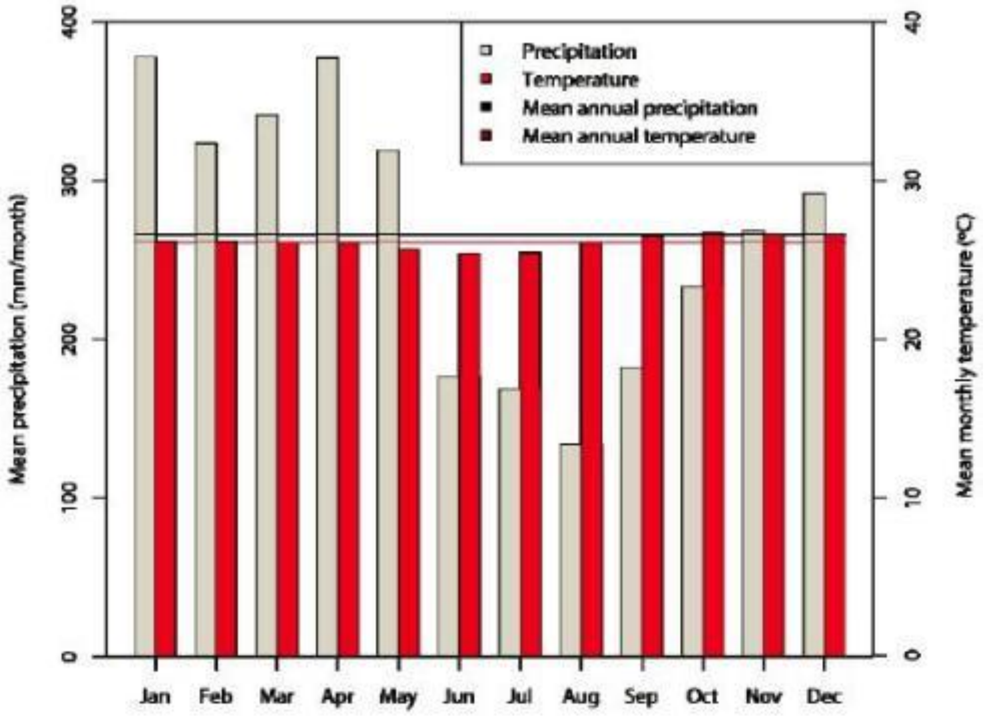

Figure 2.2 Temperature and monthly rainfall -average based on the records from the Vasquez Cobo (Leticia) and Puerto Nariño climatological stations between 1992 and 2007. Raw data provided by the IDEAM.

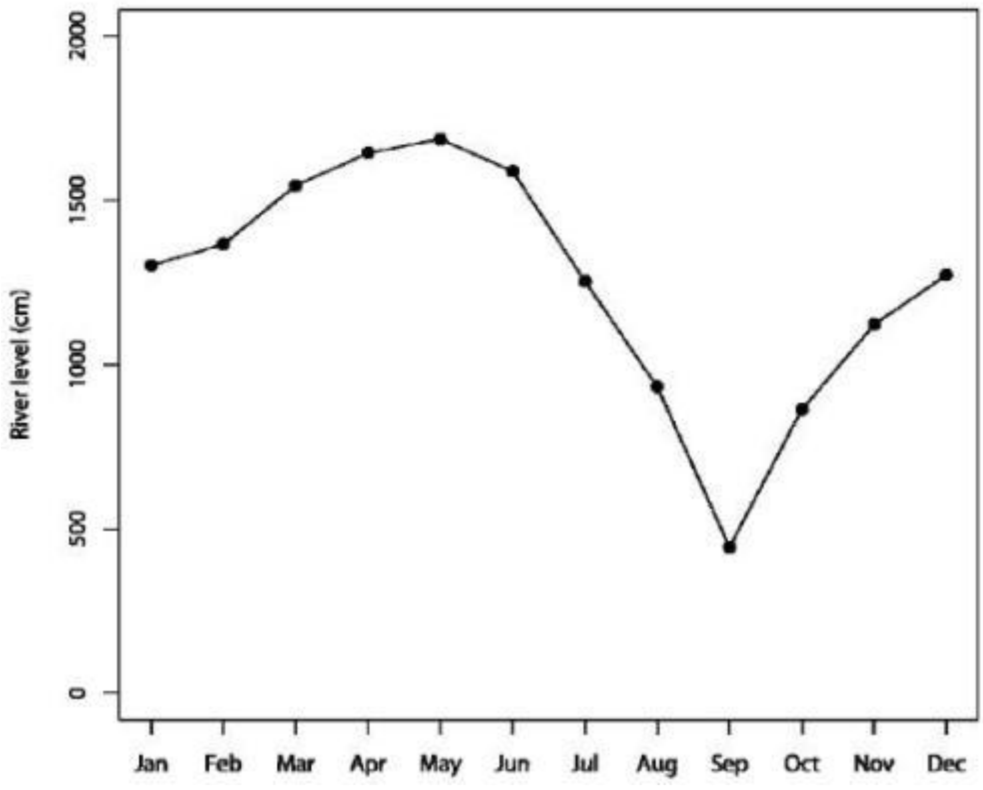

Figure 2.3 Monthly variation of the level of the Amazon River for a ten year period (1998-2007).

Data collected at the Vasquez-Cobo meteorological station in Leticia. Raw data provided by the IDEAM.

The Amazon formation consists of an oligomictic conglomeration with a high content of iron oxides, which covers the middle and east part of the ANP, presenting a dissected surface. The Quaternary deposits, forming the alluvial plains of rivers, creeks and streams, are characterised by flat terraces that are usually poorly drained. The soils contain sand, from fine to medium grain, mud and clays [Rudas et al. 2005]. Sombroek [2000] described the western Amazonian lowlands as infertile soils (ultisols and entisols), on sediments derived from the Andean cordillera by fluvatile deposition in the Pleistocene or earlier. The results of the chemical analysis of soils in ANP report that the soils in the southern part of the park, *Terra-firme* forests present a clayey texture with variations to silty clay loam (Fig 2.4) (Table 2.1) [IGAC 1997a; Rudas et al. 2005].

Table 2.1 Summary of chemical soil analysis in ANP [Rudas et al, 2005]

Sample ID	**pH H2O**	**pH 0.1M KCl**	**Bray's phosphorus**	**Exchangeable**				
				Ca	**Mg**	**Na**	**K**	**Al**
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
ANP1	4.34	3.76	2.75	129	36	<10	55	577
ANP2	4.32	3.74	3.89	138	48	<10	57	700
Average	**4.33**	**3.75**	**3.32**	**134**	**42**		**56**	**638**

Data source: A. Prieto.

Figure 2.4 Soil sample from the Sou thern part of ANP (Photo source: A. Prieto).

2.1.2 General vegetation and water types

The Amazon rainforest contains the world's greatest terrestrial concentration of biodiversity and carbon, with approximately 30,000 plant species [Gentry 1982]. Nevertheless, the rainforests from South America remain largely unknown and large scale biogeographic patterns and processes have only recently begun to be described [Ter Steege 2003; Terborgh and Andersen 1998]. Rudas et al. [2005] carried out a floristic analysis at ANP and recorded a total of 1,482 vascular plant species grouped into 606 genera and 133 families. In this analysis, 82% of the species are dicotyledons, 14% monocotyledons, 4% pteridophytes and less than 1% are gymnosperms. A richness analysis at tree family level revealed that these account for most of the biomass in the vegetation, where the Leguminosae dominate with 93 species, followed by the Annonaceae (42 species), Lauraceae and Moraceae (33 and 32 species respectively). Shrubs are mainly represented by the family Rubiaceae (64 species), followed by the Melastomataceae (34 species), Arecaceae and Piperaceae (17 and 15 species, respectively). High ground forests, located in non-flooded environments, are identified as *Terra-firme*. This type of forest, restricted to well drained soils typified as nutrient-poor due to its lack of alluvial sediments, have been described as rich in floristic species [Haugaasen and Peres 2006; Terborgh 1992b]. Three basic types of watercourses in Amazonia had been classified by Daly and Prance [1989]; white waters, black waters and mixed waters:

i) White Waters: drain from the Andes and circulate through the upper Amazon basin. This alkaline and turbid water transports heavy sediments making its flooded forest relatively fertile, clay soils (Fig. 2.5). The floodplain forest located along white water rivers are known as *Várzea* forest, covered by successional vegetation that is exposed to seasonal inundations during the rainy season. Junk and Piedade [1993] described *Várzea* as remarkably productive eutrophic forest, owing to its seasonal influx of nutrients. Nonetheless, several studies carried out in the Brazilian Amazon suggested that floristic and faunal diversity found in *Várzea* forest are consistently lower than those of *terra-firme* forest [Haugaasen and Peres 2005a; 2005b; Peres 1997].

Figure 2.5 The Agua Blanca creek (white water) during the rainy season.

ii) Black waters: flow between the Andes and the Guyana shields; the dark water colour is due to humic acids derived from sandy plains that are poor in nutrients or oligothrophic [Rudas et al. 2005]. Consequently, *Igapó,* the type of forest flooded by black waters, is typically poor in nutrients and has low productive potential [Furch 1997], resulting in lower levels of plant species and faunal biomass as reported by Valle-Ferreira [1997] in Central Amazonia (Fig. 2.6).

iii) Mixed waters (also called clear waters), are the result of the inflow of black and white water river courses, such as the Amacayacu river and Mata-mama creek, which are the adjacent water sources draining the four study sites of this research [IGAC 1997b; Rudas et al. 2005].

Figure 2.6 The Purite river (black water) during the rainy season.

2.1.3 Fauna

The forest mosaic presented in ANP sustains a high assemblage of vertebrate fauna, including more than 150 terrestrial mammal species, four aquatic mammal species and 468 bird species of the 500 species reported for the Colombian Amazon [Alberico et al. 2000; Defler 2004; PNNA 2006]. Of the twelve primate species known in the park, only nine species were found at the southern part of ANP. Table 2.2 shows the list of mammal species detected in a total of 2,262 km of census fieldwork complemented with the records of mammals harvested during the period 2005-2009. Tables 2.3 and 2.4 provide lists of birds and reptiles reported in the hunting records.

Table 2.2 Mammal species detected during census fieldwork and records of mammals harvested in ANP during the period 2005-2009

Order	**Family**	**Latin Name**	**Common Name**
Artiodactyla			
	Cervidae	*Mazama americana*	Red deer
	Cervidae	*Mazama gouazoubira*	Grey deer
	Tayassuidae	*Tayassu tajacu*	Collared peccary
	Tayassuidae	*Tayassu pecari*	White-lipped peccary
Carnivora	Felidae	*Leopardus pardalis*	Ocelot
	Felidae	*Leopardus wiedii*	Margay
	Felidae	*Panthera onca*	Jaguar
	Mustelidae	*Eira barbara*	Tayra
	Mustelidae	*Pteronura brasiliensis*	Giant otter
	Mustelidae	*Lontra longicaudis*	Otter
	Procyonidae	*Nasua nasua*	Coati
	Procyonidae	*Potos flavus*	Kinkajou
	Procyonidae	*Galictis vittata*	Badger
	Canidae	*Speothos venaticus*	Wild dog
	Canidae	*Atelocynus microtis*	Short-eared dog
Marsupialia			
	Didelphidae	*Didelphis sp*	Common opossum
Perissodactyla			
	Tapiridae	*Tapirus terrestris*	Tapir
Primates			
	Aotidae	*Aotus vociferans*	Night monkey
	Atelidae	*Alouatta seniculus*	Colombian howler monkey
	Atelidae	*Lagothrix lagothricha*	Common woolly monkey
	Cebidae	*Cebus albifrons*	White-fronted capuchin
	Cebidae	*Saguinus nigricollis*	Tamarin
	Cebidae	*Saimiri sciureus*	Squirrel monkey

	Pitheciidae	*Callicebus torquatus lucifer*	Titi monkey
	Pitheciidae	*Pithecia monachus*	Saki monkey
	Cebidae	*Cebuella pygmaea*	Pygmy marmoset
Rodentia			
	Agouitidae	*Agouti paca*	Paca
	Dasyproctidae	*Dasyprocta fuliginosa*	Black agouti
	Erethizontidae	*Coendou sp*	Porcupine
	Sciuridae	*Sciurus sp.*	Squirel
	Hydrochaeridae	*Hydrochaeris hydrochaeris*	Capybara
	Echimyidae	*Echimys sp.*	Red-nosed tree rat
	Dasyproctidae	*Myoprocta pratti*	Acouchy
Xenarthra			
	Dasypodidae	*Dasypus sp*	Armadillo
	Dasypodidae	*Priodontes maximus*	Giant armadillo
	Bradypodidae	*Bradypus variegatus*	Three-toed sloth
	Megalonychidae	*Choloepus didactylus*	Two -toed sloth
	Myrmecophagidae	*Myrmecophaga tridactyla*	Giant anteater
	Myrmecophagidae	*Tamandua tetradactyla*	Tamandua

Table. 2.3 Reported reptile species harvested in ANP during the period 2005-2009

Order	Family	Latin Name	Common Name
Chelonia			
	Chelidae	*Podocnemis unifilis*	Yellow-headed side neck turtle
	Chelidae	*Podocnemis expansa*	South American river turtle
Testudines	Chelidae	*Chelus fimbriata*	Mata-Mata
	Testudinidae	*Geochelone denticulata*	South American yellow-footed tortoise
Crocodilia			
	Alligatoridae	*Melanosuchus niger*	Black caiman
	Alligatoridae	*Caiman crocodilus*	Common caiman

Table. 2.4 Reported bird species harvested in ANP during the period 2005-2009

Order	Family	Latin Name	Common Name
Ardeiformes			
	Ardeidae	*Tigrisoma lineatum*	Rufescent tiger-heron
Falconiformes			
	Accipitridae	*Geranospiza caerulescens*	Crane hawk
Galliforme			
	Cracidae	*Penelope jacquacu*	Cauca guan
	Cracidae	*Aburria pipile*	Common piping-guan
	Cracidae	*Crax globulosa*	Wattled curassow
	Cracidae	*Crax mitu*	Razor-billed curassow
	Cracidae	*Nothocrax urumutum*	Nocturnal curassow

	Cracidae	*Otalis sp.*	Variable chachalaca
Piciformes			
	Ramphastidae	*Ramphastos tucanus*	White-throated toucan
Procellariiforme			
	Psophidae	*Psophia crepitans*	Gray-winged trumpeter
Psittaciformes			
	Psittacidae	*Amazona farinosa*	Mealy parrot
	Psittacidae	*Ara manilata*	Red-bellied macaw
	Psittacidae	*Ara ararauna*	Blue and yellow macaw
	Psittacidae	*Ara macao*	Scarlet macaw
Tinamiforme			
	Tinamidae	*Tinamus spp.*	Tinamou
	Tinamidae	*Cryturellus undulatus*	Undulated tinamou

2.1.4 Flora

The Amazon forest consists of a mosaic of forest types that differ in soil characteristics and in floristic composition [Gentry 1988; Ter Steege 2003]. Plants and animals have coevolved and formed a complex web of interactions. For example, seed dispersal strategies are numerous as birds, primates and other large vertebrates play an important role in maintaining the forest ecosystem [Peres and Palacios 2007; Stevenson 1998; 2000b; Terborgh 1986; Terborgh and Nunez-Iturri 2006].

We conducted a plant rapid assessment in order to: i) gain an insight into the most abundant fruit bearing tree species that are consumed by primates and other large vertebrates; ii) evaluate differences in forest composition and potential fruit production of these species in four sampling sites; iii) identify plant species that are important for local people. Thus, we combined systematic taxonomic data collection with traditional ecological knowledge (TEK). TEK refers to a body of insights and knowledge on forest ecology that have been accumulated empirically by local people over generations [Berkes 2010; Halme 2007; Salovaara et al. 2003] and it is an important tool that can be used to evaluate forest composition. A minimum area of 0.1 ha is accepted for a rapid plant assessment [Gentry 1993]. There are almost no direct measurements on age distribution in rainforests because growth rates vary within a species, and over time between individuals, which make estimates subject to error

[Chambers et al. 1998]. Therefore, information documented through TEK can probably serve as an alternative approximation [Halme 2007; Jinxiu et al. 2004].

2.1.4.1 Methods

Vegetation plots were located in four different watersheds known as the Agua Blanca, Agua Pudre (in San Martin's Tikuna territory and ANP), Bacaba (in ANP) and Pucacuro creeks (in Mocagua's Tikuna territory and ANP), the same sampling sites were used to conduct census surveys (please see complete description in section 3.2.3) (Fig 2.7). A total of one hectare was surveyed at each site. Thus, ten 0.1 ha vegetation plots were located at each site, at the beginning (0 metres), middle (2000 metres) and end (4000 metres) of the three transects.

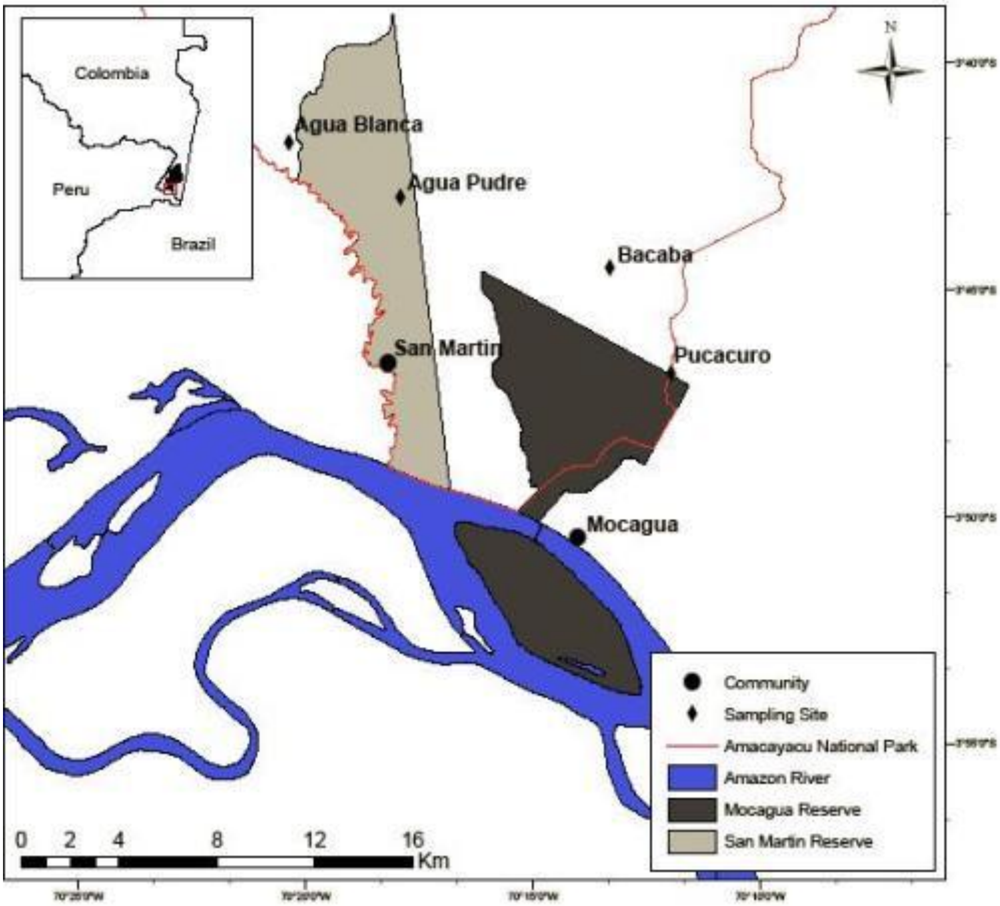

Figure 2.7 Location of Mocagua and San Martin indigenous territories and the four sampling sites (Agua Blanca, Agua Pudre, Bacaba and Pucacuro).

For the rapid assessment of the vegetation, each 0.1 ha plot was divided into four 50 x 5 m plots that were located perpendicular to the transect. The area of each plot was determined by using a 50 m measuring tape and a 2.5 m stick.

Saplings, juveniles and adults were identified. Through TEK by experienced local co-investigators, fruit bearing tree species consumed by primates were documented, along with information such as the vernacular name, name in Tikuna, diameter at breast height (DBH), estimated height, fruiting season and relationship with wildlife and humans. The angiosperm classification system proposed by Cronquist [1988] was used for taxonomical purposes and botanical samples of the unfamiliar individuals, which we were able to collect and identify up to genus level. In some cases fruits were recognised up to species level, otherwise they were documented as fruit 'types', which generally make part of the same genus. Distribution of age classes was determined through TEK and divided into three types: 1) saplings, 2) juveniles or vegetative individuals with measurable DBH and 3) adults or individuals that have reached maturity for fruiting (based mainly on tree height and DBH). This study assumes that the probability is equal among all adult individuals for producing fruit harvests and is referred to as potential fruit production.

2.1.4.2 Data analyses

All the statistical analyses were performed using SPSS V 17.0 for Windows. Normality (Kolmogorov-Smirnov) and homogeneity of variance (Levene) tests were assessed by examining histograms and the skewness and kurtosis for each of the dependent variables. As most of the data did not present normal distribution, comparisons between sampling sites were conducted using the Kruskall-Wallis non-parametric test [Pallant 2007].

2.1.4.3 Results

Reported Diversity: Local plant diversity is largely unexplained. Moreover, biodiversity in the Colombian Amazon is high due to stable climatological conditions, fertility and presence of non-native species from North America and the Andes cordillera [Ter Steege 2003]. Biodiversity in the southern part of ANP is elevated and up to 60% of the trees in one hectare are represented by one individual [D. Cárdenas, pers. comm.]. This preliminary study documented a total of 4,879 individuals in four hectares, corresponding to 2,321 individuals with measurable DBH (908 adults and 1,413 juveniles) and 2,558 saplings

(Table2.5). Analyses on potential fruit production within and between each location were based on the number of adult individuals.

Table 2.5 The most important fruiting trees used by primates and other large vertebrates, showing the abundance of each age class. Highlighted species represent key plant species documented by TEK.

Fruit type	Saplings	Juveniles	Adults	Total	%Adults	Adults/Ha
Iryanthera spp.	126	386	134	**646**	21	33
Eschweilera spp.	9	124	81	**214**	38	20
Irirtea deltoidea	19	47	63	**129**	49	16
Iryanthera juruensis	71	120	62	**253**	25	15
Inga spp.	28	113	49	**190**	26	12
Pouteria spp.	9	54	41	**104**	39	10
Euterpe precatoria	90	38	33	**161**	20	8
Maquira guianensis	17	77	32	**126**	26	8
Socratea exorrhiza	24	21	27	**72**	38	7
Theobroma subincanum	16	42	28	**86**	33	7
Pourouma spp.	40	75	25	**140**	18	6
Guatteria spp.	5	5	55	20	**80**	25
Theobroma microcarpum	10	29	19	**58**	33	5
Ocotea spp.*; Aniba* spp	1	25	14	**40**	35	3
Theobroma glaucum	2	8	12	**22**	55	3
Couma macrocarpa	0	11	10	**21**	48	< 3
Caryodaphnosis cf. tomentosa	4	1	8	**13**	62	2
Parkia cf. multijuga	0	1	8	**9**	89	2
Cecropia scyadophylla	0	10	6	**16**	38	< 2
Maquira callophylla	2	17	6	**25**	24	< 2
Minquartia guianensis	5	23	7	**35**	20	< 2
Perebea guianensis	6	26	7	**39**	18	< 2
Oenocarpus mapora	44	0	4	**48**	8	1
Anacardium cf. parvifolium	0	0	3	**3**	100	< 1
Manilkara bidentata	1	1	2	**4**	50	< 1
Oenocarpus bataua	199	5	3	**207**	1	< 1

There were no significant differences in potential fruit production within each study site and there was a marginal difference between study sites. Bacaba differs slightly from the Agua Blanca and Agua Pudre sampling sites (Kruskall-Wallis $\chi^2 = 0.068$, N= 40, $p = 0.05$), but is significantly different to the Pucacuro site (Kruskall-Wallis $\chi^2 = 0.028$, N= 40, $p = 0.03$). The total number of adults was considerably less in Bacaba and Pucacuro presenting 44 adult individuals above the average (223 adult ind/Ha). The Pucauro site represents 30% of the total adult individuals documented and almost doubles the percentage found in Bacaba sampling site (17%).

Some of the most abundant plant families (>10 ind/Ha) reported in this study are the Arecaceae, Lecythidaceae, Moraceae, Sterculiaceae and Leguminosae (Table 2.6). Richness at the family level is high in the Arecaceae and Moraceae, both represented by five genera. Important fruit bearing trees for primates and other arboreal taxa represented by more than eight adult individuals per hectare include *Eschweilera, Inga, Pouteria, Euterpe* and *Maquira* species. The most abundant fruit species for primates and other arboreal taxa in the area are *Inga* with 43 species, followed by *Pouteria* with 12 species [Rudas et al. 2005]. The Pucacuro and Agua Blanca study sites contain the most number of species, genera and families, whilst the lowest figures are found in the Bacaba site.

TEK was used for the rapid identification and assessment of local plant species and their association with primates and other large vertebrates (see Appendix I). Local fruit species that are important for wildlife are *Theobroma* spp*., Garcinia* spp*., Inga* spp*., Pouteria* spp*., Manilkara bidentata, Couma macrocarpa, Minquartia guianensis* and *Anacardium cf. parvifolium*. *Mauritia flexuosa* is the dominant species in swampy areas known locally as 'cananguchales' and also serves as an important food source for wildlife in general. Some fruiting trees in this study, which are only occasionally consumed by primates, are *Iryanthera* spp. and *Guatteria* spp. We identified six vulnerable plant species that are highly exploited for human utilisation, mostly for construction and traditional fruit harvesting: marañón de monte (*Anacardium cf.parvifolium),* acapú (*Minquartia guianensis*)*,* quinilla (*Manilkara bidentata*)*,* surba (*Couma macrocarpa*)*,* milpesos (*Oenocarpus bataua)* and bacurí *(Garcinia* spp*.)*. There were no adult *Garcinia* spp. individuals found in this survey.

Table 2.6 Some of the most important families containing fruit bearing species consumed by primates and other large vertebrates.

Family	**Saplings**	**Juveniles**	**Adults**	**% Adults**
Arecaceae	376	111	130	21
Lecythidaceae	9	124	81	38
Moraceae	37	158	62	24
Sterculiaceae	28	79	59	36
Leguminosae	28	113	49	26

Sapotaceae	9	54	41	39
Cecropiaceae	40	85	31	20
Lauraceae	5	26	22	42
Total	**532**	**750**	**475**	

2.1.4.4 Discussion

The abundance of tree species documented in this study is in agreement with general abundance patterns in the area where the Myristiacaceae, Lecythidaceae, Arecacea and Moraceae families, as well as *Inga* spp. And *Pouteria* spp., are the most predominant species [Rudas et al. 2005; Ter Steege 2003]. A large proportion of the tree species in this study have been reported as part of the diet of primates and other large vertebrates in other Colombian Amazonian sites [Defler and Defler 1996; Stevenson 2002].

ANP has three different geological formations known as the Pebas formation (lower Amazonian tertiary), the Amazon formation (Mariñame sandy unit) and the quaternary alluvial deposits or alluvial plains [Rudas et al. 2005]. The Agua Blanca, Agua Pudre and Pucacuro creeks make part of the Pebas formation known by the Tikuna as "tierra negra" (black soil), and the Bacaba creek area is typical of the "tierra amarilla" (yellow or sandy soil) or Amazon formation, with the understory being dominated by caraná palm trees (*Lepidocaryum tenue*). The marginal difference found in the Bacaba creek area may be due to the strategic location of the Bacaba creek sampling site in an area where the Pebas and Amazon formations overlap. Two censuses transects run to the north with forest complexes on highly dissected terrain typical of the Amazon formation and one transect runs to the south and is located within the Pebas formation. The northernmost tip of one of the transects was located in the head of the Purité River watershed, which occupies a large area in the central part of ANP and is considered to be part of the Mariñame sandy unit [Rudas and Prieto 1998 ; Rudas et al. 2005]. Both scientific and TEK described these forest units in the area.

L. Panduro is an experienced hunter and he considers that trees that are not used by people or animals generally remain 'unknown'. Some of the most vulnerable species are primary forest plants with slow growth and species that are appreciated for their timber [Shanley and Luz 2003]. Fruit species such as surba, milpesos, quinilla and bacurí are usually harvested in the local area by cutting down the tree. Acapú and quinilla are valued as timber sources and marañón de monte is a rare primary forest giant. These species are considered to be important for the people as well as for the wildlife in the local area and the results of this study have been used to design a plant pictorial guide in Spanish for educational activities (see Appendix II). It is important to note that the total area of 4 hectares sampled was probably insufficient to estimate the true number of fruit bearing tree species consumed by large vertebrates at our study sites, but provided a general understanding on the most abundant and vulnerable species in the area.

2.2 The Tikunas

Earlier Tikunas were well known as nomadic hunters and gatherers, who specialised in *terra firme* habitats. They occupied the north of the Amazon River inland forests [Rianio 2003]. Their access to flooded forest (*varzea*) and the islands of the Amazon River were restricted by the Omaguas, their enemy tribal group with the largest population in the area [Acuña 1986; Franco 2006]. As a consequence of the incursion of the Catholic missionaries during the late 1600s to the Omaguas territory, a smallpox epidemic reduced their population [Nimuendaju 1952]. Consequently, the Tikunas begun to move into the Omaguas territory towards the Amazon River. The Omaguas, weakened by the missionaries, did not fight the Tikunas and were progressively displaced by them [Grohs 1974]. In 1768, after the eviction of the missionaries, the Tikunas were recognised as expert hunters and fishermen [Nimuendaju 1952]. Fishing techniques were developed after their relocation close to *varzea* forests and access to fishing tools such as hooks and nets. Tikuna people were also trading blow pipes (*cervatanas*) and poison (*curare*) for hunting equipment, representing one of their most important trading sources [Nimuendaju 1952; Porro 1996].

During the early 1900s, the Tikuna in Colombia suffered profound changes due to their involvement in extractive economies such as rubber exploitation, skin trade (e.g. big cats, caiman and otter skins) and the massive exploitation of different tortoise species for international markets [Franco 2006; Rianio 2003]. During the1960s, the high levels of wildlife trade (mainly primates for the biomedical research market in the US) drastically affected Tikuna's traditional use of resources and commercial hunting was the main economic income in the area [Franco 2006]. In the 1980s, the boom of coca impacted on Tikuna society as access to money became common; traditional activities such as agriculture were abandoned, bringing alcoholism, prostitution, scarcity of cultivated food, among other problems related to the cultivation and trafficking of cocaine [Franco 2006; Rianio 2003]. As a result of their participation in extractive economies, along with the loss of cultural beliefs and taboos, there has been a clear disruption between Tikuna people and their traditional relationship with nature. This has, in turn, tainted the Tikuna people's view of conservation projects and hindered recent attempts towards cooperation with governmental and non-governmental organisations regarding management and use of natural resources.

Nowadays, the Tikuna indigenous group is widely distributed along the Amazon River in Peru, Colombia and Brazil, with an approximated population of 40,000 inhabitants, being one of the largest indigenous groups in the area [Franco 2006; Lopez 2000]. Other minority ethnic groups such as the Cocamas, Yaguas and Huitotos, also share territories with Tikunas in the study area [Rianio 2003]. In the Colombian Amazon the Tikuna population, of approximately 7,100 inhabitants, represents only 1.3% of the Colombian population [DANE 2005]. Their economy relies mainly on land cultivation based on small slash-and-burn patches (*chagras*), fishing, gathering and trade. Tourism also provides alternative income. Tikunas are still involved in drug trafficking and illegal extraction of cedar (*Cedrela* spp.) [Rianio 2003; Zarate 2008]. Hunting was a traditional cultural activity, although nowadays it represents an important economic activity. The trade of meat finances commodities such as medicine, school supplies and clothing. In addition, meat is sold in order to pay the additional costs incurred during the hunting treks.

2.2.1 Mocagua community

The first settlement located in Mocagua's territory was occupied by Peruvian indigenous groups, mainly Tikunas as this area was previously Peruvian territory [Franco 2006; Zarate 2008]. In 1950, the Jesuit missionaries established the first Catholic school in the area, but not until the 1960s was Mocagua formally founded [Franco 2006]. Mocagua's indigenous territory was delimited and legalised in September 1983 [PNNA 2006]. Mocagua lies next to the visitor centre of ANP (Fig 2.7). Its indigenous territory has an area of about 400 km^2, and its population consists of approximately 510 inhabitants [Reyes 2008]. They provide the main labour for the running of the park, in the form of guides, cooks, carpenters and general workers. This means of cash acquisition helps the community to minimise the extraction of natural resources. The Mocaguans have been Catholics since the establishment of the Jesuits school and it is currently managed by Catholics. There is no secondary education in the community, thus students have to go to boarding schools in the next community (Macedonia) or Puerto Nariño and Leticia (closest municipalities), which has a dramatic impact on their traditional way of life. Tikuna language is spoken by approximately 10% of the community [C. Panduro, pers. comm.].

During the early 1970s, the wildlife in the area was radically affected by the skin and fur trafficking (jaguar and otter mainly). Owing to its proximity to the land. As a consequence, the wildlife within a radius of 6 km from the community decreased and wildlife to hunt became scarce for local people [van Leijsen and Vleut 2005]. In contrast to most Tikuna communities, Mocagua conservation initiatives are welcomed as the local population are aware of the decrease in wild populations of large mammals and the economic benefits from research and tourism. Currently, Mocagua is the only community in the area applying a hunting ban for woolly monkeys, which was implemented in 2003 as part of a management plan for resource use designed by ANP and collaborators (see section 2.3.1.1). However this situation is volatile, influenced by numerous factors, such as the continuous change of indigenous authorities.

2.2.2 San Martin de Amacayacu community

San Martin is located on the Amacayacu river, one of the most important local tributaries of the Amazon River (Fig 2.7). Its indigenous territory covers approximately 430 km² and also forms part of Puerto Nariño's indigenous territory, which has an area of 1,400 km² [Franco 2006]. The community has some 480 inhabitants [Martinez 2006], all of whom speak the Tikuna dialect. It is one of the most traditional communities in the area and hunting practices are still strong. In the early 1980s illicit crops were common in the area, and two runways for illegal trade were established in San Martin's indigenous territory. In the late 1980s, the Colombian army bombarded the area, destroying the runways and the laboratories for coca processing, eradicating the illicit crops from the area. Unfortunately, this illegal trade had brought income to the community, upon which they were dependent [Franco 2006]. Currently, illegal cedar (*Cedrela* spp.) extraction and commercial hunting provide economic incomes for the non-indigenous people from Puerto Nariño (the closest town and part of the general indigenous territory) and a small group of Tikunas that work for them. The community is monitoring the area and the involvement of local people in illegal activities, which is decreasing but still present. Despite this, economic income is still needed to implement an ongoing and sustainable monitoring programme. As San Martín is located 13 kilometres away from the visitors' centre of ANP, access is more difficult. Transport availability is limited and the cost of fuel is beyond most people's means, therefore San Martin receives less income from tourism than Mocagua [Buitrago 2008].

Commercial hunting in the San Martin indigenous territory is higher than in the other two Tikuna communities overlapping ANP, Mocagua and Palmeras [PNNA 2006]. The meat is sold or exchanged mainly in Puerto Nariño, especially at the Catholic boarding school as part of the payment for education fees and child maintenance. Hunting during illegal logging of cedar is not monitored but is thought to be high. San Martin would like to be independent from the large indigenous territory, Puerto Nariño and also wishes to extend its territory to include land from the other two communities overlapping ANP, which is causing enormous disagreements over land tenure amongst the three communities (see section 5.3.1.4).

2.3 Tikunas and Amacayacu National Park

The Colombian Amazon covers approximately 5% of the total Amazon basin area and has a human population density of approximately 3.3 inhabitants per km² [Franco 2006; PNNA 2006]. It represents 35% of the Colombian territory and contains 52 ethnical groups distributed in 162 Indigenous territories [COAMA 2009]. Additionally, it includes 12 protected areas, which cover about 385,000 km² of forest [PNNA 2006]. Most of the indigenous settlements located on the Amazon River margins did not have legal rights on land tenure and their eviction by illegal colonists was a threat. In order to provide legal rights over land for indigenous people, the Colombian government established indigenous territories (Resguardos indigenas) during the early 1970s [PNNA 2006; Rianio 2003]. Simultaneously, the designation of forest land as protected areas (e.g. forest reserves, national parks, natural reserves) was implemented by the INDERENA (National Institute for natural Resources) [PNNA 2006]. Ten percent of ANP overlaps the indigenous territory of the large Puerto Nariño's resguardo (including San Martin's territory), Mocagua, Palmeras, Macedonia, El Vergel and the Cotuhe-Putumayo indigenous territories [PNNA 2006]. Since the establishment of ANP, the Colombian environmental authorities (INDERENA until the late 1980s, latterly the Colombian Park System) anticipated the disagreement of indigenous people when protected areas were overlapping their traditional land. Consequently, the INDERENA included an outline for the special management of overlapping areas during the design of protected areas [Franco 2006].

2.3.1 The Special Management Regime (REM) of natural resources in ANP

From 2001-2003, ANP and six Tikuna indigenous communities, three of whom overlap the Park's territory (Mocagua, Palmeras and San Martin), established hunting, logging and fishing bans and restrictions. However, effective monitoring of this initiative has been difficult to establish and only Mocagua applies some of the hunting restrictions. Currently, the ANP and San Martin community are mapping the cedar distribution in the indigenous territory, to quantify it and look for management alternatives, in order to mitigate its illegal extraction and trade. However, not until March 2006 did ANP formally introduce the concept of the REM (Regimen Especial de Manejo – special management regime) to the authorities of the overlapping Tikuna territories. The REM aims to design a participatory management plan to regulate the use of resources. It also aims to integrate indigenous and governmental legislations [Franco 2006].

During this initial approach, it was intended to gather socio-cultural and economic information from the Tikuna communities, in order to understand current uses of natural resources. Nonetheless, the discourse presented by the representatives of the Park System did not have the acceptance of local people for several reasons: i) the vision that indigenous people have about their territory, does not follow western ways of land delimitation. Indigenous ancestral territory cover large extensions of forest as it is related to the origin of Tikuna people, the location of their previous settlements (malocas) and the concentration of important natural resources [L. Panduro and H. Gregorio, pers. comm.]. On the other hand, the REM aims to delimit areas for use and management; ii) for Tikuna people the establishment of ANP is seen as a way to control their legal rights over land. They do not agree with the Colombian legislation where commercial extraction of resources is illegal inside protected areas; however this has been the only legal mechanisms applied to control the illegal extraction of cedar in San Martin's indigenous territory; iii) the REM is presented as a legal agreement, where local authorities have to sign a document that is intended to be for an undefined period of time. For local people the requirement of a signed agreement is a way to manipulate their land ownership and to restrict their use of resources [Franco 2006; L. Gregorio, pers. comm.]. Furthermore, the internal issues among Tikuna communities regarding indigenous territories delimitation are a big obstacle for the implementation of the REM and any other approach for resources management (see section 5.3.1.4).

2.3.1.1 Preliminary resources management plan in ANP

The REM aims to consider relevant aspects for the implementation of resources management: land delimitation, governability, research (scientific and TEK), protection and control (by the ANP and local authorities), restoration of ecosystems of threatened species, sustainable use and management of game species (includes economic alternatives such as captive breeding, however it should be outside the ANP's territory as this is not allowed under Colombian legislation), use of resources for handcraft elaboration, use of traditional knowledge and genetic resources, reforestation with native species, ecotourism and recreation, rescue of TEK, zoning, design and implementation of local projects that improve the wellbeing of local people bearing in mind resources carrying capacity [Franco 2006]. Below I summarise the proposed use and management of wildlife for Mocagua[1] and San Martin as well as the zoning proposed by the ANP. This information was gathered during meetings between the indigenous communities and ANP in the period 2001-2003 and in 2006; however the management strategies presented here were designed without any information on the current status of the exploited species in the area.

In the Mocagua's island the extraction of mammals and birds is Forbidden

- Special emphasis in hunting prohibition is the manatee (*Trichechus inunguis*), the Amazon river dolphin (*Inia geoffrensis*), the grey river dolphin (*Sotalia fluviatilis*) and the wattled curassow (*Crax globulosa*)
- Only one capybara (*Hydrochaeris hydrochaeris*) can be hunted for crop-raiding pest control
- The use of shotguns for personal protection has to be authorised by the Curaca and or Cabildo[2]
- It is prohibited to capture or collect eggs of the South American river turtle (*Podocnemis expansa*)

Mocagua's continental territory

- In the Matamata's watercourse area it is forbidden to hunt the woolly monkey (*Lagothrix lagothricha*), the white-fronted capuchin (*Cebus*

Mocagua's island[1]

[1]Mocagua Island located opposite Mocagua, on the Amazon River (see fig 2.7), whose jurisprudence is shared between three indigenous territories: Mocagua, Macedonia and El Vergel PNNA. 2006. Línea base del Parque Nacional Natural Amacayacu. Leticia: Unidad Administrativa Especial del Sistema de Parques Nacionales Naturales (UAESPNN). 162 p..
[2]Each Tikuna community has a social and political hierarchy composed of the Cabildo and the Curaca. The Cabildo is a committee, similar to a town council, chosen by the community. The Curaca is the local leader and representative, whom oversees meetings of the Cabildo.

albifrons), the wattled curassow and the nocturnal curassow (*Nothocrax urumutum*)

- It is forbidden to hunt paca (*Agouti paca*), and black agouti (*Dasyprocta fuliginosa*) from March to May and from September to November, when local people reported females are likely to be pregnant
- The maximum number of tapirs (*Tapirus terrestris*) that one hunter can harvest is two animals per year

San Martin (and Palmeras)

- Hunting for subsistence purposes is legal
- Commercialisation of meat is allowed only inside the communities
- Inside the indigenous territory of Palmeras and San Martin, only members of the community are allowed to hunt
- The commercialisation of caimans, primates, tortoises and capybara is forbidden
- It is forbidden to hunt in the salt-licks and to clean preys in the area
- The access of tourists to the salt-licks is forbidden as well as the implementation of camp sites inside or nearby salt-licks
- It is forbidden to hunt manatee
- The maximum number of tapirs that one hunter can harvest is two animals per year
- It is forbidden to trade any live animal species
- With the permission of the Curaca a maximum of 30 kg of meat can be sold to the Catholic boarding school in Puerto Nariño
- Hunters cannot hunt near the villages

In the management plan design by the ANP there is a proposed zoning of the park [PNNA 2006]. The document is very clear in acknowledging that such zoning division is proposed taking into account the park's and indigenous communities, location of infrastructure and the main watercourses, which offer a geographical division facilitating the zoning. Therefore soil fertility, forest structure and phenology, levels of habitat disturbance, status and distribution of wildlife and key plant resources are not included in this zoning design as the data is not available. This is due mainly for the lack of funding resources of the Park System [PNNA 2006]. The ANP divided the total area of the park into four main categories of use (Fig. 2.8):

- Specified used (natural recuperation): north and west units. These areas have been subject to long-term selective logging of cedar (*Cedrela odorata*). For instance during 2002-2003 ANP with the collaboration of local people, confiscated approximately 17,000 pieces of cedar [PNNA 2006]. In addition, at the north of ANP there is also the illegal dredge mining for gold exploitation. The ANP suggests that the following activities could be conducted in these areas: i) subsistence use of resources only for the indigenous settlers; ii) monitoring; iii) research; iv) photography and filming.
- Special preservation (intangible zone): east unit. It is known that the area does not have indigenous inhabitants and there is no infrastructure for monitoring. The Ome ecological station (OES) has a camp site and a trail system where research (mainly on primates) has been conducted by Prof. TR Defler and the Universidad Nacional de Colombia. The team of the OES is currently doing the monitoring of the area, however only during a few months a year when research is carried out.

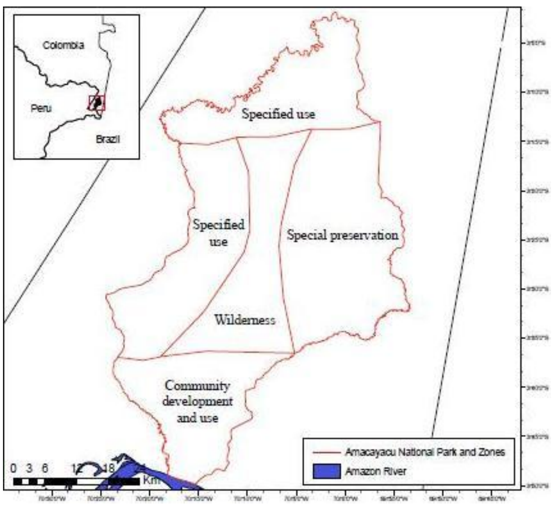

Figure 2.8 Proposed zoning for ANP.

Community development and use (high human density and use): south unit. This area has the highest human population and habitat disturbance. The activities proposed by the ANP are: i) subsistence use of resources only for the indigenous settlers; ii) monitoring; iii) research; iv) ecotourism; v) recreation and education; vi) infrastructure for education, accommodation for ANP's personnel; vii) implementation of sustainable economic alternatives.

- Wilderness (buffer zone): central area. The ANP wants to give total protection to this area in order to mitigate the incursion of illegal settlers to the south-east of the park and the north-west area. This unit is proposed by the ANP to be part of a biological corridor that will join Brazilian territory (south-east of the park) and private reserves. This area does not have human settlements [PNNA 2006].

Up to now there are no formal agreements between the Colombian Park System and the indigenous authorities for the implementation of the REM or any other alternative to manage the natural resources in the overlapping areas between the ANP and the indigenous territories.

3. THE IMPACT OF SUBSISTENCE HUNTING AND MEASURES OF ITS SUSTAINABILITY

The baseline information required in order to identify the sustainability of hunting of game species relies mainly in information on the carrying capacity of the sampled area, as well as the species' biology. Thus, is it crucial to evaluate the balance between production and harvest [Zapata-Rios et al. 2009]. A major limitation is the scarcity of the appropriate biological data and the difficulty in obtaining this information, especially for wildlife populations exposed to continuous hunting [Zapata-Rios et al. 2009]. The development of simple mathematical models, that do not require detailed biological information, provide a coarse approximation of hunting sustainability [e.g. Bodmer and Robinson 2004; Robinson and Redford 1991b; Zapata-Rios et al. 2009]. These models, although useful, present several limitations providing a restricted approximation of overharvesting, thus their results have to be taken with caution [e.g. Bodmer and Robinson 2004; Robinson and Redford 1991b; Zapata-Rios et al. 2009].

Measuring the effects of subsistence hunting by indigenous people on wildlife populations has several limitations such as: i) the lack of data regarding previous hunting patterns, which limits the interpretation of current data; ii) population densities, for both human inhabitants and game species are constantly changing; iii) differences in methods employed to determine the sustainability of hunting may produce dissimilar conclusions depending on the aims of the study and researchers' scientific backgrounds [Jerozolimski and Peres 2003]. For instance, Terborgh [1999] describes over-hunting by the Matsigenka indigenous group, as the main human activity decreasing the population of large-bodied vertebrates in Manu National Park, Peru. Terborgh argues that the maintenance of diversity is not compatible with an increasing human population. Conversely, Ohl-Schacherer et al. [2007] suggest that the hunting of the Matsigenka is sustainable, basing their arguments on sourcesink dynamics. These imply that even with continued human population growth within a settlement, off-take for each hunting species will eventually reach an asymptote. Yet data on wildlife populations' responses to varying degrees of hunting pressure under different environmental conditions remain scarce or nonexistent for most tropical game species [e.g. Peres 2000b; 2010].

In this chapter, I present a qualitative and a quantitative profile of the harvesting of the most hunted species in overlapping areas between the territories of two Tikuna indigenous communities and ANP. The aim of this chapter is to examine the effects of hunting on game species. I compare the hunting patterns undertaken by the two Tikuna communities, in order to assess the sustainability of the harvest for the 10 most preferred game species. The data provided are: i) the hunting profile for two Tikuna indigenous communities including hunting core areas; ii) a qualitative assessment of hunting including the life history strategy of game species, their relative abundances and number of animals extracted; iii) a quantitative assessment that includes the Standing density model, the Stock-recruitment model, the Production model and the Unified harvest model. Formulas and definitions are included in Appendix IV.

3.1 Models to Determine the Sustainability of Hunting

When evaluating the sustainability of hunting in a relatively short period of time, the most commonly applied approach is the comparative design which contrasts variables between sites exposed to different degrees of hunting pressure [Robinson and Redford 1994]. Hunting pressure should be the most contrasting variable between sites, while the other variables should be as constant as possible, so sampling sites should have the same habitat structure [Bodmer and Robinson 2004]. Here I explain the relevant models for evaluating the sustainability of hunting in the Mocagua and San Martin indigenous communities. Appendix III provides information on the biology and conservation of the 15 most preferred game species. Other models such as the Effort model, Age structure model and the Source-sink model, were not applied as those models require: i) extensive data on the daily activities of hunters; ii) long-term data in order to determine demographic changes over time; iii) information of source and sink populations and movements of animals between those areas [Bodmer and Robinson 2004].

3.1.1 Abundance, density or standing biomass comparison models

This model relies on density, abundance and/or biomass estimates, an assumes that changes between sites are a consequence of hunting [Robinson and Redford 1994]. Changes in density or biomass of a species can also be compared between unhunted sites and sites exposed to different levels of hunting pressure [Bodmer et al. 1997; Peres 2000a]. To minimise the bias of this model, bearing in mind that differences in density or biomass of a species not necessarily implies overhunting because harvest will usually result in a decrease of population density, information on the life history of the studied species should be correlated [Bodmer and Robinson 2004]. Whether hunting is sustainable depends on how the rate of recruitment varies with population densities [Caughley and Sinclair 1994; Sinclair et al. 2006]. A long term study carried out in the Tamshiyacu-Tahuayo Community Reserve in Peru [Bodmer et al. 1997], suggested that mammals with higher intrinsic rates of increase (r_{max}), shorter life spans, and shorter generation times are less susceptible to overhunting that mammals with smaller intrinsic rates of increase, longer life spans, and longer generation times [Bodmer and Robinson 2004].

3.1.2 The production model

Robinson and Redford's population growth model [Robinson and Redford 1991b], was developed to provide a first estimate of harvest rates for different forest mammal species. They calculated maximum production (in number of individuals per square kilometre). These production estimates were intended to represent the natural population of a given species under the best possible environmental conditions. Thus, population density and intrinsic rates of increase were calculated. This model also measures the potential harvest (in number of individuals per square kilometre), for all species. This represents the optimal sustainable harvest expected if the production is at a maximum and hunting has the minimum effect on the natural population [Robinson and Redford 1991b].

This model is useful when data on densities and actual production in a given site are not available, as the model uses predicted densities (D_2) derived from a linear regression of $\log_{10}$ population density against $\log_{10}$ body mass for subsets of game species divided into dietary categories [Robinson and Redford 1986a; 1986b]. This provides information on overharvest but not for sustainable hunting [Robinson and Bodmer 1999]. However, as Peres [2000b] states, the use of predicted densities calculated in sites different to the study area, should be avoided as those estimates based on average densities at carrying capacity (K), might overestimate or underestimate (in the case of *terra firme* forests) potential game production in typical Amazonian sites.

The calculations needed for this model are:

- *Calculation of production:* To determine the production (P), the actual density (D_1) of both adult and juvenile animals is recorded and presented as individuals per square kilometre. The production model assumes that populations of wildlife are density dependent, with maximum production at 0.6K. As with the other models K is estimated from non-hunted, undisturbed populations. Maximum production (P_{max}) is calculated by multiplying the density at maximum production (estimated as 0.6K) by the finite rate of population increase (λ_{max}) and subtracting it from the previous year's density (also estimated at 0.6K), using:

$$P_{max}=(0.6K*\lambda_{max})-0.6K$$

- *Calculation of harvest:* The harvest (H) is the number of animals of a species extracted by human hunting per square kilometre in a year. Maximum harvest is attained with maximum production and reduced natural mortality (H= P and density =0.6K). Here it is assumed that density cannot be below 60% of K, and presumes that the harvested population can be maintained at or above the density of maximum productivity. Robinson and Redford [1991b] assumed that in short-lived species, natural annual mortality is high, thus harvest can take a larger proportion of the production without reducing the standing population; the opposite pattern is expected for long-lived species; they divided species in three categories (Table 3.1):

Table 3.1 Categories and limits of harvestable production

Life History Strategy	Maximum percentage of production harvestable
Short-lived	60%
Medium-lived	40%
Long-lived	20%

3.1.3 The stock-recruitment mode

This model is based on density-dependent population models that use maximum sustainable yield estimates (MSY) and carrying capacity (K) [Robinson 2000; Robinson and Redford 1991b]. This model can provide a first assessment of sustainability in the absence of complete data on demographic structure of harvested populations and the impact of hunting on that structure. This model also includes estimates of population production, which are compared with observed hunting to obtain a measure of sustainability. Most species of tropical wildlife that are hunted are K-selected species and should have density-dependent recruitment [Caughley 1977]. The stock-recruitment model predicts the riskiness of harvests for different population sizes [McCullough, 1987 in Bodmer and Robinson 2004]. The greatest base population is at carrying capacity (K) and the smallest at extirpation (0). A sustainable harvest can be realised at any base population size, however, there is only one point that the sustained harvest is at the maximum, or MSY [Caughley 1977; Sinclair et al. 2006].

Thus, MSY is achieved when the hunting rate equals the population's recruitment rate by reproduction, so it varies from one species to another. For instance, for species with significant non-hunting annual mortality and high rates of population increase, 30% to 50% of the population is the maximum suggested off-take rate [Crete, et al, 1981; Gore et al, 1985 in Robinson 2000]. However, for K-selected species, the suggested off-take rates are much lower. Bodmer and Robinson [2004] presented the MSY as an estimate of K for hunting target mammal species in the neotropics as: i) 60% of K for short and medium-lived species such as peccaries, deer and large rodents, and ii) 80% of K for long-lived species such as tapirs and primates. Bodmer and Robinson [2004] suggested that: "*A species population in a hunted area can be compared* *to a predicted K and MSY. This is accomplished by comparing the density of the hunted population (N) to an estimated K as N/K. MSY is also denoted as a proportion of K. In sequence, the hunted population is positioned in relation to MSY, which in turn is used to evaluate the riskiness of hunting*" (Fig. 3.1).

The stock-recruitment model does not provide data on the sustainability of current hunting. This model provides accurate calculations for examining the potential for long-term sustainability. If current hunting is affecting the stability of wild populations, this implies that hunting would be risky in the long-term, thus this model is a valuable conservation tool. Nonetheless Bodmer and Robinson [2004: 307] explained the limitations of this method as: "*estimating K from non-hunted populations represents an equilibrium population and might be an underestimate of the real K. This is especially true for predator limited species, where prey densities are held below K by predators. An underestimate of K would lead to an underestimate of MSY and a misrepresentation in the relationship between N and the actual MSY".*

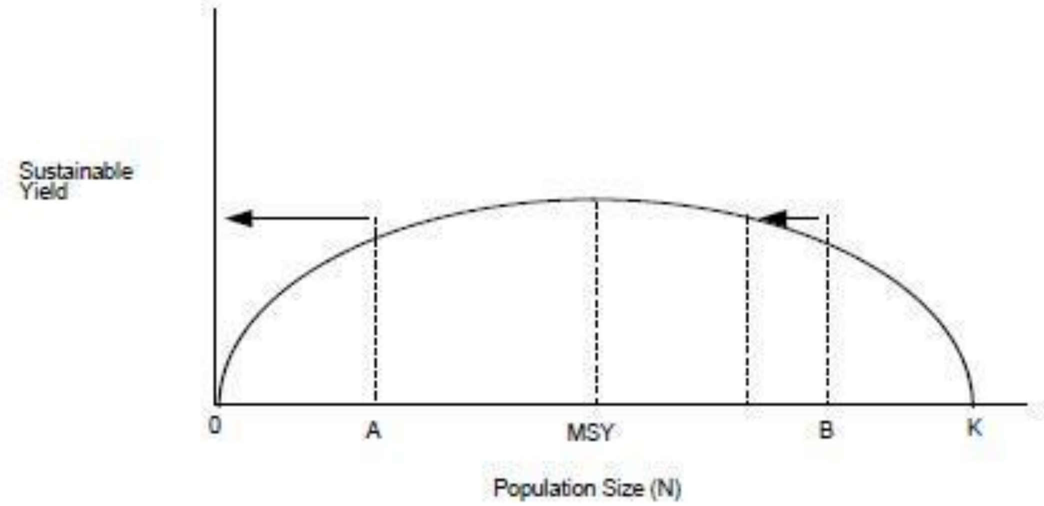

Figure 3.1 Representation of the stock-recruitment model, showing carrying capacity (K) and maximum sustainable yield (MSY). Overhunting at point A would drive the population to extirpation, while overhunting at point B would mantain a sustainable harvest at a lower population size. Figure source: Bodmer and Robinson [2004].

This model includes production estimates derived from reproductive productivity and population density. Reproductive productivity is determined from data on reproductive activity of females and uses information on 1) litter size and 2) gross reproductive productivity (number of young/number of females).

Population density is determined from field censuses of wildlife species. Animal densities are then multiplied by reproductive productivity to give an estimate of production, measured as individuals produced/km^2 as:

$$P= (0.5D)(Y*g)$$

where Y is gross reproductive productivity, g is the average number of gestations per year, and D is the population density (discounted by 50% under the assumption that the population sex ratio is 1:1) [Bodmer and Robinson 2004]. The harvest model is a useful way to evaluate the sustainability of hunting in an area, because it uses information on production and harvests from the field sites. However, this is a closed population model and does not take into account immigration or emigration of animals from adjacent areas [Bodmer and Robinson 2004].

3.1.4 The unified harvest model

This model evaluates the sustainability of hunting and the potential of hunting for long-term sustainability, by integrating the stock-recruitment and harvest models [Bodmer and Robinson 2004]. This model is used to evaluate whether a harvest level is risky or safe depending on the population size relative to the predicted MSY. The calculations included in this model are productivity, harvest rates and density at hunted areas, all of them presented as individuals per square kilometre. Bodmer and Robinson [2004] defined the limits of maximum production harvestable and calculated the MSY for hunting sensitive mammal species in the Neotropics as follow (Table 3.2):

Table 3.2 Estimated Maximum sustainable yield (MSY) as a percentage of carrying capacity (K) for game species

Life history strategy	Maximum % of production harvestable	Estimates MSY as a % of K
Short-lived	60%	50%
Medium-lived	40%	60%
Long-lived	20%	80%

The unified harvest model also analyses the riskiness of harvests in terms of the potential for long-term sustainability by incorporating the stock-recruitment analysis. This is done by determining the proximity of the current harvest to carrying capacity (K) and to the estimated maximum sustained yield (MSY). This model can then combine the percent of production of a harvested population with its position relative to MSY to give both a measure of the current sustainability and the long term riskiness of the harvest [Bodmer and Robinson 2004].

3.2 Methods

3.2.1 Harvest assessment

Hunting pressure was determined by quantifying the total biomass extracted by hunters over a 48 month period, from February 2005 to February 2009 at the four sampling sites (Bacaba and Pucacuro in Mocagua, and Agua Blanca and Agua Pudre in San Martín). Local coordinators kept a log of: hunted species, sex/age, weight, body measurement, hunter's name, place of hunting event, who consumed or bought the meat and price per kilo [after Bodmer and Puertas 2000]. Quantitative criteria for ranking hunting sites included the total biomass of game species extracted by hunters at each site, the proximity to Tikuna settlements (number of km) and number of hunting trips. Thus hunting pressure ranged from 1 (lowest hunting pressure) to 4 (highest hunting pressure) [Peres 1999a; Peres and Dolman 2000] (Table 3.3).

Table 3.3 Quantitative criteria used to rank the hunting pressure at different sites

Study site (Coordinates)	Total frequency of hunting trips3	Total Extracted biomass (kg)	Distance from nearest village (km)	Hunting Pressure rank
Bacaba (3°45' S,70°13'W)-MOC[1]	113	2,957	11.6	1
Pucacuro (3° 47'S, 70° 12'W)-MOC	165	3,657	7.8	2
Agua Blanca (3°41'S, 70° 20' W)-SM[2]	180	6,139	12.5	3
Agua Pudre (3°43' S, 70° 18'W)- SM	369	13,956	6.7	4

[1]MOC: Mocagua. [2]SM: San Martin. **3** During the study period.

The total number of hunted prey in each community, during the four years of study was corrected to a full year in order to annualise the observed harvest rate (OH= hunted animals/km_2) [Peres and Nascimento 2006; Townsend 2000] (please see Appendix IV). Extracted game meat (kg) was estimated by multiplying the number of hunted animals per species, by the average weight of males and females from all age classes hunted at both communities. When weight registered by local people did not correspond to the ranges of weight reported in the literature (mostly small-bodied species or infrequently hunted species), weighs were taken from Emmons [1999] for mammals, Emmons [1989] for the yellow-headed side neck turtle and from Hilty and Brown[1986] for birds. From a total of 49 game species recorded during this study, only the 15 most important species for Tikuna people were included in the qualitative analyses of hunting sustainability.

The selection of the 15 most important game species was based on the number of individuals extracted at each indigenous community. This information is presented in rank order of preference from the total harvest. However three important species in Tikuna diet, such as the mata-mata turtle (*Chelus fimbriata*)*,* the capybara (*Hydrochaeris hydrochaeris*) and the kinkajou (*Potos flavus*), were not included in the analyses as data on densities were not available, and therefore calculations of sustainability could not be precisely derived [Peres 2000b]. The above mentioned species were replaced by the following preferred game species whose densities were accurately calculated and whose populations had been decimated drastically by past hunting pressure, as reported by Campos-Rozo [1987] (howler monkey (*Alouatta seniculus*) N=18; night monkey (*Aotus* spp.) N=22 and woolly monkey (*Lagothrix lagothricha*) N=12). From the 15 preferred game species, only 10 species are included in the quantitative analyses, excluding the South American yellow-footed tortoise (*Geochelone denticulata*), the white-lipped peccary (*Tajassu tajacu*), the lowland tapir (*Tapirus terrestris*), the coati (*Nasua nasua*) and the curassows (*Crax* sp.). This is because accurate density estimates were not obtained, owing to the reduced sample size of visual detections.

3.2.2 Hunting areas

The mapping of the hunting areas at each community was completed between 2006 to 2009, with the participation of elder hunters who know their indigenous territory extensively. Hunting sites were grouped by proximity and waypoints were recorded using a GPS unit. The organisation of field trips for mapping was based on the list of sites recorded in the hunting forms filled out by the local co-investigators, which helped to standardise the location/distance of hunting sites and their use depending on their proximity to the communities. Mocagua's core catchment area was about 210 km², while San Martin's hunting area was about 200 km² (Fig. 3.2).

3.2.3 Census techniques

Following standardised census protocols [Buckland et al. 2001; Peres 1999b], line transects were conducted on a monthly basis over a period of 41 months from June 2005 to May 2009 to assess wildlife densities at the four sampling sites. Data were collected for a total of 236 days of effective fieldwork and a total walked distance of 2,262 km (Mocagua=1,197 km (Bacaba= 471 km, Pucacuro= 726 km) and San Martín= 1,065 km (Agua Blanca=512 km and Agua Pudre=438)). A total of 14 transect lines over 57 km were monitored; 8 transects of 4 km in Mocagua and 6 transects of 4-5 km in San Martin. Information recorded included: climatic conditions, date, time, species, group size, perpendicular distance (PD) to the first animal sighted, or to the centre of the group (when possible) for social species; height of animal group above ground for arboreal species, location along the trail and detection cue.

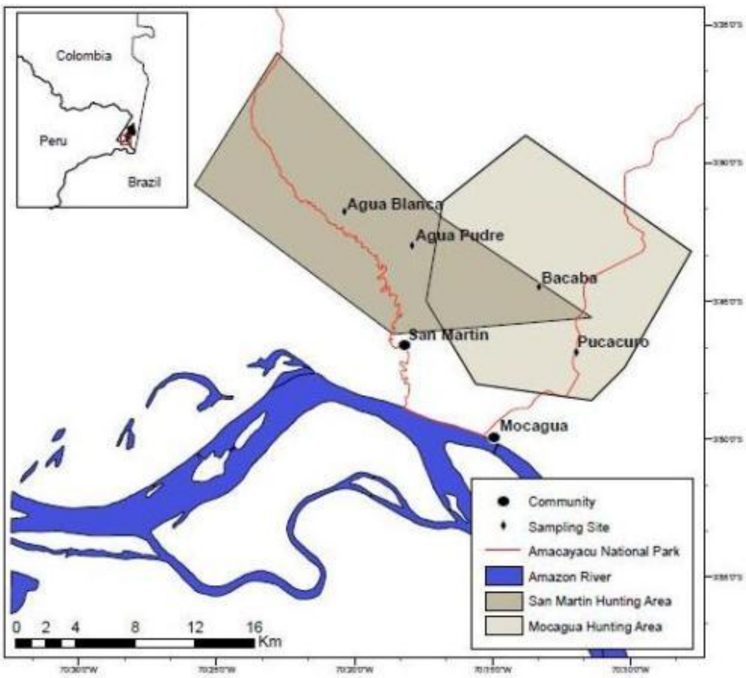

Figure 3.2 Location of the hunting areas of Mocagua and San Martin Tikuna communities.

Additional information such as group composition, activity (travelling, foraging, resting, social behaviour), diet and association with other species was recorded when possible. Census speed was 1.2 km/hr and observers stopped every 100 m to listen and look around. Censuses were cancelled when it rained. Some criteria were adapted in order to record reliable data contextualising the limitations of field conditions corresponding to hunting sites and community-based research. These were tested during a six months pilot period (data not used in the analyses), and included:

- Continuous training on census techniques focusing on measuring perpendicular distance and keeping the average speed of 1,2 km/hr using a GPS. During the first year, training was carried out before each field trip.
- Census walks were conducted by two couples of observers; each couple included one expert hunter and one researcher who was in charge of registering data. Additionally, it was necessary to have at least two people to actually measure the PD with a measuring tape, while recording data simultaneously. The pilot study showed that single observers did not measure PD with the tape and group sizes were overestimated.
- Expert hunters continuously trained students and young Tikuna coinvestigators in tracking techniques. The pilot period demonstrated that non-Tikuna observers did not notice silent groups or did not detect animals before they moved, while expert hunters were accurate in locating animal groups on the trail before they moved. Thus, the input of expert hunters to improve the effectiveness of detecting cryptic species was essential.
- The first couple carried out census fieldwork starting after dawn when light allowed good visibility, usually between 5.45 h and 6.30 h, in order to cover the earliest high activity patterns of diurnal species. The second couple left camp at 10.30 - 11.00 h, walking to the end of the trail silently, and then starting the census at approximately 14.00 h from the other end of the trail and returning towards point zero to cover the second peak of primate activity during the afternoon.

Indexes of abundance (IA) are expressed as number of signs/100 km, thus tracks and faeces are included [Naranjo et al. 2004]. Fresh tracks were counted within 1 m strip along the transects and erased to avoid counting the same track twice [Naranjo et al. 2004].

3.2.4 Data analysis

3.2.4.1 Estimates of population densities

From data obtained during the line transect surveys, only visual detections were included in estimate densities, with the exception of howler monkeys, a species for which acoustic cues are the most effective method of detection owing to their cryptic habits in Amazonia [Defler and Pintor 1985]. Data were analyzed with the software DISTANCE 5.0, using the half-normal and uniform models with cosine adjustment [Buckland et al. 2001; Thomas et al. 2005]. When observation numbers in each community were greater than 20 observations, un-stratified analyses were derived [Buckland et al. 2001]. With sample sizes of less than 2, all the observations for each species were pooled in order to post-stratify the global model to derive new detectability models and therefore new density estimates by community [L. Thomas and C. Peres, pers. comm.]. In order to improve the reliability of the estimates, perpendicular distances were truncated to avoid outliners. The truncation was based on the lowest Akaike's Information Criterion (AIC) values and the best fit of curve. In most cases truncation was made at 10% [L. Thomas, pers. comm.].

Following Peres and Nascimento [2006], observations of red deer (*Mazama americana*) and grey deer (*Mazama gouazoubira*) were pooled, due to the dificulty of identifying the animals at species level during surveys, as well as the reduced number of visual detections of *M*. *gouazoubira* in San Martin's sampling sites. Therefore biomass estimates for grey and red deer are presented for the genus *Mazama*, using the average body weight of both species. Similarly, observations for the wattled curassow (*Crax globulosa*) and the razor-billed curassow (*Crax mitu*) were pooled. Biomass (ind/km$_2$) was estimated by multiplying 80% of adult body weight of adult males and females (see section 3.2.1).

3.2.4.2 Qualitative estimates of hunting sustainability

The qualitative analysis aims to reduce the risks of extrapolating the results from the small areas actually surveyed to the total catchment areas in Mocagua and San Martin. Ranks were determine by using the minimum, mean, maximum, lower mean and higher mean of average values of Mocagua and San Martin for abundance (total number of animal signs registered during the study period) and number of hunted animals. As the 15 game species belong to the medium and long-lived categories of life history strategy (see Table 3.1), I ranked each species taking into account their age of last reproduction (Table 3.4). Thus life history strategy was ranged from 1 (short life expectancy) to 4

Table 3.4 Information on life history strategy and percentage of Maximum Production Harvestable (MPH) for the 15 most important prey species.

Species	**Age of last reproduction**	**Life expectancy**	**% MPH**
Agouti paca [4]	12	Medium-lived	40%
Dasyprocta fuliginosa[1]	10	Medium-lived	40%
Dasypus sp[1]	8	Medium-lived	40%
Tayassu pecari[1]	13	Long-lived	20%
Mazama sp. [1]	8	Medium-lived	40%
Geochelone denticulata	30	Long-lived	20%
Tayassu tajacu[1]	13	Long-lived	20%
Tapirus terrestris[1]	25	Long-lived	20%
Nasua nasua [5]	10	Medium-lived	40%
Crax spp.[3]	18	Long-lived	20%
Myoprocta pratti[2]	10	Medium-lived	40%
Penelope jacquacu[3]	14	Long-lived	20%
Alouatta seniculus[1]	20	Long-lived	20%
Aotus sp[2]	14	Medium-lived	40%
Lagothrix lagothricha[1]	20	Long-lived	20%

(very long life expectancy) (Table 3.5).

Table 3.5 Criteria used to rank the life history of the 15 most hunted game species. Ranks are presented in ascending order reflecting the susceptibility of hunting of each game species

Life expectancy	Age of last reproduction (yr)	Rank value
Short	8 to 11	1
Medium	11.5 to 14.5	2
Long	15 to 22	3
Very long	23.5 to 30	4

Abundance were ranged from 1 (very high abundance) to 6 (very low abundance), based on average values of total signs of wildlife presence in Mocagua and San Martin (Table 3.6).

Table 3.6 Criteria used to rank the abundance of the 15 most hunted game species. Ranks are presented in descending order reflecting the susceptibility of wildlife populations to hunting based on their abundances

Abundance	N[1]	Rank value
Very high	> 237	1
High	161 to 236	2
High intermediate	84 to 160	3
Intermediate	45 to 83	4
Low	5 to 44	5
Very low	0 to 4	6

Hunting pressure ranged from 1 (very low) to 6 (very high), based on average values of hunted animals in Mocagua and San Martin (Table 3.7).

Table 3.7 Criteria used to rank the hunting pressure of the 15 most hunted game species

Hunting pressure	N. individuals	Rank value
Very low	0 to 6	1
Low	7 to 33	2
intermediate	34 to 59	3
High intermediate	60 to 186	4
High	187 to 313	5
Very high	>314	6

Thus, final ranks ≤ 6 suggest that hunting is sustainable (YES); ranks = 7 were either sustainable (YES) or too ambiguous to interpret (UNKNOWN). For instance, here the UNKNOWN classification is given when either the abundance range was low (5) or hunting pressure was high (5). When final ranks were = 8, hunting was either unknown or unsustainable. In this case hunting was unsustainable when abundance was either low (5) or very low (6) and hunting ranged from high intermediate (4) to very high hunting pressure (6). Lastly, scores ≥ 9 suggest overhunting (NO). A detailed table including all the ranking probabilities is presented in Appendix V.

3.2.4.3 Quantitative estimates of hunting sustainability

Although density estimates and observed hunting data presented several limitations when applying the models to measure the sustainability of hunting, I report results using the four models in order to compare this study with others conducted in the Amazon, where there were similar data limitations, forest structures and hunting pressures. In the absence of a non-hunted site to determine carrying capacity, and to avoid using predicted densities obtained from published data, Mocagua is defined as the slightly hunting area, while San Martin is the heavily hunted area. Therefore density (ind/km^2) and biomass (kg/km^2) estimates are compared between the two Tikuna communities. For all the models, production was calculated using Robinson and Redford's (1991) formula:

$$P_{max} = (0.6K * \lambda_{max}) - 0.6K$$

Estimates of finite rate of increase (λ_{max}), derived from the intrinsic rate of population increase (r_{max}) were obtained from literature reviews, as these parameters are more likely to be more constant within a species at different sites because of its dependence on more phylogenetically intrinsic traits like body size and diet [Peres 2000b; Robinson and Redford 1986b; 1991b]. Thus productivity as P= (0.5D)(Y*g), was not estimated owing to the lack of complete reproductive parameters for the 15 studied species. The observed annual harvest rate (OH= hunted animals/km$_{2\text{-}1}$) per unit area was estimated for Mocagua (hunting area: 207.72 km^2) and San Martin (hunting area: 198.65 km^2). Estimates of harvested biomass (kg/km^2) were calculated by multiplying the number of hunted animals by the average body weight of all the carcasses accurately weighed during the study period [Peres and Nascimento 2006].

3.2.5 Statistical analysis

SPSS V. 17 was employed to conduct all the statistical analyses. Normality (Kolmogorov-Smirnov) and homogeneity of variance (Levene) tests were assessed by examining histograms and the skewness and kurtosis for each of the dependent variables. As some of the variables did not present a normal or homogenous distribution, I employed a $\log_{10}$ transformation to meet assumptions of parametric tests when necessary. Comparisons between Mocagua and San Martin were tested using ANOVAS and Chi-square tests. For all the analyses, descriptive statistics (Mean (M), Standard Deviation (SD)), as well as complete results of statistical tests and graphs are included in Appendix V.

3.3 Results

3.3.1 Harvest assessment

During the study period game harvest was quantified for a total of 827 days. Wildlife harvest was recorded from 44 adult male hunters and two women who hunted occasionally (92% of total hunters in Mocagua and 85% of total hunters in San Martin). (See sections 5.3.3.1 and 5.3.3.2). A total of 2,101 prey items were hunted by Mocagua and San Martin Tikuna communities, corresponding to 49 species of vertebrates, with a total extraction of some 26,700 kg of game meat (Table 3.8). From the total harvest, about 80% (N = 1,713) of the prey species were mammals, about 10% (N = 221) were birds and 8% (N = 167) were reptiles (Table 3.9). In addition, males represented approximately 60% (N = 1,308) of the total harvest.

Table 3.8 Game species harvested at Mocagua and San Martin from February 2005 to February 2009, ANP.

Species	Common name	MBW (kg) (±SD)	Total harvest (ind.)	Total extracted (kg)	Mocagua		San Martin	
					No. Harvested	Harvest (kg)	No. Harvested	Harvest (kg)
Artiodactyls								
Mazama americana	Red Deer	30.1± 10.9	83	2,498	16	482	67	2,0167
Mazama gouazoubira	Grey Deer	16.5 ± 3.6	46	759	20	330	26	429
Tayassu tajacu	Collared Peccary	17.8 ±10.8	72	1,282	25	445	47	837
Tayassu pecari	White-lipped Peccary	25.8 ± 8.3	149	3,844	12	310	137	3,535
			350	**8,383**	**73**	**1,566**	**277**	**6,817**
Carnivores								
Eira barbara	Tayra	4 ± 0.8	4	16	-	-	4	16
Leopardus pardalis[1]	Ocelot	10	1	10	-	-	1	10
Leopardus wiedii[1]	Margay	5	2	10	-	-	2	10
Nasua nasua[1]	Coati	3.7	56	207	22	81	34	125
Potos flavus	Kinkajou	4.1 ± 0.8	22	90	15	62	7	28
Speothos venaticus	Wild dog	9.3 ± 5.8	3	28	2	19	1	9
			88	**361**	**39**	**162**	**49**	**200**
Perissodactyls								
Tapirus terrestris	Tapir	113.2 ± 44.3	**65**	**7,358**	**13**	**1,472**	**52**	**5,886**
Primates								
Alouatta seniculus	Howler Monkey	6 ± 2.2	18	108	9	54	9	54
Aotus sp. [1]	Night Monkey	1.5	22	33	10	15	12	18
Callicebus torquatus [1]	Titi Monkey	2.2	12	26	7	15	5	11
Lagothrix lagothricha[1]	Woolly Monkey	9.6	12	115	1	10	11	106
Pithecia monachus[1]	Saki Monkey	2.8	6	17	2	6	4	11
Saguinus nigricollis[1]	Black-mantled Tamarin	0.6	6	4	1	0.6	5	3
Saimiri sciureus[1]	Squirel Monkey	1.4	11	15	5	7	6	8
			94	**350**	**38**	**120.7**	**56**	**229**

Species	Common name	MBW (kg) (±SD)	Total harvest (ind.)	Total extracted (kg)	Mocagua		San Martin	
					No. Harvested	Harvest (kg)	No. Harvested	Harvest (kg)
Agouti paca	Paca	8.4 ± 2.7	626	5,258	184	1,546	442	3,713
Coendou sp. [1]	Porcupine	4.5	1	5	1	6	-	-
Dasyprocta fuliginosa	Black agouti	5.5 ± 1.1	254	1,397	108	594	146	803
Echimys sp. [1]	Red-nosed tree rat	0.9	2	2	1	1	1	1
Hydrochaeris hydrochaeris	Capybara	27.7 ± 11.9	22	609	11	305	11	305
Myoprocta pratti[1]	Acouchy	0.9	29	26	2	5	27	24
Sciurus sp. [1]	Squirel	1	2	2	2	2	-	-
			936	**7,299**	**309**	**2,454**	**627**	**4,846**
Xenarthrans								
Bradypus variegatus	Three-toed sloth	5.2 ± 1.2	11	57	6	31	5	26
Choloepus didactylus	Two -toed sloth	8.6 ± 1.5	10	86	-	-	10	86
Dasypus sp	Armadillo	6.3 ± 1.8	151	951	68	428	83	523
Myrmecophaga tridactyla[1]	Giant Anteater	30.7	3	92	-	-	3	92
			180	**1,395**	**74**	**460**	**106**	**936**
TOTAL MAMMALS			***1,713***	***25,147***	***546***	***6,233***	***1,167***	***18,914***
BIRDS								
Ardeiforms								
Tigrisoma lineatum	Rufescent Tigerheron	2 ± 0.6	**11**	**22**	**7**	**14**	**4**	**8**
Falconiforms								
Geranospiza caerulescens	Crane Hawk		**6**	**11**	**4**	**7**	**2**	**4**
Galliforms		1.8 ± 0.7						
Aburria pipile	Common Piping-Guan	2.4 ± 0.5	16	38	12	29	4	10
Crax globulosa	Wattled Curassow	3.4 ± 1.5	46	156	12	41	34	116
Nothocrax urumutum	Nocturnal Curassow	3.1 ± 1.7	11	34	-	-	11	34

Species	Common name	MBW (kg) (±SD)	Total harvest (ind.)	Total extracted (kg)	Mocagua		San Martin	
					No. Harvested	Harvest (kg)	No. Harvested	Harvest (kg)
Otalis sp.	Chachalaca	4 ± 1.1	13	52	11	44	2	8
Penelope jacquacu	Cauca Guan	1.7 ± 1.5	29	49	21	36	8	14
			115	**330**	**56**	**149**	**59**	**181**
Procellariiforms								
Psophia crepitans	Gray-Winged Trumpeter	1.2 ± 0.5	**25**	**30**	**19**	**23**	**6**	**7**
Psittacids								
Amazona farinosa[2]	Mealy Parrot 2	0.7	3	2	-	-	3	2
Ara macao	Scarlet Macaw	1.0	1	1	-	-	1	1
Ara sp. [2]	Macaw	1.0	31	31	28	28	3	3
			40	**39**	**29**	**29**	**11**	**10**
Tinamiforms								
Cryturellus undulatus	Undulated Tinamou	1.7 ± 0.5	6	10	3	5	3	5
Tinamus sp.	Tinamou	3 ± 0.6	18	54	12	36	6	18
			24	**64**	**15**	**41**	**9**	**23**
TOTAL BIRDS			***221***	***497***	***130***	***263***	***91***	***233***
REPTILES								
Crocodils								
Caiman crocodilus	Common Caiman	10.6 ± 6.2	18	191	-	-	18	191
Melanosuchus niger	Black Caiman	13.1 ± 5.7	17	223	-	-	17	223
			35	**414**	**-**	**-**	**35**	**414**
Testudines								
Geochelone denticulata	S. American Yellow-Footed Tortoise	4.9 ± 2.2	101	495	22	108	79	387

Species	Common name	MBW (kg) (±SD)	Total harvest (ind.)	Total extracted (kg)	Mocagua		San Martin	
					No. Harvested	Harvest (kg)	No. Harvested	Harvest (kg)
			129	**657**	**25**	**125**	**104**	**532**
Chelonia								
Podocnemis unifilis[3]	Yellow-headed side neck turtle	4.2	**3**	**13**	**-**	**-**	**3**	**13**
TOTAL REPTILES			***167***	***1,083***	***25***	***125***	***142***	***958***
Overall Total			**2,101**	**26,709**	**701**	**6,622**	**1,400**	**20,105**

[1] Weight information obtained from Emmons [1999]
[2] Weight information obtained from Hilty [1986]
[3]Weight information obtained from Emmons [1989]
MBW: Mean Body Weight: Average body mass of all carcases weighed and live-captured animals, including females and males from all age classes at Mocagua and San Martin

Considering the total number of harvested animals and extracted kilograms of meat at each sampling site, Agua Pudre (hunting rank-4) in San Martin community, accounted for 52% of the total extraction. There were significant differences between the average weight of prey hunted between communities (χ^2 = 503.44; df=89; p <0.0001). The average prey weight in Mocagua was about 10 kg while average weight of hunted prey in San Martin was 15 kg. In both communities, there was a marked preference for adult prey, representing about 80% (N = 1,611) of the total harvest (Fig. 3.3).

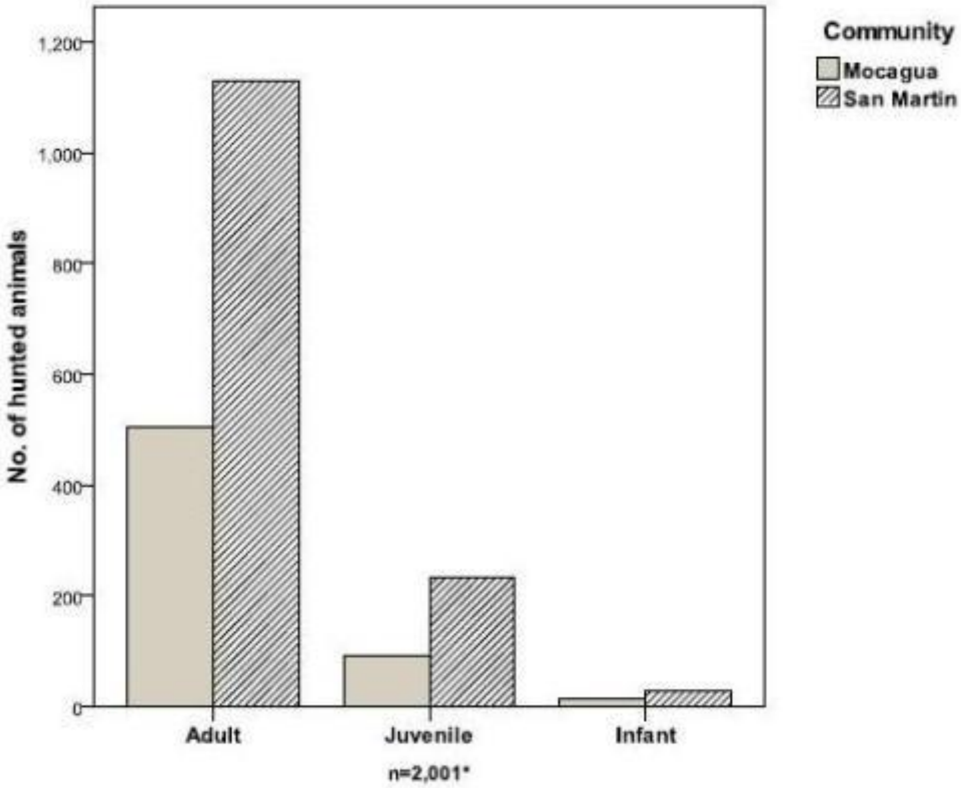

Figure 3.3 Age class distribution of game species consumed in Mocagua and San Martin Tikuna communities

*n=2,001 = total number of animals that could be aged accurately

Harvest of the 15 most important game species included a total of 1,770 hunted prey (Fig 3.4). Rodents contributed to half (52%) of the total harvest, followed by ungulates with almost 20%. When comparing the number of hunted prey at each community, San Martin's harvesting (70%) was significantly higher than at Mocagua (30%) (χ^2 = 48,13; df=7; p <0.0001).

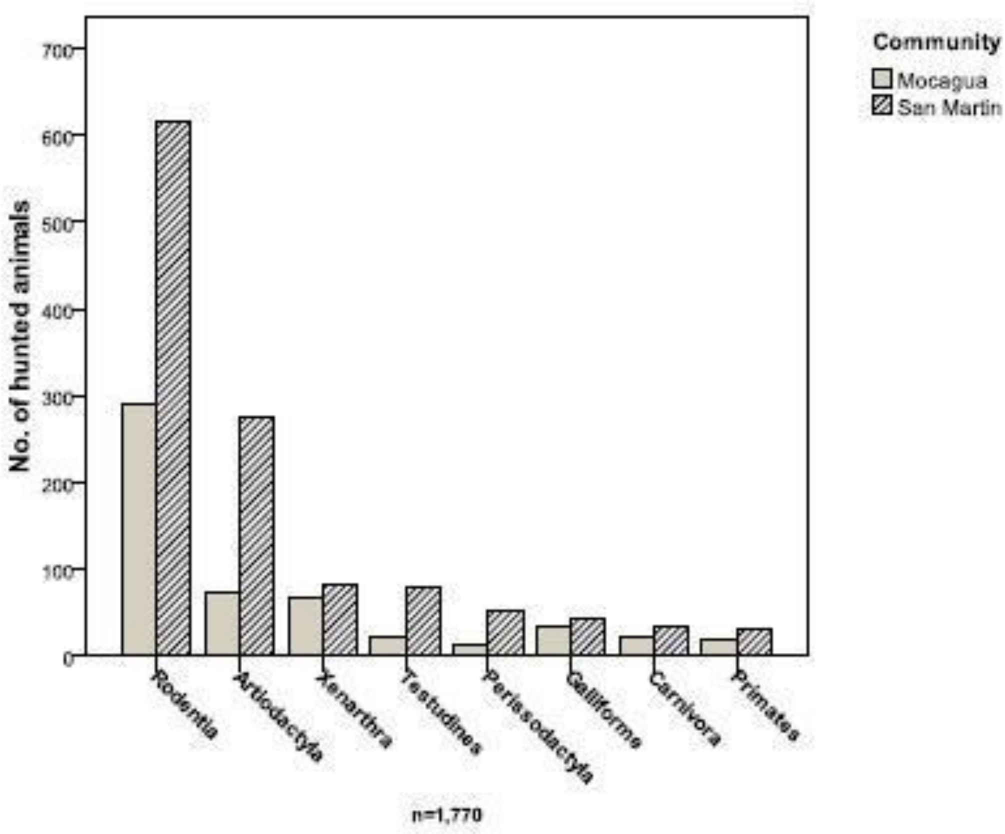

Figure 3.4 Total harvest in Mocagua and San Martin of the 15 most important game species grouped by order.

3.3.2 Qualitative estimates of hunting sustainability

The qualitative evaluation of hunting sustainability for Mocagua community suggested that the deer (M*azama* sp.), the collared peccary (*Tajassu tajacu*), the acouchy (*Myoprocta pratti*) and the night monkey (*Aotus* sp.) are sustainably hunted. The results also indicated that it is not clear if the hunting of the paca (*Agouti paca*), the black agouti (*Dasyprocta fuliginosa*), the armadillo (*Dasypus* sp.), the lowland tapir (*Tapirus terrestris*) and the cauca guan (*Penelope jacquacu*) is sustainable or not (UNKNOWN). The rest of the game species seemed overhunted, being the South American yellow-footed tortoise

(*Geochelone denticulata*) and the curassow (*Crax* sp.) the most overharvested species, as they had the highest scores (11 and 10 respectively) (Table 3.9).

Table 3.9 Qualitative evaluation of hunting sustainability for the 15 most hunted game species in Mocagua

Species	Common name	LH	A	H	Rank	Sustainability
Agouti paca	Paca	2	2	4	8	UNKNOWN
Dasyprocta fuliginosa	Black agouti	1	3	4	8	UNKNOWN
Dasypus sp.	Armadillo	1	3	4	8	UNKNOWN
Tayassu pecari	White-lipped Peccary	2	4	3	9	NO
Mazama sp.	Deer	1	2	2	5	YES
Geochelone denticulata	S. American Yellow-Footed Tortoise	4	5	2	11	NO
Tayassu tajacu	Collared Peccary	2	3	2	7	YES
Tapirus terrestris	Tapir	4	2	2	8	UNKNOWN
Nasua nasua	Coati	1	5	2	8	NO
Crax sp.	Curassow	3	5	2	10	NO
Myoprocta pratti	Acouchy	1	5	1	7	YES
Penelope jacquacu	Cauca Guan	2	4	2	8	UNKNOWN
Alouatta seniculus	Howler Monkey	3	4	2	9	NO
Aotus sp.	Night Monkey	2	4	1	7	YES
Lagothrix lagothricha	Woolly Monkey	3	5	1	9	NO

LH = Life history strategy; A = Abundance; H = Hunting

For San Martin community, the qualitative evaluation suggested that the hunting of the deer (*Mazama* sp.) is sustainable, while hunting for the black agouti (*Dasyprocta fuliginosa*), the armadillo (*Dasypus* sp.), the collared peccary (*Tajassu tajacu*), the cauca guan (*Penelope jacquacu*) and the night monkey (*Aotus* sp.) are unknown. The rest of the game species seemed overhunted. The South American yellow-footed tortoise appears to be the most overharvested species, with the highest score (14), followed by the paca (*Agouti paca*) and the curassow (scores = 11) (Table 3.10).

Table 3.10 Qualitative evaluation of hunting sustainability for the 15 most hunted game species in San Martin

Species	Common name	LH	A	H	Rank	Sustainability
Agouti paca	Paca	2	6	3	11	NO
Dasyprocta fuliginosa	Black agouti	1	4	3	8	UNKNOWN
Dasypus sp.	Armadillo	1	4	3	8	UNKNOWN
Tayassu pecari	White-lipped Peccary	2	4	4	10	NO
Mazama sp.	Deer	1	4	1	6	YES
Geochelone denticulata	S. American Yellow-Footed Tortoise	4	4	6	14	NO

Tayassu tajacu	Collared Peccary	2	3	3	8	UNKNOWN
Tapirus terrestris	Tapir	4	3	3	10	NO
Nasua nasua	Coati	1	3	5	9	NO
Crax sp.	Curassow	3	3	5	11	NO
Myoprocta pratti	Acouchy	1	2	5	8	NO
Penelope jacquacu	Cauca Guan	2	2	4	8	UNKNOWN
Alouatta seniculus	Howler Monkey	3	2	5	10	NO
Aotus sp.	Night Monkey	2	2	4	8	UNKNOWN
Lagothrix lagothricha	Woolly Monkey	3	2	5	10	NO

LH = Life history strategy; A = Abundance; H = Hunting

3.3.3 Quantitative estimates of hunting sustainability

I recorded a total of 860 visual detections for the 15 most important game species. Sixty percent of all sightings were registered at Mocagua (N = 513), the lightly-hunted site. From the 15 vertebrate species, only two small-bodied species, the Spix's guan (*Penelope jacquacu*) and the acouchy (*Myoprocta pratti*) presented higher densities at the heavily hunting site, San Martin. Density estimates of six harvest-sensitive species, all of them with a long-lived history strategy, were evidently higher in Mocagua than in San Martin. For instance, the woolly monkey's (*Lagothrix lagothricha*) density in Mocagua was 11 times higher in Mocagua than in San Martin, while the South American yellow-footed tortoise (*Geochelone denticulata*), the howler monkey (*Alouatta seniculus*) and the lowland tapir (*Tapirus terrestris*) presented a density three times higher in Mocagua. There was a marginal statistical difference in population densities between Mocagua and San Martin ($F=_{1\text{-}28}= 4.3$; $p= 0.047$). The aggregated biomass in Mocagua was 635 kg/km², while San Martin's aggregated biomass was 255 kg/km². Nonetheless there was no statistically significant differences in biomass amongst the communities ($F=_{1\text{-}28} = 2.78$; $p= 0.10$). From a total of 2,700 animal signs recorded during this study, approximately 60% were registered in Mocagua (N = 1,532). Animal signs included tracks, faeces and visual detections (Table 3.12).

A one-way between-groups ANOVA was conducted to explore the effect of body size on population densities ($\log_{10}$ transformed). Categories for body size were ranked as small, medium and large taking into account the average body weight of each species in relation to its order category inside the group of 15 game species. It shows a significant difference between the three groups

($F_{2\text{-}27}$= 6.23; p= 0.006). Post-hoc comparison using the Tukey's HSD (Honestly Significant Difference) test suggested that main differences were presented by medium-bodied size species (M = 0.59; SD = 0.29) and large bodied species (M = 0.03; SD = 0.35) (Fig. 3.5).

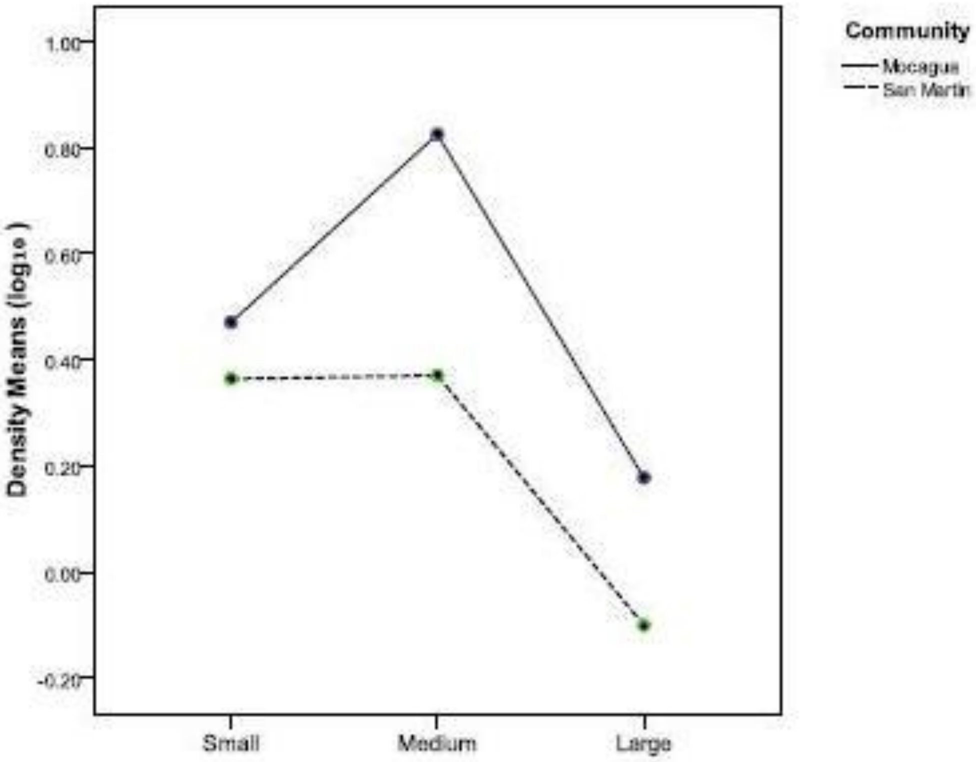

Figure 3.5 Main differences in density (log10) means of game species among body size categories in Mocagua and San Martin.

Table 3.11 Information required for calculating abundance indexes (AI), individual density (individuals/km²) and biomass (kg/km²) for the 15 most important game species ranked by preference order at Mocagua and San Martin

Species	ABW (± SD)	80% of ABW (± SD)	Group size (Individuals ± SD)		N1 for AI estimates		AI (sign/100km)	
			MOC	SM	MOC	SM	MOC	SM
Agouti paca	8.4 ± 2.7	6.7 ± 2.2	1.0	1.0	199	135	8.8	6.0
D. fuliginosa	5.5 ± 1.1	4.4 ± 0.9	1.0	1.0	207	152	9.2	6
Dasypus sp.	6.3 ± 1.8	5.0 ± 1.4	1.0	1.0	139	91	6.1	4.0
Tayassu pecari	25.8 ± 8.3	20.6 ± 6.6	3.4 ± 4.6	2.3 ± 1.1	82	48	3.6	2.1
Mazama sp.	23.3 ± 7.2	18.6 ± 5.8	1.0	1.0	217	254	9.6	11.2
Geochelone denticulata	4.9 ± 2.2	3.9 ± 1.8	1.0	1.0	6	3	0.3	0.1
Tayassu tajacu	17.8 ± 10.8	14.2 ± 8.6	3.4 ± 5.6	1.9 ± 1.3	120	92	5.3	4.1
Tapirus terrestris	113.2±44.3	90.6 ± 35.4	1.0	1.0	305	196	13.5	8.7

Nasua nasua[1]	3.7	3.0	6.0 ± 9.0	4.9 ± 3.0	22	37	1.0	1.6
Crax sp.	3.2 ± 1.6	2.7 ± 1.3	1.0	1.0	8	6	0.4	0.3
*Myoprocta pratti*1	0.9	0.7	1.0	1.0	11	16	0.4	0.7
Penelope jacquacu	1.7 ± 1.5	1.4 ± 1.2	1.8 ± 1.3	2.1 ± 2.6	59	57	2.6	2.5
Alouatta seniculus	6 ± 2.2	4.8 ± 1.8	4.4 ± 1.3	4.1 ± 2.1	59	27	2.6	1.1
Aotus sp. [1]	1.5	1.2	2.4 ± 0.8	2.2 ± 1.0	57	47	2.5	2.0
L. lagothricha[1]	9.6	7.7	16.0 ± 11.5	14.7 ±5.2	41	11	1.8	0.5

ABW = Average Body Weight; N= Total number of tracks and faeces; [1]Weight information taken from Emmons [1999]

3.3.3.1 Abundance, density or standing biomass comparison model

The density comparison confirmed that, from the 15 game species included in the analysis, 13 species presented higher population densities in Mocagua than in San Martin. There was about 34% of relative change in the standing density between sites (Table 3.12). The relationship of body size means of game species (expressed as $\log_{10}$ mean body weight) and density (ind/km^2) – biomass (kg/km^2) was investigated using Pearson product-moment correlation coefficient. There was a strong correlation, with an increase of body weight and the increase of the standing biomass (Pearson's $r = 0.68$; n = 30; $p < 0.0001$), but there was no correlation between body size mean and density ($r = -0.46$; n = 30; $p = 0.88$).

Table 3.12 Population density and biomass of the 15 most important game species ranked by preference order at Mocagua and San Martin

Species	N		ESW		Group density (groups/km^2 ± SD)		Individual density (individuals/km^2 ± SD)		Biomass1 (kg/km^2 ± SD)		Change[2]
	MOC	SM	MOC	SM	MOC	SM	MOC	SM	MOC	SM	
Agouti paca	20	12	1.6	1.4			5.7 ± 9.2	3.9 ± 5.2	38 ± 19.9	26.2 ± 11.2	-31. 0
Dasyprocta fuliginosa	34	32	9.2	7.9			1.9 ± 0.6	1.6 ± 2.3	8.3 ± 0.5	7.2 ± 2.0	-12.8
Dasypus sp.	137	91	3.7	3.0	3.7 ± 0.3	2.1 ± 0.2	8.7 ± 5.5	4.0 ± 4.6	43.8 ± 7.9	20.3 ± 6.6	-53.8
Tayassu pecari	84	48	1.0	1.0			12.6 ± 4.5	4.9 ± 1.6	260.4±29.9	100.6 ± 10.6	-61.3
Mazama sp.[3]	35	28	15.2	17.6			1.0 ± 0.5	0.9 ± 0.9	17.9 ± 2.9	16.0 ± 5.2	-10.4
Geochelone denticulata	6	3	0.5	0.5			5.6 ± 1.3	1.2 ± 1.6	21.9 ± 2.3	6.5 ± 6.9	-70.3
Tayassu tajacu	10	9	6.9	6.9	1.3 ± 0.6	0.6 ± 0.2	2.0 ± 4.5	1.2 ± 1.6	29.0 ± 38.9	16.5 ± 13.8	-43.2
Tapirus terrestris	10	5	11.6	11.6			0.5 ± 0.7	0.2 ± 0.3	48.9 ± 24.8	18.1 ± 10.6	-63.0
Nasua nasua	12	8	14.9	14.9	0.1 ± 0.3	0.3 ± 0.7	2.0 ± 6.2	1.2 ± 0.9	5.9	3.6	-38.1
Crax sp. [3]	8	6	1.9	1.9			2.0 ± 5.6	1.3 ± 2.1	5.4 ± 7.2	3.6 ± 2.7	-33.2
Myoprocta pratti	11	15	3.0	5.8			1.5 ± 2.0	2.5 ± 2.7	1.1	1.8	59.7
Penelope jacquacu	42	44	12.0	21.1	1.4 ± 1.9	1.6 ± 1.3	2.4 ± 3.9	3.3 ± 2.7	3.3 ± 4.7	4.5 ± 3.2	37.4
Alouatta seniculus	52	21	24.0	19.0	2.0 ± 2.2	0.7 ± 0.9	8.6 ± 8.7	2.8 ± 4.1	41.2 ± 15.3	13.4 ± 7.2	-67.5
Aotus sp.	20	16	12.8	12.8	4.1 ± 3.6	3.4 ± 2.0	9.8 ± 8.5	7.5 ± 6.1	11.8	8.2	-30.1
Lagothrix lagothricha	32	9	14.8	21.2	0.8 ± 1.1	0.1 ± 2.7	12.8± 12.7	1.1 ± 0.5	98.3	8.5	-91.4
	513	347							635.2	255.1	

N**=** Number of visual detections by species
ESW = Effective Strip Width
[1]Biomass was estimated using the 80% of average body weight of adult females and males hunted at Mocagua and San Martin and values from Emmons [1999] (see Table 3.11)
[2]Relative change in population density between Mocagua and San Martin
[3]Visual detections of *Mazama americana* and *Mazama gouazoubira* were pooled, as well as visual detections of *Crax globulosa* and *Crax mitu*
* Average of total relative change in population between Mocagua and San Martin

3.3.2.2 The Production model

In order to evaluate the current harvest rates of San Martin in comparison with Mocagua, I compared estimates of maximum production (Pmax) and annualised observed harvest (OH) from Mocagua and San Martin communities, (all the estimates are presented per km²), for 10 hunting game species, within each community's catchment area, as follow (Table 3.13):

Table 3.13 Calculation of annual potential production (Pmax) and observed harvest (OH) for the 10 most important game species in rank order of preference at Mocagua and San Martin.

Species	**Density (ind/km²)**		**λmax**	**Pmax**		**OH* ind/km²**	
	MOC	**SM**		**MOC**	**SM**	**MOC**	**SM**
Agouti paca	5.7	3.9	1.9	3,1	2,1	0,39	0,98
Dasyprocta fuliginosa	1.9	1.6	3.0	2,3	2,0	0,23	0,32
Dasypus sp	8.7	4.0	2.0	5,2	2,4	0,14	0,18
Mazama sp	1.0	0.9	0.4	10,0	3,9	0,08	0,21
Myoprocta pratti	1.5	2.5	3.0	0,3	0,3	0,004	0,06
Penelope jacquacu	2.4	2.6	3.3	1,8	3,0	0,04	0,02
Alouatta seniculus	8.6	2.8	1.2	0,7	1,0	0,02	0,02
Aotus sp.	9.8	7.5	1.3	0,9	0,3	0,02	0,03
Lagothrix	12.8	1.1	1.2	1,5	1,1	0,002	0,02

*Results of OH are presented with 2 and 3 decimals in order to provide figures.
λmax (finite rate of increase) (see Appendix IV for definition): Values from Robinson and Redford [1991], Bodmer et al [1997], Begazo and Bodmer [1998] and Peres and Nascimento [2006].

The production model analyses demonstrated that current hunting by San Martin community is unsustainable for four species (Table 3.14). Two game species presented hunting levels far above their MSY in San Martin. For instance the deer and the paca extraction rates were 160% and 76%, respectively. When comparing hunting patterns among communities, there was a significant difference between the observed harvest (OH) from Mocagua and San Martin (t = 2.093; df = 28; p= 0.04). Additionally there was a strong correlation between the increase of body size and the observed harvest (OH (ind/km²) = r = 0.814; n = 30; p < 0.0001 and OH (kg/km²) r = 0.773; n = 30; p < 0.0001).

Table 3.14 The Production Model: Evaluation of current harvest in San Martin

Species	OH	MSY	%Removed	% MPH	Sustainable
Agouti paca	1.0	1.3	76	40	NO
*Dasyprocta fuliginosa**	0.3	0.9	36	40	NO
Dasypus sp	0.2	2.1	9	40	YES
Tayassu pecari	0.3	0.6	52	20	NO
Mazama sp	0.2	0.1	160	40	NO
Myoprocta pratti	0.1	0.8	8	40	YES
Penelope jacquacu	0.02	0.3	7	20	YES
Alouatta seniculus	0.02	6.0	0.3	20	YES
Aotus sp.	0.03	0.6	4	40	YES
Lagothrx	0.02	0.2	11	20	YES

*Current harvest is unsustainable as the removed percentage is almost equal to its MPH [Caughley and Sinclair, 1994].
OH= Observed Harvest
MSY= Maximum Sustainable Yield defined as 0.2 of **Pmax** for long-lived species; 0.4 of **Pmax** for medium-lived species and 0.6 of **Pmax** for short-lived species [Robinson and Redford, 1991].
% Removed= OH/MSY*100
MPH= Maximum percentage of production harvestable. Values taken from Robinson and Redford [1991]; Bodmer and Robinson [2004].

3.3.3.3 The stock-recruitment model

This model suggests that hunting for half of the game species is carried out as a risky strategy in San Martin. Although the paca's predicted population (values of N/K) is above its MSY in 9%, I included this species in the risky category as this marginal value is too close to the MSY [Caughley and Sinclair 1994].

Table 3.15 The stock-recruitment model: summary of the riskiness of hunting in the long-term

Species	K	N	MSY	N/K	STRATEGY
Agouti paca	5.7	3.9	60	69	Risky
Dasyprocta fuliginosa	1.9	1.6	60	87	Safe
Dasypus sp	8.7	4.0	60	46	Risky
Tayassu pecari	12.6	4.9	80	39	Risky
Mazama sp	1.0	0.9	60	90	Safe
Myoprocta pratti	1.5	2.5	60	160	Safe
Penelope jacquacu	2.4	3.3	80	137	Safe
Alouatta seniculus	8.6	2.8	80	33	Risky
Aotus sp.	9.8	6.9	60	70	Safe
Lagothrx	12.8	1.1	80	9	Risky

N= density in the hunted area (San Martin); K= carrying capacity calculated from density values from Mocagua;
N/K= predicted population.

3.3.3.4 The Unified-harvest model

Using this model, I examined both the sustainability of current hunting and the potential for long-term sustainable use [Bodmer and Robinson 2004]. For this analysis, information on the life history strategy of the 10 game species is included, as well as the percentage of Maximum Harvestable Production (MHP) and MSY, which is estimated as a percentage of carrying capacity (K) from the hunted population. The results of the unified-harvest model indicated that in San Martin community hunting for seven species appears sustainable. The deer presented the highest rate of overhunting (MPH-extraction) (-75%), followed by the paca (-38%), and the woolly monkey (-11%) (Table 3.16).

Table 3.16 The Unified Harvest Model. Evaluation of the sustainability of current hunting and the potential for long-term use [Bodmer and Robinson, 2004].

Species	MSY	OH	MPH%	Extraction %	Sustainability
Agouti paca	1.26	0.98	40	78	Overhunted
Dasyprocta fuliginosa	1.18	0.32	40	28	Appears sustainable
Dasypus sp	1.43	0.18	40	13	Appears sustainable
Tayassu pecari	3.09	0.30	20	10	Appears sustainable
Mazama sp	0.18	0.21	40	115	Overhunted
Myoprocta pratti	1.77	0.06	40	3	Appears sustainable
Penelope jacquacu	0.79	0.02	20	2	Appears sustainable
Alouatta seniculus	0.23	0.02	20	9	Appears sustainable
Aotus sp.	0.64	0.03	40	4	Appears sustainable
Lagothrx	0.08	0.02	20	31	Overhunted

OH= Observed Harvest
MSY= Maximum Sustainable Yield defined as 0.8 of **Pmax** for long-lived species and 0.6 of **Pmax** for medium-lived species using **Pmax** from the harvested population
% Removed= OH/MSY*100

3.4 Discussion

Reported wildlife harvest by Amerindians in the neotropics has been consistent with marked preferences for large vertebrate species with long and medium-lived life history strategies. These species have long gestation periods, long inter-birth intervals and long life spans, making them extremely susceptible to hunting that even at subsistence levels could drive game populations to local extinction [Bodmer and Robinson 2004; Cullen et al. 2004; Fragoso et al. 2004; Jerozolimski and Peres 2003; Mittermeier 1991; Peres 1990a; 2010; Peres and Nascimento 2006]. Additionally, several studies demonstrated that hunters in the neotropics make inter-specific prey choices that maximise return rates, as explained by Alvard's [1993] foraging theory [Jerozolimski and Peres 2003;

Naranjo et al. 2004; Vickers 1991; Zapata-Rios et al. 2009]. Thus, hunters are inclined to select large-bodied prey that yield the greatest amount of meat per unit of energy or time invested, despite their local population density and risk of extinction [Bodmer 1995b; Bodmer et al. 1997; Jerozolimski and Peres 2003; Vickers 1994]. In accordance with those statements, hunting preferences by Tikunas at Mocagua and San Martin presented a marked inclination for large bodied mammals (81%) and adult prey (82%). Combining the results of the qualitative evaluation of hunting and the quantitative models, it seems that at least eight game species included in the analyses are overhunted.

Campos-Rozo [1987] conducted an ethnographic assessment of hunting patterns by Tikunas in San Martin community, reporting the consumption of 46 vertebrate species where 56% of the species were mammals. A total of 4,020 kg of game meat was consumed during a 6 month period. Arias and Castellanos [2000] reported 450 kg of game meat in San Martin during the period 1998-1999 as the total consumption. Here it is relevant to mention that Campos-Rozo [1987] recorded the hunting data by herself while figures reported by Arias and Castellanos [2000] were compiled by local hunters, thus it is likely that low numbers of hunted animals reported during 1998-1999 reflect a bias in the data. However, when comparing the harvest assessments conducted in San Martin by Campos-Rozo in 1987 and this study, it seems that hunting preferences remain similar. For instance, there has been a marked preference for mammals where approximately 90% of the total harvest (kg) has been represented by this vertebrate class (Table 3.17), while the consumption of bird species has decreased over time, in terms of number of hunted animals.

Table 3.17 Historical comparison of harvest composition in San Martin

	Campos-Rozo, 1987 (6 months)		Arias and Castellanos (2000) (12 months)		Maldonado (2005-2009) (48 months)	
Class	**% Ind. (n=362)**	**%kg (n=4,020kg)**	**% Individuals (n=24)**	**%kg (n=449kg)**	**% Ind. (n=1,410)**	**%kg (n=20,095)**
Mammals	62.6	95.0	56	90.4	83.5	94.1
Birds	27.7	1.2	20	1.6	6.5	1.1
Reptiles	9.7	3.8	24	8.0	10.0	4.8

3.4.1 Population density comparison with other studies

Population density estimates at Mocagua and San Martin are lower in comparison to densities reported in other Amazonia sites, with comparable habitat structure and similar hunting pressure [Mena et al. 2000; Peres 2000b; Peres and Nascimento 2006; Zapata-Rios et al. 2009]. These studies assessed hunting sustainability using the same models included in this study. Table 3.18 presents a density comparison. The white-lipped peccary (*Tayassu pecari*) was the only game species that presented higher population densities in Mocagua and San Martin, while population densities of the black agouti (*Dasyprocta fuliginosa*), the deer (*Mazama* sp.), the spix's guan (*Penelope* sp.), and the woolly monkey (*Lagothrix* sp.) were particularly low at Mocagua and San Martin (Table 3.18).

Table 3.18 Density comparison (ind/km²) of preferred game species in lightly/unhunted, and hunting sites, Amazon basin.

Species	**Maldonado**		**Mena et al. 2000**	**Zapata-Rios et al. 2009**	**Peres and Nascimento, 2006**		**Peres, 2000**	
	Colombia		**Ecuador***		**Brazil (23**		**Amazonian sites)**	
	LHA[1]	**HA[2]**	**LHA**	**HA**	**UA[3]**	**HA**	**LHA**	**HA**
Agouti paca	5.7 ± 9.2	3.9 ± 5.2	14.3	9.7	4.5	0.5	(-)	(-)
Dasyprocta sp.	1.9 ± 0.6	1.6 ± 2.3	16.7	13.8	43.3	12.5	7.6 ± 10.5	2.9 ± 1.7
Dasypus sp	8.7 ± 5.5	4.0 ± 4.6	(-)	19.3	(-)	(-)	(-)	(-)
Tayassu pecari	12.6 ± 4.5	4.9 ± 1.6	(-)	(-)	0.04	0	1.7 ± 1.4	0.1 ± 0.4
Mazama sp	1.0 ± 0.5	0.9 ± 0.9	18.8	4.7	4.5	1.7	1.3 ± 0.7	0.4 ± 0.4
Myoprocta pratti	1.5 ± 2.0	2.5 ± 2.7	19.3	8.6	(-)	(-)	3.5 ± 2	4.3 ± 2.6
Penelope sp.	2.4 ± 3.9	3.3 ± 2.7	31.7	21.4	22.3	14.2	8.5 ± 4.4	5.2 ± 2.9
Alouatta sp.	8.6 ± 8.7	2.8 ± 4.1	17.2	6.8	8	0.4	4.3 ± 3.7	1.6 ± 1.3
Aotus sp.	9.8 ± 8.5	7.5 ± 6.1	37.5	8.4	(-)	(-)	(-)	(-)
Lagothrx lagothricha	12.8± 2.7	1.1 ± 0.5	36.8	4.8	(-)	(-)	15.1 ± 9.4	1.7 ± 3

(-) The species is not present at the study site or values were not reported in the publications.
* Densities reported for Ecuador cornenspond to the same study area, with different levels of hunting pressure.
LHA: Lightly hunted area; HA: Heavily hunted area; UA: Unhunted area.
All values were approximated to one decimal only.

3.4.2 The sustainability of hunting

The application of several models to determine the sustainability of hunting was used to take account of crucial variables such as density estimates at both light and heavily-hunted sites, production and observed hunting. This should therefore provide comparable estimates of sustainability. Also the use of several models might reduce the bias related to each individual model. However none of the models included in this analysis consider potential effects of migration from unhunted areas to subsistence areas. This is because migration was not measured during this study and historical data are not available (source-sink dynamics). This is difficult to measure as practically nothing is known about the population flows and dispersal patterns of neotropical game species [Peres 2001; 2008]. It is likely that source-sink dynamics are responsible for maintaining an influx of wildlife between source and sink areas within Mocagua and San Martin.

Summarising the results of the qualitative evaluation and the quantitative assessment (standing density comparison, stock-recruitment model, production model and unified-harvest model) hunting patterns in the San Martin community are unsustainable for six hunting-target species: the paca, the armadillo, the white-lipped peccary, the deer, the howler monkey and the woolly monkey. Here I have assumed that there is an unsustainable harvest when at least three of the models suggested this (Table 3.19). The qualitative evaluation of hunting sustainability also indicated that the South-American yellow-footed tortoise, the wattled curassow and the lowland tapir, are overhunted (see Tables 3.9 and 3.10).

Table 3.19 Summary of results for the qualitative and quantitative evaluation of hunting sustainability in San Martin. Species in bold suffer from unsustainable hunting, supported by at least three models.

Species	**Qualitative evaluation**	**Standing density model**	**Stock recruitment model**	**Production model**	**Unified Harvest model**
	Sustainable	Change	% Strategy	Sustainable	Sustainability
Agouti paca	NO	-31,0	Risky	NO	Overhunted
Dasyprocta fuliginosa	UNKNOWN	-12,8	Safe	NO	Appears sustainable
Dasypus sp	NO	-53,8	Risky	YES	Appears sustainable
Tayassu pecari	NO	-61,3	Risky	NO	Appears sustainable
Mazama sp	YES	-10,4	Safe	NO	Overhunted
Myoprocta pratti	NO	59,7	Safe	YES	Appears sustainable
Penelope jacquacu	UNKNOWN	37,4	Safe	YES	Appears sustainable
Alouatta seniculus	NO	-67,5	Risky	YES	Appears sustainable
Aotus sp.	UNKNOWN	-30,1	Safe	YES	Appears sustainable

Lagothrx lagothricha	NO	-91,4	Risky	YES	Overhunted

Change %: Shift in population density from Mocagua and San Martin. Negative values suggest the percentage of reduction in population density at the heavily-hunting site.

3.4.2.1 Impact of subsistence hunting on ungulates

While hunting preferences at Mocagua and San Martin include a variety of wildlife species, my findings suggests that there are clear hunting preferences for game species vulnerable to overhunting owing to their ecological traits. For instance the overharvested game species are either medium-lived or long-lived species. Although the low-land tapir (*T. terrestris*) was not included in the quantitative analyses, the qualitative evaluation of hunting sustainability suggested unsustainable hunting in San Martin (Table 3.10). Moreover, this game species is classified as Critically Endangered (CR) in Colombia [Rodriguez-Mahecha et al. 2006]. This taxon has been extirpated in wide areas of its distribution range in Colombia, mainly by subsistence and commercial hunting, followed by habitat fragmentation and deforestation [Rodriguez-Mahecha et al. 2006].

Ulloa et al. [1996] reported the local extinction of the Baird's tapir (*Tapirus bairdii*) by subsistence hunting in Utría National Park Colombia. This is where Emberá indigenous people have the right to hunt inside this fully protected area as the park was established on previous Emberá territory. The current extraction rates of low-land tapir in ANP by subsistence hunting may drive this species to local extinction. The allowed extraction of two tapirs per year (per hunter) included in the draft of the management plan of ANP and the Tikina communities (see section 2.3.1.1) threatens the stability of tapir populations in the area. In addition, this hunting restriction has not been applied and it has several monitoring limitations and inconsistencies in its design. For instance hunters from Mocagua were following this ban for the first year. However, it was difficult to quantify the extraction per family, as the active hunters are relatives and are grouped mainly into two big families. So they argued that each male in each family has the right to hunt two tapirs a year. Nevertheless, if the original hunting restriction is applied, San Martin community with approximately 30 active hunters will have a minimum extraction of 60 tapirs a year, while

Mocagua will be allowed to extract approximately 55 tapirs annually. The current hunting restriction will allow the local extirpation of tapirs just for subsistence purposes.

Ungulate biomass in neotropical forest is low in comparison to other tropical forests [Bodmer 1989; Emmons 1984; Robinson and Bennett 2000a], thus extraction has to be carefully measured in order to maintain its viable populations. In the case of the other overharvested ungulates such as the white-lipped peccary and both species of deer, hunting represents a threat especially for deer populations as observed harvest considerably exceeds its maximum sustainable yield (see Tables 3.15 and 3.16). Although the reproductive productivity of the peccary is greater than for other ungulate species [Bodmer 1989], Peres [1996] describes that white-lipped peccaries are extremely susceptible to hunting as a large proportion of the herd can be decimated by a single encounter with hunters.

It remains unclear what were the factors that originated the local reduction or disappearance of this species reported at different Amazonian sites. For instance, Kiltie and Terborgh [1983] attributed the disappearance of white-lipped peccaries in Manu National park in Peru to overhunting. Fragoso [2004] stated that mortality from an epidemic caused a decline in white-lipped peccary population at the regional level in Maraca Island, Brazil. Vickers [1991] explained that hunting rates of the white-lipped peccary by the Siono-Secoya in Ecuador fluctuate to a great extent as a consequence of herd migrations between territories rather than hunting. In other regions as the Argentinean Chaco, peccaries remain as an important source of protein although hunting is far less than in the Amazon [Altrichter and Boaglio 2004]. The disappearance of white-lipped peccaries near to long-term settlements in the Chaco suggests that this species cannot withstand long-term hunting pressure [Altrichter 2005]. Similarly, my results suggest that in the San Martin community a 40 year old settlement, hunting of the white-lipped peccary reflects an unsustainable and risky hunting strategy confirmed by the five assessments applied.

Historical information on hunting rates of white-lipped peccaries in San Martin during the late 1980s illustrated the unsustainable extraction of this species. Campos-Rozo [1987] manifested her concern as this species represented 78% of the total harvest (kg), making it the most targeted prey. This harvest was achieved in only 11 hunting treks, supporting Peres' [Peres 1996] description of the susceptibility of hunting of this species as one encounter with hunters can eradicate a herd. On the other hand Mocagua was established during the same period as San Martin, thus it is difficult to establish if differences in white-lipped peccary's densities between communities are a result of overhunting or if this is related to differences in immigration dynamics from contiguous un-hunted areas at both indigenous territories.

3.4.2.2 Impact of subsistence hunting on medium and long-lived species

It is clear that current harvest of the paca (*Agouti paca*) and the armadillo (*Dasypus* sp.) is unsustainable and risky. Bearing in mind the reproductive patterns of these medium-lived species, their relatively high reproductive potential make them more resistant to hunting pressure [Robinson and Redford 1991b; Vickers 1991]. Most of the hunting events of rodents and armadillos were recorded near to the indigenous communities where food availability is high, close to the cultivating subsistence crops of indigenous people as reported in other studies [Naughton-Treves et al. 2002; Vickers 1991]. However, hunting restrictions should be applied to maintain wild populations of these species (see section 7.4.1).

The qualitative evaluation of hunting suggested that the curassows (*Crax* sp.), long-lived species, are the most preferred bird species in Tikuna diet and current hunting patterns are unsustainable. Bennet [Bennett 2000] reported that hunting by Tikunas in ANP and Mocagua Island seems to have played the major role in diminishing current wattled curassow numbers in the area. Several authors agreed that the rates of recovery of cracid populations make it difficult for them to tolerate high levels of continuous hunting [Begazo and Bodmer 1998; Peres 2000b]. Cracid extinction will represent more than species-specific events owing to their crucial role as seed dispersers and their extinction will probably have negative impact on forest structure [Begazo and Bodmer 1998; Bennett 2000].

It is important to point out that low levels of OH (Observed Harvest) for primate species are related to the failure of hunters to find these species in the wild, rather than hunting preferences. Thus, the production model is a poor predictor for evaluating the sustainability of hunting when current population densities of hunting-target species had been drastically depleted to the point that even expert hunters are unable to find these species. The fact that the production model does not include the densities at the hunting site suggests that the results of this model should be interpreted with caution [Bodmer and Robinson 2004; Peres and
Nascimento 2006].

Results from the qualitative evaluation also suggested that the South American yellow-footed tortoise was the most overharvested game species, presenting the highest scores at both communities (Mocagua = 11; San Martin = 14). In addition, Campos-Rozo [1987] reported that hunter's encounter rate with this species was significantly higher during her study period. Current low encounter rates may be interpreted as a depleted population. The major importance that the South American yellow-footed tortoise represented in San Martin's diet during the late 1980s was described by Campos-Rozo [1987]. She reported the consumption of this species on a regular basis. Harvest was successful throughout the study period with peaks in May and September. Observed hunting of this species suggests that current hunting patterns are unsustainable and the harvest strategy is risky for its long-term sustainability. This long-lived species is usually captured during incidental encounters, rather than hunters looking for it. As reported in other studies, the South American yellow-footed tortoise is kept alive at the hunter's household and is usually consumed during community festivities or until needed for a meal [Fachín-Terrán et al. 2004; Peres and Nascimento 2006; Vickers 1991].

The stock recruitment model suggests that taking into account the carrying capacity, even though the current off-take rates for the woolly monkey and the howler monkey are extremely low, hunting for these species is particularly risky as their predicted populations are considerably below their MSY (predicted density = MSY- (N/K)), thus long-term hunting will drastically affect the population structure of these game species (Table 3.15). The woolly monkey was one of the most important prey species in traditional Tikuna diet [Parathian and Maldonado 2010]. Elder hunters in Mocagua and San Martin revealed they could hunt this species as far as three kilometres from the communities where settlements were established. Nowadays only experienced hunters from San Martin are successful in hunting woolly monkeys. The reported densities of woolly monkeys in San Martin suggest depletion of wild populations especially within an 8 km radius around the community. Woolly monkeys are highly sensitive to hunting. Even subsistence levels of hunting can result in local extinction, as they are one of the first primate species to disappear [Laurance et al. 2006; Peres 1990b; Peres 1991; Stevenson et al. 2005]. Their vulnerability is mainly attributed to their low reproductive rates and long inter-birth intervals [Di Fiore and Campbell 2007; Peres 1990]. Peres [1990] states that selective hunting may also affect the sex ratio of woolly monkeys, thus influencing their population growth in the long term.

Woolly monkeys play important roles as seed dispersers for canopy plant species [Andresen 1999; Dew 2005; Stevenson 2002a; Stevenson 2004]. Stevenson [2007] reports that seed dispersal by woolly monkeys at Tinigua National Park, Colombian Amazon is comparable to that of the entire bird community, consisting of approximately 156 species. While there is not enough evidence to suggest that the absence of woolly monkeys in forests close to human settlements in the study areas has diminished plant diversity, Barrera et al. [2008] found higher rates of seed removal for *Apeiba aspera* (canopy species) where large-bodied primates densities were higher. It is expected that the current depletion of woolly monkey across Amazonia by subsistence hunting would drastically affect their daily rates of seed deposition reducing it from 9.5 kg of seed/km^2 in non hunted sites to only 2.24 kg/km^2 in moderately to heavy hunted sites [Peres and Palacios 2007]. The evident depletion of large bodied primates, especially the case of the woolly monkeys among San Martin community, is a good example of the "*ecological extinction*" described by Estes et al. [1989] as "*the reduction of a species to such low abundance that although it is still present in the community, it no longer interacts significantly with other species*". Atelines extinction may strongly affect community wide patterns of seed dispersal and thus plant diversity especially for large-seeded plants, which are rarely swallowed by other seed dispersers [Peres and Dolman 2000; Peres and Van Roosmalen 2002; Stevenson and Aldana 2008; Terborgh et al. 2008]. Furthermore, the sale of meat to the Catholic boarding school in Puerto Nariño by San Martin, and the sell of meat to the school in Macedonia by Mocagua, could be addressed by implementing small scale domestic animal husbandry. It is crucial to inform the school's managers of the damage to game species populations when promoting the payment of school fees with game meat.

3.5 Conclusion

These results are consistent with other studies in Amazonia were subsistence hunting appears to be the main cause of the depletion of large-bodied vertebrates [Bodmer et al. 1997; Parry et al. 2009; Peres 2000b; 2001b; Peres and Nascimento 2006; Robinson and Redford 1991b; Terborgh 1999]. As a consequence of a continuous selective harvest of large-bodied prey, it is likely that their natural populations will conspicuously decrease reflected in a low standing biomass [Lopes and Ferrari 2000; Peres 1999a; Peres 2000a; Peres and Dolman 2000]. Likewise, if the hunting profile presents an inclusion or increase in the consumption of small-bodied species, this could be interpreted as evidence of depletion of preferred species [Jerozolimski and Peres 2003]. Therefore in overhunted areas the mean biomass and diversity of mammals decline, while small adaptable species become predominant [Lopes and Ferrari 2000; Naughton-Treves et al. 2002]. A good example of this could be the case of two small-bodied species, the acouchy (*Myoprocta pratti*) and the spix's guan (*Penelope* sp.), whose densities were higher in San Martin than in Mocagua. However this study cannot provide enough biological evidence to affirm that the above mentioned species presented higher densities at the heavily-hunting area as a density compensation effect. These findings are another example of an increase in population densities of small-bodied species and the reduction of large hunting-target species as a result of overhunting [Peres and Dolman 2000; Peres and Nascimento 2006; Peres and Palacios 2007]. Moreover, the consumption of the acouchy (*Myoprocta pratti*), the coati (N*asua nasua*), the night monkey (*Aotus* spp.) and the kinkajou (*Potos flavus*) were not part of the traditional Tikuna diet, as the four species were subject to hunting taboos. It was a disgrace for hunters to bring any of these species as prey, because they were not valued for Tikunas. This is because of the size of the prey and also the taste of the meat. Nowadays, these species are commonly harvested near the communities by young hunters, in the absence of preferred game species.

As mentioned earlier, (see section 3.2.1) two important game species were not included in the analyses, the mata-mata turtle (*Chelus fimbriausa*) and the capybara (*Hydrochaeris hydrochaeris*), as we failed to detect their presence during the study period. Elder hunters confirmed that both species were common when they settled in the early 1960s, but they became scarce. Capybara meat was sold in vast amounts during the coca exploitation during the early 1980s, while mata-mata was collected for commercial purposes to be traded to Brazil [Franco 2006; L. Panduro and M. del Aguila, pers. comm.]. It is likely that those species were over-exploited in the past and wild populations have been driven to local extirpation. Nevertheless more fieldwork needs to be conducted to confirm this assertion. On the other hand the consumption of the kinkajou (*Potos flavus*) is increasing amongst Mocagua and San Martin. Kinkajou vocalisations were commonly recorded, but visual detections were not enough for estimating its densities. As socio-economic dynamics amongst Tikuna people are constantly changing due to cash markets, the use of resources for commercial purposes is increasing. Here it is crucial to define the scope to which hunting could be maintained over time, without threatening wild populations or ecosystems functioning. As mentioned before, the lack of information on source-sink dynamics at local level restricts our criteria when designing management strategies for hunting-sensitive species. Thus depending on species biology and its conservation status at local level and current hunting impact, the design of a conservation strategy would be based on using the resources efficiently or promoting restraint in the exploitation [Mace and Hudson 1999; Robinson 2001]. Moreover it is crucial to include the importance that game species have in the Tikuna traditional diet (see section 7.4.).

4. PRIMATES, TIKUNAS, AND PROTECTED AREAS: LESSONS AND CHALLENGES IN COMMUNITY RESOURCE MANAGEMENT

This chapter provides data only on the primate community since primates are often considered flagship-species and are used to evaluate the health of forest ecosystems [Peres 2008]. As well as providing a high percentage (24% - 40%) of frugivore biomass, their importance in tropical forests has often been underlined [Peres and Palacios 2007]. This makes them one of the most suitable candidates for regional-scale ecological comparisons, as they represent one of the most important biomass components of arboreal vertebrate assemblages [Emmons 1984; Peres 2008]. Primates' ecological roles in seed dispersion are increasingly appreciated for their impact on diversity [Chapman and Russo 2007; Garber and Lambert 1988; Howe and Smallwood 1982; Terborgh and Nunez-Iturri 2006]. Additionally, these charismatic animals are effectively used as flagship species for habitat conservation [Dietz et al. 1994; Maldonado 2005]. Studies have shown a negative relationship between hunting intensity and wildlife biomass in the Brazilian and Colombian Amazon [Cowlishaw and Dunbar 2000; Palacios and Peres 2005; Peres 2000b; Peres and Palacios 2007]. Densities of large primates appear consistently low in areas where hunting occurs, with the ateline primates (e.g., spider monkeys (*Ateles* spp.), woolly monkeys (*Lagothrix* spp.), and howler monkeys (*Alouatta* spp.)) most heavily impacted. The hunting of wild primates may be limited by a number of factors: a reduction in primate population density and biomass; the availability of alternative protein sources; cultural adaptations; changes in the daily routine of local people; and the perceived economic benefits gained by protecting wildlife [Parathian and Maldonado 2010].

In this chapter I provide data on the primate community in overlapping areas between the ANP, and two Tikuna indigenous communities which present differences in hunting practices. This study was carried out with the involvement of Tikuna people as co-investigators. Primate group size, sighting rate (sights/10km) population densities (ind/km^2) and biomass (kg/km^2) are reported for each species in each study site, exposed to different levels of hunting pressure. I assess the effect of a hunting ban on *Lagothrix lagothricha* implemented for six years by one of the Tikuna communities as a locally-based monitoring strategy. To conclude, I discuss the implications for large-bodied primate populations in the context of their life history traits and the acculturation of traditional hunting practices, in areas where biological and cultural conservation are both high and yet sometimes competing priorities.

4.1. Methods

4.1.1 Census techniques

For a detailed description of census techniques please refer to section 3.2.3. During primate census the estimation of perpendicular distances (PD) has been one of the most controversial measurements, where researchers have opposed views regarding the most appropriate way to measure it [e.g. Marshall et al. 2008; Plumptre and Cox 2006]. Some of the limitations when measuring the PD include poor visibility owing to forest cover and cryptic behaviour of animals fleeing silently as a result of the continuous presence of hunters. These impeded the measurement of the PD to the centre of the group, as stated by Buckland et al [2001] in the assumptions of line transect density estimation. The measurement of PD to the centre of the group also requires group spread calculation; it might be achieved when surveying habituated primate groups in habitats that offer good visibility [Marshall et al. 2008]. However calculations of group spread might tend to be unreliable due to biases associated to daily variations (of group spread) [Plumptre 2000], the assumption that the average primate group shape is almost circular [Whitesides et al. 1988] and subjectivity in measurements. In addition it is time consuming [Plumptre and Cox 2006].

Thus PD was measured to an “approximate” centre of the group for primate species that live in small groups such as the pygmy marmoset (*Cebuella pygmaea*), the black-mantled marmoset (*Saguinus nigricollis*), the titi monkey (*Callicebus torquatus*), the saki monkey (*Pithecia monachus*), the white-fronted capuchin (*Cebus albifrons*) and the red howler monkey (*Alouatta seniculus*). While for primate species that live in large and uncohesive groups, such as the squirrel monkey (*Saimiri sciureus*) and the woolly monkey (*Lagothrix lagothricha*), PD were measured to the first animal sighted in each subgroup. *Saimiri* and *Lagothrix* tend to spread over 1 km [Palacios and Peres 2005;

Peres 1997], resembling more a line/queue than a cohesive group, limiting the probabilities of determining a group centre. Animals detected moving far away from the line transect were not included for density estimates. The measurement of PD to the first animal has been criticised as it is stated that this method underestimates the PD of each group therefore increases the number of groups in the lowest distance band, overestimating densities [Marshall et al. 2008]. An alternative option to determine the centre of the group is by summing the observer to group edge distance and the mean radius [Whitesides et al. 1988]. However, in the real context all these calculations are unfeasible to measure when conducting census surveys in hunted Amazonian forests.

4.1.2 Estimates of population densities

I show primate relative abundances expressed as sighting rates (SR= number of individuals/ 10 km), as this estimate often requires a low sampling effort for reliable assessments and it is commonly included in descriptions of Amazonian primate communities, thus facilitates the comparison between sites [de Thoisy et al. 2005; 2008]. For a complete description of estimates of population density and biomass please refer to section 3.2.4.1. Data were analysed with the software DISTANCE 5.0 when observation numbers were greater than 20. With smaller sample sizes, I employed two methods to calculate primate densities in order to compare the estimates and decide which method provides more reliable estimates based on reported densities from other Amazonian sites with similar characteristics, as well as on my experience [Marshall et al. 2008; Peres 1999b]:

i) **Stratified analysis-DISTANCE 5.0**: all the observations for each species were pooled in order to post-stratify the global model to derive new detectability models and therefore new density estimates by site [Buckland et al. 2001, C. Peres, pers. comm.]. Diurnal primate species were ordered by increasing adult body mass and were grouped in three size categories:

Small body size (< 1.5 kg): pygmy marmoset (*Cebuella pygmaea*), blackmantled marmoset (*Saguinus nigricollis*), squirrel monkey (*Saimiri sciureus*) and titi monkey (*Callicebus torquatus*).

Medium body size (1.5 – 4.0 kg): saki monkey (*Pithecia monachus*) and white fronted capuchin (*Cebus albifrons*).
Large body size (> 4kg): red howler monkey (*Alouatta seniculus*) and woolly monkey (*Lagothrix lagothricha*) [Peres and Dolman 2000].

ii) **King's formula**

$$D = n / (L * 2d)$$

Where *n* is the number of groups seen; *L* the length of the transect (in km) and *d* the effective distance (in km).

The effective distance (ED) was calculating using Whitesides et al. [1988] formula:

$$ED = (Nt/Nf) * FD$$

where Nt = species specific total number of group sightings; N**f =** species specific total number of group sightings at distances less than the fall-off distance; FD = Fall-off distance from PD histograms. This distance was estimated from the first interval at which the number of detection of groups for a particular species dropped to half (50%) or less that of the immediately previous interval [Whitesides et al. 1988].

4.1.3 Statistical analysis
Normality (Kolmogorov-Smirnov) and homogeneity of variance (Levene) tests were assessed by examining histograms and the skewness and kurtosis for each of the dependent variables. As biomass did not present a normal distribution, I employed a $\log_{10}$ transformation to meet assumptions of parametric tests. For all the analyses, descriptive statistics, complete results of statistical tests and graphs are included in Appendix V. Population densities and biomasses between sites were compared using ANOVAS (analysis of variance) and MANOVAS (multivariate analysis of variance).

4.2 Results

Sighting rates (SR) (relative abundances) of the eight primate species, group size and total number of visual detections used for the DISTANCE estimates (after truncation) are presented in Table 4.1. Table 4.2 summarises the variables from the un-stratified density estimates from DISTANCE (N>20). Table 4.3. presents the variables obtained from stratified analyses (N<20). Density and biomass estimates from stratified analyses were calculated for the pygmy marmoset (*Cebuella pygmaea*) at the four sites; the white-fronted capuchin (*Cebus albifrons*) at Bacaba, Agua Blanca and Agua Pudre; the howler monkey (*Alouatta seniculus*) and the woolly monkey (*Lagothrix lagothricha*) at Agua Blanca and Agua Pudre (Table 4.5).

Table 4.1 Primate relative abundances expressed as sighting rate (SR= number of individuals/ 10 km). Sampling sites are presented by ascending rank order of hunting pressure. Bacaba (BAC), Pucacuro (PUC), Agua Blanca (AB) and Agua Pudre (AP). N= number of visual detections.

Primate Species	**Site group size (± SD)**				**N**				**SR (Sight/10km)**			
	BAC	**PUC**	**AB**	**AP**	**BAC**	**PUC**	**AB**	**AP**	**BAC**	**PUC**	**AB**	**AP**
Small (<1,5 kg)												
*Cebuella pygmaea**	5.6	5.6 ± 0.3	5.6	5.7 ± 2.3	1	3	2	8	0.02	0.04	0.04	0.18
Saguinus nigricollis	5.0 ± 2.0	5.3 ± 2.0	5.3 ± 3.3	4.8 ± 2.4	76	127	72	76	1.8	1.8	1.4	1.7
Saimiri sciureus	20 ± 11.1	17.6 ± 10.6	23.6 ± 11.7	21.7 ± 12.8	7	13	13	11	0.2	0.2	0.3	0.3
Callicebu torquatus	3.1 ± 1.2	3.0 ± .08	3.1 ± 1.0	3.1 ± 0.8	26	59	60	46	0.6	0.8	1.2	1.1
					110	**202**	**147**	**141**				
Medium body size (1.5 - 4.0 kg)												
Pithecia monachus	4.1 ± 0.7	3.7 ± 1.2	4.0 ± 1.7	4.0 ± 1.3	45	36	26	22	1.1	0.5	0.5	0.5
Cebus albifrons	9.2 ± 7.6	6.6 ± 3.3	9.7 ± 7.7	6.0 ± 2.4	14	20	11	7	0.3	0.3	0.2	0.2
					59	**56**	**37**	**29**				
Large body size (>4.0 kg)												
Alouatta seniculus	4.1 ± 1.7	4.8 ± 0.8	3.8 ± 1.4 4	.5 ± 2.8	20	32	8	13	0.5	0.5	0.2	0.3
Lagothrix lagothricha	14.6 ± 9.3	16.4 ± 13.0	14.7 ± 10.3	14	11	21	8	1	0.3	0.3	0.2	0.02
					31	**53**	**16**	**14**				

*****SR for *Cebuella pygmaea* are presented with three decimals in order to provide figures

4.2.1 Comparison of density estimates

When comparing estimates obtained with the King's formula (Table 4.5) and stratified analyses from DISTANCE 5.0 (Table 4.3) for all the primate species, a two-way Analysis of Variance (ANOVA) showed that there were not significant differences between the density (group/km², ind/km²) and biomass (kg/km²) amongst the four sites (Density = Distance = F1-28 = 0.15, *p*= 0.92; King's = F1-28 = 0.47, *p*= 0.7; Biomass = Distance = F1-28 = 0.92, *p*= 0.44; King's = F1-28 = 0.87, *p* = 0.46).

However, the interaction between study site and group density was significant (Distance = F1-28 = 22.72, *p* = 0.01; King's = F1-28 = 15.82, *p*< 0.001). Thus, I conducted a Multivariate Analysis of Variance (MANOVA) in order to test the effect/difference of group density estimates (DISTANCE or King's formula) amongst the four sites for the three primate body size classes (small, medium and large). Post-hoc comparison using the Tukey's HSD (Honestly Significant Difference) test suggested that main differences in group density estimates from King's formula were presented in large-bodied species at Agua Blanca (F1-4 = 221,08, p< 0.001). This overestimation of group density generated high biomass estimates. Owing to the intensity of hunting at Agua Blanca, the biomass of large bodied primates is unlikely to be between the ranges produced by the King's formula (e.g. *L. lagothricha* = 81.8 kg/km²) (Table 4.5), while the estimates generated by the stratified analyses from DISTANCE are more in accordance with the hunting pressure at Agua Blanca (e.g. *L. lagothricha* = 3.1 kg/km²) and other Amazonian sites subject to similar hunting pressure [e.g. Mena et al. 2000; Peres 2000b; Zapata-Rios et al. 2009]. Therefore, the density and biomass from stratified estimates using DISTANCE 5.0 are included in all the analyses as summarised in Table 4.6.

Table 4.2 Summary of un-stratified analyses at the four sampling sites using DISTANCE 5.0. N= Number of observations; W= Truncation distance; ESW= Effective strip width; Detection Probability with 95% Confidence interval (CI)

Species	Total Effort (km)	Primate groups (N)	Truncation (%)	W (m)	ESW (m)	Detection Probability (CI)
Bacaba						
Saguinus nigricollis	416	76	10%	19.2	13.3	0.57-0.83
Callicebus torquatus	416	26	None	25.5	13.9	0.42-0.70
Pithecia monachus	416	45	None	26.6	14.2	0.42-0.60
Alouatta seniculus	416	20	10%	18.4	8.8	0.35-0.65
Pucacuro						
Saguinus nigricollis	701	127	10%	23.0	16.5	0.65-0.79
Callicebus torquatus	701	59	10%	20.0	18.0	0.66-1.00
Pithecia monachus	701	36	10%	30.0	17.6	0.46-0.73
Cebus albifrons	701	20	None	28.0	18.2	0.45-0.92
Alouatta seniculus	701	32	10%	22.0	15.4	0.50-0.96
Lagothrix lagothricha	701	21	None	25.0	17.1	0.48-0.96
Agua Blanca						
Saguinus nigricollis	512	72	10%	18.0	11.4	0.44-0.73
Callicebus torquatus	512	48	None	20.0	11.3	0.41-0.70
Pithecia	512	26	10%	17.5	10.3	043-0.79
Agua Pudre						
Saguinus nigricollis	438	76	10%	25.0	13.8	0.45-0.67
Callicebus torquatus	438	46	None	28.0	10.9	0.32-0.46
Pithecia monachus	438	22	10%	19.2	11.5	0.43-0.82

Table 4.3 Summary of stratified analyses (pooled data) at the four sampling sites using DISTANCE 5.0. N= Number of observations; Truncation= metres or % based on best fit of curve; W= Truncation distance; ESW= Effective strip width; Detection Probability with 95% Confidence interval (CI) (Total census effort=2,067 km)

Species	N	Width	ESW	Truncation (m - %)	Detection Probability (CI)
Cebuella pygmaea	14	45.0	17.6	45m	0.14-0.22
Saimiri sciureus	44	35.0	16.7	35m	0.38-0.58
Cebus albifrons	43	27.0	16.2	10%	0.47-0.77
Alouatta seniculus *	70	22.0	12.8	10%	0.47-0.71
Lagothrix lagothricha	32	35.0	17.5	35m	0.35-0.69

*Includes visual detections and vocalisations

4.2.2 The primate community at overlapping areas

During the study period, a total of 895 primate visual detections (after truncation) were recorded at Bacaba, Pucacuro, Agua Blanca and Agua Pudre, with a total of 8 diurnal primate species observed (Table 4.1). There were not consistent changes in the overall primate density across the four sampling sites (one-way ANOVA, $F_{3-20} = 2.16$, $p = 0.14$) (Fig 4.1). The aggregate population density at Agua Blanca and Bacaba were similar (100 ind/km^2 and 104 ind/km^2 respectively). Equally, densities at Agua Pudre and Pucacuro (79 ind/km^2) were the same. Conversely, there were significant differences on primate biomass across sites (one-way ANOVA, $F_{3-20} = 14.19$, $p < 0.001$) (Fig 4.2). The aggregate biomass showed marked variations between communities; Mocagua, the community who currently applies a hunting ban for woolly monkeys since 2003, has a total primate biomass of 398 kg/km^2, where large bodied primates made up 70% of the total biomass. In San Martín primate biomass was 199 kg/km^2 and large-bodied primates constituted 22% of the total biomass (Table 4.4).

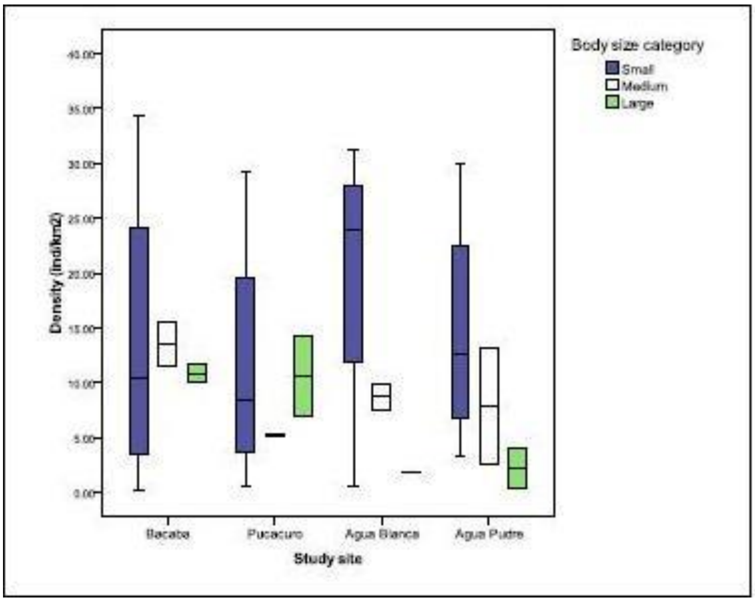

Figure 4.1 Density of primates by size-class categories at the four sampling sites, ANP.

Table 4.4 Summary of Means and Standard Deviations (SD) of biomass for size categories at each sampling site.

Site	Small-bodied		Medium-bodied		Large-bodied	
	Mean	SD	Mean	SD	Mean	SD
Bacaba	7.42	5.53	26.64	1.20	66.80	20.49
Pucacuro	6.24	4.49	10.42	1.44	67.93	44.37
Agua Blanca	14.25	12.90	17.15	0.24	10.83	2.07
Agua Pudre	8.35	6.02	14.40	12.38	11.94	12.57

I conducted a one-way between-groups ANOVA to explore the effect of body size (categories: small, medium and large-bodied) on primate biomass at each sampling site. There were significant differences in biomass between the three body size categories amongst the four sites ($F3\text{-}20 = 4.77$, $p = 0.01$). Post-hoc comparison using the Tukey's HSD test suggested that main differences were presented by small-bodied primates between Pucacuro and Agua Blanca. For medium-bodied primates differences in biomasses were significant between Bacaba and Pucacuro, while significant differences in biomass of large-bodied species were presented between Pucacuro and Agua Blanca (see Tables 4.4 and 4.6). In San Martin, the small-bodied primates represented 45% of the total biomass. When comparing the four study sites, Bacaba, has a primate biomass of 217 kg/km², 2.5 times higher than the biomass presented at Agua Pudre (86 kg/km²). While in Agua Blanca and Pucacuro, these parameters were intermediate (113 kg/km² and 182 kg/km² respectively), where Pucacuro presented a biomass 1.6 times higher than Agua Blanca's.

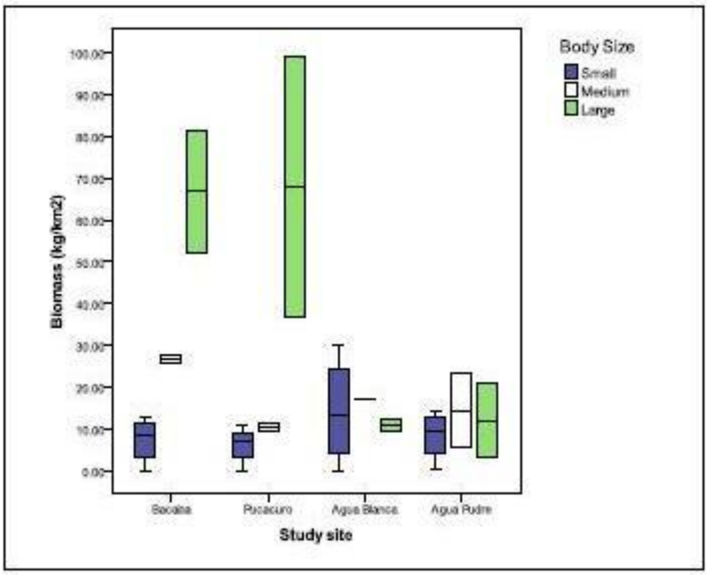

Figure 4.2 Biomass of primates by size-class categories at the four sampling sites.

Table 4.5 Primate population densities and biomass estimated with King's formula at the four terra firme forests in overlapping areas in ANP.

Species	80% of ABW	Primate groups (N)	Effective Distance (m)	Group size	Group Density* (G/km²)	Individual Density* (ind/km²)	Biomass* (kg/km²)
Bacaba							
Cebuella pygmaea	0.1	1	12	5.6	0.06	0.3	0.03
Saimiri sciureus	0.8	9	16	20.0	0.7	14.0	10.5
Cebus albifrons	1.8	14	10	9.2	0.7	6.4	11.3
Alouatta seniculus	5.2	18	19	4.1	1.6	6.6	34.1
Lagothrix lagothricha	7.0	12	14	14.6	0.8	11.7	81.3

Pucacuro							
Cebuella pygmaea	0.1	3	8	5.6	0.06	0.3	0.03
Saimiri sciureus	0.8	14	11	17.6	0.4	7.0	5.3
Agua Blanca							
Cebuella pygmaea	0.1	2	15	5.6	0.1	0.6	0.1
Saimiri sciureus	0.8	14	19	23.6	1.0	23.6	17.7
Cebus albifrons	1.8	13	16	9.7	0.8	7.8	13.7
Alouatta seniculus	5.2	10	19	3.8	0.7	2.7	13.8
Lagothrix lagothricha	7.0	8	22	14.7	0.8	11.8	81.8
Agua Pudre							
Cebuella pygmaea	0.1	8	31	5.7	1.1	6.3	0.6
Saimiri sciureus	0.8	10	16	21.7	0.7	15.2	11.4
Cebus albifrons	1.8	10	10	6.0	0.4	2.4	4.2
Alouatta seniculus	5.2	12	19	4.5	1.0	4.5	23.4
Lagothrix lagothricha	7.0	1	22	14.6	0.1	1.5	10.2

ABW: average body weight.
[1] Source: Ford and Davies, 1992; Peres, 1997.
* Some values are presented with two decimals in order to provide figures.

4.2.2.1 Small species

When comparing total densities of small-bodied primates between communities, San Martin's primate density was 1.35 times higher than in Mocagua. Agua Blanca and Pucacuro presented a remarkable difference in small size primates. Moreover, Agua Blanca surpassed Pucacuro's density by 40% and *Callicebus torquatus* density was almost 80% higher (in Agua Blanca). In the case of the pygmy marmoset (*Cebuella pygmaea*), Agua Pudre, the heavily hunted site, had the highest density, representing 70% of the total density of this species. Although the pygmy marmoset was detected only 14 times during this study, this is not an indicator of its population status, merely resultant of the cryptic habits of this species.

In the case of the squirrel monkey (*Saimiri sciureus),* Agua Blanca's population density was 2.5 times higher than in Pucacuro, with the aggregated biomass at both communities following similar patterns (as those of density); while San Martin's aggregated biomass values were 40% higher than those in Mocagua. In the case of the titi monkey (*C. torquatus*), there were outstanding differences in biomasses; Agua Blanca recording 4.5 times more (biomass for this species) than in Bacaba and Pucacuro, both which had the same values (7 kg/km^2), whereas Agua Pudre had an intermediate biomass (14 kg/km^2) of this species.

Table 4.6 Primate population densities and biomass estimated with DISTANCE 5.0 at the four terra firme forests in overlapping areas, ANP.

Primate Species	Group Density* (groups/km²)				Individual Density* (ind/km²)				Biomass* (kg/km²)			
	BAC	**PUC**	**AB**	**AP**	**BAC**	**PUC**	**AB**	**AP**	**BAC**	**PUC**	**AB**	**AP**
Cebuella pygmaea	0.03	0.01 ± 0.4	0.1	0.6 ± 0.9	0.1	0.6 ± 0.1	0.6	3.3 ± 1.9	0.01	0.05	0.05	0.3
Saguinus nigricollis	6.9 ± 14.8	5.5 ± 6.2	4.4 ± 6.8	6.3 ± 7.0	34.3±29.7	29.2±12.4	23.2±22.7	30.1±16.8	12.6	10.8	8.5	11.1
Saimiri sciureus	0.7 ± 0.2	0.6 ± 0.2	1.0 ± 0.1	0.5 ± 0.1	13.9 ± 0.2	10.0 ± 0.2	24.6 ± 0.1	10.2 ± 0.1	10.5	7.6	18.5	7.7
Callicebu torquatus	2.2 ± 3.6	2.3 ± 4.6	10.0±14.0	4.8 ± 6.4	6.9 ± 4.2	6.9 ± 3.9	31.2±24.0	15.0 ± 5.1	6.6	6.6	30.0	14.4
	9.8	***8.4***	***15.5***	***12.2***	***55.1***	***46.7***	***79.5***	***58.6***	***29.7***	***25.0***	***57.0***	***33.5***
Pithecia monachus	3.8 ± 7.2	1.5 ± 1.8	2.5 ± 3.7	3.3 ± 1.9	15.6 ± 5.0	5.3 ± 2.1	9.8 ± 6.1	13.2 ± 2.5	27.5	9.4	17.3	23.2
Cebus albifrons	1.3 ± 1.1	0.8 ± 1.0	0.8 ± 3.4	0.4 ± 0.8	11.5 ± 4.8	5.1 ± 3.0	7.6 ± 4.9	2.5 ± 3.9	25.8	11.4	17.0	5.6
	5.1	***2.3***	***3.3***	***3.7***	***27.1***	***10.5***	***17.4***	***15.7***	***53.3***	***20.8***	***34.3***	***28.8***
Alouatta seniculus	2.4 ± 3.6	1.5 ± 1.9	0.5 ± 2.2	0.9 ± 1.8	10.1 ± 6.3	7.0 ± 1.5	1.8 ± 3.2	4.0 ± 5.1	52.3	36.6	9.4	20.8
Lagothrix lagothricha	0.8 ± 0.7	0.9 ± 1.4	0.1 ± 2.6	0.03	11.7 ± 6.1	14.3±17.9	1.8 ± 2.6	0.4	81.3	99.3	12.3	3.1
	3.2	***2.4***	***0.6***	***0.9***	***21.8***	***21.3***	***3.6***	***4.4 9***	***133.6***	***135.9***	***21.7***	***23.9***
Total	**18.1**	**13.0**	**19.4**	**16.7**	**104.1**	**78.5**	**100.5**	**78.6**	**216.6**	**181.7**	**113.0**	**86.1**

*Some values are presented with two decimals in order to provide figures

4.2.2.2 Medium-bodied species

Total population densities and biomass of medium-bodied monkeys in Mocagua and San Martin were similar (33 - 38 ind/km² and 63 - 74 kg/km² respectively); while Bacaba, the lightly hunted site (rank 1), presented the highest total density across the four sites (27 ind/km²). Contrasting values were reported for the saki monkey (*Pithecia monachus),* where its density in Bacaba was 3 times higher than in Pucacuro (16 and 5 ind/km² respectively), while Agua Blanca and Agua Pudre presented similar values (10 and 13 ind/km² respectively). In the case of the white-fronted capuchin (*Cebus albifrons*), the highest biomass was recorded at Bacaba, being 80% higher than in Agua Pudre, where this species was detected only 7 times.

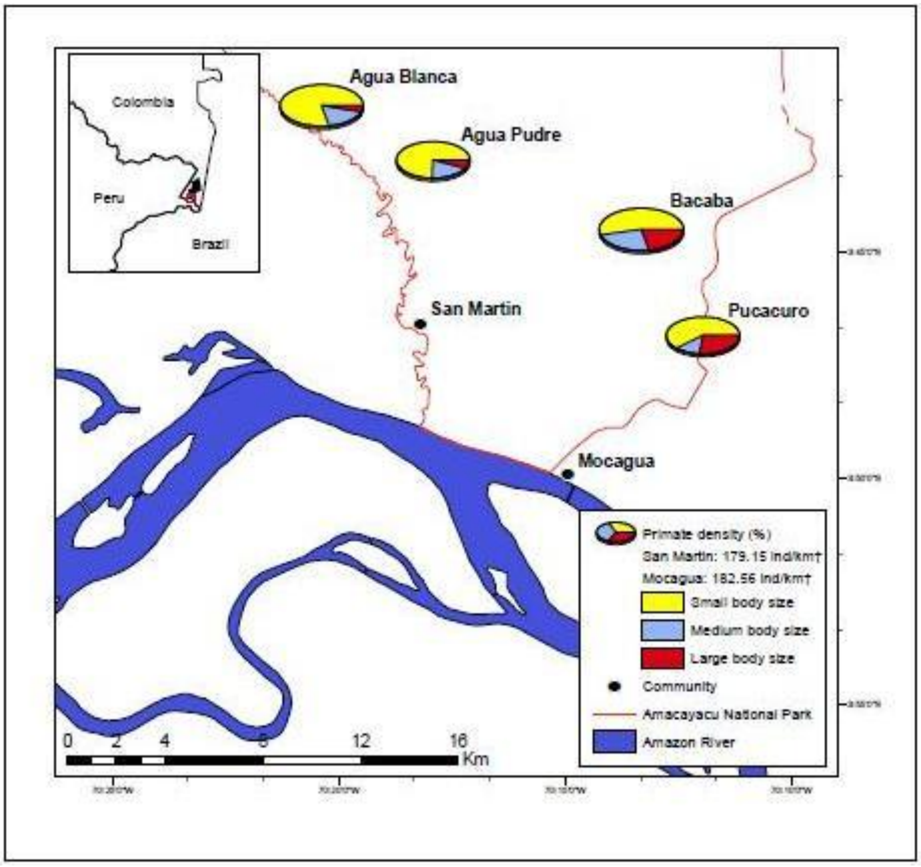

Figure 4.3 Density of primate populations at the four sampling sites presented by body size categories.

4.2.2.3 Large-bodied species

In this primate size class, estimated total densities at Mocagua were significantly higher than those of San Martin (43 and 8 ind/km² respectively), densities at Bacaba and Pucacuro were almost equal (22 and 21 ind/km²).

Unexpectedly, the moderately hunted site (rank 2) at Mocagua (Pucacuro) contained the highest biomass across all of the sites (136 kg/km²). Densities of red howlers (*Alouatta seniculus*) were 80% higher in Bacaba than in Agua Blanca, while densities of woolly monkeys (*Lagothrix lagothricha*) at Pucacuro represented 43% of the total biomass of large bodied primates of this study. It is important to note, that average group size of woolly monkeys at Pucacuro was higher than those at the other sites (16.4 ind). When comparing the two sites exposed to similar hunting pressure, Pucacuro and Agua Blanca, Pucacuro's biomass was 6 times higher than that reported for Agua Blanca (136 - 22 kg/km² respectively). Mocagua accounts for 85% of the total aggregate biomass of large-bodied primates in overlapping areas at ANP. During the study period *L*. *Lagothricha* was detected only once at Agua Pudre, (a heavely hunted site-rank 4), this observation being a solitary male.

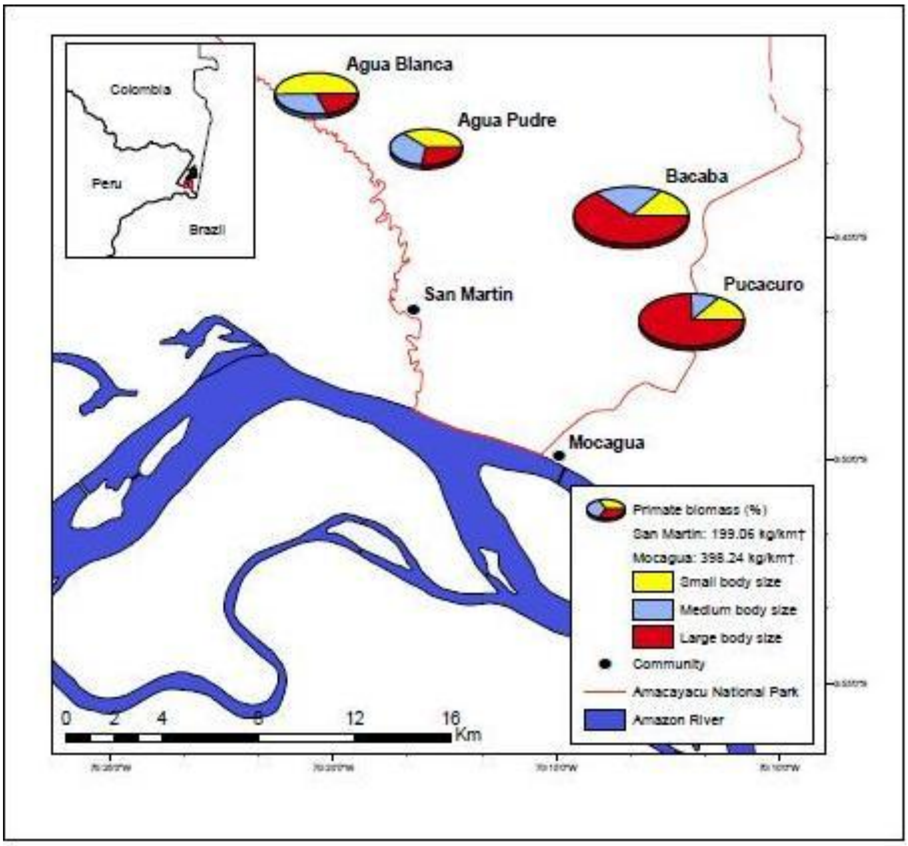

Figure 4.4 Biomass of primate populations at the four sampling sites presented by body size categories.

4.3 Discussion

4.3.1 Primate community in overlapping areas

Bearing in mind that forest structure and soil fertility are homogenous at the southern part of ANP [Rudas et al. 2005] my results suggest that hunting pressure seems to be the main cause for differences in primate biomass between Mocagua and San Martin. This argument is supported by historical data: elder hunters from both communities affirmed that woolly monkeys were common 30 years ago no more than 3 km from their communities, and atelines were more heavily targeted during the early 1900s as they were used as bait for hunting big cats during the skin trade. This was also reported by Defler [1983] in the Mirití-Paraná, Colombian Amazon.

Mocagua's ban on the hunting of *L. lagothricha* has been applied for six years. Already the total primate biomass in the vicinity of Mocagua is twice that of San Martín (398 – 199 kg/km² respectively). While the current time period is too short to assume the recovery of large-bodied primate populations as a direct result of the hunting ban, current density and biomass assessments in Mocagua indicate that primate groups are once again using an area of forest previously unutilised due to high hunting levels. When compared with previous studies in the area these indications also appear to be true. A four month study conducted by van Leijsen and Vleut [2005] in Mocagua in 2004, reported densities of *L. lagothricha* as 3.2 ind/km², while a 12 month study carried out four years later by Barrera et al. [2008] found *L. lagothricha* densities to have increased up to 4.3 ± 5.3 ind/km². Both studies employed line transect methods. This evidence supports the suggestion that selective hunting assists the success of large-bodied primates [Cowlishaw and Dunbar 2000; Laurance et al. 2006; Peres 1990b].

4.3.2 Density under-compensation

Density compensation amongst continental primate communities' remains inconclusive [Peres and Dolman 2000; Sussman and Phillips-Conroy 1995] and the consequences of subsistence hunting for density/biomass compensation requires not only the measurement of hunting pressure but also the collection of consistent evidence. Such evidence consistency would require sufficient sample sizes (census effort), appropriate replications (number of sampled sites) and the assessment of the potentially confounding environmental variables such as soils fertility, forest structure and productivity which have a critical effect on the structure of primate communities [de Thoisy et al. 2005; Peres and Dolman 2000; Peres and Janson 1999]. Nevertheless, I was able to document both dry and rainy seasons over a period of three years, in an attempt to minimise the bias of primate's presence/absence at the study sites owing to seasonal fluctuations of available food resources, thus influencing the use of home ranges during times of scarcity and abundance [de Thoisy et al. 2008; Terborgh 1983b; Terborgh and van Schaik 1987].

The results, while acknowledging the absence of control for the environmental variables and based mainly on hunting pressure, suggest an under compensation in terms of density and biomass of small sized species in areas of heavy hunting pressure, the community of San Martin. These results are in agreement with Barrera et al. [2008] where they described that densities of small bodied species were higher in the vicinities of Mocagua community than at 8 km from the human settlements. In San Martin, small-bodied primates biomass surpasses 40% and represents the highest biomass across the three body size classes in this community. These results are in agreement with Peres [1999a] and Peres and Dolman [2000] where it was stated that in a large scale comparison of primate communities in Amazonia, the extinction or depletion of large-bodied primates cannot be compensated in terms of biomass owing to the disproportionate contribution of large bodied species to the total primate community biomass. Large-sized primates at San Martin represent only 20% of the aggregated biomass.

4.4 Conclusion

Several experiences of management of natural resources by local people have shown that as they are initiated by an external stakeholder, when it leaves the process and funding is not available, local monitoring decreases over time or stops completely [e.g. Poulsen and Luanglath 2005; van Rijsoort and Jinfeng 2005]. One of the main challenges to overcome in local monitoring processes is that the income resulting from protecting biodiversity does not ensure an appropriate monetary return for local people [Garcia and Lescuyer 2008]. Although currently there is a resources management plan designed alongside Tikuna communities and ANP (see section 2.3.1.1), the lack of follow-up by the external stakeholders and lack of commitment by local people demonstrates that as mentioned above, for effective monitoring and management of resources, the design of the management strategy has to provide an alternative income that replaces the income obtained from the exploitation of resources.

The case of the hunting ban for woolly monkeys represents a monetary return as the Mocagua community perceives income from wildlife tourism and research. With the implementation of a community-based primate rescue centre managed by a local foundation established by two locals and one American biologist (Dr. S. Bennett), this programme offers an income for a group of guides. Income from research has been permanent as the present study continues conducting fieldwork census in Mocagua. While it is important to have accurate data on primate densities in areas where humans and primates coexist, such data have limited conservation value without an understanding of the significance of primates in local peoples' lives [Hill 2002]. The challenge now is the implementation of the hunting bans and restrictions for other target species, whose populations had been drastically reduced by subsistence hunting such as the low-land tapir (*Tapirus terrestris*) amongst other species. It is crucial that San Martin community monitor their harvest and apply at leat the hunting restrictions and bans they included during the design of the management plan (see section 2.3.1.1).

Protected areas are critically important as a pool for Amazonian biodiversity and cultural diversity [Colchester 2004; Terborgh and van Schaik 2002]. Whether as an isolated reserve, indigenous territory, overlapping area or buffer-zone of a protected area, these areas are crucial to maintain forest connectivity to secure viable populations of wildlife that, like the ateline primates are key for the dispersion of important plant species [Peres 1994; Stevenson 2000c; Terborgh and Nunez-Iturri 2006]. Thus, our effort as conservationists should be more active than just criticising the detrimental effects of people inside protected areas as we could be passive witnesses of the extinction of our research subjects. Providing our research findings to the stakeholders (policy/decision makers, local people, donors and protected areas managers) communicating them effectively at all the literacy levels could be an active way to support feasible alternatives of resources monitoring. Locally-based management of resources has to address the social and economic dynamics for its success. Nonetheless, management systems are only viable if local people and decision makers are aware that game populations are decreasing drastically and eventually will become locally extinct if harvest is not monitored and managed in a short frame of time.

5. FACTORS INFLUENCING THE SUSTAINABILITY OF HUNTING

The establishment of protected areas covering highly bio-diverse ecosystems has been a commonly implemented conservation strategy to provide protection of natural habitat refuges for faunal populations [Worboys and Winkler 2006]. The initial establishment of national parks during 1872, was aimed at defending nature against hunters, loggers and miners, as well as from the activities of "indigenous people and local communities" [Anderson and James 2001]. In most cases, these protected areas were developed within existing indigenous territories where inhabitants had been relying, for millennia, on wildlife to fulfil their protein requirements [Robinson and Bennett 2000a; Robinson and Bodmer 1999; Robinson and Redford 1991a; Roosevelt et al. 1996; Smith 1978]. It is expected that prior to the implementation of a protected area, baseline information on the boundaries of the proposed area and its ecosystems, communities and populations should be identified [Cowlishaw and Dunbar 2000]. Yet, the vast areas covered by both indigenous land and protected areas, and the lack of financial resources invested by local governments, make this crucial approach unfeasible [Anderson and James 2001; Peres 2002].

These issues influence the legislation that should be applied to regulate the use of resources. Opposing views are held regarding the presence and impact of local people in protected areas. Some argue that indigenous people can live within protected areas without depleting natural resources [Alcorn 1993; Colchester 2004; Keller and Turek 1998; Ohl-Schacherer et al. 2007; Peres 1994; Zimmerman et al. 2001]. Others point out that the harmonious coexistence between indigenous people and wildlife in the neotropics relies deeply on low human densities and technological limitations, especially shotguns [Alvard 1994; Galetti 2001; Terborgh 1992; 1999; Terborgh and Peres 2002]. A common concern expressed by both conservationists and indigenous people's advocacy groups is the commercial extraction of resources from both the indigenous land and the protected areas. Illegal logging is not only fragmenting the highly bio-diverse ecosystems [Chapman and Peres 2001; Laurance et al. 2006; Michalski 2007], but is also disrupting local people's traditional common property regimes [Alcorn 1993; Colchester 2002]. In addition, access to currency in the form of cash is not evenly distributed within community members and extraction quotas are not determined based on forests' carrying capacity [Redford and Stearman 1993].

The current situation of massive depletion of natural resources inside indigenous territories, protected areas and their overlapping land, makes one question the efficacy of the hypothetical status of *protected* [Terborgh and Davenport 2002]. In the Amazon basin both wildlife and indigenous cultures are facing an imminent risk of extinction if over-extraction of resources, habitat disturbance and the increase of human population are not managed in the short term [Fagan et al. 2006; Peres and Michalski 2006]. How can we deal with these complex issues when governments, local people and their advocacy groups, as well as conservationists, do not have baseline information about the Amazonian ecosystems? Without this information how can we persuade policy makers to invest in conservation as a strategy to counteract the scarcity of resources at a global level? Moreover, how can we convince local inhabitants that the concept of the *never-ending forest* is no more than a delusion? Alvard [1993: 357] stated: "*Individuals that are truly altruistic, and restrain from taking more of a resource than would be in their best interest for reasons of conservation, are expected to be replaced through natural selection by more selfish and exploitive actors"*.

However, human wellbeing and the conservation of harvested species do not have to be mutually exclusive. Indeed, Robinson and Redford [1991b] pointed out that a harvest that is not ecologically sustainable cannot be economically sustainable or socially sensible. Viable solutions to this issue require the understanding of the role that wildlife has in local people's traditions and livelihoods, as well as the limitations of wildlife to overcome hunting [Bennett and Robinson 2000; Hill 2002]. In the particular case of indigenous territories overlapping protected areas, there are several impediments to the sustainable use of resources throughout management. Terborgh and Davenport [2002] summarised these impediments such as: i) ambiguities in land ownership legal status; ii) the need for monitoring the use of resources is not always recognised, especially in the case of developing countries where transparency and public accountability are still new and largely untested concepts; iii) methods for monitoring the use of biodiversity in a systematic way are not standardised yet. Thus, management of resources becomes a challenge.

5.1 Hunting: An Overview

5.1.1 Resources management by early Amazonian hunter-gatherers

There are several discrepancies about the adaptations that early Amazonian hunter-gatherers had to engage in order to survive in a poor environment such as the Amazon basin [Mora 2001; Rival 1999]. However it is widely accepted that they adapted to pre-neolithic conditions [Lathrap 1968 in Mora 2001; Rival 1999]. Meggers [1996] argued that low population density, slash and burn horticulture and food taboos were the result of human adaptations to environmental limiting factors, to the depletion of critical natural resources. Others argued that early Amazonian hunter-gatherers adapted to the poor Amazonian flood-plains, thanks to their “domestication” of the environment [Baleé 1992; Posey 1992]. This domestication involved intentional and nonintentional practices and activities such as cultivation of key plant species and the increase of animal production [Baleé 1987 in Baleé 1992; Fowler and Turner 1999].

Good [1993 in Rival 1999] reported that the Yanomamö group from Venezuela based their diet on hunting and gathering, 40-60% of the year through trekking, while garden produce makes up less than 10% of their diet. The Yanomami adopted plantain (*Plantago* spp.) as their main crop and it constitutes two-thirds of their village diet [Good 1987]. Tukanos from the Colombian Northwest Amazon used polycultural and polyvarietal systems, where roots, tubers, and low successional vegetation are used to attract game animals, such as large rodents, peccary, and deer [Dufour 1990; Hames 1983]. In order to increase plant and animal productivity early Amerindians used different management practices. Fowler and Turner [1999] summarised the practices for improving plant production as: burning, trimming, coppicing, thinning, bark-ringing, selective harvesting, water diversion, sparing, replanting or propagating, fertilising, mulching, weeding, and transplanting.

The management and enhancement of animal production practices was summarised by Fowler and Turner [1999] as: culling, sparing, monitoring, selective fishing and hunting based on lifecycles and animal densities, alternative resource use, transplanting of eggs and young (fish), relocating game, occasionally raising of young, and habitat manipulation by clearing and burning to promote better forage for game. However, most of those traditional management practices were lost after the contact with "*the outsiders*" (white people) [Anderson 1996; Campos-Rozo 1987; Mora 2001].

The contact of Amerindian hunters and/or gatherers with missionaries as well as governmental agents, aiming to establish local people in permanent communities, was the most frequent cause of hostilities regarding extraction of natural resources from indigenous land [Nimuendaju 1952; Stearman 2000]. Additionally, indigenous people provided them with the necessary commodities to sustain large numbers of white people working during the exploitation of resources [Porro 1996; Stearman 1984; Zarate 2008]. This earlier contact with western markets drove modern Amerindians to transform their environment. As a result, indigenous people modified the structure and composition of game species all over the Amazon basin for subsistence and commercial purposes [Terborgh 1999].

Stearman [2000] outlines how Amerindian's social change and modernisation have had a detrimental effect on the sustainability of their hunting. She describes four factors namely sedentarism, population growth, market involvement and technological enhancements. Sedentarism plays a crucial role in the localised depletion of wildlife. For instance, nomadic tribes are now confined to settlements and are consequently heavy consumers of the resources in the nearby forest. Their hunting of sensitive taxa like ateline primates and tapirs are contributing to the drive towards local extinction [Fragoso 1991; Peres 1991]. Vickers [1983] reported how inhabitants of the Siona-Secoya horticultural villages in Ecuador had to relocate owing to the depletion of game species. Good [1987] documented the intra-village conflicts caused by meat scarcity and internal socio-political issues among the

Yanomamö of Venezuela and Brazil, resulting in the fissioning and relocation of indigenous villages.

Population growth facilitated by the shift from foraging to farming and the loss of traditional methods for population control results in a rapid rate of population increase [Campos-Rozo 1987; Stearman 1987]. For instance, Tikunas from Mocagua increased in numbers from 350 in 2003 to 510 in 2008. Nowadays, numbers of Amazonian inhabitants are far too high to be sustained by the poor nutrients in Amazonian soils [Terborgh 1992]. As a result of market involvement and technological enhancements, subsistence and commercial hunting pose one of the most alarming and unnoticeable threats for large vertebrate communities [Bodmer and Robinson 2004; Galetti 2001; Robinson and Redford 1991b]. Nonetheless bushmeat represents the main protein intake in indigenous diet, followed by fish when this resource is available [Harris and Ross 1987; Townsend 1996; 2000]. Reichel-Dolmatoff [1997], described how the Desana indigenous group from Vaupes Colombia (Northwest Amazon), drastically decimated game animal populations. This was due to the disappearance of their hunting taboos and the adoption of shot guns for commercial hunting to fulfil the demand for meat by the missionaries (both Catholic and Protestant), government officials and rubber collectors during the 1960s. Nowadays, Desana people have been forced to modify their traditional diet as game has become scarce.

In this chapter, I present a hunting profile for Mocagua and San Martin. A combination of qualitative data collection techniques were use to: i) identify the socio-cultural and economic factors influencing current hunting patterns; ii) gather historical information on traditional resources management by Tikunas; iii) and current perceptions of wildlife utilisation. This information is crucial when designing a management strategy in the overlapping territories within Tikuna indigenous land and ANP.

5.2 Methods

A combination of ethnographic techniques was used during data collection, including: semi-structured interviews (SSIs), unstructured or ethnographic interviews (USIs), oral history interviews (OHIs), conversation analysis, focus groups and participant observation. The combination of different techniques allows a team with a multidisciplinary background to produce qualitative results, involving the active participation of local people and different stakeholders in a systematic way [Beebe 1995].

5.2.1 Data collection

Three samples of households were used for different purposes: i) a purposive sample (or key informant sample) of 46 hunters and their families, covering 92% of the total number of hunters in Mocagua (n=22) and 85% of the total number of hunters in San Martin (n=24); and a purposive sample of 5 members of staff from ANP involved with the design/implementation of the management plan at the park (100%); iii) a randomly selected sample of community members from different gender/age classes, who attended four workshops and 21 community meetings organised by the research team from 2003 (pilot project) to 2009.

From 2005 to 2009 the collection of qualitative data was conducted by an interdisciplinary team composed by the research team (myself and volunteers with different academic backgrounds including ecology, botany, anthropology, sociology, primatology, veterinary, media production, economy and art) and two local co-investigators as requested by the Tikuna communities. A summary of the research techniques employed according to the topic investigated are presented in Table 5.1.

Table 5.1 Summary of qualitative research techniques employed for data collection

Research topic	Research technique	Period of data collection	Data collector	Target group	Context/location
Identification of socio-cultural factors influencing current hunting and use of resources	Interviews (Is) and participant observation (PO)	2005 to 2009	Local co-investigators, AM (A. Maldonado), volunteer team	Is = Hunters and ANP staff PO = community members (adults, both genders) Average # participants 55.	Community meetings were held every 6 months. Monthly meetings with co-investigator team (n=22)
Historical information of hunting and traditional use of resources	Is, conversation analysis (CA)	2005 and 2008	Local co-investigators, AM	Hunters (n=46), elder (n=18) and hunter's family members (n=12)	Data collected at the interviewee house/compound
Current hunting practices	Is, CA, and PO meetings	2006 to 2009	Local coinvestigators, AM, volunteer team	Hunters and their families; elder	Is = Data collected at the interviewee household PO= field trips, workshops and community
Traditional Ecological Knowledge of the life history of game species	focus groups (FG), CA and PO	2008	AM, volunteer team	Hunters, elder and community members (adults, both genders).	FG= Workshops with an average participation of 17 people CA & PO= during field trips with hunters and workshops
Tikuna calendar for hunting, fishing and agriculture	FG and PO	2008	AM, volunteer team	Hunters, elder and community members (adults, both genders).	FG= Workshops with an average participation of 17 people CA & PO= during field trips with hunters and workshops
Economic income obtained by Tikuna communities from ANP	Is, CA and PO	2006 and 2008	AM	ANP staff	Is = tape-recorded interviews and economic data collected by the ANP staff

5.2.2 Triangulation

The term triangulation comes from navigation or physical surveying and describes an operation for finding a position or location by means of bearings from two known fixed points [Beebe 1995]. When applied to ethnographic methods, triangulation aims to assess the sufficiency of the data according to the convergence of multiple data sources or data-collection procedures. It seeks corroboration of information among sources or techniques and the convergence of information on a common finding or concept. Triangulation may enable the researcher to highlight their interpretation of the phenomenon under review, whilst at the same time considering that phenomenon in terms of the participant group, their cultural background and day-to-day experiences [Maggs-Rapport 2008]. Triangulation involves a systematic selection of research methods and team members based on the resources available and the topic of interest [Beebe 1995]. During 2005, the first year of research, local co-investigators were collecting data on their own after preliminary training. Only volunteers whose first language was Spanish were collecting qualitative data to avoid the use of interpreters [Beebe 1995]. During 2006 and 2008, I triangulated data previously recorded by other members of the research team.

This research was conducted with the permission of local Tikuna indigenous authorities and with a research permit granted by the Colombian Park System. Additionally, this study had the ethical approval of Oxford Brookes University. Consent forms were signed by adults when the respondents were younger than 18 years old (see Appendix VI). When respondents were illiterate, the communities, ANP and I, agreed to video-record verbal agreements before collecting data with local people. Before conducting interviews, participants were informed of their right to not participate or answer any question which they did not want to. When respondents agreed to participate, they were informed that they were able to withdraw from the research at any stage. Anonymity and confidentiality were assured (see Appendix VII). Copies of the video tapes recorded are held in the resources room at ANP. A copy of the de-identifying data is held in the communal houses as arranged with the Tikuna communities. The original interviews are held at Oxford Brookes University. Different techniques were tested during a pilot project carried out in 2003 in order to select the more appropriate techniques bearing in mind the cultural tradition of communication by Tikunas (orality) and the literacy level.

5.2.3 Research techniques

For all the interview techniques, the interviewers, one literate hunter selected by the communities (one for each community), received training before carrying out the interviews. They were told to read the interview guide several times (Appendix VIII) and ask me about any unclear question. The interview questions were then piloted with family members. These results were not included in the data analysis. After this initial trial I had to modify the interview guide as a few questions made biased assumptions regarding hunting practices and others were not well understood by interviewers. Further questions, mostly open, were also added as suggested by the interviewers and their families. It was clear that interviewers needed the guide with them during the interviews as they tended to read the questions from the guide and would otherwise forget to ask a few questions.

In San Martin the interviews conducted by the local co-investigators were done in Tikuna language, while in Mocagua interviews were conducted mainly in Spanish as the hunters from this community have different ethnic backgrounds (e.g. Cocama and Yagua indigenous groups). With the approval of local indigenous authorities, I repeated 50% of the interviews in Spanish from 2006 to 2008 in order to triangulate the data elicited by the two local coinvestigators. Interviews (SSI, USI and OHI), were flexible and allowed new questions to be brought up as a result of what the interviewee said. Each interview lasted an average of 45 minutes. When allowed by the informant, interviews were tape-recorded.

5.2.3.1 Semi-structured interviews (SSIs)

This method uses a series of questions in the general form of an interview but where the sequence of questions can be varied [Bryman 2006; 2008]. The design of the SSIs used in this research had a combination of closed and open questions to allow respondents to answer in their terms and to obtain unusual responses (see Appendix VIII).

5.2.3.2 Unstructured interviews (USIs)

Also called ethnographic interview [Spradley 1979]. The interviewer has a list of topics or issues that are addressed, following an interview guide or *aidemémoire*. This technique is particularly useful when the informant's cultural way of sharing information is by oral communication. Another advantage of the USIs is that indigenous people did not feel intimidated by the interviewer as the USIs were carried out during fieldtrips, community meetings and social events.

5.2.3.3 Oral history interviews (OHIs)

This is an SSI in which the respondent is asked to recall events from his/her past and to reflect on them. There is usually a section of specific research concerns to do with a particular period or event [Bryman 2008]. The OHI were mainly used to gather information on the perceived changes of hunting and to confirm dates of particular commercial/extractive activities carried out by foreigners in the area, in which local people participated.

5.2.3.4 Conversation analysis

Conversation analysis is an examination of talks as they occur in interaction in naturally occurring situations. The talk is recorded and transcribed in order to carry out a detailed analysis [Bryman 2008]. The three basic assumptions of the conversation analyses were summarised by Heritage [1987 in Bryman 2008] as: i) talk is structured and it avoids infering the motivations of speakers from what they say or ascribing their talk to personal characteristics; ii) talk is forged contextually and follows a logical sequence; iii) analysis is grounded in data and it requires a detailed transcription of the conversation.

5.2.3.5 Focus groups (FGs)

This method is a form of group interview where several respondents participate and there is an emphasis on the questioning of a particular topic; there could be more than one interviewer who is in charge of moderating the discussions and recording data during the activity [Morgan 1996]. Participants might be divided into groups and similar or different topics are given to each group. The overall result of a FG is a discussion amongst participants that might be presented orally, in a performance or in a written format (e.g. graphs, maps, reports) [Bryman 2008; Morgan 1996]. Some of the advantages of FGs are: i) people have ownership during the process; ii) it facilitates the comparison of answers of respondents under a different context (individual vs. social) assisting the triangulation of information; iii) people with different levels of literacy can participate without feeling excluded; iv) FGs provide the space for using audio-visual techniques which help the transmission of information to illiterate participants; v) it decreases the bias in data collection related to differences in gender, authority and knowledge of respondents [Chambers 1997; Morgan and Spanish 1984; Mosse 1995].

Hunters and their families were selected to participate in the FGs, to gather information on TEK of the life history of game species, with an average sample of 17 participants. During FGs, participants were divided into two groups and two group members were subsequently nominated as scribes to write or paint information provided by the group. At the end of the session, participants shared their results with the other group [Morgan and Spanish 1984]. No samples were segmented (gender/age) as the aim of the FGs was to record the local knowledge of the community members that have a close contact with the hunting activity, the hunters and the prey (see Table 5.1). Similarly, while gathering information on the Tikuna calendar for hunting, fishing and agriculture, community members from both genders and different age classes participated as those activities are practised by the majority of the community. Although the groups were not homogenous, the mixed groups provided a reliable outline of TEK and also reduced the number of groups, which in turn facilitated the active participation of most community members and the analysis of the data. The FGs were held in the community houses of Mocagua and San Martin.

5.2.3.5 Participant observation (ethnography)

The participant observer or ethnographer becomes immersed in a group of people for an extended period of time observing behaviour, and listening to what is said in conversations both between others and with the fieldworker [Bryman 2008]. The data obtained with this technique are usually used as a triangulation technique to corroborate data collected by other researchers or data gathered using other techniques [Beebe 1995]. Participant observation aims to develop an understanding of the culture of the group and people's behaviour within the context [Chambers 1997]. Participant observation was an effective way to triangulate information previously recorder by the local coinvestigators.

5.2.4 Data analysis

As the data obtained were not normally distributed or homogenous, results are summarised in most of the cases with descriptive statistics and all the analyses were carried out with SPSS V.17.0. When data allowed, I conducted Mann-Whitney *U* test to examine differences between categorical variables among Mocagua and San Martin. Other non-parametric tests such as Chisquare were not included as the data violated the assumption of minimum expected cell frequencies [Pallant 2007].

5.3 Results

5.3.1 Factors influencing hunting by Tikunas in ANP

5.3.1.1 Sedentarism

The direct impacts that sedentary life has on game species are: i) the depletion of wildlife by overhunting around human settlements in an estimated radius of 10 km [Fragoso et al. 2000; Leeuwenberg and Robinson 2000]; ii) habitat fragmentation due to the increasing land conversion to agriculture gardens, which isolates large extensions of land from primary forest, affecting drastically the home range of species that require large extensions of forest to fulfil their diet requirements through the year [Cullen 2001; Peres 1996; Silvius 2004]; iii) loss of traditional hunting practices: hunting treks for several days, where a whole family set up a camp site and stayed for periods of weeks to months, hunting and gathering fruits is no longer applied by the Tikunas from Mocagua or San Martin. However, Tikunas from San Martin, sporadically visit their relatives from Buenos Aires community located at the north of ANP, for traditional festivities, or cultural events including several Catholic celebrations (e.g. weddings, baptisms). During these trips, hunting becomes necessary as the journey (by foot) takes between two days (for expert hunters) to five days (when children, women or elders are part of the group). Medina [1977] reports that Tikunas were semi nomadic and they lived in two types of settlements: Malocas, one big house where several families lived together and small settlements (6-10 families) were each family lived in a small hut. In both types of settlements, the whole community moved three to four times a year.

5.3.1.2 Population growth

The estimated annual population growth ratio for Mocagua is 4.7%, while for San Martin is 6.7% [Martinez 2006; Reyes 2008]. Young couples (16-35 years old) are still having big families composed by 4 to 7 children. Thrirty two percent of Mocagua's population is under 10 years old [Reyes 2008]; similarly San Martin's population under 10 years old represents 29% of the total inhabitants [Martinez 2006]. Since 2007 the Colombian health service is visiting the indigenous communities in the southern Amazon, where contraceptive methods have been presented. A big proportion of the male population sees female contraception as a way of promoting polygamy. In addition, men see vasectomy as castration and they have rejected any contraceptive practice. For first time in Mocagua, seven women with more than three children had hysterectomies in 2008. Traditional contraceptive methods are not practiced anymore and most of young women do not have the knowledge to apply or prepare these methods. Emigration contributes to less that 0.05% of the annual population growth in both communities [Martinez 2006; Reyes 2008].

5.3.1.3 Participation in market economies

At the current scale of cultural and economic transition faced by Tikunas in the area, it is clear that market involvement of indigenous people is inevitable and has to be addressed correctly. The extraction of cedar increases the demand for bushmeat, as illegal loggers spent several months in the forest and game is the main source of protein. Expert hunters from indigenous communities are hired to provide the bushmeat necessary during the logging campaign. The involvement in market economies is one of the primary contributors to the loss of traditional practices by indigenous people as it brings access to new technologies, increases the demand for unnecessary commodities and alters traditional power hierarchies, amongst others [Silvius 2004].

Silvius [2004] also states that access to seasonal or permanent wage labour disrupts indigenous people's traditional practices as hunting and agriculture. However, as the involvement in market economies is unavoidable, and the present loss of traditions is reflected in Tikuna's daily life, sustainable alternatives should be placed in order to decrease the dependence of local people on income obtained by commercial extraction of resources in order to promote conservation [IIED 1994; Niesten and Rice 2006; Redford et al. 1995]. Currently, 4% of Mocagua's inhabitants are employed at the tourist centre of ANP, representing 90% of the total staff [PNNA 2006]; nine percent of Mocagua's population receive an economic income from research, tourism, commercialisation of hand crafts and from jobs provided by the government (e.g. curaca, cabildos, school teachers) [Reyes 2008]. In San Martin, only 8% of the community receive an income from tourism, sale of hand crafts and from jobs provided by the government [Martinez 2006]. The involvement of indigenous people from San Martin in illegal logging and commercial hunting is higher than in Mocagua, however the figures are unknown. During the period 2006-2008, Mocagua obtained 63% (USD 52,000) of the total income from ecotourism at the tourist centre of ANP, while San Martin received only 12% (USD 9,700). This income comes from services (local people working as tourist guides and employees) and the sale of food and handcrafts [Buitrago 2008].

5.3.1.4 Land ownership

San Martin indigenous community wants to be independent from the large indigenous territory (Resguardo Mayor de Puerto Narino) they are part of. Leaders from San Martin manifested that their main reason in looking for their independence is to prevent the overextraction of resources, as the authorities of the large resguardo provide logging permits to colonist in the area. It is known that the local authorities receive a monetary recompense for the emission of logging permits. Furthermore, San Martin's proposal includes the extension of their territory. For this extension they are claiming land from ANP, approximately 80% of the territory of Palmeras Tikuna community and 40% of Mocagua's territory. Palmeras and Mocagua see the expansion of San Martin's territory as the violation of their land ownership, and this originated a division amongst them. Community leaders from San Martin argue that their territory extension is based on their cosmological relationship with the claimed land. On the other hand, leaders from Mocagua and Palmeras argue that the only interest behind the extension of San Martin's resguardo, is the concentration of cedar located in the claimed area. Thus, the socio-political and economic reasons behind San Martin's territory independency and extension are unclear. Currently, there is not communication related to resources management between the three Tikuna communities.

5.3.2 Traditional resources management by Tikunas

The Tikuna social organisation was based on a patrilieal exogamic clan division, designated with names of terrestrial animals, birds and plant species [Lopez 2000; 2002]. The clan organisation had elder men as the head, where community decisions were firstly discussed by the elders (*Abuelos*) and *Payé*s [3] (shamans), and then communicated to the entire community. Nowadays, the main socio-political authorities are the Curaca and the Cabildo, who are elected by the community, however this democratic election is very much influenced by the number of relatives the candidate has in the community rather than his/her skills for deserving to be the first authority in the community. As a consequence of this "democratic" election, current Tikuna communities lack leaders with experience who represent the interest of the community; political corruption by Curacas is common in the area. Nimuendaju [1952] who lived with the Brazilian Tikunas nearby Leticia during the late 1940s, stated: "*The Tukunas* (Tikunas) *never had the slightest political cohesion. There is absolutely no political organisation today"* [Nimuendaju 1952: 64]. This lack of political cohesion was apparently related with the lost of the spiritual authorities (*The Payés*).

In Tikuna culture, hunting is considered as one of the most important and respectful occupations, not only for the intrinsic relationship between the hunter and the *Payé* and the spirits of the forest, but also for providing meat to the community [Campos-Rozo 1987]. This is in agreement with the description

[3]Payés were the shamans of the Tikunas. They were the spiritual and political authorities. Community decisions were made after the advice of the Payés and the elders. Payés were in charge of mediating between the supernatural world, natural resources and humans [Campos-Rozo 1987].

made by Stearman [2000], where for the Yuquí and Sirionó indigenous groups in Bolivia, prestige is accrued through hunting and the provision of meat, and not from gathering plants or planting crops that present no danger, require no chase, and rarely are considered a scarce resource. Hunting brings a man status among his peers and the social rewards that extend to his close relatives [Stearman 1987; Stearman 1989; Stearman 1990]. Among Tikunas, hunting skills are learnt and inherited in a patrilineal way. In the past, usually the father, grand-father or any other male close relative, took children (as young as 5 years old) to hunting treks in order to familiarise them with the forest and to teach them how to hunt. This patrilieal transmission corresponds to the Tikuna's clan organisation [Goulard 1998 in Lopez 2002].

5.3.2.1 Shamans (Payés)

As with most Amerindian groups, the Tikunas had a close relationship with nature and resources management was controlled by the spiritual authorities. These authorities were mainly composed by the *Payés* and elders who had an extensive knowledge of nature, such as the use of plants for food, construction and medicinal purposes. In addition, they knew the location of key resources, taking into consideration game migration and seasonality of forest resources in their indigenous territory [Campos-Rozo 1987]. The role of the shaman in most hunter-gatherers Amerindian tribes was also to provide spiritual protection. They intercede between the social/human world and the unpredictable world of the supernatural [Brightman 2007; Lee and Daly 1999a; 1999b]. *Payés* were also the mediators of the spiritual relationship between humans and the "*Owners of the game*[4]" (or the master of animals). They could perform specific rituals, such as asking the owners of the game for permission to hunt a specific animal species, to protect that species from evil spirits, or to protect game from being hunted by other communities or tribes [Brightman 2007]. Also they performed rituals where they protected hunters before embarking on hunting treks, to help them find good prey and to protect them from disease. The *Payé*'s

[4]The owners of the game are mythological representations of people, animals or plants who rule, manage and organise the use of specific natural resources [Fajardo en Campos-Rozo, 1987].s

relationship with nature includes transforming himself [5] into an animal. Although they adopt several animal species personifications, the jaguar is the most common transformation [Guenther 1999; Reichel-Dolmatoff 1997; H. Gregorio; L. Panduro, pers. comm.].

5.3.2.2 Hunting taboos

Several species of animals were subject to hunting taboos, most of them related to the Tikuna belief that animals have a spirit that could be benign or malignant, or that the animal might have the spirit of a *Payé* [Cardoso de Oliveira 1983]. For instance the tapir, the humming bird and the toucan are possessed by benign spirits, while the deer, the paca, the South-American yellow-footed tortoise, the jaguar, all snake species, the owl, the night monkey and most of the prey birds have malignant spirits or could be a *Payé*'s personification. Thus, hunting those species was forbidden by the *Payé* [Campos-Rozo 1987]. Hunting bans were imposed by the *Payés* during certain months of the year, for other common hunting prey.

The hunters' disobedience to a hunting restriction or ban made by the *Payé*, could bring bad luck during hunting, the disappearance or scarcity of preferred game species, sadness, disease and even the death of the hunter, his family or the curse of the entire community [Reichel-Dolmatoff 1997; H. Gregorio; M del Aguila; L. Panduro, pers. comm.]. For Tikunas, Tukanos and Yukunas Colombian indigenous groups, the hunters release of game species such us the tapir, the deer, the peccary, the primates and the curassow was severely restrained [Reichel-Dolmatoff 1996; van der Hammen 1992]. In contrast, other game species such as the paca, agouti and armadillo were not subject to hunting taboos [Reichel-Dolmatoff 1996; van der Hammen 1992]. As hunters are predisposed to sudden encounters with animals and unusual situations, Tikunas and several Colombian Amazonian tribes, believed that hunters were the community members who had more chance of meeting the owner of the game in the forest, which had important ecological implications [Reichel-Dolmatoff 1996].

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[5] In Tikuna culture, the *Payé's* biological gender is male [Lopez 2000]

The owner of the game is likely to appear as a severe gamekeeper trying to protect his territory from overhunting and any other form of depletion [Reichel-Dolmatoff 1996]. Therefore, an encounter with the owner of the game is a warning, which often will be seen as punishment in the form of an illness. This encounter usually involves people who are aware of ecological problems, people who are actively involved in environmental disturbances, who have consciously or unknowingly violated the norms [Reichel-Dolmatoff 1997]. Reichel-Dolmatoff [1996] described that among the Tukano tribe from the Colombian Northwest Amazon, shamans had to pay the owner (master) of the animals a reward to his/her favours. "*The shamans paid them with human souls* (lives)*. The victims were those who disobeyed the norms, who depleted natural resources, killed too many game animals, cut down trees, poisoned creek to catch fish. People who destroyed the environment had to pay the price"* [Reichel-Dolmatoff 1996]. This severe punishment way was metaphorical, and it was referred to shamans' supernatural powers where they cast evil spells, throw magical pathogenic substances in someone's direction, or curse people or other shamans.

5.3.2.3 Sacred areas

In Tikuna culture the designation of sacred sites is closely related to their mythological origins [Cardoso de Oliveira 1983]. For instance the Tuirupw hill, located nearby the Amacayacu river, and inside San Martin's indigenous territory, is where *Yoí* and *Ipi* (two Tikuna brothers who are the main deities and first ancestors of the Tikunas), were born and several *Payés* were buried in the area [Barona 2007, A. Vasquez, pers. comm.]. Thus, the indigenous territory of San Martin community was considered a sacred place by early Tikunas (including the Peruvian and Brazilian Tikuna groups) owing to its religious and mythological significance [A. Vasquez; M. Vasquez, pers. comm.]. Furthermore, the Tuirupw hill is the origin of the headwaters of the Amacayacu and the Loretoyacu rivers, the two biggest tributaries of the Amazon River in the area. Any kind of resources extraction was forbidden most of the time at the Tuirupw hill; access to resources in the area was only allowed by the *Payé* after he obtained permission from the owner of the game. Testimonies by elders from San Martin state that the owner of the game, at the Tuirupw hill, (*Chenawa*) is an old man who looks like a tapir and is often found around the area transformed into this animal [A. Vasquez; M. Vasquez, pers. comm.]. This area has a high concentration of cedar (*Cedrela odorata*) one of the most valuable wood species in the Amazon basin [Barona 2007]. In Mocagua's territory, Bacaba's area (one of the study sites) has an important cultural value, as this was the area where the last *Payé* of the community was living; his sons and grandsons are the best hunters in Mocagua and Palmeras communities, all of them relatives of the Panduro family.

For most Amazonian tribes, salt-licks represented one on the most sacred environmental areas of the forest [Reichel-Dolmatoff 1996]. For Tikunas saltlicks were the sacred place where the *Payés* meet the owners of the game personified by animals such as the tapir, jaguar, deer, macaw and howler monkey amongst others [Campos-Rozo 1987; A. Vasquez, pers. comm.]. They gather to talk and to receive instructions about hunting restrictions and bans. Also, several food restrictions were communicated to the *Payé* by one of the animals attending the party; most of these food restrictions were related to animals that often visit the salt-licks (see section 5.3.2.4). At the end of the meeting they had a party when everyone gets drunk [Campos-Rozo 1987; A. Vasquez; M. Vasquez; L. Panduro, M. del Aguila, pers. comm.]. There are several Tikuna tales where salt-licks were the centre of reunion and important decisions were made by the *Payé* regarding wildlife utilisation [Campos-Rozo 1987; A. Vasquez; M. Vasquez; L. Panduro, M. del Aguila, pers. comm.]. The hunting bans applied by Tikunas in salt-licks, might be related to their knowledge of game emigration during certain seasons of food scarcity. For instance, during the dry season, game species rely on the nutrients found in salt-licks for long periods of time [Lozano 2004]. Thus, source-sink dynamics of game populations were allowed, and Tikuna's cosmological politics played an important role in wildlife conservation.

5.3.2.4 Food restrictions

For most of the indigenous groups distributed in the Colombian Amazon, food restrictions (better understood as *abstinence, fast* or *diet*) were common for all members of the community [Reichel-Dolmatoff 1997; van der Hammen 1992].

Reichel-Dolmatoff [1996] states that food restrictions were based on the intrinsic relationship between men and nature where man is allied with nature and this fact implies the observance of rules of measure. Furthermore, animals posses energy that is related to the specific types of environment they live in and also to the people who live in the surrounding forests. The differences in animal energies depend to a large extent on the availability and abundance of their food resources. Therefore, these considerations provide the basis for food restrictions and for certain culinary preparations [Reichel- Dolmatoff 1996]. Most food restrictions were related to birth control, pregnancy, gestation, childhood and convalescent people. Other food restrictions were related to certain activities that imply having a close contact with nature, such as hunting, gathering, cultivating and fishing [Campos-Rozo 1987; Reichel-Dolmatoff 1996; van der Hammen 1992].

5.3.2.5 Hunting tools

Traditional hunting tools used by Tikunas, were described by Nimuendaju [1952] as four principal tools: i) the blowgun, which is a simple weapon consisting of a small tube for firing light darts. The darts are usually dipped in *curare* poison in order to paralyze the prey, they were very effective for hunting primates; ii) a lance of approximately 260 cm long made with deadbark palm tree (*Iryanthera* spp.) with an arrow poison with *curare* at the end, used to hunt large prey such as tapirs; iii) another lance of approximately 230 cm long made with prickly palm (*Bactris* spp.), very effective for hunting peccaries; iv) a shorter lance with a wooden end mostly used to kill big cats. Nimuendaju [1952] reports that during his last visit to Tikuna communities in Brazil in 1942 only the prickly palm lances and short lances were used for hunting, while the blowgun and the dead-bark lance were no longer in use.

5.3.3 Profile of Tikuna hunters

5.3.3.1 Mocagua

A total of 22 hunters were interviewed in Mocagua, representing 92% of the total number of hunters. From this sample two of the hunters were females. The average age of the hunters was 45 years old (SD = 14.3) and the average hunters’ family group was 7 people (SD = 2.3). The hunters that belong to the

Tikuna ethnic group represent 40% of the total sample, while the rest of the hunters are from different ethnic backgrounds (Cocama = 36%, Yagua, Huitoto, Cabloco = 24%). The average number of years of experience as hunters was 25 years (SD = 13.8). Sixty percent of the hunters prefer to hunt on their own; hunting trips last in average 10 hours (SD = 4) and they hunt an average of 3 times a month (SD = 2). Respondents state that the minimum distance they have to walk to hunt large prey is 4-6 km from the village (73%) while small prey can be found at 1-3 km from the village, nearby the cultivated gardens (82%). Meat division in Mocagua is mainly for the hunter's family consumption and the rest is sold within the community (95%). Hunters affirmed that only at the beginning of the school's academic year they trade meat for buying children uniforms and school materials. However, data registered through participant observation, confirmed that meat was sold to Macedonia, the nearest Tikuna community, for Catholic religious festivities (n=7). The dry season is the preferred time to hunt (60%) because animals are easy to hunt close to water sources, especially at night (23%) and also because it is easier to hear animals walking on dry litter (20%). Hunting, agriculture and fishing represents 50% of hunter's economic income, while tourism represents 20%. Other activities such as hand craft elaboration, construction and research bring additional but sporadic income to the hunters' families (30%).

In order to assess hunters' preference for game species, animals were divided into three categories: birds, mammals and reptiles. Here, the interviewer asked what the most frequent hunted species within each category were. The Spix's guan (*Penelope jacquacu*) occupied the first rank among bird species (46%) followed by the common piping guan (*Aburria pipile*) (9%). However, 23% of the hunters affirmed that they do not hunt birds, because birds are not worth the investment of cartridges in relation to the amount of meat they have. The paca (*Agouti paca*) and the black agouti (*Dasyprocta fuliginosa*) were the most commonly hunted mammal species (50% and 27% respectively) reported by respondents. In the reptile category the South American yellow-footed tortoise (*Geochelone denticulata*) was ranked as the most preferred species (73%). Ten percent of the interviews affirmed that they do not hunt reptiles, as they are difficult to find. Personal preference for game species was based on the taste of the meat, and the paca was the most preferred meat (73%) followed by tapir's meat (*Tapirus terrestris*) (14%). The majority of the respondents prefer bush meat (74%), followed by fish (14%) and chicken (12%).

5.3.3.1 San Martin

The hunters' sample size in San Martin was 24, representing 85% of the hunters in the community. The hunters average age is 51 years old (SD = 15) and the hunters average family group is 8 people (SD = 3). All the hunters in San Martin are Tikunas, and 63% belong to the Ardilla clan (squirrel), while 21% are from the Paujil clan (wattled curassow), followed by the Picon clan (toucan) and the Garza clan (heron) (13% and 3% respectively). Respondents in San Martin have an average of 26 years of experience as hunters (SD = 18.1). While 58% of the hunters prefer to hunt on their own, 42% hunt in small family groups, usually composed by the father, 1-2 sons and grandchildren. Women are part of the hunting trips when they are trekking for more than 3 days and they are in charge of preparing the meat, which implies cooking, salting and smoking the meat to be preserved. Hunting trips last in average 11.2 hours (SD = 8.5) and the average frequency of hunting trips is 3.5 times a month (SD = 2.3). Nonetheless data recorded during participant observation (6 months period) confirmed that three of the most expert hunters were hunting trekking an average of 6 times per month, but during the interviews they affirmed that they only hunt twice a month. The majority of the respondents (75%) stated that they have to walk approximately 6 km from the village to find large prey while small prey are found around 1-3 km close to the cultivated gardens (100%).

Meat distribution in San Martin, includes family consumption, friends (usually the good fathers and good mothers of the hunter's children) and sales in the community (75%). In addition, meat is often offered during the mingas (25%), which is a collaborative work where one family invite people from the community to participate voluntarily in the slash and burn of land for agriculture, house construction, garden cultivation etc. The family offers masato (alcoholic drink made with manioc (*Manihot esculenta*), or peach-palm (*Bactris* sp.)) and a meal. Large numbers of people attend mingas, when meat is offered (H. Gregorio and A. Vasquez pers. comm.). When triangulating this information with the data recorded by local co-investigators, it seems that commercial hunting was not reported during the interviews. Harvest records confirmed that 25% (n = 342) of the total number of animals hunted in San Martin (n=1,401) were sold outside the community, mainly at Puerto Nariño's market and the Catholic boarding school. As in Mocagua, hunters affirm that commercial hunting is done only to pay children's education (e.g. uniforms, books, stationary, school fees, food) and to purchase fuel for river transportation. However, local co-investigators confirmed that when (illegal) logging takes place in the area, hunters from San Martin were hired by the loggers to provide meat, or hunters were hunting and selling meat to the loggers independently. Nonetheless, this research only recorded prey hunted and brought to the community. Season preference for hunting included: dry season (33%), beginning of the dry season (21%), (because it is easy to spot animals and because animals gather in fruit patches); rainy season (17%), beginning of the rainy season (17%) (it is easier to find tracks and because there is a lot of food for animals) and any time (12%). Hunters obtain income mainly from hunting, agriculture and fishing (78%), while research, tourism and logging provided alternative and sporadic income. From 24 interviewees, only one person reported to receive income from logging. However, data collected by the local co-investigators confirmed that six of the hunters actively sale cedar and/or hunt for the loggers.

Among the bird category of most hunted prey, respondents reported the preference of three bird species: the Spix's guan (30%), the wattled curassow (30%) and the common piping-guan (21%). In the mammal category, the paca (25%), the collared peccary (*Tayassu tajacu*) (17%) and the tapir (17%) were reported as the most hunted prey. The South American yellow-footed tortoise was reported as the most hunted reptile species (80%) (Fig. 5.1), followed by the caiman (*Caiman crocodilus*) (20%). Personal preferences for game species were mainly reported for the collared peccary (25%) and the paca (21%), while the deer, the South American yellow-footed tortoise and the white-lipped peccary occupied the third rank of preference (8% for each species). The majority of the hunters prefer bush meat (80%), followed by fish and chicken (8% for each species).

Figure 5.1 Young hunter from San Martin with South American yellow-footed tortoise (*Geochelone denticulata*).

5.3.4 Current resource management practices

*5.3.4.1 Shamans (*Payés*)*

The last *Payé* from Mocagua and San Martin died in the early 1980s. El abuelo Panduro (Panduro's grandfather) was the last *Payé* in Mocagua and his descendants are settled in Mocagua and Palmeras communities. Adult males from the Panduro family are the expert hunters and are also leaders in the community. El abuelo Gregorio was the last *Payé* in San Martin and his descendants are expert hunters in the community and are part of the community leaders. The lost of the spiritual authority had detrimental effects for the management of resources as food taboos and restrictions are not followed anymore. Some elders from San Martin believe that the current scarcity of game species is the product of fights between *Payés* from Tikuna communities located at the north in the Cothue river basin, where they closed the paths of game species to stop them travelling to the south (where San Martin is located).

5.3.4.2 Hunting taboos

Among Mocagua and San Martin hunting taboos are not applied by young hunters (≤30 years old; n=6; 13%) as they do not believe or are not aware of the taboos. However, young hunters will not go on their own for a hunting trek if an elder hunter (relative) had a dream related to snakes or jaguars, as they believe it is a sign of bad luck, and they could get lost. Furthermore, there is a common believe that the *Curupira*, the owner of the forest, who is a small male/female whose feet are pointing backwards make hunters get lost. As hunters follow his/her footprints to find their way out, but when following the *Curupira's* footprints, they deviate their path to dense forest and get lost. Elder hunters manifested that the only time they do not hunt is during Easter as for their Catholic believes they avoid eating meat during at least three days during this religious festivity. Some of the hunters who participated in illegal logging treks became ill, mainly with malaria, and they stated that this was a punishment of the *Curupira*. Elder hunters in San Martin believe that when white people are part of the hunting treks, this brings bad luck and diseases for the Tikunas.

5.3.4.3 Sacred areas

As mentioned earlier, the Tuirupw hill in San Martin was a sacred site. Nowadays this in one of the areas where illegal logging of cedar is carried out, with the involvement of Tikuna people. Currently, hunting in the salt-licks is very common as they are the most frequent places to hunt tapir. During the dry season hunters establish camps to wait for the animals at night to hunt. In Mocagua and San Martin, the Bacaba creek area represents one of the most visited hunting sites, where 30% of the respondents state that they visit this site at least once a month as it is a good place to hunt large prey.

5.3.4.4 Food restrictions

Hunters from both communities were able to provide a detailed list of animals that were not hunted in the past and species they do not hunt or avoid hunting nowadays. Descriptions of hunting taboos and use of animal parts for other purposes are listed in Table 5.2.

5.3.4.5 Hunting tools

All the male hunters stated that they always hunt with shotguns, while the two female hunters hunt with machete and dogs. In both communities hunters always take a shotgun and a machete (41%) to the hunting treks, while five hunters from Mocagua affirmed they also take arrows (11%) and 20% of the hunters also hunt with dogs. Only one respondent, an elder hunter from San Martin, has a blowgun but he cannot use it as he does not have *curare* (poison). The only Tikuna people preparing curare in the area are a couple of elders from the north, nearby the Cothue river. Hunting treks are conducted by foot in the majority of the cases (52%), or by foot and canoe during the rainy season (41%). Only 3 elder hunters prefer the canoe for transportation, mainly because they feel too old to walk (7%).

Table 5.2 Food restrictions, taboos and other uses of animals reported by a total of 46 hunters from Mocagua and San Martin. Responses obtained from semi-structured interviews.

Hunters' responses	Frequency	Perc. %
Giant anteater is hunted now because of the scarcity of prey with better meat	10	22
Jaguars were not consumed in the past because their meet is not good, it has a bad taste. Its meat is harmful for children	6	13
Sloths were not eaten in the past because there were better preys that were abundant	5	11
Deer is hunted now because it has enough meat	4	9
Giant otters were not consumed in the past because they produce cough and typhus disease. Its meat is harmful to children	3	7
Capybara wasn't eaten because this caused skin diseases to people	2	4
Giant anteater was not eaten because traditionally for Tikunas, it has bad spirits and it is an impure animal. Its meat is harmful to people	2	4
[1]Wild dog was not consumed in the past because people said that its meat has a bad smell. Nowadays we hunt it when we find it	2	4
Deer was not eaten because elders said they were humans	1	2
Deer was not eaten because it was an impure animal. Nowadays is one of the favourite preys	1	2
Deer was not eaten because people who ate its meat became a deer	1	2
Deer was not eaten because they were protected by the Shaman and eating its meat makes people mad	1	2
Deer's bones are use as medicine for children to strengthenthe bones in their legs	1	2
Giant anteater and deer were not eaten in the past without the permission of the Shaman, otherwise people gos mad	1	2

Giant otters were not consumed in the past because they were considered sacred animals	1	2
Jaguars were not hunted because in the past they didn't sell the skin	1	2
Tamandua because elders said this animal eats people	1	2
Tamandua is not eaten because this animal gives bad luck	1	2
[1]Monkey skins were used for drums elaboration	1	2
[1]Vultures were not eaten in the past because they were considered evil spirits	1	2
	46	100

[1]Responses included in Fig. 5.2 as "other".

Hunting in the past: Most of the hunters reported that in the past, Tikuna people had several food restrictions and hunting taboos based on their religious believes and their close relationship with nature. The reported animal species subject to hunting taboos or food restrictions revealed significant differences between communities (Mann-Whitney *U* test; $U = 152$; $z = -2.56$; $p = 0.01$). Figure 5.2 summarises the main game species which were not hunted by Tikunas in the past. Elder hunters reported that their parents did not hunt deer or capybara for different reasons (Table 5.2) and only inexperienced hunters were the ones hunting these species. Both species are preferred prey today.

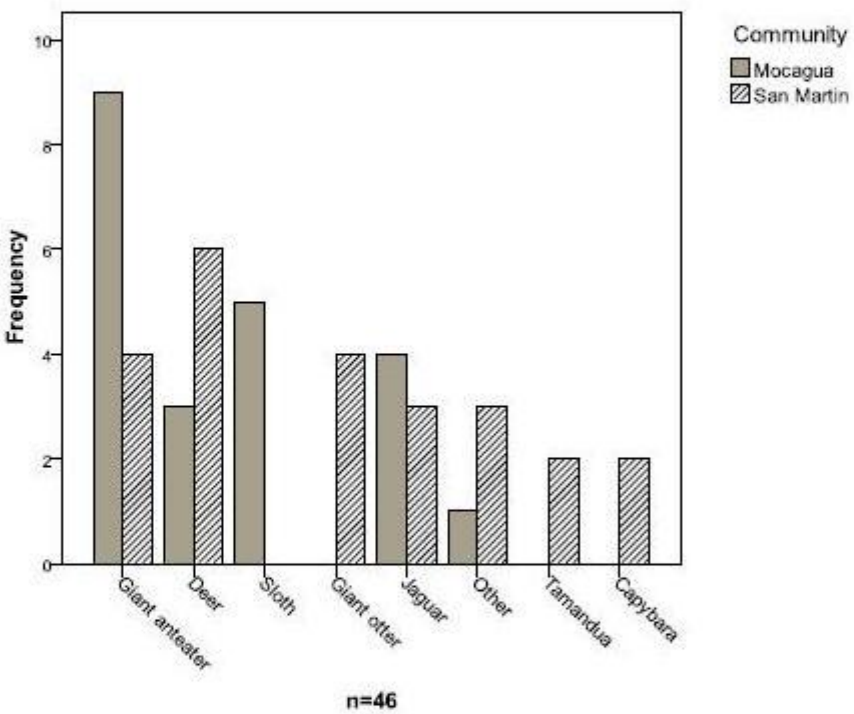

Figure 5.2 Summary of animals subject to meat restrictions or taboos by Tikunas in the past reported by hunters (others: included in table 5.2).

Hunting today: Unhunted or avoided prey among communities did not present significant differences (Mann-Whitney *U* test; $U = 208.5$; $z = -1.248$; $p = 0.21$). In Mocagua, 32% of the respondents avoid hunting the giant anteater (*Myrmecophaga tridactyla*). Nonetheless 41% of the total sample stated that they hunt this species owing to the scarcity of other preferred prey, and because this animal has enough meat for a family. Interviewees from San Martin avoid hunting the tamandua (*Tamandua tetradactyla*) (33%) and the giant anteater (21%) as they dislike the taste of their meat; however they hunt both species sporadically close to the cultivation gardens in the absence of preferred prey species (Figure 5.3). For hunters in both communities, the jaguar is not consumed (Mocagua =14%; San Martin= 21%) mostly because they dislike the taste of its meat and they believe that jaguar meat is harmful for people. The majority of elder hunters (≥ 56 years old; n=13; 20%) believe that jaguars have the spirit of *Payés* and killing them brings bad luck during hunting trips and even diseases. Local people believe that the consumption of the giant otter and the jaguar meat produces cough and diseases related with the respiratory system.

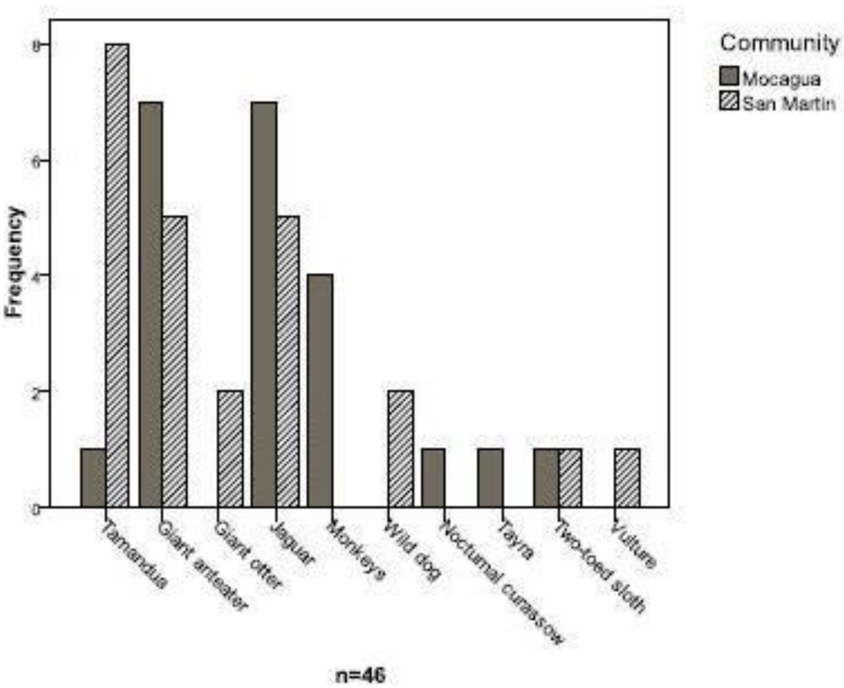

Figure 5.3 Animal species unhunted or avoided by hunters in Mocagua and San Martin

5.3.5 Perceptions of hunting today

Hunters from Mocagua and San Martin provided different responses when explaining the perceived decrease in game species (Mann-Whitney U test; U = 171; z= -2.41; p = 0.016). However, respondents agreed that there are significant changes in hunting today such as: i) animals are scarce and now they have to walk long distances to hunt medium and large-bodied preys (n = 34; 74%); ii) hunters believe that the disappearance of the white-lipped peccary, the tapir and the collared peccary nearby the villages is as evidence of game depletion (n = 12; 26%). Half of the respondents (n = 22; 48%) stated that the reduction of preferred game species is the result of overhunting; also because of the increase of human population (n = 9; 20%). Other factors influencing the decrease of wildlife reported by respondents were (n= 15; 32%): i) the use of western hunting tools; ii) *Payés* closed the way for animals to come close to our community; iii) presence of white people in the forest; iv) the noise of the saw and shotguns; v) commercial hunting to pay children's education; vi) hunters targeted the big preys and they do not live in the area anymore. During the focus group activities participants were asked to list the game species that are important in Tikuna diet, and that they believe are scarce or more difficult to hunt nowadays. In addition ecological data were gathered and shared within participants (Tables 5.3 and 5.4).

Table 5.3 List of game species and their ecological information provided by participants from Mocagua during focus group activities.

Species	**Lifespan (yrs)**	**Age 1st reproduction**	**Litter size/inter-birth interval**	**Hunting preference for sex/age class**
Paca	50	1 yr old	1- once a yr	Preference for M
Black agouti	50	1 yr old	2-4 -once a yr	Preference for M
Armadillo	100 (killed only by jaguar or human)	1 yr old	1-6 -once a yr	Preference for M
White lipped peccary	60 (killed only by jaguar or human)	1 yr old	3-8 -once a yr	Adults M & F
Deer	80 (killed only by jaguar or human)	1 yr old	1- once a yr	Adults M & F
Collared peccary	50 (killed only by jaguar or human)	1 yr old	4-6- once a yr	Adults M & F
Tapir	100 (killed only by jaguar or human)	1 yr old	1- once a yr	Adults M & F
Howler monkey	50-60	1 yr old	1- once a yr	Adults M & F
Night monkey	15	2-3 months	2- every 6	Hunted only

		old	months	when nothing else was hunted
Wooley monkey	60	1 yr old	1- once a yr	Adults M & F
Capybara	80-90	1 yr old	4-7- once a yr	Preference for M, especially during the dry season
Giant armadillo	Never dies-(killed only by jaguar or human)	1 yr old	1- once a yr	Very difficult to find. M & F
Giant anteater	100	1 yr old	1- once a yr	Adults M & F

F = Female; M = Male

Remarkable comments during the workshops in San Martin highlight that local people still believe that some animals are immortal (e.g. giant armadillo) or are personifications of the owner of the animals. For instance, an elder lady and her husband who is the most respected hunter in the community stated: "*Some animals like the jaguar, the tapir, the giant armadillo and the woolly monkey they never died, they live forever, or only died if the jaguar, boa or people kill them. However, if the jaguar is not killed by people, they go back to their (supernatural) world. In the case of the tapir, when they are tired of living, they become another animal, like a manatee, or they just go to their (supernatural) world"* [M. Vasquez; H. Gregorio, pers. comm.]. Other testimony from an elder in San Martin was: "*Most of the monkeys, but especially the large ones like the woolly monkeys and the howler monkeys, are like people, they reproduce all the time, when they want"* [A. Vasquez, pers. comm.].

Table 5.4 List of game species and their ecological information provided by participants from San Martin during focus group activities.

Species	**Lifespan (yrs)**	**Age 1st reproduction**	**Litter size/inter-birth interval**	**Hunting preference for sex/age class**
Paca	70	1 yr old	1- once a yr	Preference for M
Black agouti	70	1 yr old	1-3- once a yr	M & F
Armadillo	60	1 yr old	2- once a yr	M & F
White lipped peccary	50	1 yr old	5- once a yr	M & F
Deer	80 red deer/20 gray deer	1.5 yr old	1- once a yr	M & F
Collared peccary	15	1.5 yr old	5- once a yr	M & F
Tapir	100	1 yr old	1- once a yr	Adults M & F(females are more common)

Howler monkey	100	1 yr old	1- once a yr	Preference for M
Night monkey	60	1 yr old	1- once a yr	M & F
Wooley monkey	100	1 yr old	Anytime of the year	Preference for M
Capybara	80	1 yr old	2-6- once a yr	M & F
Giant armadillo	100	1 yr old	1- once a yr	M & F
Giant anteater	80	1 yr old	1- once a yr	Adults M & F

There were significant differences between communities regarding the use of animal parts (Mann-Whitney *U* test; $U = 137.5$; $z = -2.9$; $p = 0.004$). In San Martin 54% of the interviewees responded that they do not use other part of hunted prey. However, 30% of the respondents in San Martin use animal parts for medicinal purposes and for skin collections (13%). In Mocagua, animal parts were mostly used for medicine (41%), followed by hand craft elaboration (27%) and the improvement of land fertility using bones (10%). Medicinal uses reported include: i) grated deer's bones applied on children's legs to strength their bones; ii) grated tapir's hoof to stop haemorrhages; iii) paca's bile is used to disinfect snake's bites and to cure diabetes; iv) the penis of the coati (and river dolphin) is believe to cure impotency (Fig 5.4). Parathian and Maldonado [2010] also reported the use of howler monkey throat sacs as a medicinal cure for laryngitis.

Respondents from both communities reported different preferences for animal species kept as pets (Mann-Whitney *U* test; $U = 105.5$; $z = -3.63$; $p = <0.001$). In Mocagua the most common species kept as pets were the paca (27%), the acouchy (10%) and the white-fronted capuchin (10%). Most of the hunters in San Martin stated that they do not keep wild animals as pets (58%), but in the past the most common pets were wooley monkeys (33%), black agouties (5%) and white-fronted capuchins (4%).

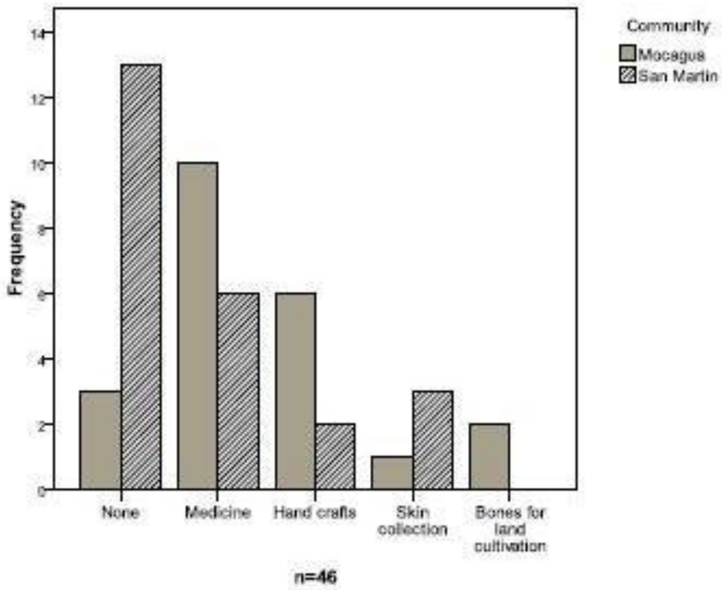

Figure 5.4 Use of animal parts in Mocagua and San Martin.

5.4 Discussion

The loss of traditional management practices by Tikunas in ANP is another example of the inevitable consequences of settler incursion and indigenous participation in extractive economies [Redford et al. 1995]. It is clear that the contact with the missioners drastically disrupted Tikunas' semi nomadic life style, as well as the loss of food taboos and restrictions intrinsically linked with their religion and traditional knowledge. This phenomenon has been widely reported for other Amerindian tribes in the Amazon basin [Brightman 2007; Good 1987; Grohs 1974; Stearman 1984; Stearman and Redford 1992]. The Tikunas in the area have tolerated for centuries the depletion of their resources and nowadays they are active actors in market economies, where commercial extraction of resources is culturally accepted. Other factors such as population growth, lack of governability and local organisation, and the need to formalise tenure agreements between Tikuna communities, also affect their use of resources. Malnutrition and increased susceptibility to illness are common nowadays and might be related to the change in their traditional diet and semi-nomadic lifestyle [Stearman 2000]. It is clear that Tikuna people need access to cash in order to satisfy needs that were not part of their traditional lifestyle, such as education, transportation, access to commodities (communication, clothing, recreation, etc).

Data from both communities confirm that hunting treks last in average one day and hunters prefer to hunt on their own, which is in agreement with the results obtained by Campos-Rozo [1987] in San Martin. She analysed how the change of hunting tools relates with game depletion and the duration of individual hunting treks. She stated that individual hunting treks are the result of: i) Tikuna communities no longer live in Malocas and families live in separate households; thus hunting is usually done by one male within the family, while in the past groups of hunters were necessary to clean and transport enough meat for the whole community; ii) the current absence of large prey, restricts the number of hunters trekking together as they can no longer divide the scarce prey between several hunters; iii) individual hunting is common nowadays as the use of shotguns reduces the risks hunters faced in the past when hunting on their own. The increase of short individual hunting treks evidences game depletion and also increases selective hunting of large species.

The increased consumption of small and medium-bodied species that were subject to food restrictions in the past and the inclusion of undesirable animal species in the Tikuna diet also reflects game depletion. This has been reported for many Amerindian and colonist communities throughout the neotropics [Altrichter 2005 in Argentina; Bodmer et al. 1997 in Peru; Fragoso et al. 2000 in Brazil; Ulloa et al. 2004 in Colombia; Smith 2005; 2008, in Panama; Townsed 2000 and Stearman 2000 in Bolivia]. For instance the paca, the deer and the capybara were not consumed in the past by Tikunas, while nowadays are preferred prey species, as those medium and large-size animals not only provide enough meat for a family but also are one of the favourite game species in the nearby municipalities. Young hunters commonly hunt kinkajous (*Potos flavus*), an undesirable prey in the past (see Fig. 5.5). Hunting in previously sacred areas such as salt-licks is drastically threatening the population of the tapir, classified as critical endangered (CR) by IUCN, Colombia [Lozano 2004; Rodriguez-Mahecha et al. 2006]. Selective logging of cedar in sacred sites like the Tuirupw hill in San Martin, where local people work with the loggers, clearly reflect the changes of cultural values.

Figure 5.5 Tikuna girl from Mocagua with hunted kinkajou (*Potos flavus*), an undesirable species in the past (photo source: Nelson Suarez – Mocagua).

A lack of veracity was reflected in the data, mainly from San Martin community. For instance, hunted species that are subject to hunting bans were not reported by the interviewees as preferred game species or pet species, such as the tapir and the woolly monkey. However, data collected during participant observation and focus groups revealed clear preferences for tapir's and woolly monkeys' meat. Furthermore, during informal conversations over the course of the study a number participants (n = 11) from both communities talked about having had or having known someone who had reared woolly monkeys (*Lagothrix lagothricha*), howler monkeys (*Alouatta seniculus*), owl monkeys (*Aotus* spp.) and saki monkeys (*Pithecia monachus*) [Parathian and Maldonado 2010]. In 2008, I observed three blackmantled marmosets (*Saguinus nigricollis*) kept as pets in San Martin; however, the animals were not reported in the harvest sheets neither while interviewing the owners of the pet monkeys. Follow up discussions with individuals (n = 10) suggested that infant primates were usually kept as pets following the death of their mothers, which had, typically, been hunted for food [Parathian and Maldonado 2010].

When looking at the results of the focus group activities (workshops), the reported lifespan for most of the overharvested species, clearly reveals a lack of accurate knowledge of the biological limitations of game species to hunting. Therefore local people believe that several game species are immortal like the giant armadillo or live in average 70 years (n = 26; SD = 26.6) (Fig. 5.6). Participants reported that they believe animals have the first reproduction during their first year of life and they reproduce every year. The statement of the elder who believes that large primates reproduce *"when they want"* is common among local people. These local beliefs help us to understand why local people are sceptical when we present the results of the research reporting that several game species might become locally extinct if hunting remains unsustainable. On the other hand, I felt privileged for having the opportunity to hear the Tikuna tales related to the immortality of animals, and their mystical origins and/or ways of dying, as only elders have this traditional knowledge and usually they do not share this with white people.

Figure 5.6 Giant armadillo (*Priodontes maximus*) hunted in San Martin, considered as immortal by elder Tikunas. Classified as EN by IUCN-Colombia (Rodriguez-Mahecha et al, 2006) (Photo source: Diana Deaza-ANP).

Local knowledge on the use of animal parts for medicine is no longer applied as early Tikunas did. Elders from both communities stated that when the Catholic missionaries arrived in the area, they censured any use of traditional medicine as they argued that was witchery. Instead, the missionaries and the government provided western medicine to the communities located nearby rivers banks. This seems to be one of the main reasons why Tikunas no longer know how to prepare traditional medicine. Other common use of animal parts in the area is for hand craft elaboration, however, its commercialisation is illegal under Colombian legislation; this is considered illegal trade of wildlife, which helped to reduce the large amounts of animal parts bought by tourists in the area [PNNA 2006].

Nimuendaju [1952] related that the loss of the knowledge to prepare the *curare* (poison), is linked with the relocation of Tikunas nearby river courses during the 1700s, as most of the plant species used for the *curare* preparation are only found in *terra-firme* forests and have a restricted distribution. He also stated that this was one of the main reasons why Tikunas rapidly switched to shotguns. The replacement of traditional hunting tools creates a dependency to the market system; the acquisition of a shotgun requires a substantial initial investment; In addition, hunters need cash to purchase cartridges, fuel for outboard motors, batteries for torches, salt to conserve meat. Consequently, cash is the only way to acquire those commodities, justifying the commercialisation of meat to remain functional [Redford et al. 1995; Stearman 2000]. Taking into account the current situation where land use is not clear, it is crucial that governmental organisations such as the INCODER (in charge of the land tenure legislation) and the Colombian Park System mediate between the communities and provide the policy/legislation scenario necessary to clarify this situation. ANP has been supporting the three Tikuna communities in order to formalise an agreement on territory boundaries and use of natural resources but up to now there are no formal agreements.

5.5 Conclusion

The results presented in this chapter provide an insight of current hunting practices and perceptions of Tikunas in ANP, providing a better understanding of the significance that wildlife has in Tikuna daily life. Local people acknowledge that the lost of cultural and religious traditions had impacted their use of resources and they have a clear idea of the external factors decreasing wildlife in the area. However, game depletion is not seen as a consequence of their long term presence in the area and their participation in the market system. The design of a conservation strategy in the area has to address complex external forces and internal cultural changes, that are difficult to eliminate but that might be modified. For instance, it is crucial to be aware that local people will be interested in management strategies only if the conservation of wildlife will provide an income that will subsidise their need for cash to pay basic needs and commodities, in order to eradicate commercial hunting. In addition, is it essential that the new Tikuna generations have an understanding of the biological limitations of wildlife to sustain hunting in the long term, as well as basic knowledge to monitor their use of resources. At the same time, traditional use of resources should be rescued and reinforced to be applied by the new generations. Therefore, a combination of traditional and scientific knowledge and an economic sustainable alternative should be placed to address the challenges of conservation in the area, before hunting is left behind because there is nothing else to hunt. In chapter 7 I provide a list of feasible alternatives to diminish commercial hunting.

6. TRADE IN NIGHT MONKEYS *AOTUS* SPP. IN THE BRAZIL – COLOMBIA – PERU TRI-BORDER AREA: INTERNATIONAL WILDLIFE TRADE REGULATIONS ARE INEFFECTIVELY ENFORCED

During the late 1960s and early 1970s, the Amazon basin was the main source for wild harvested neotropical primates for export to overseas markets [Mittermeier et al. 1994]. From 1972 to 1976, India, Colombia (Barranquilla and Leticia) and Peru (Iquitos) were the main trading centres supplying 65% of the total international market of primates for biomedical research [Held and Wolfle 1994]. Grimwood [1968] reported that 4 or 5 primates died during or after capture for each animal exported from the Peruvian Amazon. However, important traders such us Tsalickis [1969] reported a mortality rate of just 7% of the 8,587 primates purchased by him in 1968. Between 1961 and 1975, Peru legally exported 392 396 primates [Neville 1975a; 1977; Smith 1978] while Colombia exported 52 848 primates between 1972 and 1975 [Smith 1978]. During the early 1970s, Colombia and Peru, together with India, were the main source countries, supplying 65% of the total international market of primates for biomedical research [Held and Wolfle 1994]. In India where about 20,000 juvenile monkeys were exported every year, wild populations of rhesus monkeys *Macaca mulatta* were drastically decimated by the demand for this species for the biomedical research and pharmaceutical markets [Southwick and Siddiqi 2001]. In all three countries, the continuous exploitation of primates was carried out with minimal consideration of population status and distribution, data which are required to quantify extraction numbers [Bailey et al. 1974].

The alarming official export figures which are quite possibly underestimates, caused an international debate, resulting in Peru and Colombia implementing national bans on the export of primates in 1973 and 1974 respectively [Held et al. 1987]; as a result the volume of traded primates dropped, but this led to other countries, such as Guyana, supplying primates of different species to those provided by Peru and Colombia. Nevertheless, in 1975 illegal exports from Colombia were reported [Cowlishaw and Dunbar 2000; Donadio 1975]. In 1973, the Convention of International Trade in Endangered Species of Wild Fauna and Flora [CITES] came into force. This convention is an international agreement among governments which aims to ensure that international trade in wild animals and plants does not threaten their survival. Of the Amazonian countries, Brazil and Peru were the first to accede to CITES in 1975, and Colombia became a Party to it in 1981.

In an attempt to compile baseline information on wild populations to allow for sustainable exploitation, biomedical organisations such as the Pan American Health Organization (PAHO) and the National Institute of Health (NIH) of the United States funded census fieldwork in the neotropics. This provided primate density estimates in a few locations throughout the Peruvian, Colombian and Bolivian Amazon regions [Castro 1978; Freese 1975; Heltne et al. 1975; Muckenhirn et al. 1975; Neville 1975b]. These data were expected to be sufficient to convince governments that most of the species used in biomedical research (squirrel monkeys *Saimiri* spp., night monkeys *Aotus* spp., tamarins *Saguinus* spp., common marmosets *Callithrix jacchus*, and tufted capuchins *Cebus apella*) were common enough to allow extraction without compromising the stability of wild populations [CETS 2006; Mittermeier et al. 1994; Smith 1978]. Simultaneously, in order to reduce the capture of wild animals, the PAHO, the Peruvian government and San Marcos University set up the first in situ captive breeding centre for Neotropical primates in 1975 in Iquitos, Peru. However, the higher costs involved in captive breeding due to longer quarantine and acclimatisation periods, training of personnel, and more stringent transport and import requirements, have contributed to the continuing demand for wild-caught monkeys [Held et al. 1987; Held and Wolfle 1994; Mittermeier 1991].

6.1 Status of *Aotus vociferans* and *Aotus nancymaae*

The genus *Aotus* is widely distributed throughout Central and South America [Defler et al. 2001; Hernandez-Camacho and Cooper 1976; Hershkovitz 1983]. Its taxonomic status has been a matter of academic dispute due to the wide number of different karyotypes reported without clear phenotypic distinctions between intra- and inter-population variations [Defler and Bueno 2007; Ruiz-Herrera et al. 2005]. The genus is divided into two groups: the red- necked species group distributed south of the Amazon-Solimões River and the grey-necked species group found mainly north of the Amazon River [Hernandez-

Camacho and Defler 1989; Hershkovitz 1983]. The focus of this study is mainly on the two species which are targeted for biomedical research, viz. the Amazonian night monkey *Aotus vociferans* and Nancy Ma's night monkey A. *nancymaae*, although Brazilian informants reported the capture of the black-headed night monkey *A. nigriceps* as well. *Aotus vociferans* is found in Colombia, east of the Cordillera Oriental and west of the Negro River, south to Brazil, north of the Amazon-Solimões River, to the Marañón River in Peru and into the Ecuadorian Amazon. A. *nancymaae* is found in Peru from the right bank of the Amazon River to the Marañón River, as well as in the enclave between the Tigre and Pastaza Rivers, and south of the Solimões River in Brazil.

A. nigriceps occurs in Brazil south of the Amazon, west of the Tapajos- Juruena Rivers and into Peru [Aquino and Encarnacion 1994; Groves 2005]. A. *nancymaae* and *A. nigriceps* have been recorded in Brazil and Peru but only *A. vociferans* has been recorded in Colombia. However, although no official records exist, in the early 1980s J. Hernandez-Camacho and P. Hershkovitz observed both A. *nancymaae* and *A. nigriceps*—reportedly from Colombia—in the laboratories of the Fundacion Instituto de Inmunologia de Colombia in the early 1980s [Defler 2004].

All species of night monkeys are included in CITES Appendix II, which regulates all international and commercial trade. In the 3 countries discussed in this study, national legislation regarding the commercial exploitation of wildlife listed in the CITES Appendices is explicit. For instance in Colombia, Article IV (22 January 1981) of Law 17 states that commercial exploitation of wildlife listed in CITES Appendix II requires an export/import permit to be granted by the Environmental Ministry [Congreso-de-Colombia 1981]. In the case of Brazil, Section II (21 September 2000) of Decree No. 3.607 declares that for the export/import of wildlife, it is necessary to obtain a license approved by the CITES Management Authority, Brazilian Institute of Environment and Renewable-Natural Resources (IBAMA) [Presidência-da- República 2000]. Likewise in Peru, Law No. 27308 (16 July 2000) states that Ministry of Agriculture is the entity in charge of issuing permits for importing/exporting wildlife [INRENA 2003].

Aotus nancymaae, *A. nigriceps* and *A. vociferans* are listed by the International Union for Conservation of Nature (IUCN) as 'Least Concern', partially owing to their wide distribution [Cornejo and Palacios 2008; Morales- Jiménez et al. 2008]. While the IUCN listing suggests no major threats to these taxa, data to support this conjecture are meagre, since little fieldwork has been done in areas where human pressure is increasing, including the triborder area. The IUCN has recently recommended the monitoring of the extraction, legal or otherwise, of *A. vociferans* and A. *nancymaae* in order to understand its effect on populations [Cornejo and Palacios 2008].

In this chapter, I provide an overview of the trade in live-caught night monkeys *Aotus* spp. from the Brazil–Colombia–Peru tri-border area. The demand for these animals comes from the biomedical industry, and this is facilitated primarily through a biomedical research institute in the Amazonas Department, Colombia. Given the existing confusion on the taxonomic status of night monkeys in this part of Amazonia, I first provide an overview of the status of night monkeys, after which I present data on trade volumes. I finish by giving recommendations on how to tackle the illegal trade of night monkeys in this region.

6. 2 Methods

6.2.1 Reported levels of international trade

Data on international trade in night monkeys from Brazil, Colombia and Peru as reported by CITES Parties were retrieved from the World Conservation Monitoring Centre (UNEP-WCMC) CITES database [UNEP-WCMC 2001]. Only traded wild-caught individuals are included in Table 6.1; thus all individuals that were listed as captive-bred, ranched or farmed were excluded. Data were available for 1975 to 2006, with some information being available for 2007 (not all Parties had submitted their reports at the time of the analysis); data for 2008 and 2009 were not yet available.

6.1.2 Assessment of trade in the tri-border area

Through a combination of field work and interviews, I assessed the illegal trade in night monkeys in the area of the Brazil–Colombia–Peru border triangle, roughly located along the south and north banks of the Amazon River, from Gamboa, Peru (4° 12.54’ S, 70° 04.64’W) to San Juan de Atacuari, Colombia (3° 48.35’ S,70° 40.20’ W) (See Figure 6.1). I established that the total number of communities collecting night monkeys for biomedical research in the Brazil-Colombia-Peru border triangle is 28 (8 in Brazil, 5 in Colombia and 15 in Peru), involving an estimated 185 active traders/collectors. Interviews were conducted with members of 11 of these communities (comprising Tikuna, Yagua and Cocama indigenous groups and a minority of ‘caboclos’ or mixed ancestry communities).

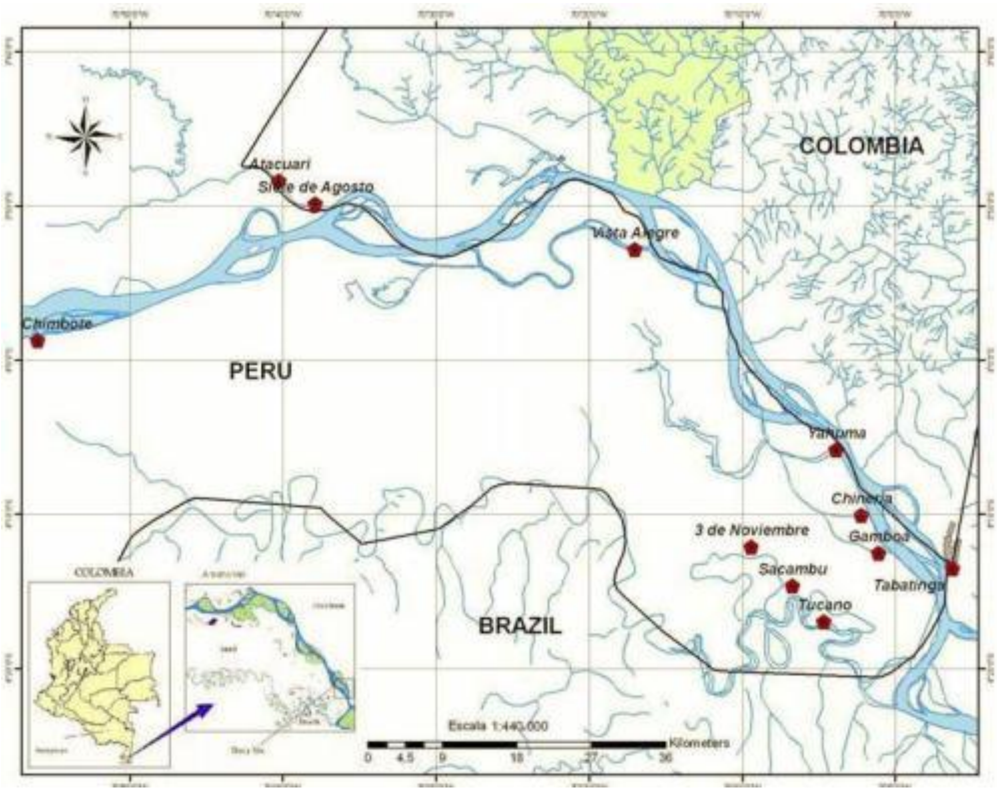

Figure 6.1 Location of the 11 indigenous communities that participate in the trade of night monkeys, in the Brazil-Colombia-Peru tri-border area.

I focussed on communities that had been capturing night monkeys on a regular basis and which still have permanent teams for this activity, although they are not full-time hunters and receive additional income from fishing and cultivation. For Peru and Colombia, this included all communities with >4 collectors but because of strict regulations restricting contact with indigenous people in Brazil, only one ‘caboclos’ community was visited (Tabatinga). The aim was to interview about a third of the collectors/traders in each of the 11 communities; in all, 43 of 139 traders/collectors who were reportedly active were interviewed. Interviews were recorded from 28 May to 10 July 2008. The research team consisted of a wildlife veterinarian specialising in primates, a sociologist and a Tikuna indigenous researcher. Some visits were accompanied by a Brazilian ex-trader who was well known in the Peruvian communities and acted as the interpreter in interviews with the Brazilian informants. As the research interest was only in trade in night monkeys, it was specified before starting the interviews.

When arriving at each community, the team visited the indigenous authority (the 'Curaca' in Colombia and the 'Intendente Municipal' in Peru), in order to obtain consent to contact the collectors/traders. A sample of collectors/traders was interviewed and all participants were free to withdraw from the study at any time, without giving any reason. We asked the informants for permission to video or voice record the interviews and/or to take photos. Some of the communities were revisited in order to interview key informants who were away during the first visit. The structured interview was designed to provide information on i) the number of night monkeys collected during the previous year by each person, including a phenotypic description of the animals; ii) the price and date of the last sale; iii) the buyer and the nature of the economic transaction; iv) capture techniques and training for capturing primates; v) collection sites; vi) the number of years the informant had been involved in capturing monkeys; vii) the level of satisfaction regarding capture effort; viii) the price per animal; and ix) interest in participating in a conservation project for night monkeys (see Appendix IX).

6.3 Results

6.3.1 Reported international trade

International trade in wild-caught night monkeys from Brazil, Colombia and Peru is largely restricted to *Aotus trivirgatus*, *A*. *nancymaae* and *A. vociferans* (Table 6.1). The international trade in *A. trivirgatus* is recorded from the period 1981–1994 when only an average of 250 wild-caught individuals were exported per year. Here, it is important to note that before Hershkovitz's [1983] assessment of the *Aotus* genus, all the night monkey species were considered as *A.*

trivirgatus. Therefore, it is likely that the figures presented in Table 6.1 for *A. trivirgatus* in Peru correspond to either *A*. *nancymaae* or *A. nigriceps* as *A. trivirgatus* does not occur in Peru. Similarly, figures for *A. trivirgatus* for Colombia could correspond to *A. griseimembra* or *A.brumbacki* [Green 1978]. In this study, we only report the international trade in *Aotus nancymaae* and *A. vociferans* from 1994 onwards, when respective averages of 75 and 25 individuals were exported per year.

Table 6.1 Numbers of wild-caught night monkeys listed as exported or originating from Brazil, Colombia or Peru on the world Conservation Monitoring Centre [UNEP-WCMC 2001] Convention on International Trade in endangered Species of Wild Fauna and Flora (CITES) trade database animals of specimens listed as captive-bred, ranched or farmed (source codes C, R or F) are excluded.

Country (acceded to CITES)	**Species**	**Numbers exported**	**Period**
Brazil (1975)	*Aotus trivirgatus*	2	1981–1987
Colombia (1981)	*Aotus trivirgatus*	1446	1981–1989
	Aotus lemurinus	1	1999
Peru (1975)	*Aotus trivirgatus*	1843	1981–1994
	Aotus nancymaae	1059	1994–2007
	Aotus vociferans	265	1994–2004
	Aotus spp.	30	1981–1994

6.3.2 Trade in the Brazil–Colombia–Peru tri-border area

The 11 communities reported an extensive trade in night monkeys, with between 144 and 700 individuals reportedly being captured annually per community, giving a total of approximately 4,000 individuals per year (Table 6.2). On average, each community had been catching night monkeys for a period of 12 years, with five communities active in 2008. Regarding species composition, informants described marked phenotypic differences between *Aotus nancymaae* and *A. vociferans*, but it was more difficult to confirm differences between *A. nancymaae* and *A. nigriceps*. The Brazilian collectors gave detailed descriptions of 2 different monkey species based on fur colouration and sleeping sites where the animals were captured, which agreed with descriptions published by Aquino and Encarnacion [1986a; 1994] and Ford [1994]. All communities reported trade in *A*. *nancymaae*, the Colombian and Brazilian communities mentioned that they captured small numbers of *A.*

vociferans, and descriptions from Brazilian and Peruvian traders suggest the possibility that *A. nigriceps* is traded as well.

Table 6.2 Overview of trade in night monkeys *Aotus* spp. in the Brazil-Colombia-Peru triborder area for the period 2007–2008

Community	Traders/ collectors (N)	Interviewees (N)	Annual harvest (ind.)	Period [Bran don et al.]	Species	Date of last sale	Price ind[1] (USD)
Colombia							
Atacuari	11	4	276	3	*A. nancymaae, A. vociferans*	Jun 2008	16*
Siete de Agosto	15	3	720	7	*A. nancymaae, A. vociferans*	May 2008	16*
Brazil							
Tabatinga	6	2	222	18	*A. nancymaae, A. vociferans, A. nigriceps* (?)	Dec 2007	23
Peru							
Vista Alegre	20	8	320 230	17	*A. nancymaae* *A. nancymaae, A. vociferans*	Dec 2007 Feb 2008	23 16*
Chineria	20	7	700	16	*A. nancymaae*	Dec 2007	23
Yahuma	19	5	480	15	*A. nancymaae*		
Sacambu	13	4	270	13	*A. nancymaae*	Feb 2007	23
Tucano	6	3	144	16	*A. nancymaae*	Jan 2007	23
Gamboa	11	2	180	9	*A. nancymaae, A. nigriceps* (?)	Apr 2008	33
Tres de Noviembre	6	2	192	7	*A. nancymaae*	Dec 2007	23
Chimbote	12	3	225	13	*A. nancymaae*	Feb 2008	23
Total	139	43	3,959				

Local people from each country of the tri-border region of the Amazonia did not have different names for each species of the genus *Aotus*; night monkeys are called 'buri-buri' in Colombia, 'musmuqui' in Peru and 'macaco da noite' in Brazil. The traders and collectors who were interviewed understood that cross-border trade was illegal without a permit. Their justification for these illegal practices is their lack of access to cash needed for commodities such as petrol and school uniforms. While the interviewees were from a wide range of communities from three different countries, all agreed that the end-buyer of the night monkeys they captured was a local laboratory in the Amazonas Department in Colombia, close to the tri-border area. Interviewees in Peruvian communities indicated that personnel from this laboratory visited them regularly to order night monkeys, allegedly for use in the laboratory. The laboratory had a permit granted by the regional environmental authority (CORPOAMAZONIA) to acquire 1,600 *Aotus* [CORPOAMAZONIA 2006]. Prices paid by Colombian intermediaries in all three countries were in Colombian pesos (COP), and ranged between USD 23 per individual in 2007 to USD 33 per individual in 2008.

A Brazilian trader who had collected and sold approximately 2,000 night monkeys over an 18 year period, stated that after being captured twice by the Colombian police in 2007, he decided to stop collecting monkeys. This incident alerted the Peruvian traders who then began to use other methods to continue the trade in monkeys. Collectors from Vista Alegre in Peru subsequently started selling night monkeys to a Colombian intermediary located in Siete de Agosto, who had a legal permit to provide monkeys to the laboratory, provided that the trader originated from Colombia. This intermediary paid only half (USD16) of the price paid by the laboratory, but the Peruvian collectors maintained that this way was safer, as they were not exposed to capture by the Colombian police. Other Peruvian collectors stated that they continued to sell night monkeys directly to the laboratory using Colombian identity cards belonging to relatives or friends, thus concealing their nationality. Trapping night monkeys is a family activity where usually at least three members of the team of approximately 5 are relatives. The interviewees were described as the leaders of the capture teams and were usually the people in charge of making the economic transaction and paying the rest of the team.

6.3.3 Monetary value

Data for annual harvest were calculated from the approximate number of monkeys captured by the informant's team during the previous year. These figures were multiplied by the total number of teams in each community. Informants from different communities agreed that a team captured from eight to 15 monkeys per month, depending on the demand. These figures indicate that the annual harvest of night monkeys in the area is around 4,000 animals. At an average price of USD 23–33 per individual, this suggests a total annual monetary value of about USD 90,000 for the collectors (averaging USD 625 per collector) plus approximately USD 20,000 for the Colombian intermediaries.

6.4 Discussion

The results of the interviews suggest that there is an extensive and continuing trade in night monkeys in the tri-border area of Brazil, Colombia and Peru. This represents trade within Colombia, between Peru and Colombia and between Brazil and Colombia. While the estimated domestic trade in Colombia is in the order of 1,000 individuals per year, the estimated international trade is three times this number. No import of night monkeys from Peru or Brazil is reported by Colombia, nor does Peru or Brazil report the export of night monkeys to Colombia. The assertion by those involved in the trade in all three countries that prices were paid in Colombian currency supports the suggestion that trade is primarily for the Colombian market. If correct, and with all three countries being Party to CITES, this highlights violation of CITES regulations. All people involved in the trade in night monkeys in the tri-border area that we contacted indicated that the monkeys were sold to a single laboratory in the Amazonas Department of Colombia.

Data supported by government documentation confirms that this laboratory was allowed to legally acquire up to 1,600 *Aotus vociferans* within Colombia over a 24 month period. The interview data suggest not only that a much larger number of individuals was acquired, but also that these represented different species (primarily *A. nancymaae*), and included a substantial number of individuals from outside Colombia. Publications resulting from research conducted at the facility in the Amazonas Department indicate that indeed both *A. nancymaae* and *A. nigriceps* are used [Baquero et al. 2006; Cardenas et al. 2005; Daubenberger et al. 2007; Patarroyo et al. 2006; Spirig et al. 2005; Suarez et al. 2006].

Long-term studies suggest that even common species such as rhesus macaques can become severely threatened if harvested unsustainably [Southwick and Siddiqi 2001]. In the case of *Aotus* sp. in the tri-border area, interviewees confirmed that it now takes considerably more time to trap the same number of night monkeys, with many hunting trips proving unsuccessful as animals are becoming difficult to find. The ecological effects of the continuous extraction of *Aotus* sp. since 1984 in the Brazil-Colombia-Peru border are unknown. As all night monkeys are listed in Appendix II of CITES, Parties are obliged to report international trade in these species. In recent years (2003 onwards), only Peru has reported international trade in night monkeys, both captive-bred and wild-caught, with all specimens going to the USA. The reported high levels of trade among the three countries in the triborder area are in stark contrast with what has been reported as international export, suggesting a lack of enforcement of international trade regulations.

6.5 Recommendations

6.5.1 *Law enforcement*

The significant levels of harvest of night monkeys in the Brazil–Colombia– Peru tri-border area appear to be in violation of both national and international laws and regulations. For instance under Colombian legislation, Article 85 (22 December 1993) of Law 99 clearly states fines and sanctions that should be applied in cases of illegal import of wildlife, with fines and sanctions varying depending on the gravity of the infraction [Congreso-de-Colombia 1993]. I strongly recommend that environmental and conservation authorities in Colombia, Peru and Brazil try to resolve this through cooperative action. The international nature of the trade, which violates CITES regulations, makes the CITES Management Authorities in each of the three countries the best bodies to take the lead in this process. Furthermore, it is crucial that the Colombian Ministry of the Environment investigates the species composition, origin and volumes of night monkeys used in the biomedical laboratory in the Amazonas Department as data from collectors and traders suggest that these numbers are not in correspondence with national permits.

6.5.2 *Taxonomic and distribution clarification of traded species*

It is crucial for the primatological community to acquire research permits allowing the capture of *Aotus* sp. to obtain samples for DNA identification and clarify the taxonomy of the genus *Aotus* in the Brazil-Colombia-Peru border area. Additionally, it is urgent to carry out a survey in this area to assess the conservation status of *Aotus* sp. and to clarify its distribution. For example, the IUCN/SSC [2008] distribution map for *A. nigriceps* does not cover the northwest section of the Rio Solimões (Amazon River), while Brazilian collectors reported its capture in this area. Groves [2005] described *A. nigriceps'* northern distribution limit as the south of Rio Solimões, but it is not clear from which section of the river. [T.R. Defler, pers. comm.]. It is probable that *A. nancymaae* and *A. nigriceps* are sympatric in the area.

Regarding the distribution of *A. nancymaae,* it is possible that the species may have been introduced into Colombian territory by humans, for example, the continuous release of animals after biomedical research experiments [FIDIC 2006]. Alternatively, it may have existed in an enclave between Peru and Colombia on islands created by the shifting levels of the Amazon River. If either of these processes occurred, it is likely that the distribution, and thus the densities, of wild populations of *A. nancymaae* in Colombia, will be highly restricted. According to the updated version of Guidelines for Using the IUCN Red List Categories and Criteria V 6.2 [2006], geographical range is a priority for assessing the conservation status of a species. If this species is found in Colombia it should be classified as Endangered [Rodriguez-Mahecha et al. 2006], thus prohibiting its capture for biomedical research. It is therefore a priority to confirm the presence and population status of *A. nancymaae* in Colombia or its possible sympatric distribution with *A. vociferans* through census fieldwork [Emmons 1999]. Data on their abundance may also provide an incentive to further protect these species if numbers are proven to be low.

6.5.3 *Trade monitoring*

The reception of night monkeys by the lab in Leticia, Colombia should be overseen by the Colombian environmental police and a local NGO to avoid internal collusion. It is crucial to confirm the nationality of the traders, the origin of the animals and blood samples should be taken and analysed by the local NGO (not by the lab or local authority) to confirm the taxonomy of the species. The monitoring will incur further economic costs which should be covered by the local environmental authority. It is also recommended that a reception centre for confiscated animals be established in Leticia, with suitable enclosures and trained personnel to handle the animals confiscated by the environmental police.

6.5.4 *Economic incentives for indigenous collectors*

Informants from the three countries agreed to take part in conservation projects on night monkeys if implemented. They said that the only reason for hunting the monkeys, legally or illegally, was their need for cash to buy commodities such as gasoline and school uniforms for their children. The implementation of a survey of *Aotus* sp. in the area could provide the initial income needed to replace that received for capturing night monkeys for biomedical research. However, a long-term project that provides a selfsustainable income has to be designed; one possible option could be the observation of night monkeys as a wildlife attraction, guided by local people. In order to preserve the only nocturnal primate genus endemic to this area, it is imperative that environmental authorities enforce a new approach to managing the environmental resources to benefit a broader segment of the local population. If animals are to be acquired from Brazilian or Peruvian sources in the future, this has to be with official permits from the respective national authorities.

7. GENERAL CONCLUSIONS AND RECOMMENDATIONS

In this thesis I examined the anthropogenic factors that affect the stability of game species populations inside overlapping areas between Tikuna indigenous land and ANP, Colombian Amazon. I presented a brief description of the plant resources used by game species, which are also important for local people's livelihood. In addition, I assessed plant production at four sampling sites to have an insight into the influence of food availability on game species abundances (Chapter 2). I estimated the abundances and extraction rates of important game species and I compared these results between two Tikuna territories exposed to different hunting pressure (Chapter 3). I compared the primate community between the two Tikuna territories, as primates are remarkably useful when evaluating the health of forest ecosystems (Chapter 4). I presented a qualitative profile of the factors affecting hunting sustainability by Tikunas as well as, local people's perceptions of past and present hunting. This ethnographic assessment provides a background to the cultural and socio-economic challenges and opportunities that must be addressed when designing a resources management strategy with the involvement of Tikuna indigenous communities and the ANP (Chapter 5). I provided a case study on the illegal trade of night monkeys for biomedical research and presented recommendations to address the trade (Chapter 6).

In this chapter I present the limitations I faced during this study. I provide recommendations for other researchers interested in conducting fieldwork in the study area, in order to make the most of the scarce time and funding resources available in this research field. Following, I then summarise the results of chapters 3 and 5 in order to provide an overview of the possible management alternatives that might be implemented by the local stakeholders in ANP, in order to use wildlife and other important resources such as cedar in a sustainable way. Lastly, I give an outline of possible sustainable economic alternatives that might be put into practice as part of the management strategy to improve local livelihoods and decrease illegal extraction of resources in the study area.

7.1 Research Limitations

During the implementation of this research, I realised the various limitations I was facing regarding data collection. After successfully obtaining a research permit from the Colombian Park system (UAESPNN) and the written approval of indigenous authorities to develop a community-based research project, several socio-cultural and economic factors limited the accomplishment of all the research aims. Here I describe the main obstacles I faced during this study and I provide recommendations to help overcome these difficulties and to inform researchers about situations that may arise in similar contexts.

7.1.1 Sampling site in undisturbed forest

During the design of research I was expecting to conduct census surveys at Mocagua, San Martin, and at least one non-hunting sampling site. This was intended to examine if there were differences in the distribution and abundance of large vertebrates and their responses to human disturbance (e.g. hunting, selective logging and forest fragmentation). However, local beliefs made it impossible to establish a camp site in an area not subjected to human activites in overlapping areas between ANP and the indigenous territories of Mocagua and San Martin.

Local people were reluctant to set up a camp site for research as they have the belief that if white people (especially people they do not know) go to remote areas, the "*owner*" of that forest will be upset and indigenous people working there will become ill. Additionally, game species will hide from them. I believe this is based in their past experiences with the rubber collectors, illegal loggers and coca cultivators. Local people became ill and suddenly died in the forest as white people brought several diseases that were lethal for indigenous people, as mentioned in Chapter 5. In San Martin, a group of people disagreed with the establishment of a new camp as they did not want researchers to learn about the illegal extraction of cedar inside their indigenous territory.

In order to search for a suitable site without human intervention, during December 2006 – February 2007, I decided to visit Ome Ecological Station (OES), directed by my external supervisor professor Thomas Defler. OES is located at the extreme northwest part or ANP in a remote and pristine forest (3º 32.188’ S and 69º 53.531’ W on the Purité River) (see section 2.3.1 and Fig. 2.8). A grid system marked every 50 m had been established to conduct ecological studies of the primate community since 2001. In a straight line, Mocagua village and OES are separated by only 90 km of dense primary forest. However to get to OES, with equipment and food for a few months, river transportation and/or a cargo flight are essential. I went to OES with my local research coordinator and co-investigator from Mocagua (Francisco del Aguila). We started the journey in Leticia through the Amazon river, the Putumayo river and finally the Purite river, to get to OES. The total distance covered was 750 km. On the way back as we did not have to carry food we took the Purite river, the Putumayo river (approximately 300 km) but then went to Tarapaca (the nearest town with an airport) and from Tarapaca we took a cargo flight to Leticia.

OES is located nearby the Purite river, which is a black- clear (mixed) water river, with a distinctive feature; during the rainy season the river is mainly irrigated by black water, while during the dry season the Purite river has clear water. When comparing the results of soils analyses between the southern part of ANP and OES, values for determining soil fertility were similar between sites in relation to pH, Carbon (Ca) and Aluminium (Al) but differences in the soil concentration of Magnesium (Mg), Phosphorous (P) and Potassium (K), were evident as well, suggesting that soils in OES have a lower productivity potential.

The high financial costs and access limitations of OES meant that it was not feasible to conduct census fieldwork on a regular basis to achieve a census effort (km) comparable with that at Mocagua and San Martin. In 2008, I visited the Calderon river basin located at approximately 55 km from Leticia. This area has high human intervention in a radius about 10 km from the main settlements, but after this radius this forest in not inhabited by people and wildlife populations seem relatively stable. Currently my research team is conducting census surveys in the area, for further comparisons of large vertebrate assemblages in the area. I recommend that further researchers aiming to sample a forest without human intervention close to ANP, explore the Calderon river. This implies applying for another research permit and to deal with all the bureaucracy from the regional environmental authority. This can take between 3 to 12 months, thus the design of a research project in the area requires at least 18 months of preliminary organisation.

7.1.2 Measurement of environmental factors

Mocagua and San Martin are located in an homogeneous mosaic of habitat structures with similar edaphic conditions [Rudas et al. 2005]. Thus it is likely that environmental factors such as floristic composition, habitat structure and soil fertility are not influencing those differences in standing biomass. However this statement is speculative as the lack of historical data reduces our understanding of current ecological dynamics. During the design of this research it was clear that a phenological study was necessary for measuring forest production. However, time and funding constrains made me to decide that census surveys and collection of hunting data were the priority. The rapid plant assessment provided preliminary information about biodiversity and richness of fruiting tree species, but it is important to conduct a more detailed study in the area to have a better understanding of the plant community at the four sampling sites. I advice, that for any research determining large vertebrate densities in the area, the implementation of a phenological study should be included during the research design. Nevertheless, in the event of limitations in funding I recommend to approach the SINCHI institute, who are currently establishing a permanent plot in ANP as part of the RAINFOR project. A collaborative/volunteer project with the SINCHI may save time and funding.

7.1.3 Cultural limitations on resources management

As mentioned in Chapter 5, local people's perceptions of wildlife such as immortality of game species (e.g. giant armadillo) or that they can reproduce at any time (e.g. large-bodied primates), indicates that environmental education focused on wildlife biology and ecology should be implemented in the local schools. The new Tikuna generations should be prepared for the forthcoming shortage of natural resources. Education is one of the most valuable tools to provide an understanding of the ecological limitations of wildlife to maintain viable populations under hunting pressure.

Other cultural limitation in the area, is the lack of political organisation that has been reported since the Tikuna group became sedentary, also influenced by the disappearance of spiritual authorities (*Payés*) [Nimuendaju 1952]. This issue is intended to be addressed by the indigenous authorities (TICOYA), where training is offered to young Tikunas, providing them basic lectures on indigenous legislation (e.g. land ownership, human rights). However, this training has resulted in some negative views, of the environmental authorities and NGOs. A way to promote a more neutral view on political organisation, local governability and use and management of natural resources, could be that indigenous leaders from other areas (such as the lower-Caqueta river), who have a strong political indigenous structure, provide training to local Tikuna leaders. Fundacion Tropenbos, has been leading this kind of exchange, but it needs to be intensified and implemented in the long-term. Thus, the participation of local and regional stakeholders is necessary to strength local governability.

7.2 Recommendations for the Design of a Management Strategy in ANP

As mentioned in Chapter 1 strategies of resource management are only feasible when local people's needs and socio-cultural and economic contexts are included during their design, as well as allowing for the biological limitations of each overhunted species. Yet the implementation of a conservation alliance between indigenous people and relevant stakeholders has to satisfy common pool resources principles, which can be difficult to achieve [e.g. Garcia and Lescuyer 2008; Niesten and Rice 2006; Zimmerman et al. 2001]. What is clear from previous experiences is that strategies that may work in a specific situation and location might not be applicable in a different context and, the design of the locally-based management strategy involves the weighing of several options [Niesten and Rice 2006; Sayer and Campbell 2004].

The criteria for the design of the management strategy for Mocagua and San Martin are based on two main goals for sustainable use of game species: efficiency and restraint [e.g. Mace and Hudson 1999; Robinson 2001]. The criteria were implemented through workshops with Tikuna communities and from meetings with relevant stakeholders. Further guidance included CITES and IUCN recommendations for wildlife management, the IIED guidelines for approaching community based resources management, and several experiences of locally-based management strategies that provided evidence of success under similar ecological and socio-economic contexts [e.g. Bodmer and Puertas 2000; Fragoso et al. 2000; Townsend 2000; Ulloa et al. 2004; Zimmerman et al. 2001]. Table 7.1 presents the main goals and indicators for sustainable use of resources that will be addressed in this chapter.

Table 7.1 Main indicators of sustainable use according to management goals [Robinson 2001].

Management goal	Indicators of sustainable use
Species conservation	1. Wildlife populations show no consistent decline
	2. Wildlife populations are not vulnerable to extinction
	3. Wildlife populations maintain ecological role
Ecosystem health	1. Maintenance of species richness and diversity
	2. The primary productive of the ecosystem is maintained
	3. Nutrient cycles and landscape patterns are maintained
Human livelihoods	1. Total harvest is maintained
	2. The harvest composition is maintained

7.2.1 Management Goal: Species Conservation Strategies

In order to achieve this management goal each harvested species has to maintain its population above its maximum sustainable yield (MSY), bearing in mind the carrying capacity of the habitat and the health of the ecosystem [e.g. Caughley and Sinclair 1994; Robinson 2001; Sinclair et al. 2006]. The main limitations for this approach are: i) the lack of data regarding population dynamics, reproductive productivity, sex and age structure and source-sink processes in the study area [Kokko et al. 2001; Lande et al. 2001]; ii) most of the species included in this analyses naturally present low population densities, being highly vulnerable to environmental or demographic stochasticity that will lead to catastrophic reproduction or recruitment failures [Petersen and Levitan 2001].

7.2.2 Management Goals: Ecosystem health and human livelihoods

When looking at the indicators of sustainable use presented in Table 7.1, it is difficult to conclude if the current anthropic activities are affecting the ecosystem at the southern part of ANP owing to the lack of historical data on species richness and diversity. Moreover indicators related to the nutrient cycling in the ecosystem are very difficult to measure in Amazonian rainforests [Peres 2008]. Dobson et al. [1997] stated that the amount of habitat conversion is a more easily measurable indicator. Van Leijsen and Vleut [2005] conducted a redundancy analyses (RDA) where they measured the impact of human activities (hunting, selective logging and conversion of forest into agricultural land) in the adjacent forest to Mocagua in order to test the influence of these factors on primate species. Their results suggested that the main activity reducing primate occurrence in the area is hunting. Agricultural land and deforestation did not represent an impact, owing to the small area used for agricultural purposes [van Leijsen and Vleut 2005]. San Martin's agricultural area is also limited.

When looking at the indicators of sustainable use for human livelihoods (Table 7.1), it is clear that the total harvest and its composition are not maintained over time by Tikunas in ANP. The data presented by Campos-Rozo [1987], shows that the harvest of large game species is decreasing over time in the San Martin community, and the current inclusion of small prey is drastically changing the harvest composition over time. Therefore it is clear that a management strategy has to be implemented in order to maintain human livelihoods in the long term. To achieve effective conservation, several authors postulate different approaches based on indicators such as: i) sustainability for improving human livelihoods; ii) equity in resource distribution based on availability; iii) free market economy is essential to increase resources availability. Robinson [2001] provides a list of indicators supported by several case studies with measurable success throughout tropical forests as follow:

- *Use of resources should further local community involvement in resources management*: community's right to ownership and tenure must be secured for sustainable wildlife management [IIED 1994].
- *Use should further the integration of wild species and people across the landscape*: reintegration of people and nature by removing the "hard-edge" division between wild areas and human-influenced areas. Hutton and Dickson [2001] stated that use of resources by native people has to be allowed even in protected areas through management strategies in

order to decrease illegal and commercial extraction of resources, and to guarantee local people's livelihoods.

— *Use should promote local economic activity*: the different approaches to this indicator are controversial. For instance, some authors argue that wild species must pay their own way in the modern world [Child and Child 1990 in Robinson 2001]. On the other hand, several examples clearly confirm that the commercialisation of wildlife without a management strategy is driving large vertebrates to local extirpation in the Amazon basin [Begazo and Bodmer 1998; Bodmer and Pezo 2001; Laurance et al. 2006; Peres 2001a; Peres 2001b; Terborgh 1999].

7.2.3 Monitoring: Key component for the management strategy

Garcia and Lescuyer [2008] state that decentralisation is the main component for the implementation of an effective management strategy and is seen as a key component for the design of environmental policies. Decentralisation of natural resources management is characterised by a power shift from a central state structure to a local body [Ribot and Larson 2005]. Here, it is important to identify the type of power being transferred, the nature of the recipient structure and the mechanisms of accountability [Ribot and Larson 2005]. Thus it is expected that the decentralisation of resources management generates three main benefits: i) an increase in the well-being of local people; ii) improvement of the preservation of the ecosystem and iii) better local governance by empowering local communities and enabling them to control resources management [Garcia and Lescuyer 2008].

Holck [2008] states that the main aim of monitoring is to generate data that describe the environmental status of a site at a certain time. These data may be used as baseline for the design, implementation and evaluation of a management strategy. Monitoring can be seen from the management point of view as aiming to identify the state of the ecosystem and to provide information on the ecosystem's responses to management action. Whereas monitoring from the scientific point of view is aimed at learning and understanding the behaviour and dynamics of a system [Yoccoz et al. 2001]. Nonetheless, past experiences in monitoring have shown that conventional biodiversity collection approaches by professional scientists are often considered irrelevant by local managers and also, may be far too expensive to be sustainable for continual monitoring in many developing countries [Lawton et al. 1998; Sheil 2001]. As a result, decision-makers often lack the information needed to make the best decisions, which can lead to massive underestimations of the current rate of human activities such as habitat disturbance, deforestation and hunting [Laurance and Useche 2009; Padmanaba and Shei 2007]. Thus, monitoring has to integrate both management and scientific views bearing in mind its long-term economic sustainability.

The locally-based management approach demands the involvement of the relevant stakeholders and participatory monitoring has to be achieved. For the successful operation of monitoring, the inclusion of the following ingredients are crucial: i) knowledge and measurement of the goods and services used by local people that are derived from the ecosystem; ii) the benefits to local people involved in the monitoring have to exceed the costs; iii) conflicts between stakeholders should not limit their participation in the monitoring process; iv) data should be maintained, and made accessible locally; v) monitoring is conducted by existing traditional stakeholders [Danielsen et al. 2005; Garcia and Lescuyer 2008].

Numerous experiences of locally-based management strategies in tropical rainforests demonstrate that monitoring during the management strategy has to be sustainable over time, otherwise it will fail. A summary of the most common causes of failure are: i) the income resulting from monitoring and protecting biodiversity does not ensure an appropriate return for local people [Fraser et al. 2006]; ii) the monitoring system does not provide clear guidelines for adaptive management at a local level [Garcia and Lescuyer 2008]; iii) a change of institutional agreements occurs due to the transfer or promotion of an official [Garcia and Lescuyer 2008; Ulloa et al. 2004]. This is a very common issue in developing countries that jeopardises long-term management strategies that might have the approval of relevant stakeholders iv) shortcomings in data reliability. It has been argued that the involvement of local community members in biodiversity monitoring may compromise data accuracy and increase biases beyond acceptable levels in comparison with data collected by educated biologists [Brandon et al. 2003; Genet and Sargent 2003]. Yet, other studies reported that local people are capable of collecting accurate data if they receive adequate training in monitoring methods. It is crucial that monitoring methods are simple and cost-effective. This is decisive to guarantee the continuation of monitoring after the external funds finish [Holck 2008].

7.3 Proposed Management Alternatives

Table 7.2 shows a summary of the proposed management alternatives bearing in mind the three management goals: species conservation, ecosystems health and human livelihoods.

7.3.1 Species conservation strategies

Recommendations for overharvested game species are presented in rank order of hunting pressure, including a summary of the qualitative evaluation of hunting sustainability, and the quantitative approach, including the four models. In most cases the commercial hunting has to be banned in order to allow populations to recover. To replace the income obtained by commercial or illegal hunting, economic alternatives are explained in the section 7.3.3.

Table 7.2 Summary of the proposed management alternatives including their definitions and the required conditions and limitations for their implementation

Management Goal: Species Conservation

Management Alternative	Definition	Requirement for implementation and limitations
Hunting restriction: it is applicable when the population of a game species is currently harvested at levels close to its **MSY**[6]	A game species should be harvested in relation to restraints according to individual species characteristics such as age, sex, productive productivity, reproductive season and home range requirements.	**Local monitoring**: the community has to develop continuous monitoring to quantify their harvest. Data collection follow-up has to be permanent. Monitors have to be continuously evaluated, trained and rotated to include all the gender/age classes in the process. Wildlife surveys should be carried out in order to quantify densities of game species and determine the effects of the management alternative. Inclusion of local taboos will enhance the acceptance of the hunting ban/restriction. **Limitations**: if an economic incentive is not offered the collection of data will not be reliable over long periods of time. In addition an economic alternative has to be implemented to replace the perceived income from commercial hunting.
Hunting ban: it should be implemented when current harvest of a species surpasses its MSY (from 25%) and densities are declining	A game species should not be harvested when extraction rates surpass the ability of a species to recover from hunting owing to reproductive constrains. A hunting ban should be applied when the use of a species is reducing population numbers to where they cease to be a significant resource to human users.	Same as for hunting restrictions **Other limitations:** another source of protein should be available during the hunting ban. The preference of the game species by local people may bring several impediments for the implementation of a hunting ban.

[6]Caughley and Sinclair [1997] suggested that a margin of error approximately 25% bellow the Maximum Sustainable Yield (**MSY**) is appropriate, especially in areas where year to year variation in weather is above average.

Management Goal: Ecosystem Health

Management Alternative	Definition	Requirement for implementation and limitations
Game refuges: serveas a source of wildlife that disperses into hunting areas, facilitating source-sink dynamics	Portion of land where the harvest of wildlife is banned for a determined period of time in order to allow game species to maintain themselves or to increase. The boundaries of the refuge have to be demarcated bearing in mind home range needs of overharvested species including the availability of food sources. It is crucial to allow the socio-cultural and productive needs of the human community using the area.	The knowledge of the territory by Tikuna people and relevant stakeholders is crucial for the establishment of game refuge boundaries. **Limitations**: ANP and Mocagua and San Martin have been mapping the limits of each indigenous territory since 2005, including food source areas for humans and wildlife, salt licks, distribution of key palm and tree species (e.g. cedar) amongst others. However ,the land ownership issues are jeopardizing the delimitation of areas for human/wildlife use. Thus, the use of common property resources such as wildlife, land, water and forest products is difficult to plan as land ownership is unclear.
Shift of game refuges	The rotation of game refuges will enhance the acceptance of local people for the establishment of game refuges. Local people will not feel that their rights over land are constraint if they have access to different areas through the year.	Same as for game refuges
Enriching fallow plots	The improvement of fallow plots throughout forest management and cultivation of herbs, shrubs, vines, grasses and tree species will increase food sources for wildlife and human uses.	Taking advantage of the *Minga*, traditional Tikuna community work, this management strategy might have the acceptance of the community. As women are more willing to engage in these activities, organisation and follow up might be achieved. **Limitations:** This management alternative will require external funding, in order to cover basic costs of materials and maintenance for the people involved. This external funding has to be available for at least 2 years, or until local people can see results (e.g. increase of game around the fallow plots or increase of forest species used by them

Management Goal: Human Livelihoods

Management Alternative	Definition	Requirement for implementation and limitations
Recover traditional hunting practices	-Increase of family hunting treks to distant areas limiting the access to shotguns and increasing the use of traditional hunting tools. - Rotation of hunting sites away from the community. This would improve local people's knowledge of their territory, as well as improving their hunting returns.	Implementation of camp sites at least 15-30 km away from the community. **Limitations:** Local authorities would have to introduce this idea to the community and take charge of the implementation and the follow-up, which requires local organisation. Long hunting treks will disrupt local peoples' daily activities (e.g. children going to school, and economic activities such as agriculture, fishing and hand craft elaboration). People will demand more food supplies during hunting treks. Additionally petrol will be needed, thus access to cash for the hunting treks has to be arranged.
Sustainable economic alternatives *Captive breeding for food:* such as medium and large size rodents, large birds (curassaw), reptiles (yellow-footed tortoise), and collared peccaries. Establishment of fish ponds at family level.	Is the rearing or reproduction of domestic or wild species in captive or semi-captive conditions that achieves stable productivity, which in the long term serves as a source of protein for local people and eventually provides a profit.	Long-term commitment of stakeholders: For the success of captive breeding alternatives and fish ponds, several stakeholders have to participate and long-term follow up is crucial for the success of this alternative. The minimal requirements are: 1. Acceptance of local people to include new sources of animal protein in the case of domestic animals. 2. Permanent technical and financial support for local people. 3. Discipline and continuity in following the captive breeding process by local people. 4. Organisation at local level to administer funds and ensure even distribution of profits when available. **Limitations**: Lack of cultural tradition for:1 Husbandry of animals that required permanent attention from people (e.g. domestic species or wild species with medium and long life spans). 2. Administration of funds. 3. Administrative procedures that require attention on a daily base. Several attempts in establishing locally-based economic projects failed owing to the lack of external follow-up and local organisation [Martinez 2006].

Management Alternative	Definition	Requirement for implementation and limitations
Services and products: Ecotourism (wildlife tourism), health and beauty, workshops for visitors in the elaboration of hand crafts, traditional food restaurant, freez-dried of fruits and medicinal plants. Legal extraction of cedar by a local cooperative.	Economic activities that will guarantee an income to local people when involved in the conservation strategy. These alternatives are aimed to: 1. Control the illegal extraction of resources. 2. Minimise the commercial use of resources. 3. Increase local governance and administration of natural and economic resources.	Same as for captive breeding. **Other limitations:** any economic alternative will shift power hierarchies in the communities.

Capybara (*Hydrochaeris hydrochaeris*): As mentioned in section 3.2.4.1 this species is not included in the analyses as we failed to detect its presence during the study period. In addition, the alarming decrease in local consumption may indicate that wild populations cannot supply current hunting. This species was included in the management plan [Franco 2006] by local people and its hunting was banned during March to May and September to November, when local people reported that females were pregnant. Thus I recommend a commercial hunting ban for this species for at least five years in order to allow it to recover. This will allow females to produce about eight offspring a year, as this species has 2 litters a year comprising 3 - 5 offspring [Redford et al. 1995]. In addition I recommend the implementation of the hunting restriction suggested by local people during pregnancy periods. Low-land tapir (*Tapirus terrestris*): The qualitative evaluation of hunting sustainability demonstrated that the hunting of this game species is not sustainable (Tables 3.9 and 3.10). Tapirs are one of the most overharvested species in ANP and owing to the low birth rate (one birth every two years) they are highly vulnerable species to local extinction [Fragoso 1991; Rodriguez-Mahecha et al. 2006].

Recommendations

1. Ban hunting for commercial purposes for ten year, with special attention to the prohibition of hunting in salt-licks. This period will allow reproductive females to give birth to at least 4 offspring.
2. Ban hunting for subsistence consumption for two years, in a radius of 15 km from villages to allow populations to increase.
3. Allow the hunting of **one** animal per community for the celebration of the anniversary of the communities and the Pelazón festivities.
4. Establish salt-lick as game refuges.
5. Establish alternative income instead of commercial hunting.

<u>Brocket deer (*Mazama* sp.):</u> Population density comparison between this study and other Amazonian sites exposed to similar hunting pressures, suggests that densities at ANP are extremely low (see table 3.18). In addition, the genus in one of the most highly threatened by hunting in ANP (Table 3.19).

Recommendations

1. Ban hunting for commercial purposes for at least three years. This period will allow reproductive females to give birth to at least 3 offspring.
2. Restrict hunting deer near the villages.Thus, hunting should be done in the more distant hunting areas (Agua Blanca for San Martin and Bacaba for Mocagua).
3. Allow hunting for the celebration of the anniversary of the communities and Pelazón festivities.
4. Enrich fallow plots using *Mingas* (community work) to increase food availability for this species.
5. Establish salt-lick as game refuges to allow source-sink dynamics.
6. Enhance local hunting taboos and food restrictions (see sections 5.3.2.2 and 5.3.2.4).

<u>The common woolly monkey (*Lagothrix lagothricha*):</u> The low population densities in the area and their intolerance to hunting and habitat disturbance due to their low reproductive rates make this species exceptionally vulnerable to local extirpation [Di Fiore and Campbell 2007; Laurance et al. 2006; Peres 1990b; Peres 1991]. The harvest of this species should be banned in San Martin where it faces local extirpation in a radius of 7 km from the village.

Recommendations

1. The hunting ban implemented and followed in Mocagua has to continue for at least eight years in order to allow reproductive females to give birth to at least 2 offspring. This ban will allow the necessary time to quantify its effects on wild populations. Census surveys must be continuous.
2. San Martin urgently needs to implement the hunting ban for at least eight years to allow the recovery. Census should be implemented to monitor the impact of the hunting ban.
3. The use of the common woolly monkeys as a flagship species for habitat conservation has provided positive and tangible results for Mocagua. For instance, the increase of income from eco-tourism related to primate watching, and the use of forest close to the village by wild woolly monkeys as is the case of the Pucacuro hunting site.

4. It is crucial that Mocagua receives more formal support in the organisation of ecotourism in order to encourage locally-based management initiatives and to reward them for their positive attitude towards conservation.

The South American yellow-footed tortoise (*Geochelone denticulata*):

Comparing the historical data on hunting provided by Campos-Rozo [1987] in San Martin with my results, it seems that the decrease of hunting of the South American yellow-footed tortoise may be associated with the depletion of the population. This species is still favoured by Tikunas in the area. It is likely that the perceived decrease in hunting returns could be an effect of overhunting. Although little is known about the reproductive parameters of this species, it is known that the South American yellow-footed tortoise reproduces very slowly, making it highly susceptible to hunting [Strong and Fragoso 2006].

Recommendations

1. Ban hunting for commercial purposes. Due to the lack of information on this species it is difficult to be definite, but at least 3 years of commercial ban should be implemented.
2. Ban hunting during April and May when females are laying eggs[7].
3. Farias et al. [2007] reported high levels of gene flow in the South American yellow-footed tortoise and suggested that it is likely that this species has the capacity to colonise newly available habitats and to re-colonise areas were populations were depleted by hunting [Farias et al. 2007]. Captive rearing of this species may be an option to decrease its harvest and eventually repopulate depleted areas. This species is kept for festivities and can be fed easily with forest products. Thus, the captive rearing option might be acceptable to local people as it is part of their traditional way to manage wildlife.

[7]This information was provided during a workshop with hunters, but has to be triangulated with census surveys.

Coati (*Nasua nasua*): Coati's densities in Mocagua and San Martin are comparatively low in relation to densities reported in other Amazonian sites [see Peres and Nascimento 2006]. Owing to its reproductive potential, this species can tolerate harvest. The use of indigenous agricultural land makes this species very easy to hunt around the villages.

Recommendations

1. Ban hunting in a radius of 5 km from the villages, including cultivation lands in order to allow populations to recover.
2. Enforce meat taboos for this species.
3. Enrich fallow plots through *Mingas* to increase food availability for this species.

Wattled curassow / Razor-billed curassow (Crax globulosa / Crax tuberosa): *Crax* spp. has been overharvested in the area owing to Tikuna people's preference for its meat and for commercial purposes. *Crax* populations in_ANP are notably low in comparison to other Amazonian sites with similar_hunting pressure (see Table 3.18). Their lower rates of recovery make them_extremely susceptible to hunting [Begazo and Bodmer 1998].

Recommendations

1. Apply the bans stated in the Management Plan designed by ANP and the Tikuna communities (see section 2.3.1.1). *Crax* sp. has a hunting ban near all the main rivers and streams in the area, and in the Mocagua Island.
2. The implementation of seasonal hunting restrictions along important watercourses such as the Matamama and Bacaba creeks in Mocagua and the Agua Pudre and Agua Blanca creeks in San Martin, which can be rotated during the year, could be an option to decrease the impact on curassow populations. For instance, hunting on these areas should be banned during the reproductive seasons corresponding to June-July and December.
3. Captive rearing of the razor-billed curassow may be an option to decrease its harvest. A local family in Mocagua maintained a small stock

of this species but there have not been formal attempts to reproduce the razor-billed curassow in captivity. This could be an alternative for local consumption.

However captive breeding of this species demand an investment for enclosures as predation by small carnivores is a threat. Thus, financial and technical support will be needed.

White-lipped peccary (*Tayassu pecari*): The reproductive patters and home range requirement of white-lipped peccaries made them extremely susceptible to hunting. Current hunting is modifying *T. pecari's* use of space as they are avoiding the forest near the villages, as has been reported in other sites with hunting pressure [Fragoso et al. 2000; Peres 1996]. This is also reflected in the concern of local people as the consumption of this species is decreasing drastically over time. Therefore, current hunting patterns have to be modified in order to stabilise white-lipped peccary populations and allow them to use the forest near the villages.

Recommendations

1. Ban hunting for commercial purposes at least for three year. This period will allow reproductive females to give birth to at least 6 offspring.
2. Restrict hunting where white-lipped peccaries should not be hunted in the closest hunting areas. Hunting should be done in Agua Blanca for San Martin and Bacaba for Mocagua.
3. Allow hunting for the celebration of the anniversary of the communities and Pelazón festivity.
4. Enrich fallow plots throughout *Mingas*.
5. Establish salt-lick as game refuges.
6. Elder hunters from San Martin suggested that white-lipped peccaries can be captive bred. They also recognise that this species is highly aggressive and animals can only be fed by the same person, otherwise they will attack. They can be feed with fruits and produce from food crops; however they demand high amounts of food. Elders proposed to have large-size enclosures near land cultivation. Sowls [1997] states that

the captive reproduction of white-lipped peccaries is not successful, however collared peccaries had been successfully breeding in captivity. Thus if local people are willing to rear wild species, the collared peccary might be a viable option that will reduce the impact of hunting of white-lipped peccaries.

Paca (*Agouti paca*): Bearing in mind the reproductive patterns of the paca, its relatively high reproductive potential makes them more resistant to hunting pressure than other medium-lived species [Robinson and Redford 1991b; Vickers 1991]. In addition, this species has the advantage of being highly adaptable to disturbed forest. They feed on indigenous cultivation crops. However the paca represents one of the preferred prey by Tikunas and the implementation of a hunting ban is unlikely to be applied. During the workshops, community members from Mocagua manifested their disagreement regarding the intense hunting of pacas, and suggested economic sanctions for commercial hunting. This proposal arose several arguments between hunters.

Recommendations:

1. Ban hunting for commercial purposes at least for two year. This period will allow reproductive females to give birth to at least 2-3 offspring.
2. Following the Management Plan designed by the Tikuna communities and ANP, local people suggested a hunting ban for female pacas during the birth season (March-May and September-November). Local hunter stated that it is difficult to target only males as it is difficult to distinguish sex classes, especially at night when pacas are mostly hunted. Thus a complete ban during birth seasons should be the option. During this period, black agouties might be hunted instead of pacas as their populations are apparently stable.
3. Allow hunting for the celebration of the anniversary of the communities and Pelazón festivity.
4. Hunting restriction, where pacas should not be hunted in the cultivation lands close to the villages, in a radius of 5 km at least for a year. The closest hunting areas for this species should be Agua Pudre hunting site for San Martin this will imply hunting this species nearby Agua Pudre

hunting site and for Mocagua hunting should be restricted to Pucacuro hunting site onwards.

5. Enrichment of fallow plots throughout *Mingas*.
6. Captive breeding of this species is not recommended owing to the high maintenance costs and long term reproductive productivity of the species [Smythe 1991; Smythe and Brown 1995]. This demands the permanent presence of the keepers and this does not fit in Tikuna's daily life and culture.
7. Captive breeding of acouchies and black agouties may be a protein and income option to consider.

7.3.2 Ecosystem health

Game refuges

Salt-licks: As presented in section 5.3.2.3 salt-licks represented a sacred site for wildlife in Tikuna tradition. Nowadays salt-licks have become the main hunting sites during the dry season as most of the game species visit those areas. The lost of the Tikuna cosmo-vision and traditional beliefs towards hunting could be recovered if community members decide to implement traditional hunting taboos. I suggest that the salt-licks located in a 15 km radius from the communities should be designated as game refuges and be rotated in an annual base, in order to maintain source-sink dynamics for wildlife. However, monitoring of salt-lick has to be implemented at least during the dry season to patrol the harvest and to quantify the number of animals using these areas.

The Tuirupw hill: (see section 5.3.2.3) should be designated as a game refuge for the Tikunas in the area, which include the three indigenous communities overlapping ANP (Mocagua, San Martin and Palmeras) and the Tikuna communities located at the north of the Park (Buenos Aires and Pupunia). The access to illegal loggers should be forbidden and Tikuna authorities should implement a permanent patrolling system. This system will require external funding to cover maintenance cost for the guards as well as petrol expenses. Owing to the involvement of Tikunas from San Martin and Buenos Aries in the illegal extraction of cedar in this area, this proposal will bring conflict of interests. As an alternative to mitigate the illegal involvement of Tikunas in selective logging, I am proposing the establishment of a Tikuna cooperative for cedar extraction (see section 7.4). The territory encompassing the Bacaba area forms part of the indigenous territories of Mocagua and Palmeras, and overlaps ANP. The frequently used hunting area belongs to ANP, but not to the two Tikuna territories, as their territory's legal boundaries are outside this hunting area. As mentioned in section 2.1.4.3 this area is poor in plant species but diverse and rich in large vertebrates; large primates such as howler monkeys and woolly monkeys are easily found in this area throughout the year. This area also represents one of the main hunting sites of the Panduro family, as there was a settlement of the last *Payé* in the area, the grandfather of all the Panduro families currently living in Mocagua and Palmeras. Both communities have claimed this area as part of their territory. During a workshop in May 2009 on social cartography and territory, I enquired if both communities would be willing to establish a common use reserve managed by Mocagua and Palmeras, establishing a rotation of hunting restrictions during the birth seasons of tapirs and primates. Young community leaders were keen on this proposal, but elders still argued about the boundaries of the areas and claimed land ownership for each community. As a result of this workshop leaders from both communities manifested their interest in re-visiting the area together with representatives of ANP, in order to confirm the boundaries of indigenous territories and the ANP. Unfortunately local leaders did not organise this field trip, as communication between communities is sporadic. It is critical that local authorities and personnel of ANP clarify land ownership for this area and establish a reserve to act as an important source sink for wildlife.

Matamata and Bacaba creeks in Mocagua and Amacayacu river and Agua Pudre and Agua Blanca creeks in San Martin: The basins of these four important river courses were included in the Management Plan established in 2003, including hunting restrictions for large birds and tapirs (see section 2.3.1.1) [Franco 2006]. I recommend the revision of these restrictions, and emphasised the need for detailed description and GIS mapping of banned areas. This work was already done by San Martin, but owing to the current land tenure issues the information is not shared with the neighbouring communities which have co-ownership. It is crucial to establish the dates of hunting bans and the limits of the restricted areas, as well as a permanent patrolling system with participation by members of Mocagua, Palmeras and San Martin. This will require external funding for the implementation and follow up.

Rotation of game refuges

This will facilitate the agreement of local people to restrict the use of game refuges during the year and to allow source-sink dynamics for game species. Owing to the lack of ecological data regarding the biology and distribution of targeted game species, local knowledge should be the basis for the establishment of this management goal. Therefore, monitoring has to be established to quantify the current state of the areas, as well as to record the harvest of game species. Census surveys are crucial to gain an understanding of wildlife distribution and to gain some measure of population status.

Enrichment of fallow plots

The failure of the project "*Chagra Comunitaria*" (community cultivation plots) initiated by ANP during 2004-2006 with the involvement of San Martin and Palmeras Tikuna communities, demonstrated once again, that after the external stakeholder leaves the process, the local organisation is too weak to continue on its own [Martinez 2006]. For this reason I think that the fallow plot enrichment might be more effective if is implemented by families rather than by community groups, as coordination is difficult to achieve. Experiences in Brazil have demonstrated that basic fallow plot management, especially in seasonal flooded areas, increases diversity and maintains biodiversity [Pinedo-Vasquez et al. 2002]. Although Tikunas practise shifting agriculture, which involves leaving forest fallow periodically, there is no management for this purpose.

Enrichment of fallow plots to increase the production of fruits and timber throughout the thinning and removal of vines (e.g. thinning - planting, removal of vines – broadcasting seeds, thinning – broadcasting seeds and/or a combination of all the above options) will increase food availability for people and game species such as large rodents, ungulates and small omnivorous. Pinedo-Vasquez et al. [2002] compared the patterns of spatial and temporal variation of three different forests in the Brazilian Amazon: Fallow plots, agricultural land and forest without intervention. As a result, fallow plots managed by expert farmers, presented 10% more trees than the forest without human intervention. In addition, inventory data showed that people maintained several non-commercial species to create habitat for wildlife, particularly agoutis and several species of land birds, which increased their hunting returns. The implementation of this strategy will demand continuous monitoring by local people. However the previous experiences obtained from the "*Chagra Comunitaria*" project should be taken into account to evaluate the local structure for implementing this alternative. External funding will be required for its implementation and monitoring.

7.3.3 Human livelihoods

Recovery of traditional hunting practices

The implementation of family hunting treks was one of the management alternatives adopted by the Xavante indigenous group from the Mato Grosso in Brazil [Fragoso et al. 2000; Leeuwenberg and Robinson 2000]. They illustrated an analogy with the ranging behaviour of the jaguar, which rotates its hunting over its range, allowing the recovery of game species [Leeuwenberg and Robinson 2000]. A few traditional Tikuna families still have hunting treks. Usually the father (expert hunter), up to three sons and occasionally the mother, wife or a sister, will accompany the men to prepare the meat and to cook for the group. They travel by boat and camp for few days for hunting. Usually a large proportion of the meat collected during these treks is sold in the community, to compensate for petrol and other supplies (e.g. salt, rice, farinia, oil, mosquito nets, shot guns cartridges, plastic for the camp roof, etc). As explained in Table 7.2, hunting treks require camp sites at some 15-30 km from the villages, as well as access to cash, requiring the commercialisation of game meat. An alternative income could come from payment of families conducting the hunting treks for monitoring game. It is crucial that one of the Tikuna members of staff of ANP is included in these treks.

7.4 Sustainable Economic Alternatives

Several attempts to provide an alternative income to Tikuna communities located inside and nearby ANP, with a view to decrease illegal and commercial extraction of resources have failed. In most cases this is because these projects are alien to their cultural system and way of life. The main factors identified by Martinez [2006] during her assessment for ANP were: i) deficient long-term commitment, organisation, monitoring and administration of funds at a local level; ii) absence of long-term involvement of relevant stakeholders in maintaining an economic project; iii) lack of local leadership; iv) the influence of politicians during pre-election periods which drastically weakens the governability of Tikuna communities.

Local authorities change their agenda regarding resource management, because their involvement in political campaigns may require the extraction of resources as a contribution towards their campaigns (e.g. game meat for welcoming events; illegal extraction of cedar conceded to a particular political party etc.). In exchange, the politicians promise the improvement of local services (e.g. water, housing, transportation, etc), but usually the revenues only benefit local authorities in the way of “contributions” such as outboard motors, materials for construction and eventually cash. These considerations, along with the acculturation of Tikunas, jeopardise local governability and this has had a detrimental effect on the environment.

Suggestions for sustainable alternatives have resulted from the workshops conducted among Tikuna communities and relevant stakeholders (outlined in Chapter 5). These suggestions also incorporate principle 7 of the UNDP (United Nations Development Programme) Rio Declaration on Environment and Development: “*Provide support for the development of sustainable strategies and programmes, including decision making on investment in infrastructure and business development”* [Chandra 2006]. I divide the economic alternatives into three groups: 1. **Locally-based**: external technical support and follow up is available during the implementation of the project, but the monitoring and long-term viability is in the hands of local people 2. **Mixed**: local involvement with the long-term participation of external stakeholders, and 3. **External**: management carried out by an NGO with the involvement of local stakeholders, and the participation of Tikuna people. Fund management and administration is carried out by the NGOs, while local people provide the raw material and manpower.

After proof of success (economic equilibrium point), technology may be transferred to local people if circumstances allow.

7.4.1 Locally-based economic alternatives

Captive breeding for food: At a local level, a lack of adequate management of domestic species (e.g. pigs, chickens, cattle ranching), has contributed to the spread of diseases and death of a large proportion of the animals, resulting in an economic loss for the government agencies responsible [Martinez 2006]. Local people lost interest in these economic alternatives due to a lack of revenue. There has been some casual experience of managing wild species since women may rear the offspring of hunted prey.

- Captive breeding of medium and small-sized rodents: successful examples of captive reproduction of capybara, agouti and acouchy have been reported in funding is required for construction of enclosures and maintenance costs over a minimum of five years [Smythe and Brown 1995].
- Fish ponds: fish farming has been an activity promoted by government institutions in the Southern Colombian Amazon, mainly for food security during periods of fish scarcity [Reyes 2008]. At an international level, the FAO [Miller 2009] is promoting fish ponds as an effective way to enhance local livelihoods and to empower local people in the process of policy formulation and development planning for their land. Fish ponds can also serve as a domestic water supply as well as for irrigation of high-valued crops and vegetables [Miller 2009].

  During 2008, two families from Mocagua approached Fundacion Entropika to facilitate collaboration in developing a fish pond project. With the technical support of an economist they conducted a feasibility study which indicated that the two fish species with the highest economic potential were the tambaqui/gamitana (*Colossoma macropomum*) and Colombian bocachico (*Prochilodus nigricans*). The estimated investment for a fish pond of 300m^2 during the first five years was approximately £5,000 of external funding, and a contribution of approximately £3,000 from the families, corresponding to labour expenses. This project aimed to provide both food for the families and fish for sale at Mocagua’s school restaurant. Regular technical support is offered by the SINCHI in Leticia. Fish ponds have been successfully implemented In the Peruvian Amazon, with the technical assistance of the IIAP (Research Institute for the Peruvian Amazon) [IIAP 2000].

― *Small scale tourism*: Groups of women in Mocagua and San Martin manifested their interest in creating a restaurant where traditional Tikuna dishes could be offered close to a tourist path around the community. With the collaboration of Fundacion Entropika, the group of women put together a funding proposal. The total investment for the first year of operation was estimated to be £2,500, including a local contribution of £1,500. The women's group submitted the application to the DAFE (Administrative Department of Ecotourism, Amazonas), but there has been no response (April 2010). Workshops for hand craft elaboration for tourists, was another initiative from women and young people in Mocagua. Fundacion Entropika provided the funding for the feasibility study, but local organisation is lacking for their implementation.

7.4.2 Mixed economic alternatives

Local cooperative for the sustainable extraction of cedar (*Cedrela odorata*): in order to decrease the illegal and commercial extraction of cedar from San Martin's territory, I approached the director of ANP and proposed the implementation of a local cooperative. The aim of this cooperative is to organise a legally recognised institution to extract cedar under certain specifications (e.g. place of extraction, tree size, etc), to include the majority of families in extracting, transforming (furniture) and selling the final product, but external stakeholders will be in charge of the commercialisation process. Profits will be administrated by the cooperative, and paid labour will be rotated monthly between community members. Because elders do not have access to a pension, the cooperative will provide a pension scheme. This idea was examined during a community meeting, and was widely accepted. However, conflict of interests for local people involved in illegal logging is an obstacle.

Continuous technical support has to be offered to achieve success. Current revenue from cedar extraction was probably less than 3%, while intermediaries from furniture shops in Leticia, Cali and Bogota, retain more than 60% of the profits [pers. comm. O. Oliverio]. An economic analysis of this alternative is needed. It might provide a permanent income for the local people, decreasing their involvement in illegal extraction. Lack of local organisation and the issues of land tenure are the main limitations. The sustainable extraction of cedar has to be accompanied by a reforestation programme. As stated by Martinez [2006], cedar reforestation has been implemented in San Martin during the last decade, but it failed. Thus the revenues from a new cooperative would have to guarantee investment in reforestation. Experience of sustainable mahogany extraction by the Kayapo in Brazil illustrate that direct benefits distributed among all community members helped lead to success. This community decision was taken in the face of opposition from the community leader who wished to allow the incursion of loggers and miners into the Kayapo reserve [Zimmerman et al. 2001].

— *Health and beauty-tourism*: successful experiences such as the indigenous spa in the Ecuadorian Amazon: (http://www.laselvajunglelodge.com/index.php/spa.html) are a good example of sustainable ecotourism that provides training and income to indigenous women. Although there has not been any economic analysis for this alternative, initial investment for infrastructure and operative costs are low. A combination of Tikuna knowledge in the use of medicinal plants, with the principles of Ayurvedic medicine may add originality to this initiative to help it compete with other spa centres in the Amazon basin.

7.4.3 Externally-based economic alternatives

— *Lyophilisation of fruits and medicinal plants*: Lyophilisation is the sublimation/removal of water content from frozen food. The dehydration occurs under a vacuum, with the plant/animal product solidly frozen during the process. This process can maximise the use of forest surpluses, allowing the utilisation of biodiversity components. Fundacion Entropika carried out preliminary freeze-drying tests for several Amazonian fruits in March 2009. Two key fruit species present a high potential for cultivation and effective transportation and storage: açaí palm (*Euterpe* spp.) and moriche palm (*Maurita flexuosa*). Lyophilisation of other fruits and plants might be an option for cosmetics and pharmaceutical products, following the example of the Kayapo in Brazil [Zimmerman et al. 2001].

Brazil is the pioneer in the industrialisation of non-timber forest products such as açaí. Machinery for processing these products is available. Five palm tree species (açaí, bacaba, milpesos, chontaduro and canangucho) are commercialised in Leticia and have been identified by the SINCHI[8] as key species with high development potential. Lyophilisation could allow commercialisation of products from the Amazonas department which has been isolated from the rest of Colombia because of the lack of local processing facilities and high transportation costs. This process has multiple benefits and is an optimal tool to process the large proportion of the fruit production that spoils every year. It could potentially constitute a viable economic alternative that promotes natural resources management and sustainability around Leticia, the capital city of the Amazonas department in Colombia. Owing to the high costs of infrastructure (approximately £140,000) it would have to be implemented by an external stakeholder that can guarantee the long-term organisation needed, but high returns might offer a way to fund local monitoring and ultimately discontinue the dependence on external funding.

7.5 Concluding remarks

Zimmerman et al. [2001] summarised the success of their conservation alliance with the Kayapó in Brazil in three main points: 1. direct benefits accruing to all members of the community, 2. fulfilment of criteria for development of common pool resource institutions, and 3. long-term commitment of an external agency. The management alternatives provided in this chapter are designed to address these three elements. However, based in the local needs, potentials and limitations for success, a combination of the recommended economic alternatives should be tested in order to provide several options to local people and thereby avoid disappointment. Despite the considerable challenges

[8]Asaí, Canangucho and Milpesos are native palm trees that have a high potential as forest products. The SINCHI is a well known scientific research governmental institution based in Leticia (Instituto Amazónico de Investigaciones Científicas) and manages the Colombian Amazonian Herbarium (COAH) in Bogotá.

presented by socio-political issues, the advantages to many stakeholders of a collaborative approach is a strong motivating factor.

Conserving the natural resources in the area relies deeply on the application of a management strategy to mitigate the local extirpation of game species and key timber resources. In addition, is it crucial to guarantee livelihoods for local people, in order to avoid their relocation in the event that they cannot fulfil their dietary requirements or maintain the structure of a Tikuna community. Environmental law enforcement is crucial to obtain real protection of natural resources. As Terborgh [2002] states, internationalisation of conservation could be the only effective way of protecting nature. Financial support, technological transfer, training in the long-term and law enforcement could be achieved only if local, regional, national and international organisations join forces to preserve nature…extinction is forever and time is running out. Our role as conservationists cannot be limited to the submission of elaborate and well presented reports to policy makers and local people, that may be supported by strong ecological evidence but have little impact as the readers do not relate to the issues addressed (e.g. extinction, loss of biodiversity, etc.) or cannot understand the science [Lanch et al, 2003]. As Noss [2007] states: "*The public would prefer that scientists move beyond simply reporting results to being actively involved in interpreting and integrating results of science into policy decision*".

What is Next?

It is crucial to maintain a long-term data base on wildlife populations in the area, in order to compare past and present density estimates, as well as extraction rates. This baseline information will assist in predicting the conservation status of game species in the long term, taking into account the harvest rate. Furthermore, the implementation of a nocturnal census is critical to achieve minimum sample sizes to calculate accurate density estimates [C. Peres, pers. comm.]. Since 2009, Fundacion Entropika has carried out such nocturnal censusing in Mocagua Tikuna community and the Calderon basin (forest reserve impacted by non-indigenous settlers) in order to compare different degrees of human pressure, under different protection categories. I will present the recommendations provided in this chapter to the Colombian Park System (ANP) and the indigenous authorities (TICOYA) in order to revaluate the current management plan, which was designed without any ecological information on game species. Part of the dissemination of this information will be presented in local schools and a pictorial guide to game species will be distributed.

As the illegal extraction of natural resources in the Peru-Colombia border area is drastically affecting key timber and wildlife species, Fundacion Entropika started census fieldwork in February 2010 in new localities in the Colombian and Peruvian margins of the Amazon River, where resource extraction is high. This project aims to quantify the extraction and use of resources, while training local people in monitoring techniques. Bearing in mind the alarming extraction rates of night monkeys for biomedical research, the night monkey will be used as flagship species for habitat conservation. Furthermore, we aim to clarify the geographic distribution and taxonomy of the three species (*Aotus nancymaae, A. vociferans* and *A. nigriceps*), in areas where they have not been reported before, to demonstrate whether they are allopatric or sympatric (Chapter 6). Currently, we have a collaborative project with Peruvian colleagues and a permit to conduct research in Peru during 2010. The ultimate aim of this project is to provide recommendations to the Peruvian and Colombian environmental authorities, to restrain the illegal trade in resources and to reinforce international trade regulations (CITES), following the recommendations provided in Chapter 6. It is clear that conserving biodiversity while maintaining local people's livelihoods presents innumerable obstacles and challenges. However, it is our duty as conservationists to creatively use the available resources to mitigate biodiversity loss. Active conservation is needed in order to communicate effectively with different audiences, from local people to donors and policy makers.

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9. LIST OF APPENDICES

Appendix I

Important fruiting tree species for primates in ANP

Plant Species	*Lagothrix lagothricha*	*Alouatta seniculus*	*Callicebus torquatus*	*Pithecia monachus*	*Cebus albifrons*	*Saimiri sciureus*	*Saguinus nigricolis*	*Cebuella pygmaea*	*Aotus spp*
Anacardium cf.parvifolium	X	X	X	X	X	X	X	X	X
Attalea butyracea					X	X			
Attalea maripa	X	X	X	X	X	X	X		X
Batocarpus amazonicus	X	X	X	X	X	X	X	X	X
Caryodaphnosis cf. tomentosa	X	X	X	X	X	X			X
Cecropia scyadophylla	X	X	X	X	X	X	X		X
Clarisia racemosa	X	X	X	X	X	X	X		X
Cordia nodosa	X	X	X	X	X	X	X	X	X
Couma macrocarpa	X	X	X	X	X	X	X		X
Duguetia spp.	X	X	X	X	X	X			X
Duroia hirsuta							X	X	
Eschweilera spp.	X	X	X	X	X	X			X
Euterpe precatoria	X	X	X	X	X	X	X		X
Ficus spp.	X	X	X	X	X	X	X		X
Garcinia spp.	X	X	X	X	X	X	X	X	X
Guarea spp., *Trichillia* spp.			X	X	X	X	X	X*	X
Guatteria spp.	X	X	X	X	X	X	X		X
Herrania spp.						X	X	X	X
Hymenea oblongifolia	X	X	X	X	X	X			X
Inga spp.	X	X	X	X	X	X	X	X*	X
Iriartea deltoidea									X
Iryanthera juruensis	X	X	X	X	X	X	X		X

Plant Species	***Lagothrix lagothricha***	***Alouatta seniculus***	***Callicebus torquatus***	***Pithecia monachus***	***Cebus albifrons***	***Saimiri sciureus***	***Saguinus nigricolis***	***Cebuella pygmaea***	***Aotus spp***
Iryanthera spp.	X	X	X	X	X	X	X		X
Lacmellea cf.gracilis	X	X	X	X	X	X	X	X	X
Manilkara bidentata	X	X	X	X	X	X	X	X	X
Maquira callophylla	X	X	X	X	X	X	X	X	X
Maquira guianensis	X	X	X	X	X	X	X	X	X
Matisia spp.					X				
Minquartia guianensis	X	X	X	X	X	X	X	X	X
Naucleopsis cf. krukovii	X	X	X	X	X	X	X	X	X
Naucleopsis cf. ulei	X	X	X	X	X	X	X		X
Naucleopsis sp.	X	X	X	X	X	X	X	X	X
Ocotea spp., *Aniba* spp.	X	X	X	X	X	X	X	X	X
Oenocarpus balickii	X	X	X	X	X	X	X	X	X
Oenocarpus bataua	X	X	X	X	X	X			X
Oenocarpus mapora	X	X	X	X	X	X	X	X	X
Parkia cf. multijuga	X	X	X	X	X	X	X		X
Perebea guianensis	X	X	X	X	X	X	X	X	X
Pourouma spp.	X	X	X	X	X	X	X	X	X
Pouteria spp.	X	X	X	X	X	X			X
Socratea exorrhiza									X
Solanum cf. altissimum						X	X		
Spondias mombim	X	X	X	X	X	X	X	X	X
Theobroma glaucum	X	X		X	X	X			
Theobroma microcarpum	X	X	X	X	X	X	X		X
Theobroma subincanum	X	X	X	X	X	X			X
Zanthoxyllum cf kellermanii				X					

Appendix I

Important fruiting tree species for large vertebrates in ANP

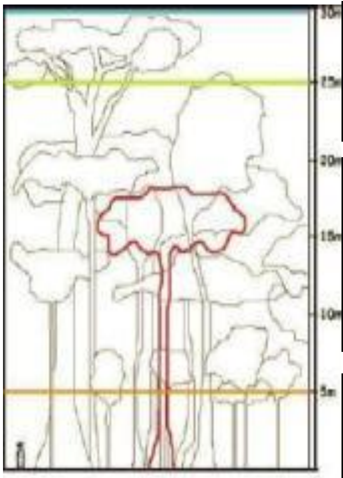
Plant Species	***Tapirus terrestris***	***Tayassu spp.***	***Mazama spp.***	***Nasua nasua***	***Dassyprocta fuliginosa***	***Agouti paca***	***Geochelone denticulata***	***Large Birds***
Anacardium cf.parvifolium	X	X	X	X	X	X	X	X
Astrocaryum chambira		X			X	X		
Attalea maripa	X				X	X		
Astrocaryum murumuru					X	X		
Attalea insignis					X	X		
Attalea maripa					X	XX		
Carapa guianensis					X	X		
Caryodaphnosis cf.tomentosa	X	X			X	X		
Caryodendron orinocense		X						
Cecropia scyadophylla								X
Clarisia racemosa	X	X	X		X	X		
Couma macrocarpa	X							
Duguetia spp.	X	X	X	X	X	X	X	
Eschweilera spp.	X	X			X	X		X
Euterpe precatoria		X		X				X
Ficus spp.	X				X	X		X
Guarea spp., *Trichillia* spp.								X
Guatteria spp.	X	X	X	X	X	X	X	X
Herrania spp.				X	X	X		
Hevea spp.		X						
Inga spp.					X	X		
Iriartea deltoidea								X

Plant Species	***Tapirus terrestris***	***Tayassu spp.***	***Mazama spp.***	***Nasua nasua***	***Dassyprocta fuliginosa***	***Agouti paca***	***Geochelone denticulata***	***Large Birds***
Iryanthera spp.		X	X		X	X		X
Jacaratia digitata			X					
Lacmellea cf.gracilis	X				X			
Manilkara bidentata	X	X	X	X			X	
Maquira callophylla	X	X	X	X	X	X	X	X
Maquira guianensis				X	X	X		X
Matisia spp.			X					
Minquartia guianensis	X	X	X	X	X	X	X	
Naucleopsis sp1.					X	X		
Naucleopsis sp2.					X	X	X	
Ocotea spp., *Aniba* spp.		X	X		X	X		X
Oenocarpus balickii					X	X		X
Oenocarpus bataua					X	X		
Oenocarpus mapora					X	X		X
Parkia cf. multijuga		X		X	X	X		
Perebea guianensis	X				X	X	X	X
Phytelephas sp.					X	X		
Pourouma spp.								X
Pouteria spp.	X				X	X		
Scleronema cf. micrantha					X	X		
Socratea exorrhiza	X	X	X		X	X		X
Solanum cf. altissimum	X	X		X				X
Spondias mombim	X						X	
Theobroma glaucum					X	X		
Zanthoxyllum cf kellermanii								X

ACAPÚ *Cheé* *Minquartia guianensis* OLACACEAE

A) Hojas de acapú por haz y envés; existe otra clase de acapú de hojas verdes en el envés. B) Detalle del fruto maduro. C) Rama de acapú con frutos inmaduros. D) Frutos de acapú en diferentes grados de maduración; los más inmaduros exudan látex blanco.

Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre



Churuco	Cotudo	Zogui-Zogui	Volador	Mono Blanco
Mico Nocturno	Mico Frayle	Bebeleche	Pielrojita	Aves

TOTAL 4 HECTÁREAS			Altura (m) y Diámetro a la Altura del Pecho (cm)			
Adultos	Juveniles	Plantulas	Producción de Frutos	Promedio Adultos	Promedio Juveniles	Árbol Más Grande
7	23	5	18m/45cm	25m/46cm	5m/4cm	30m/75cm

LOCALIDAD	Aguablanca	Aguapudre	Bacaba	Pukakuro	Promedio/ha
Adultos/ha	3	1	1	1	1

Danta	Cerrillo	Venado	Cuzumbo	Borugo	Guara	Motelo

DESCRIPCIÓN DEL FRUTO: Árbol de hasta 35 metros de altura con un periodo de fructificación a mediados del año. Los frutos están compuestos por una semilla rodeada de una pulpa de color habano, con una cáscara fina de color morado oscuro. La pulpa no es dulce y no es consumida por los humanos. La producción de frutos es masiva y la maduración es casi simultánea.

HÁBITAT: Se encuentra especialmente en tierra de altura, es un árbol con una abundancia relativamente baja y parece no tener preferencia por un tipo de suelo en particular. Crece bien en lugares donde se encuentra la pona barrigona (*Iriartea deltoidea*).

ESTADO DE LA POBLACIÓN: El número de individuos es relativamente bajo y se encuentra un individuo adulto por hectárea. Las poblaciones se encuentran sometidas a presión de extracción por su madera de alta calidad y durabilidad. Los individuos que se encontraron en el estudio son relativamente muy "jóvenes" y muy "viejos", y los individuos de porte medio son escasos.

RELACIÓN CON LOS ANIMALES: Es un fruto especial para los primates y la mayoría de los mamíferos grandes que buscan comida en el sotobosque. En la época de fructificación, cuando las "pepas" se pudren atraen a los motelos, según cuenta Arturo Naranjo en su experiencia.

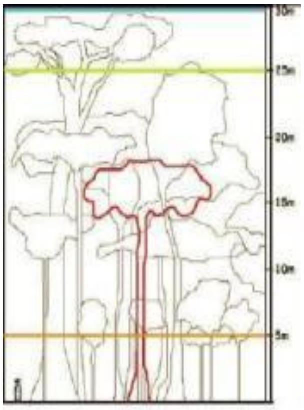
USOS: Los pepeaderos son visitados por los cazadores en busca de primates y motelo. La madera es especial para los "estantillos" en la construcción de casas, ya que puede durar más de 30 años aún en contacto con la tierra. La decocción de la corteza se usa para la anemia y como purgante.

Puente con columnas de acapú en tierra.

SURBA *Ngechí* *Couma macrocarpa* APOCYNACEAE

A) Árbol de surba sin hojas durante la floración y fructificación. B) Detalle de fruto "pintón". C) Frutos maduros de surba que probablemente cayeron verdes por acción de primates. D) Detalle de la pulpa dulce jugosa de la surba; nótese el látex blanco.

Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre



Churuco	Cotudo	Zogui-Zogui	Volador	Mono Blanco
Mico Nocturno	Mico Frayle	Bebeleche	Pielrojita	Aves

TOTAL 4 HECTÁREAS			Altura (m) y Diámetro a la Altura del Pecho (cm)			
Adultos	Juveniles	Plantulas	Producción de Frutos	Promedio Adultos	Promedio Juveniles	Árbol Más Grande
7	23	5	18m//20cm	28m/54cm	8m/7cm	25m/90cm

LOCALIDAD	Aguablanca	Aguapudre	Bacaba	Pukakuro	Promedio/ha
Adultos/ha	2	2	4	2	2

Danta	Cerrillo	Venado	Cuzumbo	Borugo	Guara	Motelo

DESCRIPCIÓN DEL FRUTO: Árbol de 30 metros de altura con producción de frutos en las ramas terminales. Los árboles de surba no fructifican todos los años y pueden pasar hasta cinco años sin producir frutos. El fruto es redondeado, de color amarillo al madurar y suave para abrir; en el interior contiene semillas embebidas en una pulpa dulce y jugosa que se desprende fácilmente de la cáscara. Al masticar las semillas se obtiene goma de mascar.

HÁBITAT: Se encuentra especialmente en tierra de altura aunque es posible encontrarlo en bordes de quebrada sujetos a inundación breve causada por lluvias. Según Don Leonel Panduro, la cuenca alta de la quebrada Bacaba es rica en surba. Esta localidad se caracteriza por ser de tierra arenosa, de terreno quebrado y con dominancia de caraná en el sotobosque.

ESTADO DE LA POBLACIÓN: El número de plántulas es relativamente bajo ya que no se registró ninguna en este estudio. Se encuentran en promedio dos individuos adultos por hectárea aunque esto tiene una fuerte influencia de la costumbre local de talar los árboles que se encuentran en producción; esto ejerce una fuerte presión sobre la especie.

RELACIÓN CON LOS ANIMALES: Es un fruto especial para los primates, especialmente para el churuco. "Pío" Cayetano comenta que generalmente si una manada encuentra un árbol de surba, no se retiran hasta no acabar toda la producción. En ocasiones los frutos que han caído y que maduran en el suelo son aprovechados por el manco y motelo; esto se observa fácilmente en sus excrementos

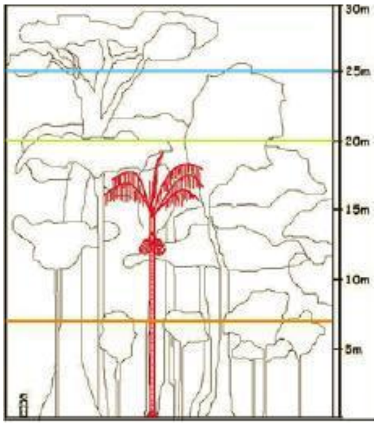
El látex del árbol de surba es medicinal.

USOS: Es uno de los frutos de la selva más apetecidos y en ocasiones es sembrado como frutal. La dieta de los antiguos Tikuna se basaba en el sábalo y la surba e incluso la palabra "comer" era *ngechí*, la misma que da el nombre actual al sábalo y la surba. Gerardo Sánchez cuenta que los antiguos usaban especialmente esta Madera para elaborar los tambores de la pelazón. La resina se toma como remedio vegetal para ciertos problemas estomacales; es espesa y levemente dulce.

ASAÍ *Waira* *Euterpe precatoria* ARECACEAE

A) Asaí en zona inundable. B) Palmas de asaí con frutos inmaduros. C) Detalle del fruto maduro. D) Racimo de asaí recién bajado de la palma por medio de escalada y cosecha manual. El jugo es muy apreciado por su delicioso sabor y alta calidad nutricional.

Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre



Churuco	Cotudo	Zogui-Zogui	Volador	Mono Blanco
Mico Nocturno	Mico Frayle	Bebeleche	Pielrojita	Aves

TOTAL 4 HECTÁREAS			Altura (m) y Diámetro a la Altura del Pecho (cm)			
Adultos	Juveniles	Plantulas	Producción de Frutos	Promedio Adultos	Promedio Juveniles	Árbol Más Grande
33	38	92	15m/16cm	20m/19cm	7m/9cm	25m/25cm

LOCALIDAD	Aguablanca	Aguapudre	Bacaba	Pukakuro	Promedio/ha
Adultos/ha	6	9	6	12	8

Danta	Cerrillo	Venado	Cuzumbo	Borugo	Guara	Motelo

DESCRIPCIÓN DEL FRUTO: Palma de 25 metros de altura con producción de hasta cinco racimos por temporada, una vez al año, con maduración entre los meses de marzo y agosto. Un racimo grande equivale a medio bulto de pepas desgranadas de asaí. Cada fruto consta de una semilla cubierta por una fina capa de carne, rica en lípidos y nutrientes. Primero se deben "chapear" las semillas con agua tibia (o en la boca) para que la capa carnosa se hidrate y suavice.

HÁBITAT: Se encuentra especialmente en lugares mal drenados, con encharcamiento y asociado a palmas de milpesos y canangucho, aunque el asaí se encuentra igualmente en tierra de altura. Es una palma "común" en todo ambiente del paisaje del sur del Parque Nacional Natural Amacayacu.

ESTADO DE LA POBLACIÓN: El número de individuos es relativamente estable en las cuatro localidades de estudio. Se encuentra un gran número de plántulas, lo cual indica una buena viabilidad de las semillas; esto se evidencia en ocasiones en la formación de asaizales, lugares de especial importancia en la selva en donde predomina la palma de asaí.

RELACIÓN CON LOS ANIMALES: Es un fruto consumido por los primates en general y por aves como el picón. Lorenzo Gregorio comenta que ha observado que en época de escasez de semillas proveen de comida al cuzumbo y los puercos de monte.

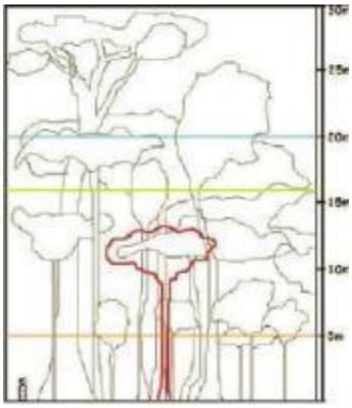
Preparación a mano de jugo de asaí.

USOS: Durante la cosecha el jugo de asaí es muy apetecido como una bebida tradicional en el trapecio amazónico, cerca a la época de Semana Santa. Las semillas se usan para hacer artesanías y los Tikuna emplean los cogollos de las hojas para elaborar artículos provisionales del vestuario tradicional. Azulay Vásquez asegura que la decocción de las raíces nuevas de color rojo es efectiva contra la gonorrea.

CABEZA DE GUACAMAYA *Charayae* *Perebea guianensis* MORACEAE

A) Rama de Cabeza de Guacamaya en fructificación. B) Pepeadero. Los frutos son aprovechados por los animales en la copa y en el suelo. C) Detalle del fruto maduro. D) Disco en el que se encuentran las flores, que al ser polinizadas formarán la infrutescencia.

Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre



Churuco	Cotudo	Zogui-Zogui	Volador	Mono Blanco
Mico Nocturno	Mico Frayle	Bebeleche	Pielrojita	Aves

TOTAL 4 HECTÁREAS			Altura (m) y Diámetro a la Altura del Pecho (cm)			
Adultos	Juveniles	Plantulas	Producción de Frutos	Promedio Adultos	Promedio Juveniles	Árbol Más Grande
7	25	6	12m/12cm	16m/17cm	5m/4cm	20m/30cm

LOCALIDAD	Aguablanca	Aguapudre	Bacaba	Pukakuro	Promedio/ha
Adultos/ha	3	1	3	0	2

Danta	Cerrillo	Venado	Cuzumbo	Borugo	Guara	Motelo

DESCRIPCIÓN DEL FRUTO: Árbol de 20 metros de altura con producción de frutos en las ramas. El periodo de fructificación es de 5 meses con un posible pico entre noviembre y diciembre. Los frutos están compuestos por un disco en el que se encuentran agrupados frutos individuales; cada uno consta de una semilla rodeada por una pulpa de color rojo, dulce, jugosa y de sabor muy agradable.

HÁBITAT: Se encuentra especialmente en tierra de altura aunque es posible encontrarlo en bordes de quebrada sujetos a inundación breve causada por lluvias. Parece no tener preferencia por un tipo de suelo en particular ya que la abundancia de individuos es similar entre Aguablanca y Bacaba, cuyos suelos de "tierra negra" y "tierra amarilla" respectivamente, son contrastantes.

ESTADO DE LA POBLACIÓN: El número de individuos es relativamente bajo y se encuentran menos de dos individuos adultos por hectárea. El promedio de juveniles por hectárea es de seis individuos y el promedio de altura se encuentra ocho centímetros por debajo de la altura a la que esta especie produce frutos. El número de plántulas es especialmente bajo ya que se registró entre 1 y 2 plántulas por hectárea. Cuenta con 1.2% de los adultos muestreados.

RELACIÓN CON LOS ANIMALES: Es un fruto especial para los primates, el cual es aprovechado en el suelo por la danta; la semilla es consumida por la guara y el borugo. El nombre en Tikuna "*charayae"* hace alusión a la similitud del fruto con el plumaje de la cabeza de la guacamaya roja (*Ara macao*).

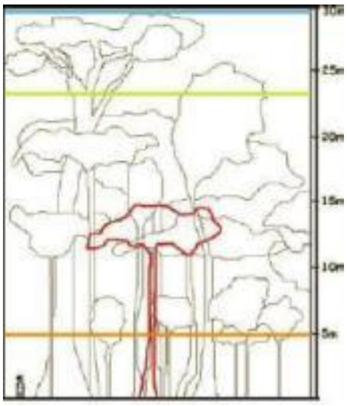
USOS: Los Tikuna han incorporado esta especie de la selva a sus chagras por el fruto comestible y generalmente los árboles adultos no se cortan cuando se socola el terreno para hacer una nueva chagra. Es difícil de cosechar ya que si los frutos maduros caen al suelo quedan prácticamente destruidos y no se pueden aprovechar.

Chupaderos de savia de micos pielrojita.

GUAMA *Kàuré (Tòreü, Ngeéreü, Okawene, Ngògüne, Deküetü, Pomawi) Inga spp.* MIMOSACEAE

A) El género *Inga* es uno de los más grandes debido a su amplia distribución y diversificación en el neotrópico; guama con semillas azules. B) Guamo curvo y con pubescencia marrón. C) Guamo recto y delgado. D) La guama "vacapaleta" se siembra como frutal

Enero	Febrero	Marzo	Abril	Mayo	Junio	Julio	Agosto	Septiembre	Octubre	Noviembre	Diciembre



Churuco	Cotudo	Zogui-Zogui	Volador	Mono Blanco
Mico Nocturno	Mico Frayle	Bebeleche	Pielrojita	Aves

TOTAL 4 HECTÁREAS			Altura (m) y Diámetro a la Altura del Pecho (cm)			
Adultos	Juveniles	Plantulas	Producción de Frutos	Promedio Adultos	Promedio Juveniles	Árbol Más Grande
49	113	28	15m/15cm	23m/34cm	5m/4cm	30m/120cm

LOCALIDAD	Aguablanca	Aguapudre	Bacaba	Pukakuro	Promedio/ha
Adultos/ha	18	14	5	12	12

Danta	Cerrillo	Venado	Cuzumbo	Borugo	Guara	Motelo

DESCRIPCIÓN DEL FRUTO: Árbol de 25 metros de altura con producción abundante de frutos. Se encuentran dos picos de fructificación durante el año y la mayoría de las especies son comestibles. Los frutos son generalmente alargados y están compuestos por una vaina dehiscente que contiene semillas individuales rodeadas por un arilo blanco, carnoso y agradablemente dulce y jugoso.

HÁBITAT: Se encuentra en todos los ambientes, aunque hay especies restringidas a las zonas inundables y de tierra firme. Al parecer la abundancia de individuos es mayor en el bosque con suelos de "tierra negra" como los que se encuentran en Aguablanca, Aguapudre y Pukakuro; el número de individuos adultos en Bacaba se encuentra más de un cincuenta por ciento por debajo del promedio de adultos en las cuatro localidades.

ESTADO DE LA POBLACIÓN: El número de individuos es relativamente alto y generalmente los árboles de guamo no se encuentran sometidos a la presión de tala por sus frutos. Hay un número alto de plántulas, juveniles y adultos por lo que se puede considerar que la población se encuentra en buen estado.

RELACIÓN CON LOS ANIMALES: Es un fruto especial para los primates y los dos picos de fructificación durante el año favorecen a los micos durante épocas de escasez. La savia hace parte de la dieta del mico pielrojita y la semilla es consumida ocasionalmente en el suelo por roedores

Chupaderos de savia de micos pielrojita.

USOS: Los Tikuna han incorporado varias especies de la selva a sus chagras por el fruto comestible. Hay algunas especies preferidas como la "vacapaleta", la cual se ha incorporado como frutal ya que crece especialmente en zona inundable cerca a las comunidades y produce un fruto relativamente grande, con "buena carne". La infusion de la corteza se usa para el dolor de estómago y se mezcla con corteza de mango y guayaba para la diarrea, según recomienda la abuela Rosamira Morán de San Martín.

BIOLOGICAL CHARACTERISTICS OF MOST-HUNTED SPECIES

During this study I estimated the sustainability of hunting for 15 vertebrate species that constitute the main source of game protein at Mocagua and San Martin Tikuna communities (see chapter 3). Here I give a brief description of each species including basic ecological information and current IUCN conservation status and CITES classification, to provide an overview of the vulnerability of each species to hunting pressure. I group the species by order class and they are listed by rank order of hunting preference. If the CITES information is not included in a specific species description, this means that the species is not included in any of the CITES appendices, thus the commercialisation or the capture of wild-born animals is not a risk for the species survival (for CITES).

Order Rodentia

The large Cavylike rodents group includes pacas, agoutis, acouchys, capybara and pacaranas. In this section I am including only pacas, agoutis and acouchys which are included in the analyses to determine the sustainability of hunting. All have large heads with bulging muscles, short ears, short to miniscule tails, and cylindrical and sometimes piglike bodies [Moskovits, 1985 in Bodmer 1991; Emmons 1999].

Paca (*Agouti paca*)

This medium size species (5-13 kg) is nocturnal, terrestrial, and is found alone or rarely in pairs. Pacas are monogamous and territorial, with a mated pair sharing a territory, which can be up to 3.5 hectares. However, their territories are not exclusive and may overlap with other pairs of pacas. This mediumlived species has usually one litter per year composed by one offspring, but two or three litters in one year have been reported. Pacas live primarily in rainforests near rivers and streams. They can also be found in seasonally dry areas, swamps, and deciduous forests bordering water sources. Pacas are commonly founded near to gardens and plantations. Pacas are one of the most prized neotropical game species for the high quality of the meat; they are easily hunted by day with dogs or at night with headlights. Due to overhunting pacas are scarce or locally extinct in some parts of their geographic distribution [Emmons 1999]. Several attempts to domesticate pacas had been implemented, however its production for commercial purposes has not been proven to be economically viable owing to very high maintenance costs [Smythe 1991; Smythe and Brown 1995]. *Agouti paca* is classified as Least Concern (LC) by the IUCN and it is included in CITES Appendix II.

Black agouti (*Dasyprocta fuliginosa*)

The average body weight of the black agouti is 3.5-6 kg and its longevity is approximately 18 years [Emmons 1999]. Black agoutis are diurnal, and are found alone or in pairs [Emmons 1999]. They use similar habitat as the pacas and can persist in disturbed habitats; black agoutis are heavily hunted around indigenous food plantations [Naughton-Treves et al. 2002]. Litters are usually made up of one or two young and sometimes three occurs [Emmons 1999]. *Dasyprocta fuliginosa* is classified as Least Concern (LC) by the IUCN.

Green Acouchy (*Myoprocta pratti*)

This medium-lived rodent has an average weight of 0.8-1.2 kg and an average lifespan in captivity of 10-14 years [Nowak 1999]. The number of offspring produced in a single litter is from 1 to 3 young with an average of 2 [Nowak 1999]. Green acouchyes are diurnal, terrestrial, solitary, or more rarely in pairs. They are common in *terra firme* forest with dense undergrowth. They are widely hunted by local people throughout their distribution range. Its IUCN classification is Least Concern (LC).

Order Artiodactyla

In the neotropics this order is represented by two families, the Tayassuidae (peccaries) long-lived (13 yrs old age of last reproduction) and the Cervidae (deer) medium-lived (8 yrs old age of last reproduction) [Bodmer and Robinson 2004]. In the artiodactyla, the body weight is borne evenly on the third and fourth toes, with the centre of gravity falling between them. Peccaries have small litters of one or two precocial young. Artiodactyls are important agents in seed dispersion all over the Amazon forest, being key dispersers for palm species in Amazonia [Bodmer 1991].

All the artiodactyls are heavily threatened by subsistence and commercial hunting throughout their distribution range. [Bodmer et al. 2004] estimated that for the rural area of Loreto (Peru) the annual harvest is around 113,000 mammals. The largest number of individuals sold in the Iquitos market, Peru corresponds to peccaries with a total of 4,958 animals sold compared to 308 deer.

Collared peccary (*Tayassu tajacu*)

Keuroghlian et al. [2004] reported that the average weight of the collared peccary is 18,6 kg, while Emmons [1999] presents values between 25-45 kg; this species is highly adaptable and inhabits a wide variety of habitats from tropical forests to deserts, making them more resistant to disturbed forest and hunting than the white-lipped peccary [Cullen et al. 2004; Peres 1996]. In tropical forests, its diet is composed mainly by palm fruits, supplemented with small vertebrates and invertebrates [Bodmer 1989]. *T. tajacu* is a highly social animal, living in herds, which vary from fewer than two to over 30 individuals [Kiltie and Terborgh 1983]. Home ranges of groups average approximately 150 ha, but can range from 24 to 800 ha; usual litter size is 2 individuals [Sowls 1984]. Throughout the Amazon forest reported population densities vary from 1.6 ind/km² to 9.3 ind/km² [Keuroghlian et al. 2004; Mayer and Wetzel 1987]. The Collared peccary is widely distributed; it occurs from Arizona (US) to northern Argentina [Beck et al. 2008].

Collared peccaries are one of the most important sources for subsistence hunting and their populations are mainly threatened by over-hunting and forest fragmentation, driving them lo local extirpation over large areas of their formed range [Bodmer et al. 1994; Bodmer and Sowls 1993]. *Tayassu tajacu* is classified as Least Concern by the IUCN and included in CITES appendix II [Beck et al. 2008] (photo source: http://fireflyforest.net/firefly/2005/09/14/javelinas).

White-lipped peccary (*Tayassu pecari*)

White-lipped peccaries are one of the largest neotropical mammals, with average weight of 25-50 kg [Fragoso 2004; Sowls 1997]. Females are in reproductive condition at approximately 18 months and litter size is 1.6 individuals [Eisenberg 1989; Mayor et al. 2009]. Herds can be composed of 300 animals [Emmons 1999], thus this species requires extensive and contiguous areas of habitat to obtain sufficient resources throughout the year [Bodmer 1989; Cullen 2001]. White-lipped peccaries use a wide range of habitats such as wet and dry grasslands and woodlands, xerophitic areas like the Gran Chaco, tropical dry forests, and coastal mangroves, however its geographic distribution in concentrated in humid tropical forests [Altrichter and Boaglio 2004; Bodmer and Sowls 1993; Sowls 1984].

Fragoso et al. [2000] reported that a herd of 130 individuals use a home range of approximately 109 km². This species is extremely vulnerable to local extinction as the loss and fragmentation of their habitat also exposes them to increased hunting pressure by facilitating their location by human hunters, who can kill many individuals in a large herd during a single encounter [Peres 1996; Reyna-Hurtado and Tanner 2007]. Although reproductive patterns in all peccary species are similar, the white-lipped is more susceptible to overhunting and its local disappearance and extirpation has been reported throughout the neotropics. For instance there is strong evidence of periodic population crashes in white-lipped peccaries which seem density dependent and are most likely due to an epizootic event [Fragoso 2004]. One risk is that isolated populations that crash may have difficulties recovering since they would be cut off from dispersal from potential source population areas [Reyna-Hurtado et al. 2008]. Despite the current threats that the white-lipped peccary is facing, its conservation status is Near Threatened and the species is listed in CITES appendix II [Reyna-Hurtado et al. 2008].

Bodmer et al. [1988] and Bodmer and Pezo [2001] reported that peccary pelts are legally sold as by-product from Peru to the European leather industry, where trade revenues are not fairly distributed amongst local people. Bodmer et al. [2004] reported that exports of pelts have fallen from 200,000 skins/year to 34,000 skins/year owing to more strict trade control. However peccary meat is illegally sold at the Iquitos market in high quantities.

Deer (*Mazama* spp.)

Here I group red deer (*Mazama americana*) and gray brocket deer (*Mazama gouazoubira*), as the analyses to determine the sustainability of hunting were conducted for the genus Mazama (see section 3.2.4.1). Their gestation is approximately 7 months, and litter size is one individual and the young are weaned by about 12 months [Eisenberg and Redford 2000]. *M. americana* average weight is 24-48 kg [Emmons 1999] it is diurnal and nocturnal and solitary. Red deer prefers dense vegetation, swampy areas, riversides, and old plantations [Emmons 1999]. *Mazama gouazoubira* average weight ranges between 11 to 25 kg, and it is mostly diurnal. This species occurs in moderately humid to dry regions where there are areas of woody or brush cover.

Both species are highly threatened by subsistence and commercial hunting. In the Peruvian Amazon, the Iquitos market represents the most important trade centre were bushmeat is sold illegally [Bodmer et al. 2004]. In Colombia deer are among the most hunted species however their hunting for sport or commercial purposed is illegal. This species is classified as data Deficient by the IUCN [Duarte et al. 2008].

Order Perissodactyla

Tapir (*Tapirus terrestris*)

Tapirs are the only extant native new world odd-toed ungulates. They are the largest terrestrial neotropical mammal. Tapirs are mostly nocturnal, partly diurnal, and solitary but several use the same area [Emmons 1999]. The gestation period of the tapir is approximately 385-412 days and the litter size in one individual [Brookes et al. 1997; Nowak 1999]. The calf remains with the female for 10 to 11 months, and females can bear young once every two years. Young animals attain sexual maturity at 3 to 4 years. Reported tapir’s longevity in captivity is 35 years [Fragoso et al. 2000].

Tapirs play a critical role in the creation and maintenance of biological diversity, also working as indicators of the ecosystem [Eisenberg 1989]. In the Peruvian Amazon, *Tapirus terrestris* is the only ungulate which has the potential for regularly dispersing seeds, since fruits comprise approximately 33% of its diet and it is the only ungulate species that disperse the largest seeds [Bodmer 1991]. Habitat association varies extensively, including humid tropical forest, gallery forest, dry forest, chaco, and more open grassy habitats with water and dense vegetation. The most important habitats tend to be moist, wet or seasonally inundated areas.

Tapir are ecologically more prone to be impacted by hunting due to long gestation and generational time. Reproduction is slow enough to make recover difficult for the species is areas where there is any prolonged hunting activity.

Hunting is a serious threat along the numerous new road systems, settlement and along the agricultural frontier in the Amazon basin. Hunting also occurs around logging camps and can completely eliminate the species from seemingly viable habitat [Naveda et al. 2008]. Lozano [2004] reported that in the southern Colombian Amazon, indigenous people extensively hunted the low-land tapir at the salt-licks causing local extirpation of the species or affecting drastically their home range use. The low-land tapir is classified as Vulnerable at global level [Naveda et al. 2008], and as Critically Endangered (CR) in Colombia and it is included in CITES Appendix II [Rodriguez-Mahecha et al. 2006].

Order Testudines

The yellow-footed tortoise (*Geochelone denticulata*)

Is widely distributes in South America and it is associated with wet tropical and subtropical forests [Strong and Fragoso 2006]. This terrestrial, long-lived species has an average weigh of 6,5 kg; its reported home rage varies between 0.63 ha to 117,5 ha and its density is 0.20 ind/ha [Moskovits, 1985 in Strong and Fragoso 2006]. This species is mainly frugivorous and its diet is supplemented by fungi, leaves, insects and carrion ha [Moskovits, 1985 in Strong and Fragoso 2006]. Strong and Fragoso [2006], measured the seed dispersion of the yellow-footed tortoise in Roraima, north-western Brazil, concluding that the quantity and diversity of viable seeds defecated by tortoises and the distance travelled by tortoises while retaining seeds suggest they may be important seed dispersal agents in the ecosystems where they occur.

G. denticulata is heavily harvested throughout their range by rural and indigenous people and have been extirpated in some areas [Strong and Fragoso 2006]. Farias et al. [2007] reported high levels of gene flow in the yellow-footed tortoise suggesting that it is likely that this species has the capacity of colonise newly available habitats and to recolonise areas were populations were depleted by hunting. The yellow-footed tortoise is classified as vulnerable by the IUCN and it is included in CITES Appendix II [Farias et al. 2007].

Order: Galliformes

Cracids are a family of gamebirds (Cracidae), found predominantly throughout the neotropics and they constitute a substantial part of avian biomass [Begazo and Bodmer 1998]. Sizes range from that of a small pheasant to a large turkey. Their larger size compared to most species of birds makes them an ideal protein source for local people. Owing to the unsustainable hunting of cracids their populations are plummeting rapidly throughout their range [Ayres et al. 1991; Begazo and Bodmer 1998; Vickers 1991]. The other factor that threatens Cracids is depletion of their natural forest habitat. Although some species can tolerate moderate forest alteration, most species disappear when their natural habitat is destroyed. The reproductive strategy of most Cracids cannot compete with intensive hunting. Most species have a small clutch size of 2 eggs, and a long maturation period of 3 years (http://www.cracids.org/home.php).

Wattled curassow (*Crax globulosa*) / Razor-billed curassow (*Crax tuberosa*: synonyms: *Mitu tuberosum, Mitu tuberosa*)

Owing to the lack of data on the razor-billed curassow, I am providing ecological data on the wattled curassow. The main difference between the two species is that the razor-billed curassow is specialised in *terra firme* forest while the wattled curassow in only found in varzea forest (flooded forest).These long-lived bird species have an approximate weight of 2.5 to 3,06 kg and a life span of 25-30 years (Begazo and Bodmer, 1998; Plassé et al. unpubl. data in [Bennett 2000]. Little is known about the reproductive patterns of this species. Bennett [2000] reported that in Mocagua Island, in the Southern Colombian Amazon the apparent natural history of *Crax globulosa* reflects both the productivity and the seasonal dynamics of the Amazon River. June is the peak month for male reproductive displays and nesting. There may be a short reproductive peak in December as well, but this seems more open to question. The wattled curassow lives in pairs, and female alone incubates a clutch of 2 - 6 eggs; apparently the male and all females participate in the incubation. A polygamous mating system in the wattled curassow would be a behavioural adaptation consistent with rich and spatially-concentrated food resources [Bennett 2000].

Small groups forage on inundated ground for small fish, insects, aquatic crustaceans, other small animals and fruit. The wattled curassow inhabits lowland, riverine, and humid forest, however this species is closely linked to water, with no individual ever being found more than 300 m from the river edge despite detailed surveys extending to 3 km from the river; this habitat preference makes them conspicuously vulnerable for hunters [BirdLife-International 2008a; Hilty and Brown 1986]. Amazonian rivers are the routes for colonisation, development, hunting and transport in the region. Hunting, whether commercial, subsistence or by loggers is the main threat for the wattled curassow, with habitat loss contributory [BirdLife-International 2008a]. Until about 1950 the wattled curassow on I. Mocagua were harvested for their meat and for the white venter feathers of the males. The birds were hunted with blowguns, or trapped using corn or manioc bait, depleting this species drastically [Bennett 2000]. *C. globulosa* is classified as Vulnerable (VU) and it is listed in CITES Appendix III. The razor-billed curassow is classified as least

Concern (LC) owing to its wide geographical distribution [BirdLife- International 2008a; 2008b].

Spix's guan (*Penelope jacquacu*)

The Spix's guan average weight in 1,28 kg; its reported density in Peru is 5.46 ind/km² [Begazo and Bodmer 1998].They prefer humid forest, but adapt well to less densely forested areas such as edges of woodlands and in clearings with scattered trees. Spix's guan usually roam singly or in pairs, but not in groups, keeping to the mid-canopy and rarely come to the ground. They are more associated with flood planes levees than with and less with forest prone to inundation [Begazo and Bodmer 1998]. Their diet is mainly composed of plant matter, such as fruits, young leaves and shoots and seeds [Hilty and Brown 1986]. Spix's guan is classified as Least Concern (Lc) and CITES Appendix I [BirdLife-International 2009] (photo source: Frank Wouters).

Order: Carnivora

Coati: (*Nasua nasua*)

This medium-lived species has an average weight of 2.7-6.4 kg. Coatis are nocturnal; terrestrial and arboreal; solitary except for females with young or congregations at food sources. Reported litter size in captivity is 3-4 individuals [Gompper and Decker 1998]. This species is omnivorous and feeds mainly on fruits and small animals. Reported densities of *N. nasua* range from 5.7 ind/km² at A' Ukre, central Brazilian Amazon [Peres and Nascimento 2006] to 13 individuals/km_2 in taller gallery forests [Gompper and Decker 1998]. Coatis are commonly hunted by local people and represent an important source of protein. However as reported for Yuquí indigenous group in Bolivia, coatis are not a preferred prey owing to cultural taboos or taste preferences [Stearman 1990; Stearman and Redford 1995]. Hunting and habitat loss are their main threats [Emmons 1999; Emmons and Helgen 2008]. *N. nasua* is classified as Least Concern and it is included in CITES appendix III [Emmons and Helgen 2008].

Order: primates

Neotropical primates are primarily arboreal, and few species descend to the ground to cross an open space or to forage on the ground during the dry season, when food is scarce on the trees, such as the capuchins [Defler 2004; Emmons 1999]. With the exception of *Aotus* spp., new world monkeys are diurnal. Neotropical monkeys present a wide geographical variation in colour patterns, making very problematic their taxonomic classification [Emmons 1999]. However modern techniques for DNA identification have been useful to decrease the bias in their classification. Yet species from the

Aotidae family still cause taxonomic confusion as several species currently grouped in the same sibling species complex are phetotipically and genetically similar [Defler 2004; Defler and Bueno 2007]. The main threats for neotropical primates are deforestation, habitat fragmentation and hunting for subsistence and commercial purposes.

Colombian red howler monkey (*Alouatta seniculus*)

The average weight of howler monkeys range from 3.6 to 11 kg [Emmons 1999]. Their mean gestation length is 191 days and inter-birth intervals are approximately 16,6 months [Crocket and Sekulic 1982].This species is widely distributed in South America and is particularly adaptable and it is found in a variety of habitats such as mangrove, swamps of the Caribbean coast, gallery forest and other relatively dry regions. Red howler monkeys can be found in small and isolated patches of forest, making them one of the few new world primate species that adapts to habitat fragmentation [Boubli et al. 2008]. Red howlers are mainly folivorous; they are found in small groups, usually 4-6 individuals [Defler 2004; Neville 1972] and their home ranges varies from 4 ha in Venezuela to 180 ha in the Colombian Amazon forest [Neville 1972; Palacios and Rodriguez 2001]. Reported densities vary from 2.6 ind/km² in Penedo, Juruá river in Brazil [Peres 1997] to 25-45 ind/km² in Venezuela's gallery forest [Braza et al. 1981]. Red howlers are intensively hunted along their distribution range for subsistence consumption and for the pet trade, and they appear to be rare or extinct from hunting near human settlements in the upper Amazon basin [Defler 2004; Emmons 1999]. However *A*. *seniculus* is classified as Least Concern (Lc) and included in CITES appendix II [Boubli et al. 2008] (photo source Fundacion Entropika).

Common woolly monkey (*Lagothrix lagothricha*)

The common woolly monkey is one of the largest neotropical primates. Its average weight can range from 7 to 11.5 kg [Hernandez-Camacho and Defler 1985]. Common woolly monkeys are mainly frugivorous, but their diet also includes new leaves, seeds and arthropods [Defler and Defler 1996]. *L. lagothricha's* reported group size in the Colombian Amazon is 20-24 individuals, its home range is 760 ha, and its density is 5.5 ind/km² [Defler 1987; 1989; 2004]. The common woolly monkey's mean gestation length in 223 days, with inter-birth intervals of approximately 36.7 months [Nishimura 2003]. Peres [1991] reported that female woolly monkeys can only produce four to five offspring during a lifetime reproductive effort of 20 years [Peres 1991].

L. lagothricha's is unable to maintain viable populations under hunting pressure, owing to its reproductive characteristics [Peres 1990]. The main threats for common woolly monkeys in Colombia are hunting, the pet trade and agricultural expansion, including illegal crops [Defler 2004; Palacios et al. 2008]. Owing to its body size and the taste if its meat, *L. lagothricha* is the most targeted neotropical primate for hunting. Despite its imminent risk of extirpation in the Amazon basin, this species is classified as vulnerable (VU) and it is included in CITES Appendix II [Palacios et al. 2008] (photo source: Noga Shanee).

The Spix's night monkey or Amazonian night monkey (*Aotus vociferans*)

A. vociferans body weight is approximately 1,3 kg. This nocturnal primate is monogamous; the species is mainly frugivorous and complements its diet with leaves, flower nectar and small invertebrates [Ford 1994]. The Spix's night monkey's is distributed in Brazil, Colombia, Ecuador and Peru; little is known about the ecology on this species in Colombia. [Aquino and Encarnacion 1986b; 1994] note that *A. vociferans* in Peru prefers the lower parts of the canopy, and it makes its nests mainly in tree holes, that it shares with other species such as the kinkajou (*Potos flavus*), the bushy-tailed olingo (*Bassaricyon gabbii*) and the porcupine (*Coendu bicolour*). The main threats that this species is facing in the illegal trade for biomedical research [Maldonado et al. 2010], forest fragmentation and subsistence and commercial hunting for the pet trade. Without data on the current conservation status of this species, the IUCN classified *A. vociferans* as Least Concern (Lc) [Morales-Jiménez et al. 2008]; it is included in CITES Appendix II (photo source: Fundacion Entropika).

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GLOSARY

Carrying capacity (K): is the density of a species in non-hunted, undisturbed populations [Sinclair et al. 2006].

Community: human community: is the structure of relationships through which a localised population provides its daily requirements and interacts with its environment [Bryman 2008].

Community: A biological community is defined as the species that occupy a particular locality and the interactions among those species [Primack 2006].

Curare: A dark resinous extract obtained from several tropical American woody plants, especially *Chondrodendron tomentosum* or certain species of *Strychnos*, used as an arrow poison by some indigenous peoples of South America mainly for hunting purposes. This paralyzing poison leads to asphyxiation as the respiratory muscles of the hunted animal are unable to contract [Schultes and Raffauf 1992].

Floodplain: Refers to forest that are flooded by white water rivers (*Várzea*) and black water rivers (*Igapó*) [Irion et al. 1997].

Indigenous Territory: (Resguardo indigena) Legal and socio-political institution made up of an indigenous community, with a title of collective ownership, possesses its territory and is ruled by the indigenous code of laws and its cultural guidelines and traditions [Republic-of-Colombia 1990].

Intrinsic Rate of Increase (rmax): Is the highest rate of population increase when a species is not limited by food, space, resource competition or predation (Robinson and Redford, 1986b). The intrinsic rate of population increase can be calculated using Cole's (1954) equation:

$$1=e-rmax+be-rmax(a)-be-rmax(w+1)$$

Where a is the species-specific age of first reproduction, w is the age of last reproduction, and b is the annual birth rate of female offspring. These reproductive parameters are available in the literature from captive and wild individuals for commonly hunted species. Cole's equation is actually a measure of maximum reproductive productivity [Cole 1954].

Maximum finite rate of population increase (λmax): is the exponential of the intrinsic rate of natural increase (e**r max**), and is the increase of the population size from time to *t* +1. Thus if time is measured in years, a population that is only replacing its self will have a finite rate of increase of 1.0, while a population that doubling every year will have a rate of 2.0. The rate of population increase depends on the number of adult females reproducing and their average birth rate (number of offspring produced per year [Robinson and Redford 1991b].

Maximum production (Pmax): is calculated by multiplying the density at maximum production (estimated as 0.6K) by the finite rate of population increase (λmax) and subtracting it from the previous years density (also estimated at 0.6K), using:

$$Pmax = (0.6K * \lambda max) - 0.6K$$

Subtracting 0.6K maintains the population at the same density [Robinson and Redford 1991b].

Maximum sustainable yield (MSY): Maximum possible number of animals that can be hunted without driving the population in to decline [Caughley 1977; Sinclair et al. 2006]. For the Stock-recruitment model, MSY is defined as : i) 60% of K for short and medium-lived species such as peccaries, deer and large rodents, and ii) 80% of K for longlived species such as tapirs and primates.

Phratry: An exogamous subdivision of the tribe, constituting two or more related clans [Fine 1983].

Predicted density: Density of a species predicted from a linear regression of $\log_{10}$ population density against body mass for samples of Neotropical forest mammals broken into dietary categories [Robinson and Redford 1986a].

Production: is the addition to the population through births and immigrations during a specific period of time, whether the animal survive, emigrate, or die during the period [Banse and Mosher 1980] (See reproductive productivity).

Protected Area: An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means [IUCN 1994].

Protected Area category II: **National Park**: protected area managed mainly for ecosystem protection and recreation. Natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible [IUCN 1994].

Reproductive productivity: is determined from data on reproductive activity of females and uses information on 1) litter size and 2) gross reproductive productivity (number of young/number of females). Population density is determined from field censuses of wildlife species. Animal densities are then multiplied by reproductive productivity to give an estimate of production, measured as individuals produced/km2 as:

$$P= (0.5D)(Y*g),$$

where Y is gross reproductive productivity, g is the average number of gestations per year, and D is the population density (discounted by 50% under the assumption that the population sex ratio is 1:1) [Bodmer and Robinson 2004].

Source-sink dynamics: this ecological model examines the dynamics of populations in habitat patches of different qualities. It describes how variation in habitat quality may affect the population growth or decline of organisms [Sutherland 2002]. For instance proximity of a hunted area to a protected or un-hunted, “source” area for wildlife increases hunting sustainability [Bodmer and Puertas 2000]. On the other hand, in the absence of migration from nearby sources, sink populations will become extinct [Watkinson and Sutherland 1995].

Terra-firme*:* are those forests that are above the maximum flood level of Amazonian rivers and permanent streams [Haugaasen and Peres 2006]. *Terra-firme* represents the main forest type landscape encompassing 83% of the Amazonian forest [Hess et al. 2003].

Triangulation*:* Systematically combining the observations of individuals with different backgrounds and combining different research methods. The assumption is that for most situations there is no one "best" way to obtain information, and even if there were, it could not be foreseen in advance. Triangulation involves conscious, non-random selection of research methods and team members based on the resources available and the system being investigated. Triangulation of individuals and methods improves the quality of information and provides crosschecks [Beebe 1995].

Várzea: floodplains along white-water rivers, which are rich in nutrients and suspended matter [Irion et al. 1997]. *Várzea* is the largest type of flooded forest in South America and it covers approximately 180,000 km2 of the Amazon basin [Bayley and Petrere 1989].

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9.5 APPENDIX V
SUMMARY OF STATISTICAL RESULTS FOR CHAPTERS 3 AND 4

CHAPTER 3: THE IMPACT OF SUBSISTANCE HUNTING AND MEASURES OF ITS SUSTAINABILITY

Ranking probabilities for the qualitative evaluation of hunting sustainability

Life history	AI	Hunting	Sustainability	Rank	Life history
1	1	2	Sustainable	YES	4
1	1	3	Sustainable	YES	5
1	1	4	Sustainable	YES	6
1	1	5	Sustainable?	UNKNOWN	7
1	1	6	Not Sustainable?	NO	8
1	2	1	Sustainable	YES	4
1	2	1	Sustainable	YES	4
1	2	2	Sustainable	YES	5
1	2	3	Sustainable	YES	6
1	2	4	Sustainable	YES	7
1	2	5	Not Sustainable?	NO	8
1	2	6	Not Sustainable?	NO	9
1	3	1	Sustainable	YES	5
1	3	2	Sustainable	YES	6
1	3	3	Sustainable	YES	7
1	3	4	Sustainable?	UNKNOWN	8
1	3	5	Not Sustainable?	NO	9
1	3	6	Not Sustainable?	NO	10
1	4	1	Sustainable	YES	6
1	4	2	Sustainable	YES	7
1	4	3	Sustainable?	UNKNOWN	8
1	4	4	Not Sustainable?	NO	9
1	4	5	Not Sustainable?	NO	10
1	4	6	Not Sustainable?	NO	11
1	5	1	Sustainable?	UNKNOWN	7
1	5	2	Not Sustainable?	NO	8
1	5	3	Not Sustainable?	NO	9
1	5	4	Not Sustainable?	NO	10
1	5	5	Not Sustainable?	NO	11
1	5	6	Not Sustainable?	NO	12
1	6	1	Not Sustainable?	NO	8
1	6	2	Not Sustainable?	NO	9
1	6	3	Not Sustainable?	NO	10
1	6	4	Not Sustainable?	NO	11
1	6	5	Not Sustainable?	NO	12
1	6	6	Not Sustainable?	NO	13
2	1	1	Sustainable	YES	4
2	1	2	Sustainable	YES	5
2	1	3	Sustainable	YES	6
2	1	4	Sustainable	YES	7
2	1	5	Sustainable?	UNKNOWN	8
2	1	6	Not Sustainable?	NO	9

Life history	AI	Hunting	Sustainability	Rank	Life history
2	2	1	Sustainable	YES	5
2	2	2	Sustainable	YES	6
2	2	3	Sustainable	YES	7
2	2	4	Sustainable?	UNKNOWN	8
2	2	5	Not Sustainable?	NO	9
2	2	6	Not Sustainable?	NO	10
2	3	1	Sustainable	YES	6
2	3	2	Sustainable	YES	7
2	3	3	Sustainable?	UNKNOWN	8
2	3	4	Not Sustainable?	NO	9
2	3	5	Not Sustainable?	NO	10
2	3	6	Not Sustainable?	NO	11
2	4	1	Sustainable	YES	7
2	4	2	Sustainable?	UNKNOWN	8
2	4	3	Not Sustainable?	NO	9
2	4	4	Not Sustainable?	NO	10
2	4	5	Not Sustainable?	NO	11
2	4	6	Not Sustainable?	NO	12
2	5	1	Sustainable?	UNKNOWN	8
2	5	2	Not Sustainable?	NO	9
2	5	3	Not Sustainable?	NO	10
2	5	4	Not Sustainable?	NO	11
2	5	5	Not Sustainable?	NO	12
2	5	6	Not Sustainable?	NO	13
2	6	1	Not Sustainable?	NO	9
2	6	2	Not Sustainable?	NO	10
2	6	3	Not Sustainable?	NO	11
2	6	4	Not Sustainable?	NO	12
2	6	5	Not Sustainable?	NO	13
2	6	6	Not Sustainable?	NO	14
3	1	1	Sustainable	YES	5
3	1	2	Sustainable	YES	6
3	1	3	Sustainable	YES	7
3	1	4	Sustainable?	UNKNOWN	8
3	1	5	Not Sustainable?	NO	9
3	1	6	Not Sustainable?	NO	10
3	2	1	Sustainable	YES	11
3	2	2	Sustainable	YES	7
3	2	3	Sustainable?	UNKNOWN	8
3	2	4	Not Sustainable?	NO	9
3	2	5	Not Sustainable?	NO	10
3	2	6	Not Sustainable?	NO	11
3	3	1	Sustainable	YES	7
3	3	2	Sustainable?	UNKNOWN	8
3	3	3	Not Sustainable?	NO	9
3	3	4	Not Sustainable?	NO	10
3	3	5	Not Sustainable?	NO	11

Life history	AI	Hunting	Sustainability	Rank	Life history
3	3	6	Not Sustainable?	NO	12
3	4	1	Sustainable?	UNKNOWN	8
3	4	2	Not Sustainable?	NO	9
3	4	3	Not Sustainable?	NO	10
3	4	4	Not Sustainable?	NO	11
3	4	5	Not Sustainable?	NO	12
3	4	6	Not Sustainable?	NO	13
3	5	1	Not Sustainable?	NO	9
3	5	2	Not Sustainable?	NO	10
3	5	3	Not Sustainable?	NO	11
3	5	4	Not Sustainable?	NO	12
3	5	5	Not Sustainable?	NO	13
3	5	6	Not Sustainable?	NO	14
3	6	1	Not Sustainable?	NO	10
3	6	2	Not Sustainable?	NO	11
3	6	3	Not Sustainable?	NO	12
3	6	4	Not Sustainable?	NO	13
3	6	5	Not Sustainable?	NO	14
3	6	6	Not Sustainable?	NO	15
4	1	1	Sustainable	YES	6
4	1	2	Sustainable	YES	7
4	1	3	Sustainable?	UNKNOWN	8
4	1	4	Not Sustainable?	NO	9
4	1	5	Not Sustainable?	NO	10
4	1	6	Not Sustainable?	NO	11
4	2	1	Sustainable	YES	7
4	2	2	Sustainable?	UNKNOWN	8
4	2	3	Not Sustainable?	NO	9
4	2	4	Not Sustainable?	NO	10
4	2	5	Not Sustainable?	NO	11
4	2	6	Not Sustainable?	NO	12
4	3	1	Sustainable?	UNKNOWN	8
4	3	2	Not Sustainable?	NO	9
4	3	3	Not Sustainable?	NO	10
4	3	4	Not Sustainable?	NO	11
4	3	5	Not Sustainable?	NO	12
4	3	6	Not Sustainable?	NO	13
4	4	1	Not Sustainable?	NO	9
4	4	2	Not Sustainable?	NO	10
4	4	3	Not Sustainable?	NO	11
4	4	4	Not Sustainable?	NO	12
4	4	5	Not Sustainable?	NO	13
4	4	6	Not Sustainable?	NO	14
4	5	1	Not Sustainable?	NO	10
4	5	2	Not Sustainable?	NO	11
4	5	3	Not Sustainable?	NO	12
4	5	4	Not Sustainable?	NO	13
4	5	5	Not Sustainable?	NO	14

Life history	AI	Hunting	Sustainability	Rank	Life history
4	5	6	Not Sustainable?	NO	15
4	6	1	Not Sustainable?	NO	11
4	6	2	Not Sustainable?	NO	12
4	6	3	Not Sustainable?	NO	13
4	6	4	Not Sustainable?	NO	14
4	6	5	Not Sustainable?	NO	15
4	6	6	Not Sustainable?	NO	16

Chi-square

Age class distribution of game species in Mocagua and San Martin

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.362a	3	.010
Likelihood Ratio	11.106	3	.011
Linear-by-Linear Association	4.704	1	.030
N of Valid Cases	2001		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 7,93.

Number of hunted animals for the 15 most important prey species grouped by order in Mocagua and San Martin

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	48.135a	7	.000
Likelihood Ratio	48.557	7	.000
N of Valid Cases	1759		

APPENDIX V

Oneway ANOVA
Site (Mocagua and San Martin) and Density (log$_{10}$)

Descriptives

Density Log

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Mocagua	15	.5344	.40335	.10414	.3110	.7577	-.21	1.13
San Martin	15	.2429	.36561	.09440	.0404	.4454	-.70	.83
Total	30	.3886	.40625	.07417	.2369	.5403	-.70	1.13

Test of Homogeneity of Variances

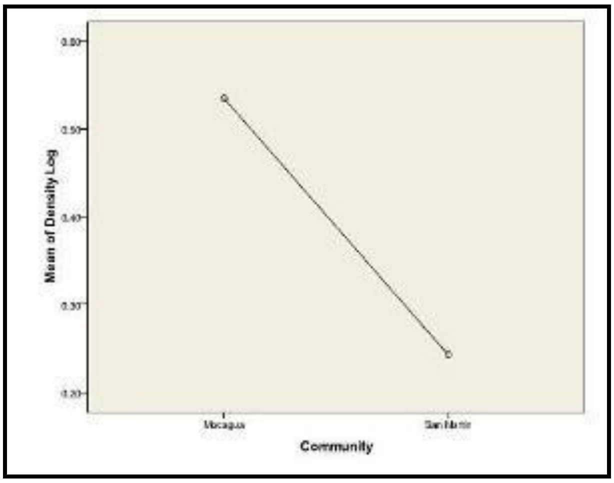
Density Log

Levene Statistic	df1	df2	Sig.
.610	1	28	.441

ANOVA

Density Log

	Sum of Squares	df	Mean Square	F.	Sig
Between Groups	.637	1	.637	4.300	.047
Within Groups 4	.149	28	.148		
Total	4.786	29			



APPENDIX V

Robust Tests of Equality of Means

Density Log

	Statistic[a]	df1	df2.	Sig
Welch	4.300	1	27.734	.048
Brown-Forsythe	4.300	1	27.734	.048

a. Asymptotically F distributed

Oneway ANOVA-Post-Hoc
Body Size categories and Density ($\log_{10}$)

Descriptives

Density Log

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Small	10	.4174	.29500	.09329	.2064	.6284
Medium	12	.5979	.35664	.10295	.3713	.8245
Large	8	.0388	.39483	.13959	-.2913	.3689
Total	30	.3886	.40625	.07417	.2369	.5403

Descriptives

Density Log

	Minimum	Maximum
Small	.04	.99
Medium	.04	1.13
Large	-.70	.57
Total	-.70	1.13

Test of Homogeneity of Variances

Density Log

Levene Statistic	df1	df2	Sig.
.481	2	27	.623

ANOVA

Density Log

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.513	2	.756	6.238	.006
Within Groups	3.274	27	.121		
Total	4.786	29			

Robust Tests of Equality of Means

Density Log

	Statistic[a]	df1	df2	Sig.
Welch	4.998	2	16.275	.020
Brown-Forsythe	6.083	2	22.317	.008

a. Asymptotically F distributed.

Post Hoc Tests

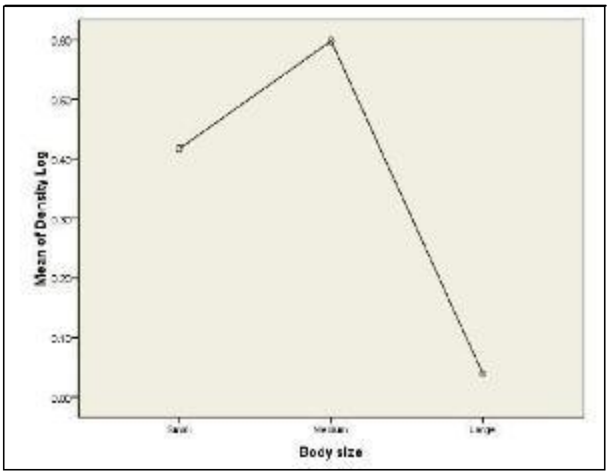
Multiple Comparisons

Density Log
Tukey HSD

(I) Body size	(J) Body size	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Small	Medium	-.18052	.14909	.457	-.5502	.1891
	Large	.37855	.16516	.074	-.0310	.7881
Medium	Small	.18052	.14909	.457	-.1891	.5502
	Large	.55907*	.15893	.004	.1650	.9531
Large	Small	-.37855	.16516	.074	-.7881	.0310
	Medium	-.55907	* .15893	.004	-.9531	-.1650

*. The mean difference is significant at the 0.05 level.

Means Plots



APPENDIX V

Oneway ANOVA
Body Size categories and Observed Hunting (log_{10}) presented as kg/km²

Descriptives

Hunt Kg Log

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Small	10	-1.2187	.54967	.17382	-1.6120	-.8255
Medium	12	-.2564	.72594	.20956	-.7177	.2048
Large	8	.4427	.45161	.15967	.0651	.8202
Total	30	-.3908	.88226 .	16108	-.7202	-.0613

Descriptives

Hunt Kg Log

	Minimum	Maximum
Small	-2.42	-.55
Medium	-1.69	.92
Large	-.18	1.12
Total	-2.42	1.12

Test of Homogeneity of Variances

Hunt Kg Log

Levene Statistic	df1	df2	Sig.
1.330	2	27	.281

ANOVA

Hunt Kg Log

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.629	2	6.315	17.146	.000
Within Groups	9.944	27	.368		
Total	22.573	29			

APPENDIX V

Robust Tests of Equality of Means

Hunt Kg Log

	Statistic[a]	df1	df2	Sig.
Welch	23.916	2	17.883	.000
Brown-Forsythe	18.929	2	26.508	.000

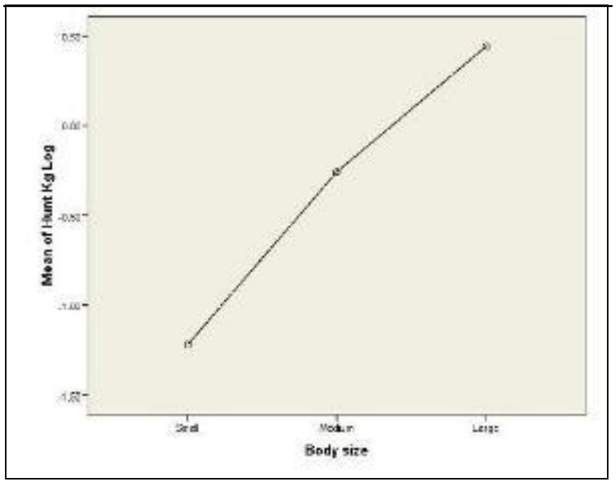
a. Asymptotically F distributed

Post Hoc Tests

Multiple Comparisons

Hunt Kg Log
Tukey HSD

(I) Body size	(J) Body size	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Small	Medium	96232*	.25984	.003	-1.6066	-.3181
	Large	-1.66144*	.28786	.000	-2.3752	-.9477
Medium	Small	.96232*	.25984	.003 .	3181	1.6066
	Large	-.69911*	.27700	.045	-1.3859	-.0123
Large	Small	1.66144*	.28786	.000	.9477	2.3752
	Medium	.69911*	.27700	.045	.0123	1.3859



Correlations
Weight – Biomass – Density (log transformed)

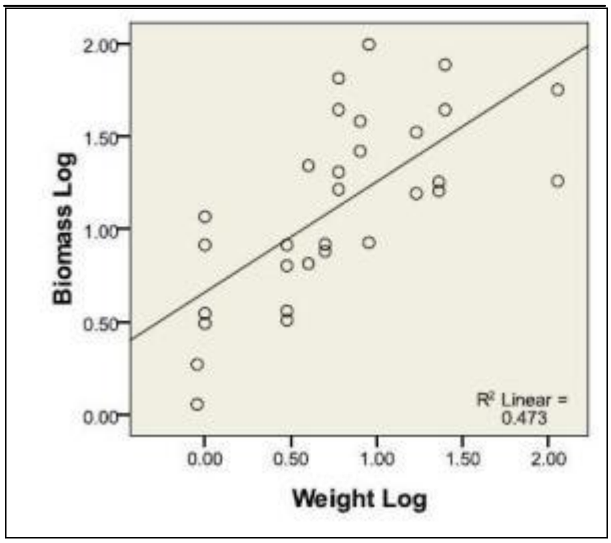
Descriptive Statistics

	Mean	Std. Deviation	N
Weight Log	.7778	.56992	30
Biomass Log 1	.1223	.49318	30
Density Log	.3886	.40625	30

Correlations

		Weight Log	Biomass Log	Density Log
Weight Log	Pearson Correlation	1.000	.688**	-.464**
	Sig. (2-tailed)		.000	.010
	N	30.000	30	30
Biomass Log	Pearson Correlation	.688**	1.000	.317
	Sig. (2-tailed)	.000		.088
	N	30	30.000	30
Density Log	Pearson Correlation	-.464**	.317	1.000
	Sig. (2-tailed)	.010	.088	
	N	30	30	30.000

**. Correlation is significant at the 0.01 level (2-tailed).



APPENDIX V

SUMMARY OF THE STATISTICAL RESULTS FOR CHAPTER 4: PRIMATE COMMUNITY IN ANP

Summary of Two-way ANOVAS: Comparison between DISTANCE and King's formula estimates at each study site

Variable	SS	df	MS	*F*-value	*P*
Group Density (Groups/km2)					
Distance (D)	2.81	3	0.93	0.15	0.92
King's formula (K)	36.39	3	12.13	0.47	0.70
Site x D	141.25	1	141.25	22.72	<0.001
Site x K	400.94	1	400.94	15.82	<0.001
Total D	318.1	32			
Total K	1146.56	32			
Individual Density (ind/km2)					
Distance (D)	71.34	3	23.78	0.23	0.87
King's formula (K)	43.47	3	14.49	0.14	0.93
Site x D	4088.56	1	4088.56	39.54	<0.001
Site x K	2.31	1	2.31	0.02	0.88
Total D	7054.6	32			
Total K	2797.24	32			
Biomass (kg/km2)					
Distance (D)	1360.9	3	453.63	0.92	0.44
King's formula (K)	1701.22	3	567.07	0.97	0.46
Site x D	11148.97	1	11148.97	22.72	<0.001
Site x K	1878.23	1	1878.23	2.88	0.10
Total D	22249.31	32			
Total K	21803.09	32			

SS: sum of squares; MS: mean squares

Descriptive Statistics

	Study site	Mean	Std. Deviation	N
Density (group/km2)	Bacaba	2.2633	2.20832	8
	Pucacuro	1.6283	1.69127	8
	Agua Blanca	2.4200	3.38757	8
	Agua Pudre	2.0925	2.37697	8
	Total	2.1010	2.38850	32
Group Dens Kings	Bacaba	-2.892	5.0745	8
	Pucacuro	-2.918	5.0536	8
	Agua Blanca	-5.386	4.9937	8
	Agua Pudre	-2.963	5.0094	8
	Total	-3.540	4.9043	32

APPENDIX V

Descriptive Statistics

	Study site	Mean	Std. Deviation	N
Density (group/km2)	Bacaba	13.0125	9.83105	8
	Pucacuro	9.8075	8.78419	8
	Agua Blanca	12.5637	12.02992	8
	Agua Pudre	9.8300	9.74665	8
	Total	11.3034	9.78155	32
Ind Density Kings	Bacaba	1.500	9.5805	8
	Pucacuro	.837	8.9919	8
	Agua Blanca	-1.625	11.9644	8
	Agua Pudre	.362	8.7907	8
	Total	.269	9.4952	32

Grand Mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Density (ind/km2)	11.303	1.797	7.622	14.985
Ind Density Kings	.269	1.752	-3.321	3.858

Descriptive Statistics

	Study site	Mean	Std. Deviation	N
Biomass (kg/km2)	Bacaba	27.0700	27.29462	8
	Pucacuro	22.7100	32.75184	8
	Agua Blanca	14.1200	8.80678	8
	Agua Pudre	10.7625	8.21817	8
	Total	18.6656	22.07052	32
Biomass Kings	Bacaba	13.779	31.0175	8
	Pucacuro	15.704	37.0872	8
	Agua Blanca	-1.688	11.2327	8
	Agua Pudre	2.850	11.8175	8
	Total	7.661	25.3523	32

Grand Mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Biomass (kg/km2)	18.666	3.916	10.644	26.687
Biomass Kings	7.661	4.510	-1.577	16.899

APPENDIX V

MANOVA Post Hoc- Site x size class

Descriptive Statistics

	Study site	Mean	Std. Deviation	N
Density (group/km2)	Bacaba	1.6150	1.15258	2
	Pucacuro	1.1750	.43134	2
	Agua Blanca	.3000	.25456	2
	Agua Pudre	.4600	.60811	2
	Total	.8875	.77724	8
Group Dens Kings	Bacaba	1.200	.5657	2
	Pucacuro	1.200	.4243	2
	Agua Blanca	-9.000	.0000	2
	Agua Pudre	.550	.6364	2
	Total	-1.513	4.6440	8
Biomass (kg/km2)	Bacaba	66.8000	20.49195	2
	Pucacuro	67.9350	44.37095	2
	Agua Blanca	10.8300	2.07889	2
	Agua Pudre	11.9400	12.57236	2
	Total	39.3763	35.49988	8
Biomass Kings	Bacaba	57.700	33.3754	2
	Pucacuro	67.950	44.3356	2
	Agua Blanca	-9.000	.0000	2
	Agua Pudre	16.800	9.3338	2
	Total	33.363	39.4275	8

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Density (group/km2)	2.280 [a]	3	.760	1.559	.331
	Group Dens Kings	150.064 [b]	3	50.021	221.088	.000
	Biomass (kg/km2)	6270.601 [c]	3	2090.200	3.277	.141
	Biomass Kings	7715.014 [d]	3	2571.671	3.248	.142
Intercept	Density (group/km2)	6.301	1	6.301	12.932	.023
	Group Dens Kings	18.301	1	18.301	80.890	.001
	Biomass (kg/km2)	12403.913	1	12403.913	19.449	.012
	Biomass Kings	8904.451	1	8904.451	11.248	.028
site	Density (group/km2)	2.280	3	.760	1.559	.331
	Group Dens Kings	150.064	3	50.021	221.088	.000

	Biomass (kg/km2)	6270.601	3	2090.200	3.277	.141
	Biomass Kings	7715.014	3	2571.671	3.248	.142
Error	Density (group/km2)	1.949	4	.487		
	Group Dens Kings	.905	4	.226		
	Biomass (kg/km2)	2551.087	4	637.772		
	Biomass Kings	3166.685	4	791.671		
Total	Density (group/km2)	10.530	8			
	Group Dens Kings	169.270	8			
	Biomass (kg/km2)	21225.601	8			
	Biomass Kings	19786.150	8			
Corrected Total	Density (group/km2)	4.229	7			
	Group Dens Kings	150.969	7			
	Biomass (kg/km2)	8821.688	7			
	Biomass Kings	10881.699	7			

[a]. R Squared = .539 (Adjusted R Squared = .193)
[b]. R Squared = .994 (Adjusted R Squared = .990)
[c] R Squared = .711 (Adjusted R Squared = .494)
[d]. R Squared = .709 (Adjusted R Squared = .491)

Estimated Marginal Means

Grand Mean

Dependent Variable	Mean	Std. Error	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Density (group/km2)	.888	.247	.202	1.573
Group Dens Kings	-1.512	.168	-1.979	-1.046
Biomass (kg/km2)	39.376	8.929	14.586	64.166
Biomass Kings	33.363	9.948	5.743	60.982

NOTA PARA LOS PADRES

REFERENCIA: *Programa de Educación Ambiental Proyecto Churuco*

Yo…………………………………………………..… Identificado (a)
con cedula de ciudadanía numero…………………………………...
En representación de mi hijo/a……………………………..……......
estudiante del grado……………………… confirmo que he leído el
cuestionario titulado……………………………………………………
…………………………………………………………………………..…
y estoy de acuerdo en que mi hijo/a llene dicho cuestionario bajo mi supervisión.

Nombre ……………………………….. Fecha …………………….……….

Firma………………………………………………………………….….

Angela Maldonado – lllugens@yahoo.co.uk
A.A. 20 Leticia-Amazonas- Colombia

PROYECTO CHURUCO COLOMBIA

APPENDIX VII

Date (as appropriate)

Dear,

STATUS AND CONSERVATION OF PRIMATES AND OTHER VERTEBRATES IN AMACAYACU NATIONAL PARK, COLOMBIAN AMAZON: A community based research project

Short title: The Woolly Monkey Project

I am writing to you to introduce myself, and invite you to take part in the research study named above.

My name is Angela Maldonado. I am a research student at the Anthropology and Geography Department in the School of Social Sciences and Law, Oxford Brookes University, Oxford, England. This research has developed from an initial pilot study carried out by myself in August 2003, and the GTI (Grupo de Trabajo e Investigacion de las comunidades del sector sur de Amacayacu) and the park system have kindly granted us permission to carry out this study.

The aim of this research is to estimate the density of large mammals (how many large animals there are) in areas of Amacayacu National Park that overlap with the communities of Mocagua and San Martin, in order to assess the abundance of wildlife in these areas. Additionally, we would like to quantify how many animals are hunted in the overlapping areas to determine whether hunting is sustainable. Finally, we will continue the training programme in quantitative methods for local coinvestigators for future monitoring of wildlife, and our education programme.

The results of this research will provide baseline information on the conservation status of the large mammal community for the implementation of the management plan currently being developed by your communities and Amacayacu National Park. This base-line information will also provide a better understanding of wildlife utilisation by your communities in order to recommend economic alternatives if results suggest that hunting is not sustainable. The reports of this study and my final dissertation (2009) will be held at the resources centre of Amacayacu National Park and the communal centre of your community.

This study has been funded from August 2003 to July 2006 by: The Monkey Sanctuary Trust, Rufford Small Grants, The Royal Geographical Society, IPPL, Kilverstone Trust, Rivett-Carnac Family and OWW (British organisations), and Fundacion Tropenbos Colombia. From August 2006, the fieldwork and education expenses of the project will be funded by Rainforest Concern and the expenses of the PhD (research degree) will be funded by an ORSAS

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ship and a Russell E. Train fellowship from WWF-EFN (Education For Nature USA). This research has been approved by the Research Ethics Officer for the School of Social Sciences & Law, Oxford Brookes University.

I hope that you will find our research of interest and benefit for your community, and that you will agree to participate by allowing me or a member of my research team to record your answers on a questionnaire about wildlife uses, and conduct a short interview with you about hunting (see Consent Form). As we will give some questionnaires to children at the school, I would appreciate it if you could sign the "*Parents consent form*" which will be attached with the children's questionnaires (see appendix 1).

The children's questionnaires will contain basic questions about wildlife in your community and their perception of wildlife, focusing on monkeys. The questionnaires will be distributed before and after the implementation of the environmental education activities. If you would like to discuss any aspects of the research further, please contact me at Amacayacu National Park or contact one of the research team members if I am away.

Finally, I would like to thank you for all the support and hospitality that you and your community have been offering to the team of "*The Woolly Monkey Project*".

Yours sincerely,

Angela Maldonado
Principal Investigator
The Woolly Monkey Project

Angela Maldonado <amaldonado@brookes.ac.uk>
< lllugens@yahoo.co.uk>, Tel (UK): 01865-484938 Tel (Col): 3135374990

CONSENT FORM

STATUS AND CONSERVATION OF PRIMATES AND OTHER VERTEBRATES IN AMACAYACU NATIONAL PARK, COLOMBIAN AMAZON: A community based research project

Name of researcher: Angela Maldonado (research student)

Address:

Parque Nacional Natural Amacayacu K9 No 6-100 Of.201 Leticia Amazonas Colombia Sur America	Dept. of Anthropology and Geography School of Social Sciences & Law Oxford Brookes University Oxford OX3 0BP UK

1. I confirm that I have read or have had read to me and understand the information sheet for the above study and that I have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐

3. I agree to take part in the above study. ☐

Name ………………………………..Date …………….

Signature…………………………………………………

Angela Maldonado <amaldonado@brookes.ac.uk>
< lllugens@yahoo.co.uk>, Tel (UK): 01865-484938 Tel (Col): 3135374990

APPENDIX VIII

SSIs GUIDE – HUNTERS

COMMUNITY__________________

Age_________ Place of birth____

Marital status__________________ How long have you been living here? _________________

Number of people in your family____

Number of family members in work ____

What kind of work do they do? ____

____

Which activities generate income for your family? ____________________________________

____

How long have you been hunting? ____

Are there other members of your family who hunt? ___________________________________

____

How did you learn to hunt? ____

____

Hunting Methods:

Birds____

____

Mammals____

____

Species hunted for consumption ____

Species trapped as pets ____

Type of meat consumed: ____

APPENDIX VIII

Which kind of food do you prefer: wild meat ☐; fish ☐; chicken ☐; meat in tins ☐

(please specify)

When is the best time of the year for hunting? ___________________________________ Why?

____

When is your proffered time of the day for hunting? ____________________________________

How long do you spend on a hunting trip? ____

How far from the community do you find big mammals? (Km and/or hours) ________________

How far from the community do you find small mammals? (Km. and/or hours) ______________

Do you hunt alone or in groups? ________; if you hunt in a group, who comprises the group?

____

How many times do you hunt per month? ____

Hunting areas:

Common name	Species	Location	Season/date	Transportation

What tools do you use for hunting? ____

____

How do you distribute the meat and animal parts? _____________________________________

____

What other uses do you give to the hunted animal and its parts? _________________________

____

APPENDIX VIII

Which mammals do you not hunt and why? ____

____

Which mammals did you not hunt before, but you hunt now? Why? _____________________

____

Have you noticed any changes in the hunting activity? ________________________________

What kind of changes? ____

____

____

Comments:

APPENDIX IX

SSIs GUIDE –TRADERS/ COLLECTORS OF NIGHT MONKEYS

1. Do you, or have you worked in the capture of nocturnal monkeys?
2. For how many years have you worked in these captures?
3. How much of your time is spent in the capture of primates?
4. How do you capture them and how many people do you work with?
5. Where are the captures carried out?
6. What is done with the primates?
7. How are the animals transported?
8. How many animals are captured each time?
9. After the animals are captured, where are they kept and how are they fed and maintained in the time between capture and sale?
10. How much is paid for the monkeys?
11. How many animals you taken in total (approximately)?
12. How long ago did you stop capturing monkeys and for what reason?
13. Are you aware of any type of accident that has happened during the captures?
14. In the case of an accident, did anyone deal with the problem?