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This dissertation is submitted in part fulfillment of the regulations for an MSc degree.

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This checklist must be completed before potential participants are approached to take part in any research.

Section I: Applicant Details

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Section III: For Students Only:

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Supervisor: Please tick the appropriate boxes:

☐	The student has read the University's Code of Practice
☐	The topic merits further research
☐	The student has the skills to carry out the research
☐	The participant information sheet or leaflet is appropriate
☐	The procedures for recruitment and obtaining informed consent are appropriate

Comments from supervisor:

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Please answer each question by ticking the appropriate box:

	YES	NO
1. Does the study involve participants who are particularly vulnerable or unable to give informed consent? (e.g. children, people with learning disabilities, your own students)	☐	☒
2. Will the study require the co-operation of a gatekeeper for initial access to the groups or individuals to be recruited? (e.g. students at school, members of self-help group, residents of nursing home)	☐	☒
3. Will it be necessary for participants to take part in the study without their knowledge/consent at the time? (e.g. covert observation of people in non-public places)	☐	☒
4. Will the study involve discussion of topics which the participants would find sensitive (e.g. sexual activity, own drug use)?	☐	☒
5. Are drugs, placebos or other substances (e.g. food substances, vitamins) to be administered to the study participants or will the study involve invasive, intrusive or potentially harmful procedures of any kind?	☐	☒
6. Will blood or tissue samples be obtained from participants?	☐	☒
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Signed: K E Mann .... Principal Investigator

* Signed: .... Supervisor or module leader (where appropriate)

Date: 9/29/05

* Original ethics form is signed by supervisor

Abstract

The purpose of this study was to determine the need for primate conservation efforts in northern Punta Burica, Costa Rica, and to lay the foundation for a primate conservation program if one was deemed necessary. This is an important area for conservation efforts because it has been proposed to be included in the Mesoamerican Biological Corridor due to its large tracts of primary forest. There have been limited primatological studies in this region and none concerning the most endangered resident primate, the Panamánian red spider monkey (*Ateles geoffroyi panamensis*). To address this question I used reconnaissance survey techniques to generate indices of relative abundance for each species of primate in two different areas of northern Punta Burica, Rio Coco and Punta Banco. In addition, vegetation quadrats were surveyed to determine the presence of spider monkey food trees and rare tree species. These were coupled with informal ethnobiological investigations to determine points of conflict between human and monkey needs. Spider monkeys were the least common, sighted at 0.07 grps/km in the Rio Coco area and were absent in Punta Banco. Mantled howler monkeys (*Alouatta palliata palliata*) were most abundant and sighted at a rate of 0.35 grps/km in Punta Banco and less frequently in Rio Coco at 0.13 grps/km. The white-throated capuchin monkey (*Cebus capucinus capucinus*) was common in both study areas with sightings rates of 0.20 grps/km and 0.25 grps/km for Punta Banco and Rio Coco, respectively. The black-crowned Central American squirrel monkey (*Saimiri oerstedii oerstedii*) was less common in both areas with sighting rates of 0.11 grps/km and 0.06 grps/km and for Rio Coco and Punta Banco, respectively. The vegetation portion of the study identified the presence of the threatened tree species *Caryocar costaricense* and *Eschweilera neii,* amongst others. Both of these species provide food for the spider monkey, with the former being an important sleeping site as well. They are also sought after for human use. The main findings suggest that the spider monkey, the squirrel monkey, and their habitat are in need of proactive conservation efforts. This need is put into the context of the cultural survival of the Amerindian Ngäbe people who share the Conte Burica indigenous territory with the habitat of the spider monkey. The possibilities for conservation efforts in collaboration with members of the Ngäbe community are explored.

Acknowledgements

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In memoriam:

Robert G. Cox
Miss-Teke

In honour of the new life that keeps the cycle going:

Jackson Adams Mann and his brother on the way

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List of Abbreviations

ACOSA	Osa Conservation Area
FMAM	*Fondo para el Medio Ambiente Mundial*
IGN	*Instituto Geográfico Nacional*
INBio	National Biodiversity Institute
IUCN	The World Conservation Union
MINAE	Ministry of Environment and Energy
NIVA	Norwegian Institute for Water Research
SINAC	National System of Conservation Areas
TSC	Tropical Science Centre
UNDP	United Nations Development Program

Chapter 1: Introduction

The purpose of this study was to determine the necessity for primate conservation efforts near Punta Banco, a village in the northern region of Punta Burica in Costa Rica. This study was instigated by a concerned resident of the village due to a perceived diminishing spider monkey population. In order to determine the need for primate conservation, two primary investigations were conducted: Firstly, the relative abundances were acquired for each non-human primate (hereafter primate) species in northern Punta Burica, including the mantled howler monkey (*Alouatta palliata palliata*; Gray 1849), the Panamánian red spider monkey (*Ateles geoffroyi panamensis*; Kellogg and Goldman 1944), the white-throated capuchin monkey (*Cebus capucinus capucinus*; Linnaeus 1758), and the black-crowned Central American squirrel monkey (*Saimiri oerstedii oerstedii*; Reinhardt 1872). In addition, I conducted a botanical investigation concerning the abundance of food trees for the spider monkey and the conflict between human needs and monkey needs in relation to botanical resources. This study also sought to gain a general understanding of the human influence on the area. This includes the human impact on the environment associated with the history of settlement and livelihood strategies. Finally, local interest in a primate conservation project was explored to determine support for an action plan if one was deemed necessary.

There is limited literature available addressing conservation from this region of Costa Rica. The last published studies borne from Punta Banco were published in 1998. This includes the rapid assessment of Boinski *et al* (1998), concentrating on the genus *Saimiri*, and the report by Gonzalez-Kirchner and Sainz de la Maza (1998), concentrating on the hunting of the primates by the Ngäbe[1] Amerindians. One unpublished thesis of Carbonell-Torres (1998) concerns the use and abundance of wildlife in the Conte Burica Ngäbe Indigenous Territory, which includes reports on the primates, and specifically mentions the need for conservation action for the spider monkey and the capuchin monkey, in addition to the green turtle (*Chelonia mydas agassizii*), the paca (*Agouti paca*), and the green iguana (*Iguana iguana*). This report also mentions the extirpation of the tapir (*Tapirus bairdii*), the white-lipped peccary (*Dicotyles pecari*), and the jaguar (*Panther onca*). However, follow up studies are lacking**.**

This investigation seeks to fill this gap by generating indices of relative abundance for each primate species by use of the reconnaissance survey method (Glanz 1991; Carbonell-Torres 1998). Surveys of endangered primates have become increasingly important in recent years to help plan conservation efforts (Koster and Butynski 1985; Charlat *et al* 2000; Matthews and Matthews 2004). The determination of abundance indices allows conservationists to identify areas of high priority for conservation action (Cant 1978; Defler and Pintor 1985; Brockelman and Ali 1987; Chapman *et al* 1988). Surveys also serve as a first step in long-term studies of primate populations (Pruetz and Leasor 2002) by providing a baseline for assessing future changes in populations (Clarke and Zucker 1994).

The primate population surveys of this investigation will be coupled with botanical surveys. The study of habitat is essential to primate conservation for the habitat represents the matrix within which primates have evolved morphological, physiological, and behavioural adaptations that define their life history traits (Ganzhorn 2003). Botanical

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[1] The Ngäbe are often referred to as Guaymí by outsiders, but they prefer to be identified by this name, which means "people" in their language (Bort and Young 2001).

studies also provide biological information on the diversity and uniqueness of the area and offer a foundation for ecological and socio-economic studies (White and Edwards 2000).

There are limited botanical studies coming from the region of Punta Banco. Kapelle *et al* (2002) conducted a broad ecological study surveying the ecosystems of the Osa Conservation Area (Fig. 1.1), but did not extend the floristic inventory to this study site. In addition, a review of the reference literature does not include botanical data specific to Punta Burica (Janzen 1983; Zamora-Villalobos *et al* 2000, 2004). This illustrates a need to initiate a botanical inventory to gain an understanding of the conservation value of the forests.

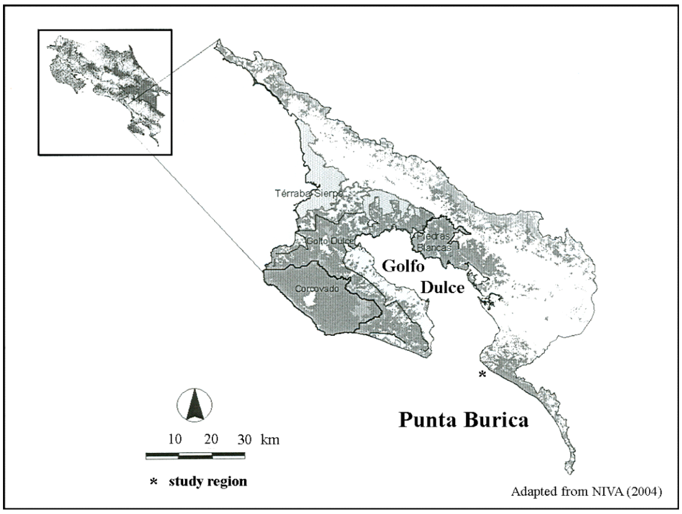

Figure 1.1 Forest cover of the Osa Conservation Area

Quadrats were utilized to sample the vegetation in order to assess abundance and distribution of food for the spider monkeys (Ganzhorn 2003). Specific attention was paid to the spider monkeys since they have the most specialized diet of the four primate species (van Roosmalen and Klein 1988) and are in the greatest threat of extirpation (Carbonell-Torres 1998). This was coupled with informal ethnobotanical investigations in order to identify potential human-wildlife conflicts. Finally, the vegetation surveys were also used to identify presence of trees important for conservation, including rare, threatened, and/or endemic species. The presence of these categories of trees may heighten the conservation value of this region.

Primate conservation is about "developing an accurate environmental narrative based on historical and contemporary human-environment interactions" (Agustin Fuentes quoted in Workman 2004, p 346). The northern region of Punta Burica represents the interface of two distinct human cultures, the *Ticos* (Costa Ricans) and the Ngäbe Amerindians, indigenous to the political nation of Panamá (Barrantes *et al* 1982). Informal interviews were conducted with members of both communities about the history of human settlement to the region of northern Punta Burica and the degree to which the human population depends on the forest. This information is essential for developing a conservation plan if it is deemed necessary (White and Edwards 2000).

The study region of Punta Burica is of high conservation value demonstrated by its identification as an area of conservation priority by an INBio and SINAC study in 2003 (NIVA 2004). Punta Burica harbours at least 6,000 ha of unprotected continuous rainforest (Fig. 1.1).

The study area is also contained within the Golfo Dulce region, which harbours some of the highest rates of endemism in Costa Rica (UNDP 2003). The importance of this area for conservation is additionally demonstrated by its proposed inclusion in the Mesoamerican Biological Corridor (Fig. 1.2), a project titled *Corredor Biológico Mesoamericano* (García 2002).

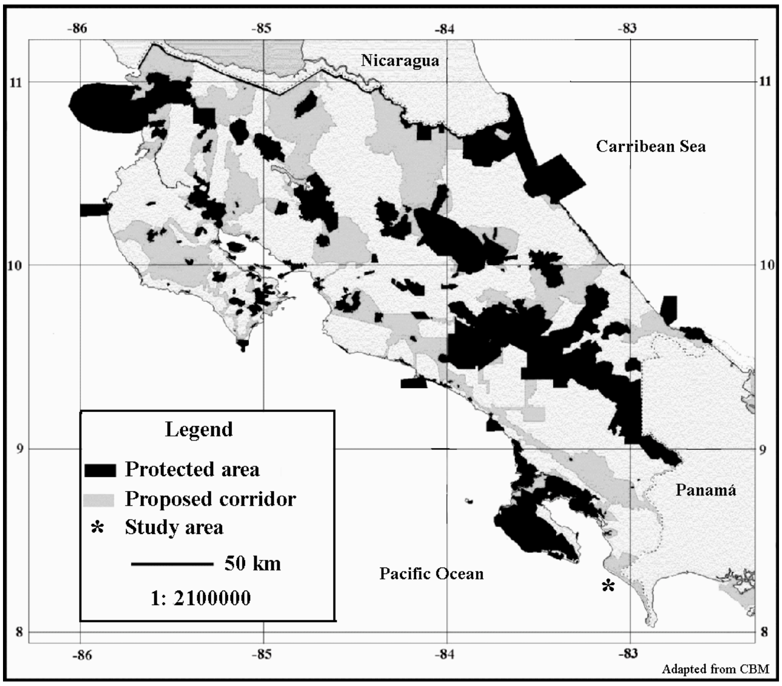

Figure 1.2 Biological corridor of Costa Rica comprising *Corredor Biológico Mesoamericano* highlighting study area as a proposed inclusion

Corridors are defined as broad internally heterogeneous swaths of habitat that permit the direct spread of many taxa from one region to another (Brown and Gibson (1983) in Noss 1991). By facilitating seasonal migration and the flow of genetic material, corridors allow greater viability to the conservation of species found in wild areas (UNDP 1999). The mobilization to create a biological corridor through Central America demonstrates the importance and need for conserving beyond boundaries of protected areas. The nation of Costa Rica demonstrates the importance of corridors.

Costa Rica boasts 25.6% of their national territory in publicly and privately owned protected areas (UNDP 2003). However, the protected areas resemble isolated islands (Boza 1993) that are juxtaposed with degradation outside of its boundaries with high levels of deforestation (Campbell 2002) at a rate of 300 km^2 per year (Lutz and Herman 1991).

In the 1980s this rate of deforestation was the highest of any Latin American country (Honey 1999). The rapid deforestation outside of the protected areas of Costa Rica demonstrates the need for conservation beyond boundaries (Noss 2002; Naughton-Treves 2003) and any conservation strategy must take in to account the biodiversity that lies outside of protected areas (UNDP 1999).

Information about the distribution of biological diversity provides the framework for conservation planning (NIVA 2004; Dupain *et al* 2005). Knowledge about the biodiversity of habitats and species is an important device for defending an area against development that may endanger their integrity (UNDP 1999). In addition, this knowledge is useful for negotiating international technical and financial cooperation. Finally, the presence of researchers in the field discourages activities detrimental to conservation (Young and Isbell 1994). It is recommended that rapid ecological assessments commence in each of the areas proposed for the corridor (UNDP 1999). This exploratory investigation into the relative abundance of the primates and the state of their habitat plays an important role in this process.

Chapter 2: Methods

2.1 Study Sites

2.1.1 Costa Rica

Costa Rica is located in Central America south of Nicaragua and north of Panamá. It is bordered by the Caribbean Sea on the east and the Pacific Ocean on the west (Fig. 2.1).

Figure 2.1 Political boundaries of Central America displaying geographic location of Costa Rica

2.1.2 Osa Conservation Area

The study was conducted in southwest Costa Rica located within the Osa Conservation Area (ACOSA) (Fig. 1.1). This is one of eleven conservation areas located in Costa Rica where 66 % of the land remains unprotected (García 2002). The protected areas in ACOSA summate to 145, 425 ha (Kapelle *et al* 2002), which includes Corcovado National Park, which was included in this study for rapid assessment.

Data were collected in the months of June and July 2005-- marking the beginning of the rainy season. Surveys occurred in four study sites within ACOSA. The two primary sites were Punta Banco and Rio Coco (Fig. 2.2), both in the northern region of Punta Burica. They have been segregated as different study sites for logistical reasons.

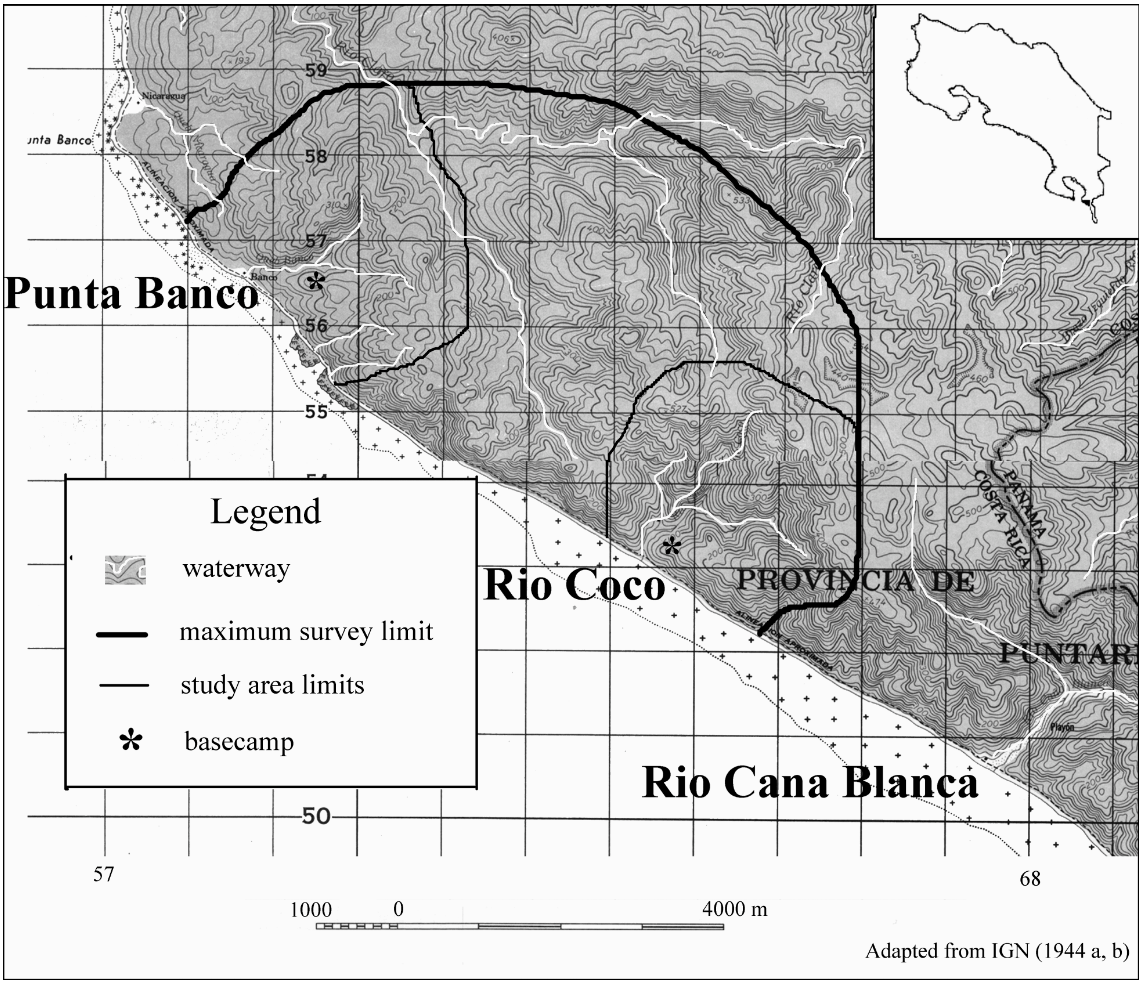

Figure 2.2 Northern Punta Burica displaying study sites of Punta Banco, Rio Coco and Coco-Banco

2.1.3 Punta Banco

Punta Banco is a small beach village, 6 km south of Rio Claro of Pavones in the Puntarenas Province. The village is located in the mouth of the Golfo Dulce opposite of the Osa Peninsula (8°56' N and 83°58 W) (IGN 1944a).

The area is accessible by dirt road and with a public bus service from San José. It is possible to fly into Punta Banco to the private airstrip of Tiskita Jungle Lodge. Excluding the Jungle Lodge, there are about 48 buildings in the village including a school, church, two small grocery stores, two restaurants and a football field (Arauz *et al* 1999).

Punta Banco is characterised by the Holdridge life zone of tropical wet forests (Tosi 1969). The survey area comprises approximately 7 km^2 (700 ha) and is surrounded by primary, secondary and riparian forests of private ownership. There are varying degrees of fragmentation as well as varying degrees of protection for the forests.

It is a humid area with a hydric index of 0.83 – 0.50 (20-100%). The temperature range is 24°C - 28°C (Kapelle *et al* 2002). The rainy season is about 8 months long, beginning in May and ending in December, with the wettest months in September and October. Annual rainfall is 3,500-4,000 mm (IMN 1982). The altitude of the surveyed area ranges between 0 and 310 m (IGN 1944a).

The geologic landforms of the terrestrial surface are volcanic in origin and composed of sedimentary rocks (Castillo-Muñoz 1983). The soils of Punta Banco are deep red in colour, heavy textured, and have low levels of fertility (Vásquez-Morera 1983).

The base camp in the Punta Banco site, the Yoga Farm, is situated in the hills, about a fifteen minute walk to the centre of town. It resides in a valley with other settlers from North America and Europe. The valley has been extensively altered by the people residing there, but the Yoga Farm has maintained tree coverage, mostly of fruit producing trees. These trees connect to a corridor of primary forest adjacent to the property.

2.1.4 Rio Coco valley

The Rio Coco valley is within the Ngäbe Indigenous Territory of Conte Burica (Fig. 2.3).

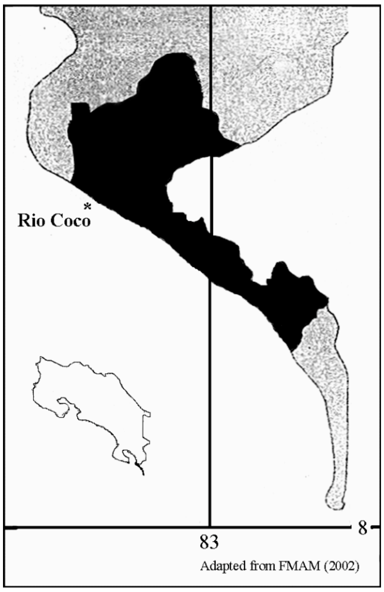

Figure 2.3 Rio Coco with respect to the Conte Burica Ngäbe Indigenous Territory

The mouth of the river is located 6 km south of Punta Banco and empties into the Pacific Ocean (8°53' N and 83°63' W) (IGN 1944b). The area is accessible by foot or horse. During the hours of low tide one can access Rio Coco via the beach at a brisk walking pace in one hour. One can also access the river valley by use of *caminos* ("footpaths") at a brisk walking pace in two hours time.

This region is characterised by the Holdridge life zone of tropical wet forests (Tosi 1969). The study area comprises approximately 7 km^2 (700 ha) of primary, secondary, and riparian forests circumventing the river valley. Scattered throughout the forests are human settlements upon the ridges and peaks of the mountains, where the altitude ranges between

0 and 554 m (IGN 1944b). The areas of deforestation are mostly around these human settlements (Carbonell-Torres 1998).

This region is characterized as a humid area with a hydric index of 0.5 – 0.83 (20-100%) (Kapelle *et al* 2002). The rainy season is about 8 months long, beginning in May and ending in December, with the wettest months in September and October. Annual rainfall is 3,500-4,000 mm (IMN 1982).

The geologic landforms are mainly marine sediments interspersed with volcanic rocks (Castillo-Muñoz 1983). The soils of the Rio Coco valley are deep red in colour, heavy textured and have low levels of fertility (Vásquez-Morera 1983).

The base camp in the Rio Coco valley was located 300 m south of the mouth of the river and 300 m up from the beach. The property is a 2 ha clearing in primary rainforest. Fruit trees were kept on property for human consumption.

2.1.5 Rio Coco-Punta Banco (Coco-Banco)

The 6 km between the village of Punta Banco and the Rio Coco river valley were surveyed during periods of travel between study sites. Three routes were utilized: one was the beach, edged by primary forest, and the other two were trails that passed through a matrix of habitat types. The first trail is the most commonly used by the locals for commuting between the reserve and Punta Banco. It consists of wide horse trails passing through forest, pasture, homesteads and cultivated areas. The second trail route is not commonly used and runs through a similar matrix of habitat types in addition to the riparian forests of Rio Claro. The surveys in this area are distinctly different than the previous two study sites as they represent a much more fragmented landscape. Due to the inclusion of Coco-Banco, an area of approximately 30 km^2 (3,000 ha) was surveyed in northern Punta Burica.

2.1.6 Corcovado National Park

Corcovado National Park is in the southern Puntarenas Province on the Pacific side of the Osa Peninsula (Hartshorn 1983). La Leona ranger station was the base camp for a 5 day rapid assessment of the primates. This is the most southeast portion of Corcovado National Park (8°26’ N and 83°30’ W) (Fig. 2.4).

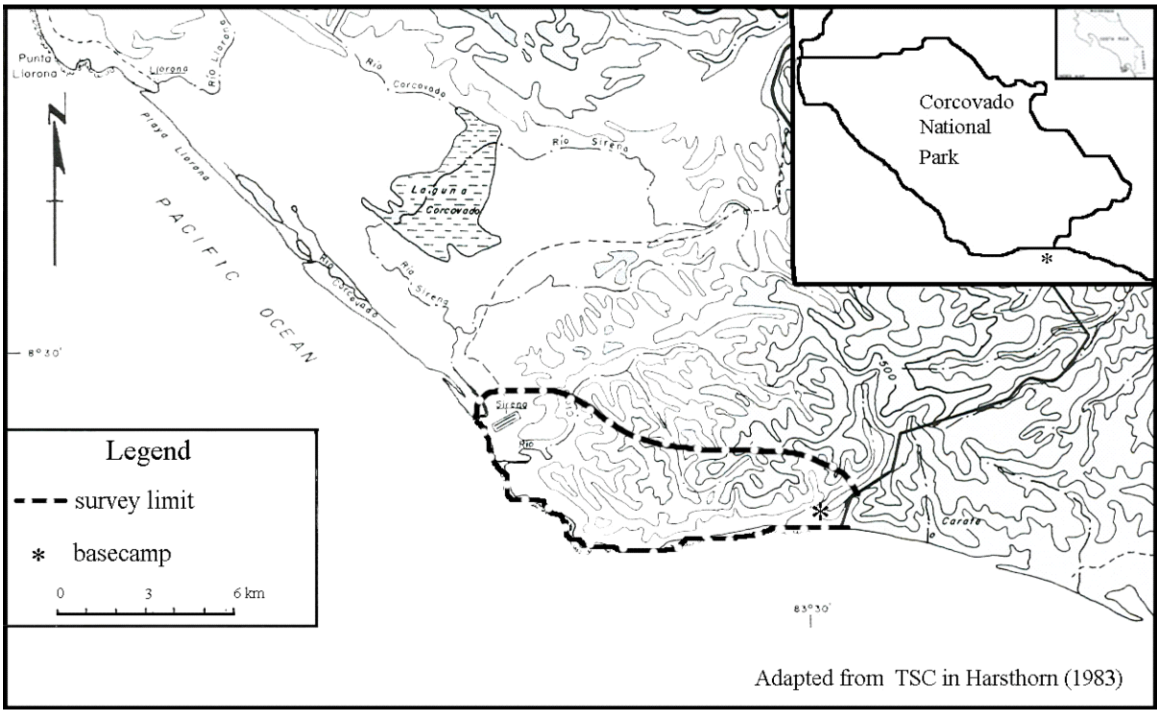

Figure 2.4 Survey area in Corcovado National Park

Access to La Leona involves a series of transportation options. A ferry of 1.5 hours carries one from Golfito to Puerto Jiménez. From here one takes a collective taxi for two hours to Carate. Next one walks for one hour at a brisk pace to arrive at La Leona, the first ranger station encountered in Corcovado.

The surveyed area encompasses approximately 28 km^2 (2,800 ha). The altitude of the surveyed area ranges between 0 and 350 m. This region is characterised by the Holdridge life zone of premontane tropical wet forests (Tosi 1969). The temperature ranges between

24°C -28°C and the area is very humid with a hydric index of 0.83-1.00 (0-20%) (Kapelle *et al* 2002). The average annual rainfall is between 5,000 and 6,000 mm and the dry season is one to two months long (Hartshorn 1983). The geologic landforms are recent alluvial and marine sediments along the coast (Castillo-Muñoz 1983). The soils are reddish, heavy textured, strongly eroded and of very low fertility (Vásquez-Morera 1983).

2.2 Background to the primates of Punta Banco

2.2.1 Mantled howler monkey (*Alouatta palliata palliata*)

The mantled howler monkey (hereafter, *Alouatta* and howler monkey) has a natural range from eastern Mexico through Panamá, with the exception of the Yucatán Peninsula. It also ranges west of the Andes from Colombia to northern Peru (Emmons 1997) (Fig 2.5).

Figure 2.5 Distribution of *Alouatta palliata palliata*

Crockett (1998) reported that this subspecies is classified as lower risk, which mirrors the absence of it on the red list of threatened species (IUCN 2004). Carpenter (1934) pioneered the study of howler monkeys on Barro Colorado Island in Panamá. Neville *et al* (1998) have reported extensive studies of this species since then. Gonzalez-Kirchner and Sainz de la Maza (1998) concluded that howler monkeys were threatened by the hunting practices of the Ngäbe Amerindians. This is also supported by the report of Carbonell-Torres (1998).

Howlers occupy a variety of forest types in the Neotropics including dense primary forest, coastal mangrove forest, secondary forest and mountain forest (Charlat *et al* 2000). However, howler densities have been positively associated with forest age (Fedigan and Jack 2001). This can be explained by their partially folivorous feeding strategy. Their feeding sources must be able to withstand their large body size while foraging at the tips of branches (Tomblin and Cranford 1994). Therefore it is expected that more howlers will be detected more often in older forests with large, robust trees (Fedigan and Jack 2001).

Each of the above forest types are represented in the study area, therefore a prediction solely based on habitat type would suggest that the howler monkeys would exist in healthy numbers throughout the study region of Punta Burica. This optimistic hypothesis is negated however by the historical use of howler monkeys as food and medicine in many parts of the Neotropics (Crockett 1998), with clear confirmation of these practices in the study forest among the Ngäbe people (Carbonell-Torres 1998; Gonzalez-Kirchner and Sainz de la Maza 1998).

The genus *Alouatta* may be under-detected due to their relative inactivity in the upper canopy (Freese *et al* 1982), however this may be counteracted by their conspicuous group sizes and loud vocalizations (Neville *et al* 1988).

2.2.2 Panamánian red spider monkey (*Ateles geoffroyi panamensis*)

The Panamánian red spider monkey (hereafter, *Ateles* and spider monkey) has a natural range extending from Panamá, west of Cordillera San Bias, excluding the Azuero Peninsula, through central western Costa Rica (IUCN 1982) (Fig. 2.6).

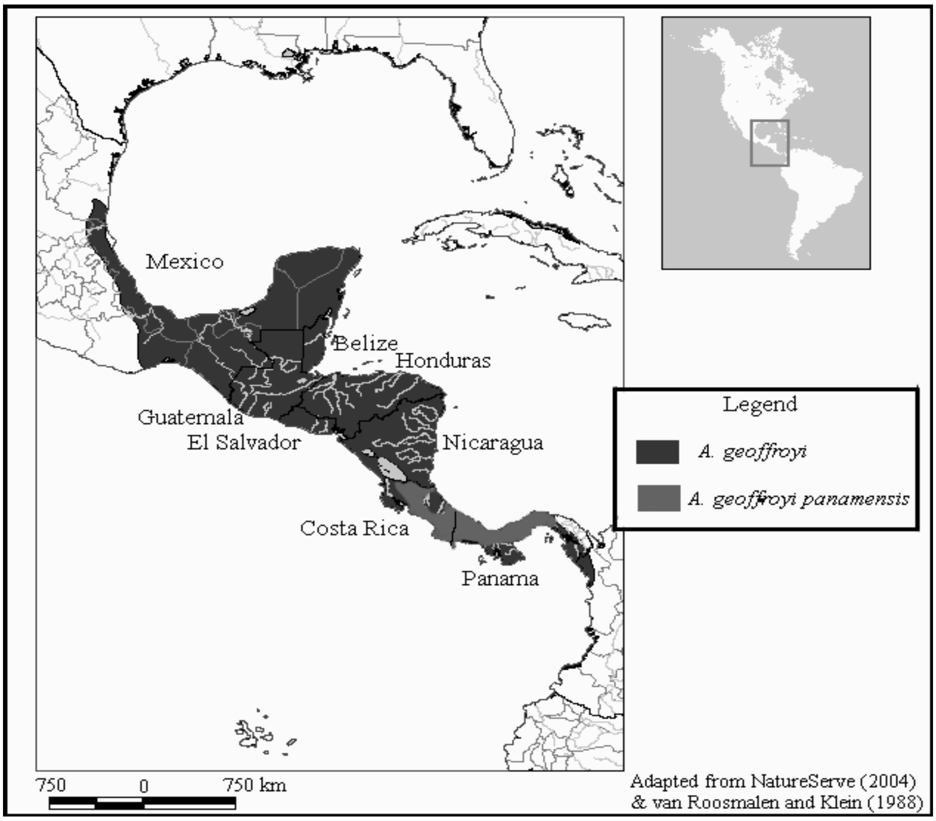

Figure 2.6 Distribution of *Ateles geoffroyi panamensis*

The first scientific documentation of this subspecies of spider monkey was made in 1935 by Carpenter in the Coto region of Panamá, near the southwest Costa Rican border. This subspecies is listed as endangered by the IUCN (Rylands *et al* 2000) and was once considered being amongst the most endangered primate subspecies in the Neotropics (Pineros 1994). Rylands *et al* (1997) reported that there are protected populations of this subspecies remaining in Corcovado National Park and the Carara Biological Reserve, both of Costa Rica. This subspecies exists in healthy numbers in Corcovado (Pineros 1994;

Rylands *et al* 1997; Weghorst 2001). There is also an introduced population in the Barro Colorado National Monument located in Panamá.

Baldwin and Baldwin (1976) did not report any sightings of the spider monkey in the Chiriquí province of Panamá, which overlaps the study region of Carpenter (1935). Carbonell-Torres (1998) additionally did not document any sightings of the spider monkey during his seven-month study of the mammals. One of his final recommendations was that the populations of the spider monkey be studied and evaluated for the ease of population recuperation. The spider monkeys of this region have been a prized source of meat for the local Ngäbe Amerindians, which have shared their reserve with the habitat of the spider monkey (Gonzalez-Kirchner and Sainz de la Maza 1998) since 1975 (FMAM). Historical hunting pressure strongly influences the abundance of the genus *Ateles* (Sorenson and Fedigan 2000) because they are a K-selected species that have a slow life history reproducing every 3-4 years (Klein and Klein 1976).

It is predicted that the spider monkeys will exist in low numbers due to their slow recovery from hunting pressure (Klein and Klein 1976) and the grim findings of Carbonell-Torres (1998). It is also expected that the populations may be underestimated due to their tendency to aggregate in areas inaccessible to humans (Branch 1983), their reputation for fleeing from humans due to high hunting pressure and their ability to travel great distances very rapidly (Fedigan and Jack 2001). Detection may be further inhibited by their tendency to aggregate in small subgroups, on account of their fission-fusion social organization (Carpenter 1935; Chapman *et al* 1993; Chapman *et al* 1995).

2.2.3 White-throated capuchin monkey (*Cebus capucinus capucinus*)

The white-throated capuchin monkey (hereafter, *Cebus* and capuchin monkey) has a natural range from Honduras south to northern Colombia, west of the Andes to northern Ecuador (Freese and Oppenheimer 1981) (Fig. 2.7).

Figure 2.7 Distribution of *Cebus capucinus capucinus*

There have been extensive behavioural studies of this species in Costa Rica, but little published data on surveys (Carrillo *et al* 2000; Pruetz and Leasor 2000; Pruetz and LaDuke 2001; Pruetz and Leasor 2002). Perhaps the lack of survey data is due to the abundant, non-threatened nature of this species (IUCN 2004). In northern Punta Burica it is known that capuchins are hunted as pest species due to their tendency to raid human crops (Carbonell-Torres 1998; Gonzalez-Kirchner and Sainz de la Maza 1998). Carbonell-Torres (1998) recommended conservation action for the capuchin monkey populations of Rio Coco.

Capuchins are opportunistic feeders, enhancing their ability to exploit a variety of habitats, including disturbed areas (Johns and Skorupa 1987). Their medium body size allows them to utilize smaller trees of secondary forests and disturbed habitats, unlike the larger genera of *Alouatta* and *Ateles* (Fedigan and Jack 2001). Due to their adaptability *Cebus* is expected to reside across a variety of habitats including gallery forests (Fedigan and Jack 2001), and human cultivated landscapes (Tomblin and Cranford 1994). Their conspicuous behaviour (Perry *et al* 2003) suggests that there will not be substantial difficulty in detecting this species.

2.2.4 Black-crowned Central American squirrel monkey (*Saimiri oerstedii oerstedii*)

The black-crowned Central American squirrel monkey (hereafter, *Saimiri* and squirrel monkey) has a limited natural range endemic to the Pacific coasts of southwest Costa Rica and northwest Panamá (Boinski *et al* 1998) (Fig. 2.8).

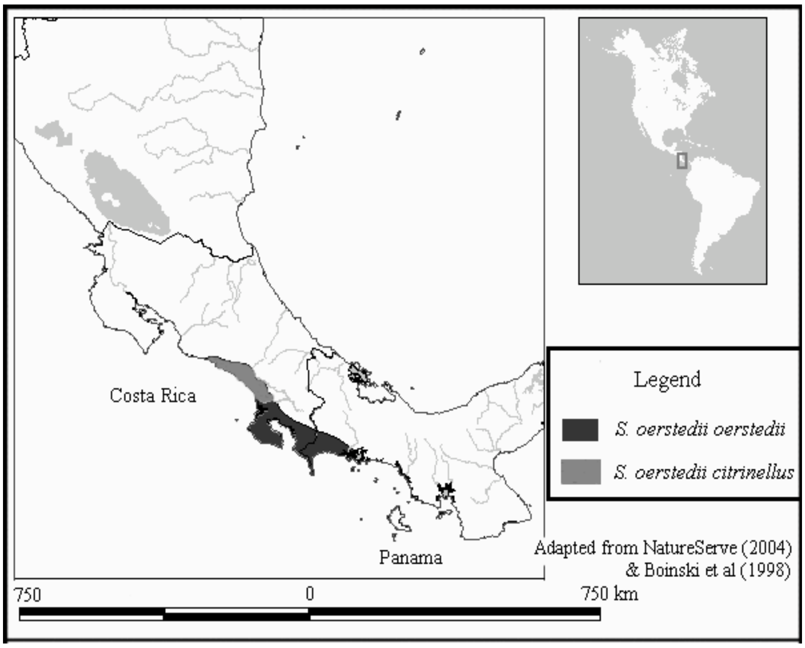

Figure 2.8 Distribution of *Saimiri oerstedii oerstedii*

The endemism of this subspecies (Rodríguez-Vargas 1999) contributes to its listing as an endangered species by the IUCN (Cuarón *et al* 2003). This monkey is the only genus that has had a specific study conducted in Punta Banco to assess its conservation status (Boinski *et al* 1998). Boinski *et al* (1998) concluded that this species was "drifting to extinction" with a count of 258 animals dispersed among 9 troops within the proposed survey area. The methodology used in the study included non-random transect sampling for a census count. This subspecies has also been studied on the Osa Peninsula (Carrillo *et al* 2000), and there are two protected populations in Corcovado National Park and the Golfito National Wildlife Refuge (Rylands *et al* 1997).

The squirrel monkey exists in a wide variety of habitats (Rodríguez-Vargas 1999), but principally exploits riparian forests (Freese *et al* 1982), secondary forests, and other disturbed habitats (Boinski 1987). The high quality and young foliage characteristic of regenerating forest invites arthropods, the squirrel monkeys principle food source (Boinski 1986). Consequently, it is predicted that *Saimiri* will be detected in disturbed habitats more often than primary forests, in addition to riparian forests (Freese *et* al 1982; Sorenson and Fedigan 2000).

The noisy nature of this genus and its tendency to travel in large groups may facilitate their detection (Boinski 1986). Observation may also be facilitated by the ease with which this species is habituated in a mere ten days (Baldwin and Baldwin 1972). However, detection may be inhibited by a potential fear of humans due to a strong history of this genus being exploited for the pet trade (Boinski *et al* 1998).

2.3 Pilot Study

The study area was visited from 3-23 January 2005 to assess the feasibility of conducting research at the site. During this time I acquainted myself with the sponsor and instigator of the project, Gabriel Schmerler, at his home, the Yoga Farm, near Punta Banco. I also spent time in the forest familiarizing myself with my guide-to-be, the study terrain, the study subjects, and the intentional methodology of line transect sampling. Line transect surveys have been used widely to quantify primate population abundance in tropical forests (Neville *et al* 1976; Peres 1999). The strict methodology of line transect surveys requires random selection of survey trails to produce robust density estimates (Buckland *et al* 2003). However, it was too difficult to randomly select trails for surveying due to the steep river valleys that dominate the study area. Alternatively, the reconnaissance survey method was opted for, which is a modification of line transects (White and Edwards 2000).

2.4 Primate survey

The reconnaissance method utilizes pre-existing forest trails and waterways to survey animal populations (Walsh and White 1999). Since the trail selection is non-random, these surveys cannot be used to generate density estimates, but produce general indices of animal abundance (White and Edwards 2000). Since they use non-randomly selected survey routes, this method introduces biased detection rates. This is because some animals are prone to utilize human trails and waterways, including the genera *Alouatta* and *Saimiri* (Freese *et al* 1982), while others are known to avoid them, including historically hunted animals (Neville *et al* 1976), exemplified by the genus *Ateles* (Gonzalez-Kirchner and Sainz de la Maza 1998). In addition, samples from reconnaissance surveys tend not to represent the study area because certain vegetation types are avoided and others selected preferentially (White and Edwards 2000).

To account for these inherent biases of the reconnaissance method, in addition to using pre-existing trails and waterways, newly cut trails were integrated into the survey design. These trails were chosen in a non-random fashion due to the mountainous terrain of the study area. Consequently, newly cut trails occurred where guides felt confident about traversing. Disturbance was minimized by limiting the use of machetes to prevent frightening off the animals (Brockelman and Ali 1987) and harming the vegetation. Use of the reconnaissance method maximized survey time because it enabled the collection of data during periods of travel throughout and between study areas, resulting in the Coco-Banco data.

Data was collected by recording observations of monkey troops while walking at a pace of 1-2 km/hr (Brockelman and Ali 1987; Peres 1999). The index sightings per kilometre was used to estimate animal abundance. This is a commonly used index of abundance (Glanz 1990; Glanz 1991; Carbonell-Torres 1998; Carillo *et al* 2000; White and Edwards 2000; Nekaris and Jayewardene 2004). Sightings are reported as groups per kilometre (grps/km), instead of individuals per kilometre, due to the difficulty of accurately assessing how many monkeys are in a troop (Defler and Pintor 1985; White and Edwards 2000). This is common practice for gregarious neotropical primates (Glanz 1991; Carbonell-Torres 1998; Peres 1999). The same survey method and index of abundance was used by a previous study of mammals at the Rio Coco study site (Carbonell-Torres 1998), and thus may offer comparable results, as abundance indices are useful in detecting changes in populations over time or across locations (Conroy 1996).

2.4.1 Preparation for surveys

Before initiating the study I familiarized myself with the study subjects, chosen methods, and data collection techniques as a precautionary measure to reduce observer bias (Pruetz and Leasor 2000). Before travelling to the habitat country I watched videos of the study subjects and carefully studied their vocalizations.

Once I reached Costa Rica, I collected data for a week, which was ultimately not used in my data set, but enabled me to practice taking accurate measurements. To further increase the accuracy of estimating distances, myself and the members of my research team, practiced estimating distances of known length until we were able to measure with accuracy (Peres 1999).

2.4.2 Data collection

Data collection for reconnaissance surveys follows that of line transect sampling (White and Edwards 2000). At the onset of each research day, the date, the trail to be surveyed, weather conditions, the individuals partaking in the survey, and the starting time were recorded (Peres 1999). Surveys were normally conducted with a local guide who had knowledge of the animals and their habitat. Three different guides were used during the course of study due to logistics of working in different study sites and also out of respect for the indigenous reserve boundaries and subsequent property lines.

Data collection began in the morning and the afternoon. Primates are known to be most active between the hours of 0600 and 0700 (Defler and Pintor 1985), therefore earlier starts are preferable, for monkeys are most active early in the morning and this ensures the best chances of detection (Peres 1999; Pruetz and Leasor 2002). An afternoon break was taken around the hours of 1100 and 1300 and surveys continued through the afternoon ending between 1500 and 1700 hours. Surveys were not commenced in the incidence of rain, and were abandoned if rain persisted for more than 15 minutes en-route (White and Edwards 2000). The presence of rain inhibits the chances of detecting the animals (Pruetz and Leasor 2002) because the noise may alter animal behaviour and/or observer efficiency (White and Edwards 2000). Upon detection of an animal(s) the following data were recorded:

- Time sighted
- Distance walked on trail*
- Weather conditions (sunny, overcast, drizzly, rainy)
- Species
- Method of detection (visual or audio)
- Number of individuals- when possible
- Age class of animals (infant, juvenile, or adult)- when possible
- Sex class of adults- when possible
- Habitat type*
- Trail type*
- Activity of animals prior to them detecting the researchers
- Behaviour of animals upon detection*
- Perpendicular trail animal/group distance (with distance measured to the centre of the group)
- Angle of observation
- Height of animal(s) (for a group the height was measured to the animal at the centre)

* Details follow bellow.

Distances were measured by pacing the trails adapting the method of Freese *et al* (1982). Every 25 steps were recorded and the pace counted was always marked when concentration was broken. Paces were converted to metres at the end of each day using a conversion factor calibrated for differences in inclination. The conversion factor was obtained by pacing out 20 m segments with varying degrees of inclination and recording the quantity of paces for walking up and down for each angle. This was obtained by finding the average of 10 trials for each angle.

Habitat type was defined using adapted forest classifications of White and Edwards (2000) and types of human induced landscapes (Table 2.1).

Table 2.1 Description of habitat classifications

Habitat type	**Description**
Primary forest	Forest with large trees and a high unbroken canopy and sparse vegetation
Old secondary forest	Forest with large trees and dense vegetation cover on the ground
Mature secondary forest	Forest with large trees showing evidence of past disturbance by humans
Mid secondary forest	Forest without mature trees
Young secondary forest	Areas recently cultivated by humans (fallows)
Riparian forest	Forest adjacent to a river or a stream
Edge	Any area on the border between two habitat types
Fruit patch	A human induced fruit orchard
Homestead	Area inclusive of human habitation
Cultivation	Areas under active human cultivation for subsistence
Pasture	Areas that are used for grazing of cattle and/or horses

Trail type was classified into four categories including horse, foot, stream and new. Horse trails are commonly travelled with horses. They are wide, highly eroded and produce disturbed edges. Foot trails are used commonly for foot travel through the forest. They are less wide and disturbed than horse trails. Stream trails were trails composed of streams or rivers. Finally, the classification of new trails defines newly established transects for the purpose of the study.

Behaviour upon detection was classified according to the typical responses of primates during the habituation process. Description of primate responses to human presence follows the definitions of Williamson and Feistner (2003) (Table 2.2).

Table 2.2 Description of primate response behaviour to human presence

Behaviour	**Description**
Flight	Panicked departure coupled with alarm or fear vocalizations
Avoidance	Groups are relatively calm, silent and disappear quickly without displaying
Curiosity	Responses range from brief monitoring to moving closer to obtain a better view of the observer
Display	Vocalizations and species typical displays are directed at the observer
Ignore	Animals show no reaction to observer

Observations were facilitated by the use of Vanguard binoculars with a view field of 1,000 yards, a Suunto MC-2 precision compass with a clinometre and a fibreglass 60 m measuring tape. Field notes were recorded in a waterproof Rite-in-the-Rain notebook and always with a pencil, to prevent smearing of ink (Bearder *et al* 2003).

Data was also gathered regarding other mammals of the forest. These data were used to report presence. Presence was determined according to site and also signs (Glanz 1991; Carillo *et al* 2000). Signs included tracks, smells and evidence of burrows. The use of detection by signs would not have been possible without the extensive traditional ecological knowledge held by my guides.

2.4.3 Data analysis

Group sightings per kilometre, designated as groups/km hereafter (Carillo *et al* 2000), were calculated manually for each primate species by dividing the number of troops detected in each study site by the total distance surveyed in each study site (Freese *et al* 1982; White and Edwards 2000). The statistics program SPSS 13.0 was used to organize, summarize and analyze the data. The non-parametric Kruskal-Wallace test was used to determine if there were significant differences in sighting rate within each species across the 4 study sites. This test does not differentiate between groups (Zar 1999), therefore when Kruskal-Wallace detected significance, the Mann-Whitney U-Test was utilized to determine what specific populations accounted for significance. This test has been used frequently for determining significant differences between populations (Freese *et al* 1982; Glanz 1991; Carillo *et al* 2000). The replicate unit for analysis was distance walked each day (modification of Carillo *et al* 2000). Significance was assigned at the arbitrary level of 5% (Fisher 1925 cited in Zar 1999).

2.5 Botanical survey

2.5.1 Quadrat

Quadrats are a sampling method that has been used extensively on plants to acquire counts (Krebs 1999). The requirements for quadrat sampling are that the survey area is known and that the organisms being counted are relatively immobile (Krebs 1999). Quadrats were placed in a non-random fashion in relatively flat areas of primary forest. Selective survey of primary forest occurred due to the time constraint. Random selection of quadrats was inhibited by the mountainous terrain. Botanical surveys occurred in the study sites of Punta Banco and Rio Coco. Coco-Banco was not considered for botanical surveys because walking the routes was an all-day-affair and time did not permit. Corcovado was not considered for vegetation surveys due to time constraints and the lack of a field guide.

2.5.2 Quadrat preparation

Quadrats were prepared using a compass to ensure that borders were created in a straight line. They were measured with a fibreglass measuring tape. Edges were noted with a string at waist height and corners were marked by posts (Bullock 1996). The quadrat size of 10 m X 50 m (500 m^2; 0.5 ha) was selected. The size of a quadrat should be proportional to the size and spacing of trees (Mueller-Dombois and Ellenberg 1974). Kent and Coker

(1992) suggest quadrats ranging from 400 m^2 to 1,000 m^2 for woodland canopies.

A long, thin quadrat was chosen because it has the ability to cross more patches than a square or circular one of the same area, thus better representing habitat heterogeneity (Krebs 1999; Ganzhorn 2003) by reducing the impact of clumped vegetation (Mueller-Dombois and Ellenberg 1974).

2.5.3 Data collection

Trees that had a circumference at breast height (CBH) greater than 30 cm were identified. This was to ensure the inclusion of trees with a diametre at breast height (DBH) of 10 cm (DeLuycker 1995; Hammel 1990). DBH is the standard measurement for trees and was calculated by measuring the circumference of the tree at a height of 1.3 m and then dividing by pi (3.1416) (White and Edwards 2000). In the case of trees with buttressed roots the diametre was measured above the buttress (Smith and Killeen 1995). If the buttress was not within reach then the diametre was estimated as if the buttress were not there (Ganzhorn 2003).

Edge effect bias, the tendency for researchers to count all trees on the edge of a quadrat, can lead to overestimated, biased counts (Krebs 1999). To reduce this bias, plants were counted as inside the quadrat if the centre of the trunk was within the quadrat (Ganzhorn 2003).

My field guides had extensive knowledge of the flora and were able to identify many of the trees by their vernacular names, which were recorded. Other identifying characteristics were recorded such as sap colour, bark colour, leaf phenology, presence or absence of buttressed roots, and the fruit and flower description if they were in season. If the trees did not have fruits or flowers at the time of survey my guides provided the colour, size, and shape of the fruits and flowers. As each tree was identified my guides also shared their knowledge concerning the use of the trees by the fauna. Food sources were noted for the monkeys and also the season of fruit availability. In addition to food sources, trees used as sleeping sites were noted. Finally the human use of the trees was recorded along with the Ngäbere names.

2.5.5 Vegetation identification

The vernacular name for each tree was recorded as it was identified by the guide. It was then cross referenced with Fournier-O. and García-D. (1998) where its scientific name was identified. If the vernacular name was not present, or there were multiple scientific names for one vernacular name, then extra careful attention was paid to writing identifying characteristics of the trees and digital photographs were taken of the bark and samples of leaves were pressed in a small vegetation press for identification at camp (White and Edwards 2000) .

At base camp multiple sources were used to cross reference trees in an attempt to correctly pair the proper scientific name with the vernacular counterpart. Further discrepancies were ameliorated with the volunteer assistance of Luis Chalia, who has extensive botanical knowledge for Costa Rica, exemplified by his employment by Katie Stoner for howler monkey botanical studies. Knowledge of Luis came late in the study, so we were unable to work together in the field.

A variety of other available resources were consulted for information regarding food sources for the spider monkeys and conservation status of the trees. These include published works of primate and botanical specialists, field guides and unpublished reports from Costa Rica. The latter were made available from the BIODOC library at Universidad Nacional, Heredia, Costa Rica.

2.5.6 Data analysis

2.5.6.1 Importance value

The importance value index (IVI) was quantified for each species by summing the relative basal area (RBA), the relative density (RD) and the relative frequency (RF) of each species (Krebs 1978). Basal area is the area covered by the cross-section of the tree (Smith and Killeen 1995) and was expressed in m^2 (White and Edwards 2000; Endress 2002). The frequency is the number of subplots in which a single species has been recorded (Smith and Killeen 1995), and the relative frequency is probability of finding the species in any one quadrat (Krebs 1978). These parameters are calculated as follows:

$$BA = r^2\pi$$ (White and Edwards 2000)

$$RBA = \frac{\text{basal area of species x}}{\text{total basal area of all species}} \times 100$$ (Krebs 1978; Endress 2002)

$$RD = \frac{\text{\# inds. of species x}}{\text{total inds. of all species}} \times 100$$ (Krebs 1978; Endress 2002)

$$RF = \frac{\text{frequency of species x}}{\text{sum of frequency values for all species}} \times 100$$ (Krebs 1978)

$$IVI = RBA + RD + RF$$ (Krebs 1978)

Since RBA, RD, RF are percentages ranging from 0 to 100 the maximum IVI is 300 (Krebs 1978).

2.5.6.2. Species diversity

The Brillouin index (H) was used to evaluate genus diversity within each quadrat. This index was selected over the more commonly used Shannon-Wiener diversity index (Basiliko *et al* 2003) because the latter index is not appropriate for non-randomly selected samples (Pielou 1975; De Oliveira *et al* 1998; Zar 1999). The Brillouin index is theoretically the more satisfactory of the two measures (Laxton 1978).

The Brillouin index is weighted towards species richness and is useful in detecting differences between sites (Laxton 1978). It was calculated as follows (Zar 1999):

$$H = \frac{(\log n! - \sum \log f_i!)}{n}$$

Where n = the total number of trees in the sample

f_i = the number of trees observed of genus i

The Brillouin index cannot determine the degree to which each factor contributes to diversity (Elliott and Hewitt 1997), therefore a separate measure for eveness (J) was caluculated as follows (Zar 1999):

$$J = \frac{H}{H_{\max}}$$

Where

$$H_{\max} = \frac{\log n! - (k - d)\log c! - d\log(c+1)!}{n}$$

Where n = the total number of trees in the sample

f_i = the number of trees observed of genus i

c = the integer portion of n/k

d = the remainder

Evenness (J) ranges from 0 to 1 to quantify the range from one dominant pattern to one of complete evenness (Basiliko *et al* 2003). If categories are distributed evenly then the sample is representative of high diversity (Zar 1999).

2.6 Human element

Knowledge of the human element of the study area, including settlement and livelihood strategies, was obtained through informal interviews. These took place with my *Tico* and Ngäbe guides during lunch breaks and were clarified during one translated session each. They did not occur until there was a significant level of comfort and trust between us. A third party was consulted, Peter Aspinall, the owner of the Tiskita Jungle Lodge, who speaks fluent English. These interviews also included their interest in collaborating on a primate conservation project.

Chapter 3: Results

3.1 Primate survey

A total distance of 167.6 km was surveyed in 138.1 survey hours. The distances were quantified using the data in Table 3.1.

Table 3.1 Average paces walked in 20 m for three degrees of inclination and declination

Angle	Up	Down
10	28	26
30	38	32
60	47	41

The distance surveyed in each study site is provided in Table 3.2.

Table 3.2 Total distance surveyed within each study site

Rio Coco	Punta Banco	Coco-Banco	Corcovado
70.9 km	37.31 km	38.83 km	20.52 km

Rio Coco consisted mostly of primary and riparian forest, whereas Punta Banco contained more old secondary forests and Coco-Banco was dominated by edge habitat and pasture (Table 3.3).

Table 3.3 Percent of habitat type traversed within each study site

Study site	Habitat type										
	1°	Old 2°	Mat 2°	Mid 2°	Yng 2°	Rip	Edge	Fruit	HS	Cult	Past
Rio Coco	61	0	5	2	3	13	3	0	3	2	7
Punta Banco	41	23	6	0	1	12	2	2	7	1	5
Coco-Banco	16	0	8	9	6	3	31*	2	0	0	25

Where 1° = primary forest; Old 2° = old secondary forest; Mat 2° = mature secondary forest; Mid 2° = mid secondary forest; Yng 2° = young secondary forest; Rip = riparian forest; Fruit = fruit orchard; HS = homestead; Cult = cultivated; Past = pasture. See Table 2.1 for definitions of each category.
* This value includes beach surveys.

A total of 81 monkey groups were sighted in the following taxa: *Alouatta* (n = 24), *Ateles* (n = 8), *Cebus* (n = 32), and *Saimiri* (n = 17). Differences in abundance varied among species and study area (Table 3.4).

Table 3.4 Sighting rates (grps/km) for each genus in each study site

Study site	**Genus**			
	Alouatta	***Ateles***	***Cebus***	***Saimiri***
Rio Coco	0.13	0.07	0.25	0.06
Punta Banco	0.35	0.00	0.24	0.11
Coco-Banco	0.00	0.00	0.05	0.10
Corcovado	0.10	0.20	0.15	0.05

The following results do not include Corcovado counts. This is because the primary purpose of including the Corcovado surveys was to investigate if there was a significant difference between the spider monkey populations of protected and unprotected areas. In northern Punta Burica a total of 147 km were surveyed in 112 hours, with an average walking speed of 1.3 km/hr. The weather was sunny and clear during 73.5% of the time, overcast 16.2%, drizzly 5.9%, and raining 4.4%. The data from the rainy day was excluded.

A majority of sightings took place in the morning cumulating to 54.4%, whereas 26.5% occurred at midday, and 19.1% in the afternoon. The morning and afternoon sightings combine to equal 73.5% of sightings occurring during the recommended hours of surveying (Peres 1999).

A total of 71 monkey troops were sighted in the following taxa: *Alouatta* (n = 22), *Ateles* (n = 5), *Cebus* (n = 29), and *Saimiri* (n = 16). The proportion of audio and visual methods of detection are summarized in Table 3.5.

Table 3.5 Method of detection for each genus presented as a proportion

	Alouatta	***Ateles***	***Cebus***	***Saimiri***
Audio	0.36	0.60	0.52	0.58
Visual	0.64	0.40	0.48	0.42

Ateles occurred highest in the canopy and *Saimiri* was the lowest (Table 3.6).

Table 3.6 Visibility values for each genus

	Alouatta	***Ateles***	***Cebus***	***Saimiri***
Perpendicular distance with range (m)	12 (0-38)	19.6 (7-31)	17.6 (0-50)	6.6 (0-25)
Height (m)	20.5 ± 8.2	22.4 ± 6.69	18.1 ± 9.42	7.8 ±3.30
Average group size with range (individuals)	4.9 (2-8)	4.3 (3-5)	5.2 (2-12	8.9 (4-18)
Number of solitary individuals	5	1	2	3

I was unable to collect consistent and reliable data on age and sex class of the primates.

3.1.1 *Alouatta*

There were highly significant differences among howler monkey populations across the study sites (Kruskal-Wallace, x^2 = 8.315, **P = 0.01). The results for the Mann-Whitney U-Test (Table 3.7) show that the significant differences occur only for the Punta Banco population.

Table 3.7 Mann-Whitney U-Test results showing that Punta Banco accounts for the significant differences in sighting rates for *Alouatta*

	Rio Coco		**Coco-Banco**		**Corcovado**	
	z	P	z	p	z	p
Punta Banco	-2.489	0.013 **	-2.582	0.010 **	-2.093	0.036 *
Rio Coco			-1.334	0.182	-.0412	0.681
Coco-Banco					-.1.748	0.080

The howler monkeys were seen in a variety of habitat types and on all trail types (Figure 3.1).

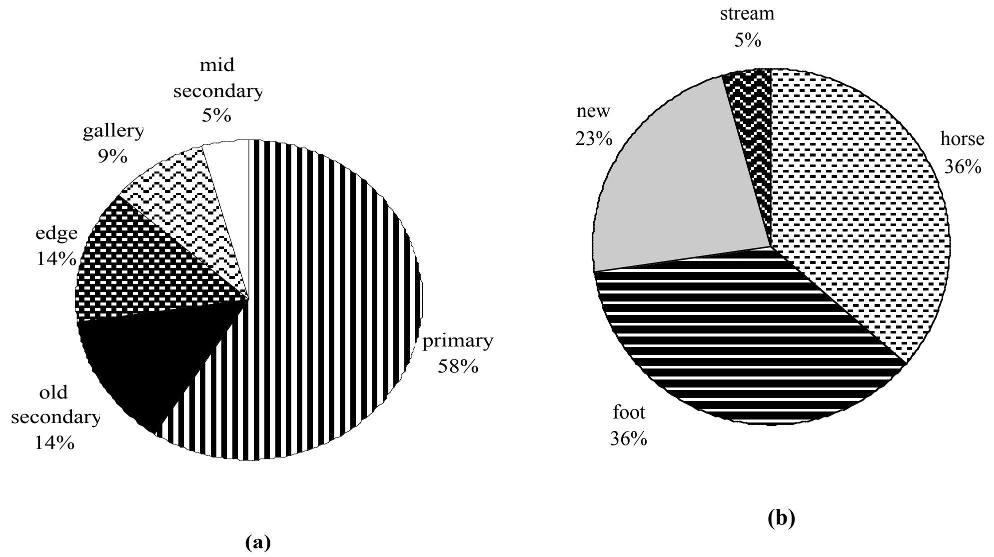

Figure 3.1 Habitat types (a) and trail types (b) where *Alouatta* were sighted (n = 22)

The howler sightings occurred 59% of the time in Punta Banco and 41% of the time in Rio Coco. Sightings occurred in protected areas 55% of the time and the remaining 45% of sightings were in unprotected areas. The howlers reacted with vocal displays 53% of the time, ignored us 35% of the time, and avoided us 12% of the time. Although there were no systematic recordings, the howler monkey was viewed foraging at the base camp of the Punta Banco study site on a handful of occasions. At one time a howler monkey was witnessed travelling along the ground to reach a food source.

3.1.2 *Ateles*

There were no significant differences between spider monkey population across study sites (Kruskal-Wallace, x^2 = 4.713, P = 0.20). The spider monkeys were witnessed exclusively in primary rainforest habitat in mostly trail-less forest (Fig. 3.2).

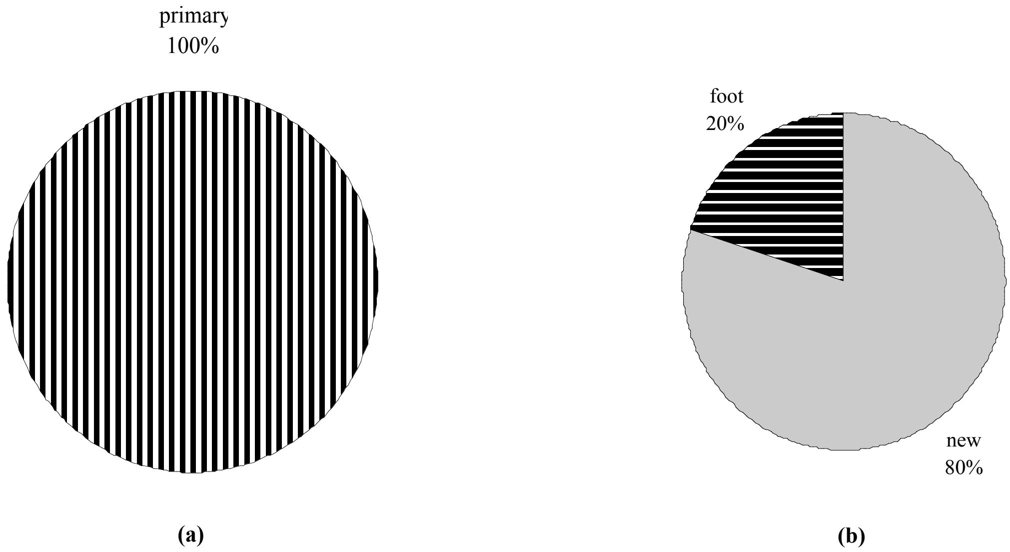

Figure 3.2 Habitat types (a) and trail types (b) where *Ateles* was sighted (n = 5)

The reactions of the spider monkeys were normally a combination of display and curiosity. When spider monkeys were encountered we terminated our data collection and viewed them for as long as possible. A total of 127 minutes was spent viewing the elusive spider monkey. During these time periods the monkeys tolerated our presence and approached us. On one occasion we initially sighted 2 animals and an additional 3 individuals approached from an area out of view, presumably from curiosity resulting from vocalizations of a tail-less adult. In one instance there was no reaction from the monkeys, but they were travelling and did not appear to notice us. Prior to data collection there were two sightings of the spider monkeys, one in January and one in mid May. On both occasions the monkeys vocalized and fled before a count could be made.

3.1.2 *Cebus*

There were no significant differences between sighting rates of capuchin monkeys across study sites (Kruskal-Wallace x^2 = 3.740, P = 0.37). The majority of sightings occurred in trail-less primary forests (Fig. 3.3).

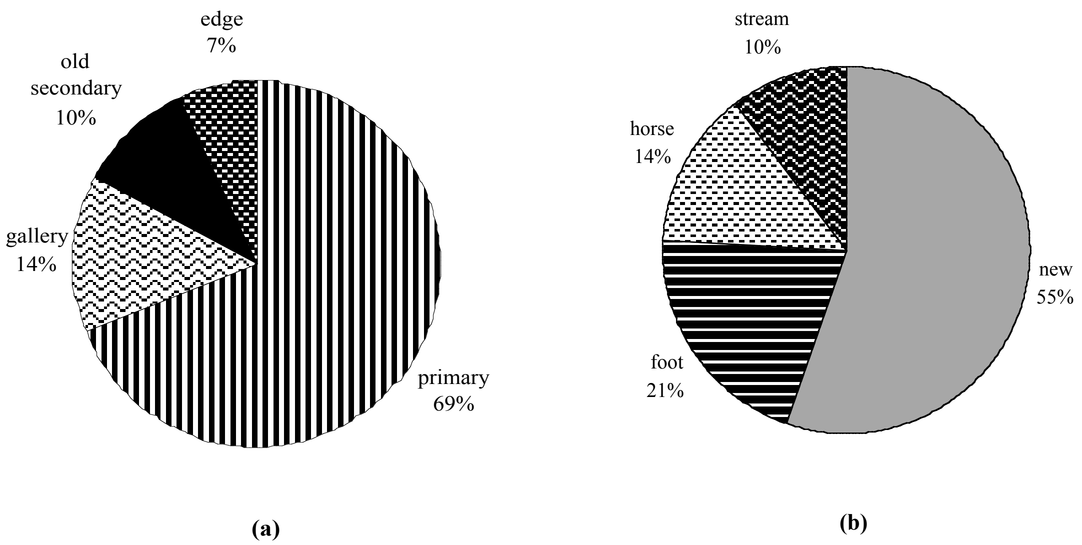

Figure 3.3 Habitat types (a) and trail types (b) where *Cebus* was sighted (n = 29)

The capuchin sightings occurred 62% of the time in Rio Coco, 30% of the time in Punta Banco, and 8% of the time during surveys between the two study sites. Sightings occurred in unprotected areas 72% of the time and the remaining 28% of sightings were in protected areas. The capuchins ignored us 63% of the time, responded by displays 30% of the time, fled 4% of the time and avoided us 3% of the time.

Although there were no systematic recordings, the capuchin monkey was viewed foraging and travelling regularly at the Rio Coco camp and once at the Punta Banco camp.

3.1.4 *Saimiri*

There were no significant differences between squirrel monkey populations across study sites (Kruskal-Wallace, x^2 = 2.399, P = 0.50). Sightings occurred in a variety of forest and trail types (Fig. 3.4).

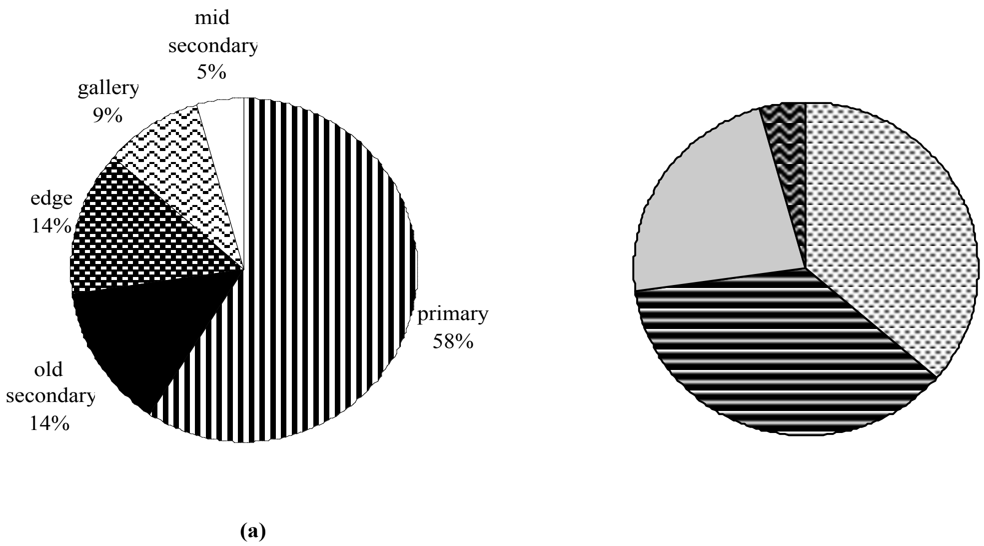

Figure 3.4 Habitat types (a) and trail types (b) where *Saimiri* was sighted (n = 16)

The squirrel monkeys ignored us 60% of the time, showed curiosity 20% of the time, and avoided us 10% of the time. There is no behavioural response data for the remaining 10% of the sightings. Although there were no systematic recordings, the squirrel monkey was viewed foraging and travelling regularly at both base camps.

3.1.5 Other mammals

A complete list of all mammals detected can be found in Appendix 1.

3.2 Botanical survey

A total of 290 trees were measured within 9 quadrats, encompassing a total area of 4,500 m^2. Of these 290 trees, 82% were accurately paired with a scientific name. The remaining 18% were unidentifiable for two reasons. In some cases my guide provided a common name, but there was no complementary scientific name in the literature. In other cases my guides could not provide a common name.

A complete list of trees identified in the field can be found in Appendix 2. Part 1 lists all of the available names with references to the source literature. Part 2 presents trees by scientific name that have ecological, conservation or cultural importance to the local people.

The 10 most important genera in northern Punta Burica are presented in Table 3.8. The 2 most important genera are also the most abundant, *Carapa* and *Virola*. Together these genera comprised 14% of the total trees surveyed. Neither of these trees are food sources for the spider monkey. However, 4 other genera represented in Table 3.8 are food sources.

Table 3.8 Ten most important trees denoted by their IVI, (where IVI = importance value index; RBA = relative basal area; RF = relative frequency; RD = relative density) with notations on their use as food by the primate species

Genus	No. of ind.	RBA	RF	RD	IVI	Food source	Ref. no.*
Carapa	33	125.59	100	11.34	125.59	No	11
Virola	19	3.43	66.67	6.53	76.62	No	35
Guazuma	14	6.00	55.56	4.81	66.37	No	23
Protium	11	2.11	55.56	3.78	61.45	2	3
Hippomane	9	4.24	44.44	3.09	51.78	No	61
Pouteria	10	3.76	44.44	3.43	51.64	1,2,3,4	94, 95
Vochysia	9	3.42	44.44	3.09	50.96	No	75
Ficus	9	3.04	44.44	3.09	50.58	1,2,3,4	46, 47
Spondias	7	3.42	44.44	2.41	50.27	1,2,3,4	51, 52
Cedrela	10	9.14	33.33	3.44	45.91	No	24, 25

1 = *Alouatta*; 2 = *Ateles*; 3 = *Cebus*; 4 = *Saimiri*

* Link to references in Appendix 2.

The genus *Cedrela*, which was the 10th most important genus includes two species of conservation significance, *C. odorata* and *C. tonduzii*, which are vulnerable (Americas Regional Workshop 1998) and threatened (García 2002) respectively (Table 3.9).

Table 3.9 Trees of particular conservation significance

Scientific name	Status	Human Use	IVI[1]	Ref. no.*
Anthodiscus chocoensis	vulnerable	construction	25.23[2]	5
Astronium graveolens	threatened	construction	NI	86
Cedrela odorata	vulnerable	construction	45.91	24
Cedrela tonduzii	threatened		45.91	25
Couratari scottmorii	vulnerable	construction	NI	13
Licania operculipetala	endemic		14.69[2]	15
Tachigalia versicolor	threatened		36.70[2]	83
Terminalia oblonga	threatened	construction	12.01	44
Vantanea barbourii	threatened	construction	NI	30

*Link to references in Appendix 2 where definitions of status are available.
NI = not identified during botanical survey
[1]IVI = importance value index; maximum value = 300; value calculated for genus
[2]Single species represented in genus

There were 3 identified food sources of the spider monkey that are rare and/or present conflict with human needs (Table 3.10).

Table 3.10 Spider monkey food trees that are important for conservation

Scientific name	Status	Human use	IVI[1]	Ref. no. *
Caryocar costaricense	vulnerable	construction	14.9[2]	2
Eschweilera neei	endemic	firewood	40.93[2]	73
Vitex cooperii		construction	NI	60

*Link to references in Appendix 2 where definitions of status are available.
NI = not identified during botanical survey
[1]IVI = importance value index; maximum value = 300; value calculated for genus
[2]Single species represented in genus

The estimate of species richness was low, denoting a low diversity of trees in the sample (Table 3.11).

Table 3.11 Overstory richness (*K,* number of genera present at site), species diversity (H), and species evenness (J) in northern Punta Burica

Quadrat	*K*	H	J
1	15	2.59	0.02
2	12	1.95	0.03
3	14	2.3	0.03
4	10	2.8	0.03
5	15	2.2	0.03
6	14	2.2	0.03
7	8	1.6	0.03
8	12	2.4	0.04
9	9	1.83	0.05
X	12.11	2.2	0.03
SD	2.62	0.37	0.01
Var	6.86	0.14	6.9×10^{-5}

X = average; SD = standard deviation; Var = variance

3.3 Human element

The settlement of Punta Banco occurred in the mid 1970s (Peter Aspinall, pers. comm.). The first wave of settlers came from *campesino* ("rural") families of the Guanacaste province in northwest Costa Rica. Legal rights to land required working the land, which entails clearing the forest (Angelsen and Kaimiwitz 1999). As a result, much of the pristine forests around Punta Banco was decimated for agriculture and cattle grazing (Peter Aspinall, pers. comm.). As the land around Punta Banco was claimed, the second wave of *campesino* families moved south into the mountains. This movement overlapped with the Conte Burica Indigenous Territory of the Ngäbe Amerindians.

The Conte Burica Indigenous Territory was established in 1975 by the Costa Rican government (FMAM 2000). This territory encompasses most of Punta Burica bordering the nation of Panamá (8º25'-8º13; N and 82º07-82º57 W) (Fig. 2.3). The territory includes 11,910 hectares (Cajiao- Jiménez 2002), where 75% is forested with varying levels of human intervention, and almost 50% is primary forest (FMAM 2000). This reserve is home to 1,500 Ngäbe people (FMAM 2000), indigenous to the political nation of Panamá (Barrantes 1993).

The Ngäbe people migrated from their homeland in western Panamá in the mid 1900s due to escalating economic pressures and exceeding the carrying capacity of their homeland (Barrantes 1982). As their populations grew, their homeland could no longer support their traditional form of subsistence, including slash and burn agriculture and the raising of livestock (Bort and Young 2001). Consequently, there has been a dispersal of Ngäbe people across the Pacific side of eastern Panamá and western Costa Rica. Today, the Ngäbe of Conte Burica provide for themselves with their traditional systems of agriculture, exerting pressure on the ecosystem. This is coupled with the limited sales of traditional crafts to tourists in Punta Banco.

It was not determined which human population was responsible for the extirpations of the megafauna of the forest in northern Punta Burica, however it is likely to be a combination of the *Ticos,* the Ngäbe, and outsiders (multiple local informants). Regardless, the extirpation of the megafauna clearly demonstrates a strong negative human influence on the region.

In recent times, the forests immediately surrounding Punta Banco have regenerated, resulting from the influx of tourism to the area (Peter Aspinall, pers. comm.), due to the Tiskita Jungle Lodge. Many members of the Punta Banco community are employed by the lodge, and subsequently gain irreplaceable economic benefits. Peter is also sponsoring the scarlet macaw (*Ara macao*) reintroduction project (*Amigos de los Aves*; "Friends of the Birds"), whose education program is showing to be successful, as there has not been abnormal losses of the reintroduced macaws (Dale Forbes, head biologist, pers. comm.). Tourists also come to volunteer for a sea turtle (four species: *Lepidochelys olivacea, Chelonia mydas, Eretmochelys imbricate,* and *Dermochelys coriacea*) restoration project (PRETOMA), which lasts for a month. Generally, the locals are grateful for the rise in tourism and prefer the tourism work to the hard labour associated with agriculture (Balbino Jimenez-Peres, field guide, pers. comm.). For the above reasons Punta Banco is currently successfully exploited as an ecotourism destination (Arauz and Montero 1997).

However, resource extraction continues, and the Ngäbe reserve remains to be exploited by outsiders for wood extraction, hunting and revenue generation via guided horseback tours (local informants, pers. obs.).

Members of both communities have expressed interest in a primate conservation project and are eager to collaborate, especially among particular members of the Rio Coco Ngäbe community. They have demonstrated the practice of conservation because they have changed their hunting behaviour in response to declining resources by creating a communal agreement five years ago to terminate the hunting of the spider monkey (Ramon Watson, pers. comm.). They have also expressed a concern for the exploitation of their land by outsiders and the increasing pressure on their traditional livelihoods and cultural survival due to capitalistic influences.

Chapter 4: Discussion

4.1 Primate survey

4.1.1 Survey biases

This study contained a handful of biases which may introduce variability and/or result in underestimation of the primate populations. The use of multiple guides introduces a potential source of variability. However, it was in the best interest for the local people and the project to respect the boundaries of the indigenous reserve and extend the employment and training opportunities.

This study had irregular survey hours at dawn and dusk, the times of day when monkeys are most active (Peres 1999), therefore there may be a downward bias in the sighting rates. The irregularity is due to logistical constraints because I did not live in close proximity to my guides. In addition, the onset of the rainy season caused for late starts on many days and the termination of work on others.

The study also contains a seasonal bias. The change in season instigates a change in use patterns by different species (Neville *et al* 1976). This may result in the animals clustering in one area due to food concentrations (Defler and Pintor 1985).

Finally, there are inherent biases associated with my lack of experience in the field (Pruetz and Leasor 2002). Regardless of these biases, I was able to get a general idea of the status of each of the monkey populations. Assuming that my data collection was accurate, and that count based indices are suitable for evaluating population change, for which there exists debate (Conn *et al* 2004), there are some interesting comparisons to be made between sites. On a general note the overall pattern of monkey abundance and habitat use is concurrent with past findings.

4.1.2 *Ateles*

The spider monkey was found to be the least abundant of the four species. *Ateles* is commonly extirpated as it is favoured food due to their large size and ease in hunting (Klein and Klein 1976; Neville *et al* 1976; Jorgenson 1995; Daily *et al* 2003). In addition, modern hunting utilizes expensive ammunition; therefore it is more cost-effective to hunt larger animals (Robinson and Redford 1994). As expected, the spider monkeys were sighted in only primary forests habitats and were only detected in areas of low human impact, mostly in trail-less forest. This is concurrent with other studies (Johns and Skorupa 1987; Sorenson and Fedigan 2000). The visibility of this species was considerably lower than that of Carpenter (1935), who encountered 200 spider monkeys every square mile.

It is interesting that there was no significant difference between the populations of spider monkey in Rio Coco and that of Corcovado, where there was an obvious qualitative difference. There are other reports concerning the abundantly healthy spider monkey populations in Corcovado (Pineros 1994; Weghorst 1997). Carillo *et al* (2000) found an extremely significant difference between the populations of spider monkeys in Corcovado and the Golfo Dulce Forest Reserve, with over 0.4 groups/km in Corcovado. This is double my count of 0.2 groups/km. My sampling effort was constrained by time and resources in Corcovado and the small sample size may not represent the populations there. Perhaps if counts were taken at individuals/km rather than groups/km there were be a higher significant difference between populations, as the spider monkey troops ranged from 3-13 individuals in Corcovado, whereas no more than 5 individuals were seen at one time in Rio Coco. An alternate explanation is that the surveys in Corcovado occurred near the edge of the park and since this genus is sensitive to human disturbance (Johns and Skorupa 1987), it may occur at lower population densities in this area of the park.

It is noteworthy that the spider monkey population is present in the officially unprotected area of the Ngäbe territory, where it has historically been a source of food (Gonzalez-Kirchner and Sainz de la Maza 1998), but absent from the privately protected area of Tiskita Jungle Lodge within the Punta Banco study area. This is an opposite trend from other studies where protected areas harbour more monkeys than non-protected areas (Carillo *et al* 2000). Tiskita is home to 320 ha of forest with a total of 300 ha committed to conservation, 160 of them being primary forest (Tiskita 2005). The home range of spider monkeys in fragmented forests in Mexico is 166 ha (Ramos-Fernández and Ayala-Orozco 2003), suggesting that the primary forest in Tiskita may be capable of housing a small number of individuals. However the narrow corridor between the two study sites is unsuitable for spider monkeys (Chapman 1987), creating a stronger explanation for their absence from Tiskita. It is also important to note that the surveys on the Jungle Lodge property took place on large horse trails, which manifested no sightings of spider monkeys throughout the entire study (Fig. 3.2). This too may contribute to the lack of spider monkey sightings, if there are any present on the property. It is doubtful however, as the owner has not heard of any reported sightings in many years (Peter Aspinall, pers. comm.).

The existence of the spider monkey in the Ngäbe territory can be explained by it being the most suitable habitat, with continuous primary forests and easily subverted human settlements. As a river valley, there are many uncut gallery forests constituted of steep mountain sides. There are two complimentary explanations for this. Firstly, the steep nature of the river valleys makes them impossible to cut. Secondly, the Ngäbe traditionally do not cut their gallery forest (Carbonell-Torres 1998).

4.1.3 *Alouatta*

While my results show an increase in the spider monkey sightings in the Rio Coco study area from 0 to 0.07groups/km, there has been a slight drop in the sightings of howler monkeys from 0.16 groups/km (Carbonell-Torres 1998) to 0.13 groups/km. The abundances of these two species may be interwoven in the matrix of human-wildlife-habitat interactions.

Carpenter (1935) found that with extremely abundant spider monkeys in his study area, howler monkeys were scarce. A reliable local informant noted that since the decline of the spider monkeys from the time that he was a child, 15 years ago, there has been an influx of howler monkeys in the region of Rio Coco. This pattern is also demonstrated in other areas where howler monkeys are the primary seed dispersers in degraded habitat (Estrada *et* al 1999; Andreson 2000; Serio-Silva and Rico-Gray 2003). To understand the significance of this, it is important to re-examine the available information concerning the spider monkey.

The year 1998 not only included the report of Carbonell-Torres, but also the report of Gonzalez-Kirchner and Sainz de la Maza (1998), who found that the spider monkeys were previously hunted weekly as a source of food. With such a high extraction rate it is clear why Carbonell-Torres did not sight any spider monkeys. Perhaps this too is what inspired a handful of Rio Coco community members to terminate hunting of the spider monkey five years ago (Ramon Watson, pers. comm.). Through interviews, Gillett (unpublished MSc data) found that howler monkeys were subsequently hunted more often after the decision was made to terminate hunting of the spider monkey. This may explain the increase of spider monkeys and the decrease in howler monkeys since the time of Carbonell-Torres' report (1998).

Despite the slight decline of howler monkeys in the Rio Coco study area, they were seemingly prolific in Punta Banco where they had the significantly highest sighting rate of all the study areas. Their stronghold in the fragmented area of Punta Banco can be explained by a matrix of factors. One is that howler monkeys are known for their flexibility and adaptability in habitat exploitation and their ability to exist in fragmented forests (Baldwin and Baldwin 1976; Crockett 1998; Andreson 2000). This is explained by their non-specialist, partially folivourous diet, allowing them to exploit fragments of forest (Crockett 1998). Secondly, the lack of spider monkeys suggests that the area can be more readily exploited by the howler monkey, keeping in mind the influx of howlers into Rio Coco after the spider monkey decline.

Finally, Punta Banco is generally more protected than Rio Coco. Glanz (1991) found that protected areas harboured higher densities of howlers. However protection status did not largely affect sighting rates, with 55% of sightings occurring in protected areas and the remaining 45% in unprotected areas. Even when the monkeys were sighted in Rio Coco, they did not display typical flight behaviour of hunted primates, suggesting that the hunting pressure in Rio Coco is not very elevated. Carbonell-Torres (1998) reported that four howler monkeys were hunted during his seven-month research term, however it is not clear whether this off take rate is sustainable or detrimental to howler populations. Peres (1997) found that in hunted forests, howlers were able to maintain their populations, albeit at low densities. He ascribes their survival to their small inter-birth interval that allows them to reproduce rapidly. Conversely, others report that only a small fraction of primates can be harvested without seriously reducing the population (Robinson and Redford 1991), suggesting that any subsistence hunting of primates is not sustainable (Crockett 1998).

The sightings of the howler monkeys at the base camp in Punta Banco is congruent with the literature, which reports that howler monkeys are able to live in close proximity to humans if they are not hunted (Crockett 1998). This is yet another illustration of their adaptability to human altered landscapes. This is also supported by the range of habitat types and trails where howler monkeys were sighted. However, the lack of sightings during the Coco-Banco surveys suggests a limit to the amount of disturbance the howler monkey can tolerate. As predicted, they showed a preference for primary forest, with 59% of the sightings occurring there.

The average troop size of 4.9 individuals may suggest a distressed howler population. Further south on Punta Burica, Baldwin and Baldwin (1976) found average howler troop to be 18.9 individuals. Lippold (1989) had an average troop size of 10.9 individuals in the Cabo Blanco Absolute Nature Reserve on the tip of the Nicoya Peninsula in Costa Rica. Taboga and La Pacifica, located in the Guanacaste province of Costa Rica, and Barro Coloroado Island in Panamá, each had group averages of 11.5, 11.9, and 15.6 individuals, respectively (Heltne *et al* 1976). The average howler troop size is clearly lower in northern Punta Burica. Although decreased group sizes is a behavioural strategy to maximize feeding efficiency (Heltne *et al* 1976; Strier 1992), the considerably low average troop size of northern Punta Burica may be a response to the fragmented landscape, suggesting inhibited howler proliferation (Heltne *et al* 1976).

4.1.4 *Cebus*

The capuchin monkey was the most highly encountered species throughout northern Punta Burica. It is notable that sightings occurred at a high rate in primary forest. This data is synonymous with the minority occurrence of sightings on human trails. This suggests that capuchins prefer primary undisturbed habitats, but their presence during the Coco-Banco surveys implies that this species is also extremely adaptable. This is congruent with the literature (Perry *et al* 2003).

There has been a slight increase in sighting rate of the capuchins since Carbonell-Torres (1998). He encountered 0.22 grps/km whereas we encountered 0.25 grps/km. During the seven-month study of Carbonell-Torres (1998), there were 13 capuchin deaths reported in the Rio Coco study area for pest control. Robinson and Redford (1991), suggest that an off take of 20% of the production of this genus is sustainable. However, without a complete census of the population this percentage can not be determined. Acknowledging that Carbonell-Torres' (1998) data may not be representative of regular off-take rates, tentative conclusions can be drawn. The capuchins have displayed an ability to grow in the Rio Coco study area, suggesting that this rate is sustainable.

The higher sighting rate of capuchins in Rio Coco in comparison to Punta Banco also suggests that the capuchin population is able to sustain itself, even when they are hunted as pests. Along similar lines, the sightings of capuchins occurred 72% of the time in unprotected areas. This implies that protection is not synonymous with capuchin population health in the region of northern Punta Burica.

Capuchin predator response behaviour consists of an incredible display of bravado, warranting them the nickname *monos bravos* (“brave monkey”) (Rose *et al* 2003). This behaviour is even exhibited towards animals that are many times their size. Displays include branch shaking and dropping, at an attempt to threaten and harm potential predators. It is suggested that predator response behaviour is a behavioural tradition among some populations of capuchins which evolutionarily respond to potentially threatening individuals (Rose *et al* 2003). The capuchins responded to us in such a manner during 30% of the sightings. While they exhibited no reaction in 63% of the sightings. This further suggests that humans are not considered a large threat to the capuchins.

4.1.5 *Saimiri*

The squirrel monkey populations exhibited the second to lowest sighting rate. However, as the survey weighted heavily on primary forests there may be an underestimation of this species. This is supported by higher sighting rates in Punta Banco and Coco-Banco than in Rio Coco, despite the smaller sampling efforts. The variety of habitat types they were found to utilize mirror the findings of Rodríguez-Vargas (1999) from the Chiriquí Province of Panamá. As expected, squirrel monkeys were sighted the most in gallery forests and secondary forests, comprising 50% of the total sightings. They were also viewed in edge habitat more than any other species. These occurrences can be explained by their foraging strategy. Squirrel monkeys are insectivorous animals and their arthropod food source occurs most in disturbed habitats (Boinski *et al* 1998). Regenerating forests, compared to primary forest, have a greater abundance of arthropods as a function of an increased proportion of plant biomass as foliage, rather than woody material (Boinski 1986).

The small percentage of sightings in primary forest can additionally be explained by the season. Boinski (1986) found that squirrel monkeys would forage more in the primary forest during the peak of the dry season, when food availability was low. The dry season is concurrent with lower arthropod abundance because there is limited fresh foliage. Synonymously, it is the fresh foliage induced by the wet season that is positively correlated with arthropod abundance (Boinski 1986).

Due to different survey methods, my results can not be directly compared with those of Boinski *et al* (1998) who conducted census counts throughout Punta Burica. However, the squirrel monkey groups still remain where they had counted them previously. They found two groups at the Tiskita Jungle Lodge, and the owner now reports that there are three distinguishable groups (Peter Aspinall, pers. comm.).

This species is threatened by the tourist activity and the development of Punta Banco (Boinski *et al* 1998). It was reported that tourists were feeding the squirrel monkeys, which may have negative impacts on their natural feeding patterns and inter-troop social relations (Brennan *et al* 1985).

4.2 Botanical survey

4.2.1 Survey biases

One bias with the botanical survey is that the quadrats were chosen non-randomly on gradual slopes in primary forests. Another bias was that I used two different guides for identifications. They may know different names for each tree, introducing variability and uncertainty into the results.

4.2.2 Species diversity

The low species diversity and low variability across the sample can partially be attributed to the survey biases of sampling forest plots that only occur on gradual slopes. This narrows the type of trees one would encounter. In a study of forest succession, Endress

(2002) found that there was lower diversity in stands of primary forests compared to stands of young forest. This offers explanation to the low diversity of the primary forest survey plots.

4.2.3 Species highlights

Caryocar costaricense, locally known as *ajo* ("garlic")*,* is a tree of ecological significance to the spider monkey, not only as a food source (Quesada-Quesada *et al* 1997), but also as a regular sleeping site (reliable local informants). It has been reported that spider monkeys use only large trees as sleeping sites and that they use the same trees repeatedly (Chapman 1989). In addition to being large, Chapman (1989) also discovered that every sleeping site appeared to have difficult access for the monkeys. The *ajo* trees identified in the field always had numerous vines growing from them and were very large. These trees fulfill the criteria for sleeping sites observed by Chapman (1989) and support my guides' knowledge. Three of the sightings of the spider monkey occurred in an *ajo* tree.

This tree is highly desired for construction, for it is extremely durable and resists rotting in the tropics (Quesada-Quesada *et al* 1997; Jiménez-Madrigal 1999). It is reported that this species occurs only in Corcovado National Park and is classified as vulnerable in Costa Rica (Americas Regional Workshop 1998) in addition to be included on Appendix II of CITES list of threatened plants (Jiménez-Madrigal 1999). There was one of these trees identified during the botanical surveys. This species requires sustainable management as there is a conflict between the needs of the humans and the spider monkey population.

Eschweilera neei, locally known as *ollita*, is endemic, restricted and rare in the southwest of Costa Rica (Harmon 2004). A reliable guide says that it is a food source for the spider monkey and Harmon (2004) reports that its seeds are dispersed by monkeys. This suggests that this species has a mutualistic relationship with the spider monkey.

This genus is valued for its wood (Hartshorn 1983) and the Ngäbe use it for firewood. This presents a conflict of interests and suggests management is necessary.

4.3 Human element

The historical human influence demonstrates excessive pressure on the forest ecosystems of the study area, illustrated by the deforestation and extirpation of the forest megafauna. The human influence on this area is similar to that of the Coto Brus region of Costa Rica. There it was found that 10% of the species supported by the region have been extirpated. They are the largest species in their families and include the giant anteater (*Myrmecophaga tridactyla*), mantled howler monkey, Central American spider monkey (*Ateles geoffroyi*), jaguar, white-lipped peccary, and the tapir. The human population of Punta Burica is bound to increase in time, which will elevate pressure on the monkey populations and their forest resources (Hill 2002). Extirpation of the megafauna in northern Punta Burica (Carbonell-Torres 1998) indicates the beginning of biodiversity degradation, with probable subsequent extirpations of the arboreal primates, if forest cover continues to decline or continues to be fragmented (Daily *et al* 2003). It is most likely that the spider monkey would be the first to be extirpated due to their specialist frugivorous diet (Carpenter 1935; Chapman *et al* 1987) and their need for large tracts of undisturbed forest (Johns and Skorupa 1987; van Roosmalen and Klein 1988; Sorenson and Fedigan 2000). Additionally, slash-and-burn agriculture, the traditional form of subsistence for the Ngäbe people, has been shown to be the number one cause for depletion of habitat for spider monkeys (Ramos-Fernández and Ayala-Orozco 2003).

The existence of the Ngäbe people within the study area is reason to elevate Punta Burica as a conservation priority. This group of people has been included in a compilation titled “Endangered Peoples of Latin America” (Stonich 2001). Since *Homo sapiens* are a part of the biota (McNeely 1993; Callicott *et al* 1999), biodiversity conservation is not just about wildlife, but is inclusive of the diversity of cultures. Cultural survival and cultural diversity are interdependent with environmental conservation and biodiversity, where the loss of either can cause the loss of both (Mc Neely 1993; Stevens 1997). Without the rainforest, drinking supplies would dry up, soil would wash away, and ocean waters would become contaminated, with undeniable threats to survival and traditional ways of life (Archibold and Davey 1993; van Ierlan *et al* 1998).

Chapter 5: Future Directions and Considerations

5.1 Biodiversity conservation and cultural survival

Biodiversity conservation and cultural survival are interdependent (Bright and Morris 2000), therefore an effective conservation policy must address the basic question: how can people be convinced to act in the interests of wild animals (Strum 1986)? The community of Rio Coco has expressed interest for a cooperative conservation effort as long as their basic human needs are met. Historically, this group of people has experienced tremendous hardship, and has sought refuge and fought acculturation by retreating to the mountains (Barrantes 1982; Tädo bu 1997; Bort and Young 2001). Now that the Ngäbe have legal land tenure they are ready to see the end of exploitation of their land by others. Today's conservation measures must be part of the cultural fabric if they are to make a valuable contribution to human welfare (McNeely 1993).

5.2 Mutualistic relations between indigenous peoples and conservation

Protected areas in indigenous territories offer the potential for a unique mutualistic relationship between biodiversity conservation and indigenous cultural survival (Martin 1993). Stevens (1997) outlines the contributions that indigenous communities have to offer conservation, with relevant selections highlighted below: Homelands of extraordinary biodiversity, distinctive cultures of inherent human value, intimate knowledge of the local geography and ecology, and a populace committed to defending land and resources from outside encroachment.

In turn protected areas offer important benefits to indigenous peoples:

Enhanced national and international visibility, including greater concern for human rights and welfare, and about threats to cultural survival, increased national and international support for the defence of their homelands against exploitative encroachment, alternative avenues to development other than commoditization of natural resources and labour include: direct income from national governments, greater legal, logistical, and financial support for grass-roots conservation and development efforts, control over tourism development and subsequent entrepreneurial opportunities, preferential arrangements for employment, and financial, political, and moral support for traditional institutions and leadership within indigenous communities (Stevens 1997).

5.3 Case study: *Otoch Ma'ax Yetel Kooh* sanctuary for spider monkeys

Recently indigenous cultures have been taking it upon themselves to ensure the protection of their lands and their livelihood, effectively conserving biodiversity (Kemf 1993). An example comes from the Yucatán Peninsula of Mexico, and it demonstrates a successful fusion of monkey conservation with the initiative of indigenous peoples. The *Otoch Ma'ax Yetel Kooh* sanctuary for spider monkeys (*Ateles geoffroyi yucatenensis)* was created and is managed by the Yucatec Maya. The sanctuary hosts conservation science studies of the spider monkey as well as ecotourism (Ramos-Fernández and Ayala-Orozco 2003). The local communities decided to protect the monkeys and their habitat due to the perception that spider monkeys are the main attraction for tourists (Vick *et al* 2004). The community members that have worked closely with the scientists in the field have extended their view of spider monkeys beyond that of a resource, to a reflection of their human nature. In addition, working with the monkeys has become a respectable activity (Vick *et al* 2004). This suggests that the experience of working with monkey conservation extends beyond monetary advancement, and is an enriching activity, both spiritually and socially. The Yucatec Maya are able to generate their own income by working within their community which maintains their culture (Vick *et al* 2004).

5.4 Incentives for conservation

Whether the incentive for conservation among human communities in habitat countries is economic, political or spiritual, is arbitrary. It is the interest of the people to collaborate and moreover claim ownership of a project that is the essential element. Without control at the local level, people will not claim responsibility for their living resources (Bower Kux 1991). Some members of the Rio Coco community are ready to claim ownership of a conservation project, but need outside resources to make it a reality.

Traditional and modern methods of resource management are at a crossroads, and if they can meet on the same road they have the great potential for creating protected areas that conserve and enrich cultural and biological diversity (McNeely 1993). In order for the spider monkey population to thrive once again there are two primary things that must happen. First, the hunting of the spider monkeys must stop, and second, pressure must be taken off of their habitat. Although the spider monkey is no longer a significant source of protein for the Ngäbe (Gillett, unpublished MSc data), there still must exist alternatives and incentives if there is to be a strict ban on hunting. There must be food, but more specifically protein alternatives, as well as timber alternatives.

Ecological sustainability can be coupled with sustainable development projects that judge success based on economic *and* ecological criterion (Callicott *et al* 1999). However, these measures must also incorporate and respect the cultural integrity of the Ngäbe people, who possess legal tenure of the land in Rio Coco. There are two possible solutions to creating food and timber alternatives for the Ngäbe which are outlined below. They include ecotourism and agroforestry. The pros and cons of each are discussed within the context of potential application in northern Punta Burica.

5.5 Ecotourism as a potential solution

The definition of ecotourism is much debated (Campbell 2002), but the Ecotourism Society defines it as "responsible travel to natural areas which conserves the environment and improves the welfare of the local people" (Western 1993, p 8). Honey (1999, p 25) offers a more detailed definition:

> Ecotourism is travel to fragile, pristine, and usually protected areas that strives to be low impact and usually small scale. It helps educate the traveller; provides funds for conservation; directly benefits the economic development and political empowerment of local communities; and fosters respect for different cultures and for human rights.

When not practiced with the utmost care, ecotourism threatens the very ecosystem on which it depends (Boo 1990; Honey 1999). Negative ecological impacts include changed animal behaviour (Brennan *et al* 1985; Lippold 1989; Goodwin and Leader-Williams 2000), reduced numbers of species, increased disease transmission (O'Leary and Fa 1993), erosion, changes in water quality, reduction of firewood and an increase in litter (Boo 1990). Additionally, basic services are required to make ecotourism a significant economic force and sought after activity.

In regards to local communities, ecotourism may contribute to the acculturation of traditionally living people. Some people think that indigenous groups should fully integrate into western society while others maintain the importance of diverse human societies. However, indigenous societies are not static (Stevens 1997) and they have the right to self determination. It is not our place to deny indigenous people of the choice to grow and change in ways compatible with the rest of humanity (Redford and Stearman 1991).

Conversely, if the principles of ecotourism are implemented properly it is apparent what the benefits are. A community-based conservation initiative involving hands-on projects with the local people teaching their crafts can be a source of empowerment for all people involved. Tours of the regional ecosystems displaying the intimate knowledge of local people are popular means of ecotourism, and are low impact (Langholz 1999). Such activities generate income and thus encourage conservation of biodiversity (Langholz 1996).

Currently the Ngäbe travel to town to sell their handcrafted hats and bags and receive enough income to meet their sustenance needs created by their marginally productive agriculture. Unfortunately, the Ngäbe are more marginalized by the current tourism activity, as Punta Bancans regularly take tourists horseback riding through the reserve to Rio Coco.

Under the umbrella of primate conservation, *Amigos de los Monos* ("Friends of the Monkeys"), will work towards ameliorating the marginalization of the Rio Coco Ngäbe families. On 3 August 2005 we held our first meeting to discuss ways in which the Rio Coco community could reap benefits from the conservation of the spider monkey.[2] Ecotourism was found to be a useful and desirable solution. Ecotourism is a good example of non-consumptive, but rewarding, use of wildlife and demonstrates that animals are often more valuable alive than dead (Méndez-Arocha and Ojasti 1995). However, in order to avoid the pitfalls of ecotourism, there is full intention of adhering to the principles outlined above. Tourists must be made secondary to the needs of the local people and conservation.

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[2] Minutes of meeting are available in Appendix 3.

The program will be developed to attract eco-travellers who recognize their role as conservationists and who are willing to provide economic incentive for protection of the resources. They must be willing to forgo luxury, convenience and costly amenities of the mass tourist trade in order to experience the authentic and natural living experiences that are becoming rare (Horwich *et al* 1993).

Specifically, the meeting was tailored to attracting research tourists and accommodating them within the reserve in private homes during their research term. A variety of students will be sought including, but not limited to: conservation biologists, primatologists, and social and cultural anthropologists. It is hopeful that the traditional and cultural integrity of the Ngäbe may be preserved in this process for the potential research may support their traditional lifestyle and ecological knowledge. In addition, by bringing employment into the reserve, the involved community members will not have to leave home to find labour work, helping to maintain strong connections with their home. Income can be generated through compensation for hospitality and/or traditional knowledge, and food alternatives can be purchased.

Despite the above benefits of ecotourism, a major pitfall is only partially addressed in the literature. It is said that investment into ecotourism is a risky business for it relies on the vagaries of world economic patterns (Groom *et al* 1991), in addition to the seasonal fluctuation of tourist activity, which equates ecotourism as an unsteady source of income (Boo 1990). What is not addressed in the literature is that the infrastructure necessary for ecotourism to operate is fully dependant upon the finite resource of petroleum (Heinberg 2003). With the impending world oil shortage and inevitable rise in oil costs (Aleklett and Campbell 2003; Simmons 2005), luxurious tourist activities will be the first budget cuts for many people in the developed world (Heinberg 2003); therefore ecotourism is not a sustainable means of income generation. Sole dependence on ecotourism is unethical for it creates reliance on a solution that is not sustainable on a long term, global level. Ecotourism serves most practically as a project initiative, with subsequent integration of tools for bioregional self-sufficiency.

5.6 Agroforestry as a potential solution

A truly sustainable conservation strategy must involve increased bioregional means of self-sufficiency (Holmgren 2002). Agroforestry is one such strategy. Agroforestry is defined by the World Agroforestry Centre as "a dynamic, ecologically based natural resource management practice that, through the integration of trees on farms and in the agricultural landscape, diversifies production for increased social, economic, and environmental benefits (Schroth *et al* 2004a, p 2). Agroforestry helps to maximize output from any given plot of land by making plant communities more resilient which maximizes productivity in return (Schroth *et al* 2004b). An agroforest plot does not serve to replace rainforest, but to maximize space and increase diversity within the home garden so less area is needed with the same or greater yield, decreasing pressure upon wild forests (Holmgren 2002). Intentional cultivation of food, fuel, fibre and timber crops creates a forest-like structure that can provide for the needs of the people and host wildlife (Leaky and Simmons 1997; Nair 1997).

Agroforestry has proven to host high levels of biodiversity. In Sumatra, Michon and de Foresta (1995) reported the density of primates were similar to that of primary forests in a damar (*Shorea javanica*), rubber (*Hevea brasiliensis*) and durian (*Durio zibethinus*) agroforest. The same authors mention the presence of highly endangered wildlife such as rhinoceros (*Dicerohinus sumatrensis*) and tiger (*Panthera tigris*) in damar agroforests, suggesting that these systems may serve as corridors and temporary habitats for these species. Due to their use as corridors and secondary habitats, agroforests offer an important contribution to the conservation of regional biodiversity by enhancing landscape connectivity and reducing edge effect (Michon and de Foresta 1995).

Agroforestry may be a less desirable solution for the local people since the economic incentive is not as strong as tourism. However it has great potential for improving their crop yield and reducing the need for income to buy food, which was the primary problem identified.

Chapter 6: Conclusions

The quantitative results of this pilot study do not strongly suggest that the Panamánian red spider monkey population in the region of Punta Banco is in need of conservation, primarily because there was no significant difference between the protected Corcovado population and the unprotected Rio Coco population. However, this discrepancy has been accounted for. On the contrary, the agreement of some of the Ngäbe community members to terminate hunting, clearly demonstrates a spider monkey population in peril, for they have forgone a preferred source of wild protein (Gonzalez-Kirchner and Sainz de la Maza 1998) and potent medicine (Gillett, unpublished MSc data) in order to ensure survival of this species. Further deforestation and fragmentation will surely instigate the extirpation of the spider monkey (Johns and Skorupa 1987; Ramos-Fernández and Ayala-Orozco 2003). An understanding of the natural history of the spider monkey and the marginalization of the Ngäbe people leads to the conclusion that the population will not increase unless conservation cooperation from the outside is initiated.

The endemic black-crowned Central American squirrel monkey also warrants conservation action supported by the claim of Boinski *et al* (1998) that there is an urgent need for the conservation of this species. Unlike the spider monkey, the may be able to survive further forest fragmentation, but complete loss of forests would be detrimental to this species (Boinski *et al* 1998), as well as to the howler and the capuchin monkey.

As the human population in northern Punta Burica inevitably climbs, local peoples' material needs will increase. Historically, when tropical dwelling peoples are left without economic alternatives, they exploit their natural resources until their decimation (Robinson and Redford 1994). Northern Punta Burica is host to a variety of trees that serve the ecological and human community alike. Their unsustainable use threatens the biotic community, inclusive of the traditional Ngäbe community.

This area is clearly desirable for conservation efforts supported by the proposed inclusion in the *Corredor Biológico Mesoamericano*. The primates in this region are charismatic flagship species and can serve as a rallying point to draw conservation attention to northern Punta Burica (Dietz *et al* 1994; Leader-Williams and Dublin 2000). The instigation of a conservation program may positively affect the primate communities and the Ngäbe people, to ensure this area as a functional biological corridor.

6.1 Recommendations

The potential solutions of ecotourism and agroforestry do not encompass the holistic vision necessary for the ecological and cultural integrity of northern Punta Burica. They are simply feasible starting points for catalyzing a conservation program. The following recommendations are segregated into useful research projects and necessary steps for the advancement of the conservation program.

6.1.1 Research projects:

- Survey the remaining areas of in tact forest of Conte Burica
- Initiate a complete census of the spider monkey populations and determine the extent of their habitat use
- Develop an experimental agroforest plot
- Document the flora of Punta Burica
- Conduct a linguistic study of Ngäbere so that educational materials can be produced in the native Ngäbe language

6.1.2 Conservation project:

- Receive approval from the Ngäbe governing bodies to conduct further work within the reserve
- Receive approval from MINAE, the Costa Rican environmental governing body, for moving forward with a conservation action plan
- Generate finances in order to provide training and at least two jobs for Ngäbe individuals to patrol their territory in order to prevent illicit hunting and timber extraction. One guard should patrol the northward border, near Punta Banco and the other should patrol the border of Panamá, above the Rio Caña Blanca river valley
- Develop educational materials in Ngäbere and Spanish to be disseminated to both the and Ngäbe and *Tico* communities

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Appendix 1 List of mammals detected including scientific and common names.

Order	Scientific	English*	Spanish	Ngäbere	Method of detection
Artiodactyla	*Mazama americana*	red brocket deer	*venado*	büra	track
	Tayassu tajacu	collared peccary	*saíno*	tirö	sight
Carnivora	*Conepatus semistriatus*	striped hog-nosed skunk	*zorro* *zorillo*	kükwä	smell track
	Herpailurus yaguarondi	jaguarundi	*tigre negro* *león breñero* *tigrillo*	küra dürie	sight
	Nasua narica	white-nosed coati	*pizote*	ngübüa	sight
	Procyon lotor	northern raccoon	*mapache*	ngübüagwräi	track
Primate	*Alouatta palliata palliata*	mantled howler monkey	*mono congo*	jüri	sight
	Ateles geoffroyi panamensis	Panamánian red spider monkey	*mono colorado* *mono araña*	münchi	sight
	Cebus capucinus capucinus	white-throated capuchin monkey	*mono cara blanca*	droä	sight
	Saimirii oerstedii oerstedii	black-crowned Central American squirrel monkey	*mono titi*	droäba	sight
Rodentia	*Agouti paca*	paca	*tepezcuintle*	nö	track
	Dasprocta puntata	Central American agouti	*guatusa*	müria	sight, track
	Sciurus grantensis	red-tailed squirrel	*ardilla*	könda	sight
Xenarthra	*Bradypus variegatus*	brown-throated three-toed sloth	*cucula* *perezoso*	cu	sight
	Cyclopes didacactylus	silky/pygmy anteater	*serafin del plantanar*		sight
	Dasypus novemcinctus	nine banded armadillo	*armadillo* *cusucu*	nusi	track
	Tamandua mexicana	northern tamandua	*oso hormiguero*	menduli	sight

*English common names according to Emmons (1997).

Appendix 2.1 Complete list of trees identified in botanical survey with common and scientific names including references. Organized alphabetically by common Spanish name.

Ref. no.	Spanish	English Translation	Ngäbere	Genus	Species	Family	F & G	H	O	II	III
1	*Aguacatón*	water….	duwä krie	*Ocotea*	*insularis*	Lauraceae	65, 101		188		
2	*Ajo*	garlic	ajo	*Caryocar*	*costaricense*	Caryocaraceae	26, 102		72		
3	*Alcanfor*	camphor	mrä	*Protium*	*copal*	Burseraceae	73, 102	347			
4	*Amargo*	bitter		*Aspidosperma*	*myristicifolium*	Apocynaceae	19, 104		32	260	
5	*Amarillón*	yellow	moräin crie	*Anthodiscus*	*chocoensis*	Caryocaraceae	18,104		71		
6	*Arbol de cal*	lime tree	jüdrädä	*Citrus*	?	Rutaceae	31				
7	*Arbol de spine*	tree of spine		?	?	?					
8	*Arbol de uva*	grape tree		?	?	?					
9	*Arrayán colorado*	myrtle red		*Weinmannia*	*pinnata*	Cunoniaceae	92, 108				
10	*Baco*		nökwäda krie	*Brosimun*	*utile*	Moraceae	23, 110	96	222		
11	*Bateo*		cüchara krie	*Carapa*	*guianensis*	Meliaceae	26, 112		210		
12	*Cacao de monte*	mountain cocoa	murä guä	*Theobroma*	*angustifolium*	Sterculiaceae	87, 117	362	316		
13	*Cachimbo*	pipe	cröba	*Couratari*	*scottmorii*	Lecythidaceae	35, 118		192		
14	*Caimito*		camindö	*Chrysophyllum*	*cainito*	Sapatoceae	30, 120				
15	*Camarón*	shrimp	keved	*Licania*	*operculipetala*	Chrysobalanaceae	55, 120	185	79		138
16	*Campanillo*	small bell	märä	*Lindackeria*	*laurina*	Flacourtiaceae	55, 121	329			
17	*Candelo*	candle		*Rollinia*	*pittierii*	Annonaceae	77, 122		29	240	
18	*Candelo*	candle		*Virola*	*surinamensis*	Myristicaceae	91, 122		250		
19	*Canelo*	fool		*Ocotea*	*veraguensis*	Lauraceae	66, 122	339			
20	*Capulín*			*Trema*	*integerrima*	Ulmaceae	88, 124		337		
21	*Cara de tigre*	tiger face		*Aspidosperma*	*myristicifolium*	Apocynaceae	19, 125		32		
22	*Castaño*	chesnut		*Castaneae*	*sativa*	Fagaceae	28, 128				
23	*Caulote*		träbä	*Guazuma*	*tomentosa*	Sterculiaceae	129				
24	*Cedro blanco*	white cedar		*Cedrela*	*odorata*	Meliaceae	28, 129		211		
25	*Cedro dulce*	sweet cedar	yöbö krie	*Cedrela*	*tonduzii*	Meliaceae	86, 130		26	38	
26	*Cedro maría*	cedar housewife		*Calophyllum*	*brasiliense*	Clusiaceae	25, 130		84		162
27	*Cerillo*	match		?	?	?	131				
28	*Chicharron macho*	porkskin male		?	?	?					

Continued. Appendix 2.1 Complete list of trees identified in botanical survey with common and scientific names including references. Organized alphabetically by common Spanish name.

Ref. no.	Spanish	English Translation	Ngäbere	Genus	Species	Family	F & G	H	O	II	III
29	*Chilamate*			*Ficus*	*goldmanii*	Moraceae	42, 133		226-34		
30	*Chiricano*		sule	*Vantanea*	*barbourii*	Humiriaceae	90, 134		182		
31	*Chonta*	palm tree	burö	*Socratea*	*exorrhiza*	Arecaceae	82, 134		47		
32	*Cirricillo*		üränä	*Guatteria*	*tonduzii*	Annonaceae	46, 136	155		233	
33	*Confatillo*		judrärä	?	?	?					
34	*Corteza*	bark	drangüan crie	*Tabebuia*	*guayacan*	Bignoniaceae	85, 143		51		
35	*Fruta dorada*	golden fruit	nivigägra	*Virola*	*koschnyii*	Myristicaceae	91, 154	261	248		
36	*Fruta dorada*	golden fruit		*Virola*	*sebifera*	Myristicaceae	91, 154	263	249		
37	*Guabillo*		solan	*Inga*	*densiflora*	Mimosaceae	51, 158				
38	*Guabo*		bü	*Inga*	spp	Mimosaceae	50, 159		135-48		
39	*Guacalillo*			*Amphitecna*	*sessilifolia*	Bignoniaceae	17, 160			289	
40	*Guácimo*		odöbä crie	*Quararibea*	*asterolepis*	Bombacaceae	75, 170		60	295	
41	*Guarumo*		küra	*Cecropia*	*obtusifolia*	Cecropiaceae	28, 161				
42	*Guarumo*			*Cecropia*	*peltata*	Cecropiaceae	28, 161	109			
43	*Guayabo*	mountain guava		*Terminalia*	?	Combretaceae	87, 164				
44	*Guayabón*	large guava		*Terminalia*	*oblonga*	Combretaceae	87, 164		97		246
45	*Higo*	dried fig	kiga kwädäre	*Ficus*	?	Moraceae	43, 166				
46	*Higuerón*	fig tree	höära	*Ficus*	*maxima*	Moraceae	43, 166		230		
47	*Higuerón*	fig tree		*Ficus*	*obtusifolia*	Moraceae	43, 166		232		
48	*Huevos de caballo*	horse balls		*Stemmadenia*	*donnell-smithii*	Apocynaceae	83, 169	360		169	
49	*Hule*	rubber	kürükwada	*Castilla*	*tuno*	Moraceae	28, 169		223		
50	*Jicaro de monte*	small mountain cup	mrü krie	*Amphitecna*	*haberi*	Bignoniaceae	17, 175				
51	*Jobo negro*		jovo	*Spondias*	*mombin*	Anacardiaceae	82, 176		23		
52	*Jocote*			*Spondias*	*purpurea*	Anacardiaceae	82, 176		24		
53	*Jocote jobo*			*Spondias*	*mombin*	Anacardiaceae	82, 176		23		
54	*Lagarto amarillo*	yellow lizard	laga crie	*Zanthoxylum*	*eckmanii*	Rutaceae	94, 181		289		

Continued. Appendix 2.1 Complete list of trees identified in botanical survey with common and scientific names including references. Organized alphabetically by common Spanish name.

Ref. no.	Spanish	English Translation	Ngäbere	Genus	Species	Family	F & G	H	O	II	III
55	*Lagarto blanco*	white lizard		*Zanthoxylum*	*monophyllum*	Rutaceae	94, 181				
56	*Lechillo*	small milk		*Brosimun*	*spp*	Moraceae	23, 182		218-22		
57	*Lija*	sandpaper	chomingo	*Pourouma*	*aspera*	Cecropiaceae	71, 183				
58	*Madera*	beam		*Gliricidia*	*sepium*	Papilionaceae	44, 185		155		
59	*Mamon*	small fruit		*Talisia*	*nervosa*	Sapindaceae		253			
60	*Manú*		dobö crie	*Vitex*	*cooperii*	Verbenaceae	91, 190	265	340		
61	*Manzanillo*			*Hippomane*	*mancinella*	Euphorbiaceae	49, 191		107		437
62	*María*	housewife	mariä	*Calophyllum*	*brasiliense*	Clusiaceae	25, 191		84		162
63	*Mayo blanco*	white May	my crie	*Vochysia*	*allenii*	Vochysiaceae	92, 193		344		
64	*Mechudo*		chüchügüädä crie	?	?	?					
65	*Mora*	mulberry		*Maclura*	*tinctoria*	Moraceae	57, 195		235		
66	*Mora blanca*	white mulberry		*Rubus*	*glaucus*	Rosaceae	78, 196				
67	*Muñeco*	boy doll	muneca	*Cordia*	*bicolor*	Boraginaceae	34, 196	310	61	315	
68	*Níspiro*	medlar	nomö	*Manilkara*	*staminodella ?*	Sapotaceae	58, 200		297		
69	*Níspiro chicle*	medlar chwing gum	nomön	*Pouteria*	*foveolata*	Sapotaceae	72, 200	244			
70	*Níspiro negro*	black medlar		*Pouteria*	spp	Sapotaceae	72, 200		301-7		
71	*Noni de la montania*	mountain noni		*Annona*	*montaña*	Annonaceae	17			200	
72	*Ojoche macho*		bere	*Brosimun*	*costaricanum*	Moraceae	22, 202	99	219		
73	*Ollita*		nibi crie	*Eschweilera*	*neei*	Lecythidaceae	41	141			
74	*Palmito*		cagun	?	?	Arecaceae	205				
75	*Palo de chancho*	pig tree		*Vochysia*	*guatamalensis*	Vochysiaceae	92, 206		346		
76	*Palo de leon*	lion tree		?	?	?					
77	*Palo de piedra*	stone tree	ägriëä	*Erythroxylon*	spp	Erythroxylaceae	41, 207				344-53
78	*Palo de rio*	river tree		?	?	?					
79	*Paloma*	dove, pigeon		*Lafoensia*	*punicifolia*	Lythraceae	54, 208		199		
80	*Pejibaye de montaña*	mountain pejibaye		*Astrocaryum*	*standleyanum*	Arecaceae	19, 212		37		

Continued. Appendix 2.1 Complete list of trees identified in botanical survey with common and scientific names including references. Organized alphabetically by common Spanish name.

Ref. no.	Spanish	English Translation	Ngäbere	Genus	Species	Family	F & G	H	O	II	III
81	*Pita*	pita fiber	kigä	*Chevaliera*	*magdalenae*	Bromeliaceae					
82	*Quebracho blanco*	white …		*Hasseltia*	*quinquinervia*	Flacourtiaceae	47, 217				
83	*Reseco*	very dry	nodä krie	*Tachigalia*	*versicolor*	Caesalpiniceae	85, 222		128		
84	*Ringion*			?	?	?					
85	*Roble*	oak		*Quercus*	spp	Fagaceae	75, 222		168-9		
86	*Ron ron*	rum rum	ködä krie	*Astronium*	*graveolens*	Anacardiaceae	19, 223		21		
87	*Salamo*			?	?	?					
88	*Suita*			*Acrocomia*	*aculeata*	Arecaceae			130		
89	*Teco*	teak	so krie	*Tectona*	*grandis*	Verbenaceae	86, 232				
90	*Vidrio*	glass	kenä	?	?	?					
91	*Yaya*	granny		?	?	?	240				
92	*Zapatero*	shoemaker	bega	*Hyeronima*	*alchornoides*	Euphorbiaceae	49, 242	174	109		440
93	*Zapote blanco*	white zapote	zäbö	*Casimiroa*	?	Rutaceae	27, 242				
94	*Zapote de monte*	mountain zapote	nomo	*Pouteria*	*sapota*	Sapotaceae	72, 213				
95	*Zapotillo*	small zapote	krie ma	*Pouteria*	*amygdalicarpa* ?	Sapotaceae	72, 243	212	301		

F & G = Fournier-O. and García-D. (1998)

H = Harmon (2004)

O = Quesada-Quesada *et al* (1997)

II = Zamora-Villalobos *et al* (2000)

III = Zamora-Villalobos *et al* (2004)

Appendix 2.2 Tree species identified that are of ecological, conservation or cultural significance. Organized alphabetically by scientific name with reference numbers linking to Appendix 2.1 where references are noted.

Ref. No.	Scientific name	Food for	Conservation significance	Use	Ngäbe use
88	*Acrocomia aculeata*				palms for roofs
71	*Annona montana*		native[1]		
5	*Anthodiscus chocoensis*	rat	vulnerable[2]	durable for construction	
4	*Aspidosperma myristicifolium*			decorative wood crafts	
80	*Astrocaryum standleyanum*	peccary			hats
86	*Astronium graveolens*	parrots	threatened[4]	cabinets	construction harvest for sale crafts
72	*Brosimun costaricanum*	spider monkey			
10	*Brosimun utile*	capuchin monkey other arboreal mammals		latex milk substitute; stomach ulcers; construction bark for blankets nuts taste like bread	
62	*Calophyllum brasiliense*	capuchin monkey	threatened[4]	floors furniture	
11	*Carapa guianensis*	paca		construction cabinets doors	
2	*Caryocar costaricense*	spider monkey	vulnerable[2]	construction resists rotting	
22	*Castaneae sativa*	spider monkey howler monkey			
41	*Cecropia obtusifolia*	monkeys sloths birds			
42	*Cecropia peltata*	monkeys sloths birds	good for reforestation project can tolerate poor soils and lots of sun[5]		

Continued. Appendix 2.2 Tree species identified that are of ecological, conservation or cultural significance. Organized alphabetically by scientific name with reference numbers linking to Appendix 2.1 where references are noted.

Ref. No.	Scientific name	Food for	Conservation significance	Use	Ngäbe use
24	*Cedrela odorata*	no	vulnerable[2]		
25	*Cedrela tonduzii*	no	threatened[4]	floors furniture	
81	*Chevaliera magdalenae*				bags
14	*Chrysophyllum cainito*	spider monkey capuchin monkey paca coati peccary			
6	*Citrus ?*	capuchin monkey toucan paca			
67	*Cordia bicolor*		pioneer species[5]		
13	*Couratari scottmorii*		vulnerable[2]	construction	harvest for sale
73	*Eschweilera neei*	arboreal mammals especially bats rodents		edible nut bark for rope	firewood
29	*Ficus goldmanii*	monkeys			
46	*Ficus maxima*	monkeys bats			
47	*Ficus obtusifolia*	birds			
58	*Gliricidia sepium*	birds		living fence posts	construction medicine for foot fungus
32	*Guatteria tonduzii*				
23	*Guazuma tomentosa*	no	threatened[4]	fine wood cabinets and other interiors insect resistant	
61	*Hippomane mancinella*	no		fine furniture	

Continued. Appendix 2.2 Tree species identified that are of ecological, conservation or cultural significance. Organized alphabetically by scientific name with reference numbers linking to Appendix 2.1 where references are noted.

Ref. No.	Scientific name	Food for	Conservation significance	Use	Ngäbe use
92	*Hyeronima alchornoides*	capuchin monkey squirrel monkey birds	vital ecological component; used in reforestation and plantation projects	rubber construction	
37	*Inga densiflora*	monkeys paca		shade tree in plantations; ant protection	
15	*Licania operculipetala*	ground dwelling rodents	endemic[3]	none, too hard	
16	*Lindackeria laurina*	birds		Panama- leaves for snakebites	
65	*Maclura tinctoria*	no		posts of corrals and fences	
68	*Manilkara staminodella ?*	spider monkey howler monkey peccary			
19	*Ocotea veraguensis*	birds			
74	Palmito				crafts
57	*Pourouma aspera*	spider monkey capuchin monkey			
70	*Pouteria* spp	spider monkey howler monkey capuchin monkey			
95	*Pouteria amygdalicarpa ?*	capuchin monkey other arboreal mammals		sweet and edible fruit	
69	*Pouteria foveolata*	capuchin monkey and other arboreal mammals paca		tasty fruit	
94	*Pouteria sapota*	spider monkey capuchin monkey birds			

Continued. Appendix 2.2 Tree species identified that are of ecological, conservation or cultural significance. Organized alphabetically by scientific name with reference numbers linking to Appendix 2.1 where references are noted.

Ref. No.	Scientific name	Food for	Conservation significance	Use	Ngäbe use
3	*Protium copal*	spider monkey birds		flammable	
40	*Quararibea asterolepis*	monkeys squirrels			
85	*Quercus* spp				construction
17	*Rollinia pittierii*		mediates succession[5]	construction	
66	*Rubus glaucus*	spider monkey howler monkey			
31	*Socratea exorrhiza*			bitter but edible	beds
51, 53	*Spondias mombin*	monkeys birds tapir			
52	*Spondias purpurea*			edible fruit living fence post	
48	*Stemmadenia donnell-smithii*	capuchin monkey		sticky sap for glue and gum	
34	*Tabebuia guayacan*	no		construction	construction harvest for sale
83	*Tachigalia versicolor*	Birds spider monkey capuchin monkey	threatened[4]		
59	*Talisia nervosa*	arboreal mammals esp. squirrel monkey and capuchin monkey		hardwood tool handles	
44	*Terminalia oblonga*	no	threatened[4]	construction cabinets	
12	*Theobroma angustifolium*	monkeys coati racoon	native to tropical America[1]		
20	*Trema integerrima*			decorative wood crafts	

Continued. Appendix 2.2 Tree species identified that are of ecological, conservation or cultural significance. Organized alphabetically by scientific name with reference numbers linking to Appendix 2.1 where references are noted.

Ref. No.	Scientific name	Food for	Conservation significance	Use	Ngäbe use
30	*Vantanea barbourii*		threatened[4]	construction	construction harvest for sale
35	*Virola koschnyii*	birds		seeds for butter and candles general construction	
36	*Virola sebifera*	spider monkey howler monkey capuchin monkey large birds		seeds for illumination wood easy to work	
18	*Virola surinamensis*	mammals large birds		furniture	
60	*Vitex cooperii*	spider monkey howler monkey birds		construction water resistant	construction
63	*Vochysia allenii*	birds		construction	
75	*Vochysia guatamalensis*	no		construction plywood	

[1] Native refers to an organism that naturally belongs to a site (Kapelle *te al* 2002).
[2] A tree is listed as vulnerable by the IUCN when the species occurs in 6-20 locations and when there are a small number of individuals (Jimenez-Madrigal 1999).
[3] Endemic refers to an organism that is restricted to a specific region or locality (Kapelle *et al* 2002).
[4] Threatened does not have a specific definition, but has been labeled as needing conservation action (Garcia 2002).
[5] A species that is able to invade an uncovered space and persist (Kapelle *et al* 2002).
[6] van Roosmalen and Klein (1998)
[7] Ramon-Fernandez and Ayala-Orozco (2003)

Appendix 3: Minutes of the inaugural meeting for *Amigos de los Monos*

Group: ***Amigos de los Monos*- Friends of the Monkeys**

Date: 3 August 2005

Location: Home of Ramon Watson and family, Rio Coco, Conte Burica

Languages: Ngäbere, Spanish and English

Follow-up action	**Person**	**Date**
Create advertisements to attract new researchers to the area	Kathryn Mann	ASAP
Find a Rio Caña Blanca community member that is knowledgeable of the flora and fauna to be employed as a guide in the area	Willian Cortez-Bejarano	soon
Communicate with the community about the project and try to gain support for the conservation initiative	Ramon Watson and family Santos Watson and family Willian Cortez-Bejarano	ongoing
Build an additional living structure for researchers to stay in	Santos Watson and family	November

Present

Kathryn Mann- primate researcher and project coordinator

Ramon Watson, Elena Watson and daughters- Focal Rio Coco family and future hosts

Willian Cortez-Bejarano - Rio Caña Blanca representative and future host

Frederic Diekmeyer- translator

Absent

Santos Watson and Griselda Watson- Focal Rio Coco family and future hosts- these individuals were unable to make the meeting due to difficulties with communications in the reserve. They agreed with all of the decisions made at the meeting.

Agenda

1) Communal meal
2) Introduction and opening remarks
3) Problem identification
4) Solutions
5) How can solution become a reality
   a. Identify needs of participating Ngäbe
   b. Identify needs of students
   c. Identify needs of the project

Discussion, decisions and assignments

1) **First agenda item**

   The meal was a great way for participating members of the meeting to acquaint themselves and relax within the group.

2) **Second agenda item**

   a) Elena shared her dream for the rise in the spider monkey population and wants it to be protected so they can see the population grow.

   b) Willian expressed his interest in the project.

   c) Ramon welcomed us to his home and showed enthusiasm for the potentials of the project.

d) Kathryn expressed her gratitude for the time and effort of the people to participate in the meeting and their enthusiasm in safeguarding the spider monkey populations.

3) **Third agenda item**

a) It was identified that the spider monkey population is in need of protection.

b) It also was identified that the Ngäbe people are subject to fluctuating crop yield and need assistance providing food for their families.

4) **Fourth agenda item**

Research tourism was agreed on as the first step in this process.

5) Fifth agenda item

a) Benefits for participating families need to be as equal as possible. This means that if there is only one student at a time at the site then one family will house the student and one family will have a member employed as their guide.

Permission to walk on property must be gained when a person from another family is not employed by the researcher. This was extended to each researcher gaining permission from every Ngäbe community member whose property overlaps with the survey area.

b) Students need reasonable cost of living to attract them to the site. $7 a day including vegetarian meals was agreed upon.

Students need to have one regular guide to work with.

c) Cooperation with the Punta Banco residents. Permission was given for a Punta Banco resident to be hired to escort future researchers to the reserve.

In the future the project needs to extend to the larger Ngäbe community. Participating member have agreed not continue to not hunt and will encourage other community members to do the same.