

**FINAL REPORT**

**“ASSESSMENT OF FRAGMENTED LANDSCAPES AS HABITAT FOR THE CENTRAL  
AMERICAN SPIDER MONKEY (*ATELES GEOFFROYI*) IN SOUTHWESTERN  
NICARAGUA”**

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## INTRODUCTION

The black-handed spider monkey (*Ateles geoffroyi*) is highly vulnerable across highly fragmented landscapes of western Northern Central America, where the species is either locally extinct or endangered. In Nicaragua, the region's largest country, only three populations of spider monkeys are known to exist along the pacific slope. There has been little documentation of these populations and no targeted conservation efforts to protect them. As part of a long-term regional conservation initiative, the environmental NGO Paso Pacífico has adopted the black-handed spider monkey as a flagship species for the conservation of Nicaragua's remaining tropical dry forests. As a first step in our long-term research program, we sought to characterize one of southwestern Nicaragua's remaining spider monkey populations and its use of a forest fragments. We also used the study as an opportunity to assess the status of two other species (mantled howler monkeys, *Alouatta palliata*, and white-faced capuchin monkeys, *Cebus capucinus*). The results of this study are a critical first step for designing and implementing a community-based reserve on private lands where this spider monkey population survives.

There have been few systematic studies of primate populations in Nicaragua (Crockett *et al.*, 1995; Quan Rodas, 2004), and there are presently no published studies on spider monkeys (Shedden-González, 2005). However, it is commonly understood among local biologists that spider monkeys are completely absent in the majority of forest areas outside of remote forest reserves located on the Caribbean slope. This condition is consistent with multiple studies across the region indicating that spider populations are not likely to persist outside of large, connected forests that are effectively protected from human predation (Sorenson and Fedigan, 2001; McCann *et al.* 2003; Estrada *et al.*, 2004; Pruetz and Leason, 2002; Crockett *et al.*, 1997). The natural history and behavioral traits of spider monkeys make them particularly vulnerable to disturbance relative to

many other new world primates (Rylands et al., 1996). Spider monkeys are exclusively arboreal and have specialized frugivorous diets, which limits their habitat use to high and continuous canopy. They also have a social system that requires a relatively large home range per individual, resulting in smaller group sizes. Additionally spider monkeys have a relatively low reproductive rate (Campbell, 2004). The highly fragmented landscape would thus be expected to have the greatest impacts on this primate species, making it imperative to identify and conserve remaining populations.

A major concern for the three known surviving spider monkey populations is that without immediate protection there is a high likelihood for population decline. There are no protected areas near the proposed study area. Anecdotal evidence and first-hand observations indicate that spider monkeys are frequently hunted in the area's privately held forests. *Ateles geoffroyi* are hunted for their meat used for household consumption and for the widespread domestic and international pet trade. This hunting pressure is of particular concern because elsewhere, sub-species of *A. geoffroyi* have been exterminated resulting from their capture for commercial trade and meat consumption (Rodríguez-Luna et al., 1996). The geographic area within the proposed study is primarily an agricultural-forest matrix. This study will provide important baseline data necessary to design a community-based private reserve, where the very property owners will be the enforcers of protective measures against hunting.

## **RESEARCH GOALS**

With this study, we sought to evaluate spider monkey use of a fragmented landscape in southwest Nicaragua, laying the foundation for the protection of this remnant population. Specifically, our aims were to: (1) Locate and map areas of potential spider monkey habitat; (2) Describe quality of habitat patches in terms of food sources, forest cover and connectivity; (3)

Evaluate the extent to which patch areas are being utilized by spider monkeys; and (4) Train local people and Nicaraguan students in basic methods in primate monitoring.

This research fits within a long-term program by Paso Pacífico to ensure the long-term protection and survival of spider monkeys along Nicaragua's pacific slope. We plan to achieve this goal by raising awareness among local people about the values of this charismatic species and the benefits of living within spider monkey habitat. This process includes conducting educational workshops, promoting local participation in primate research and monitoring, developing eco-tourism activities surrounding wildlife observation, and formulating and implementing a community-based wildlife reserve through the local landowner associations. The proposed study and the works of other researchers will provide scientific inputs to landowner association crucial for the design of the country's first community-based wildlife reserve.

## **BACKGROUND INFORMATION**

One known spider monkey population is located in the southwestern province of Rivas, bordering Costa Rica. Paso Pacífico has been working in the area for the past **six months** and our staff members and local collaborators have observed spider monkeys along the forest fragments and riparian areas within the agricultural matrix. Paso Pacífico has already begun work with landowner association Asociación Pacífico Sur in areas of agroforestry, sustainable agriculture, and eco-tourism planning. There are twelve farms in this association ranging in size from twenty to eight hectares each. In the same area we are collaborating with three landowners who each have farms of over five hundred hectares. All landowners report regular sightings of spider monkeys in forested areas.

There are no protected areas within the geographic influence of this study, in which remaining forested areas are highly , however the landowner group has expressed an interest in developing a community-based protected area. Paso Pacífico has a unique opportunity to support

this group in forming what would be the very first private and also community-based reserve in the country. Spider monkeys will be an important flagship and indicator species for this effort. In order to begin the process of reserve design, it is essential that we know the habitat patches presently used by primates, particularly endangered spider monkeys. Likewise we need to identify which habitat patches present the potential for increasing their effective size and connectedness through future forest restoration activities.

## **METHODS**

**Study Area.** The study area is located at approximately -85.66W, 11.17N , just north of the Costa Rican border. The topography is mountainous with elevations ranging from 150 to 600 m.a.s.l. Forest vegetation is primarily seasonally dry deciduous with perennial riparian areas. There is a higher proportion of perennial trees at higher elevations where there are higher levels of rainfall and humidity. We focused on a cluster of privately held farms where spider monkeys have been recently observed; Paso Pacifico has been working intensively with farm owners and community members to promote conservation and sustainable use in this region. Small farms range in size from 20 ha to 150 ha, with activities primarily focused on cattle grazing, bean production and a small amount of other staple grains and fruits (rice, corn and plantain). Most of the small farms maintain relatively intact riparian areas and forest patches along steep hillsides and hilltops. There has been selective logging in many of these patches, possibly affecting patch quality for primates. The three large farms included in this study plan are over 500 ha each and have over 200 ha of forest each. These large farms have more affluent property owners and primarily operate agroforestry plantations. Across the landscape there are multiple waterfalls and steep cliffs, where spider monkeys and other primates may be able to find protection from human predation. Our long-term conservation goals involve incorporating forested areas at a landscape scale (an area of

approximately 30,000 ha). For the first phase of habitat assessment, we focused on the farms with which Paso Pacifico has developed the strongest relationship, covering an area of approximately 2000 ha (Fig. 2).

**Identification of Forest Fragments.** The first step in protecting the remaining spider monkeys in the region was to identify remaining forest fragments in our study area and estimate their extent. To accomplish this, we used information on fragment locations from topographic maps, vegetation cover maps (produced in 2000 but using data from 1990's), and aerial photographs (2004). Currently, Paso Pacífico has contracted a Nicaraguan expert to analyze satellite imagery (LANDSAT) provide additional information on habitat distribution in our study area. Forest patches appearing in several data sources (particularly those based on more recent habitat assessments) were be located and their extent calculated. While we initially planned to focus only on fragments of >20 ha in size, because we focused on a smaller study area than originally planned, we included smaller fragments in the study (Table 1). Existence and the approximate extent of fragments were then ground truthed prior to initiating the primate survey. Once we have a final analysis of current forest extent based on recent remote sensing data (deforestation has proceeded rapidly, making maps from even the early 2000's inaccurate for assessing fragment size and shape), we will include forest site, shape, topography, and matrix quality in analyses.

**Survey of Primates in Forest Fragments.** Based on informal interviews with property owners about the presence of primates in patches, we identified forest fragments potentially suitable for use by spider monkeys and other primate species. We then trained a team of local data collectors, who were supervised by Nicaraguan mammalogist Claudia Gomez. Under her direction, they visited each forest fragment twice a month in May, June, and July of 2007, to determine the presence of monkeys in fragments. We made use of pre-existing trails, fence lines, and watercourses to establish survey routes throughout each fragment. We established six such routes, along which

we conducted directed searches for primates; due to their low densities, such concentrated searches are more successful than line-transect surveys in determining the presence of spider monkeys (e.g., Pruetz and Leason 2002). Searches were conducted during the morning hours, when primates are more active. During the searches, our team recorded data regarding all primates encountered, including the number of individuals and age-sex class when possible. We originally planned to collect GPS locations of each group sighted, as well as additional data on primate behavior (e.g., height in canopy, trees used, foods consumed); however, due to difficulties in locating and training community members qualified to collect data, we decided to reduce the amount of data collected to fit with the capacities of our local team. Data were used to calculate minimum density of each primate species encountered in each fragment (the largest number of animals sighted at once, divided by fragment area), as well as to characterize group structure and broad habitat preferences.

## **RESULTS**

During May, June, and July 2007, we carried out 36 walks along the six routes (covering ~300 ha of forest fragments). During these walks, we observed a total of 180 primates. Ninety-six (53%) were howler monkeys, 52 (29%) capuchins, and 32 (18%) spider monkeys. Table 2 presents the maximum group size and total number of each primate species sighted along each survey route. Howlers were found along all but one route, capuchins along three routes, and spider monkeys along four survey routes; only two routes (El Príncipe,  $\geq 40$  ha; Las Palmeras, ~135 ha), had sightings of all three primate species. Although spider monkeys are generally confined to large fragments, they were sighted along one route (Nacsi/Marin) passing through four small (5-15 ha each) forest fragments.

While it is possible that there are 180 individual primates in these forest fragments, it is probable that some sightings represent repeated encounters with the same groups (and possibly the

same individuals in each group). In forested areas, it is difficult to observe all group members at the same time, meaning that group sizes can be easily underestimated. Because the majority of the matrix surrounding the fragments comprises pasture or agriculture lacking arboreal pathways, we assume that primates were unlikely to travel between fragments and be resighted along other survey routes. We therefore consider the maximum group count of each species along each route representative of the fragments' minimum populations. Using this criterion, we observed a minimum of 63 howlers, 34 capuchins, and 30 spider monkeys (Table 2). An additional 8 spider monkeys were sighted on along a riparian corridor near the fragments visited along the "Soto" survey route. With an estimated 300 ha of forest fragments in the study area, these numbers suggest a *minimum* density of 0.21 individuals/ha for howlers, 0.11/ha for capuchins, and 0.10/ha for spider monkeys within the forest fragments.

***Howler Monkeys.*** Howlers were documented along all but one survey route. Given their slower movements and lack of fear of humans (they are rarely hunted), howler groups were most easily counted. Observed group sizes ranged from a solitary adult male to a bisexual group of 16 individuals; average group sizes and compositions are presented in Table 3. On one occasion, we observed a group of four adult females without a male, although it is unclear if these females were a single-sex group or a bisexual group and we were simply unable to see the male in the foliage of a tree. Otherwise, the structure of bisexual groups was typical for the species, with an average female:male ratio of 2.91 and an immature:female ratio averaging 0.19. Howlers were the most frequently encountered and abundant primate species encountered in the study area.

***Capuchin Monkeys.*** Capuchins were not encountered frequently, and only in the relatively large and well-connected forest fragments. However, relatively large groups were observed (up to 19 individuals); all capuchins were observed in bisexual groups, with immatures common in the groups (Table 3). The ratio of females to males was 2.4, and of immatures to females 0.19. When



encountered, the majority of group members fled with males remaining to threaten observers, as is typical of the species in areas where it is subject to hunting or other forms of harassment. We therefore expect that our counts underestimate the numbers of individuals in capuchin groups.

***Spider Monkeys.*** In comparison to other sites where we have worked in southwestern Nicaragua, this study area has a remarkably high density of spider monkeys, particularly given the lack of protection (other protected areas, such as Chococente and Mombacho Volcano have very few spider monkeys). Spider monkeys were observed along four out of six survey routes, including in relatively small forest fragments, presumably connected by riparian corridors. Spider monkeys typically forage in subgroups during daylight hours, suggesting that the group sizes observed represent temporary subdivisions of larger social groups. All observed subgroups were bisexual, with a female:male ratio of 2.3. However, very few immatures were observed: we recorded only 2 infants and no juveniles at all, for an overall immature:female ratio of 0.11.

## **CONCLUSIONS & FUTURE WORK**

Overall, we found that our core study area retains some well-preserved forest fragments, which are home to a surprisingly large primate population. Most significantly, spider monkeys were repeatedly encountered in several forest fragments, suggesting that this area is vital for the conservation and future recover of this species in southwestern Nicaragua. However, comparison of current forest extent with even recently-generated maps indicate that deforestation has continued in the area, threatening the long-term persistence of spider monkeys and other native forest-dependent wildlife. We thus are facing a critical moment in primate conservation: monkey populations appear healthy enough to maintain or grow numbers in the future, but if deforestation in the area continues at the current rate, these populations will surely be lost. Already, there are signs that habitat change is negatively impacting the spider monkeys: the low ratio of immatures to

females, and in particular, the lack of juveniles could indicate reduced reproductive output by females (potentially as a result of energetic stress or social instability in groups) and/or increased mortality of juveniles (older juvenile males emigrate from natal groups, but movement through a hostile matrix may limit this process).

The presence of spider monkeys in the area will serve as a focal point for our conservation activities in southwestern Nicaragua. **A BIT ABOUT WHAT PP IS CURRENTLY DOING AND HOW IT INVOLVES SPIDER MONKEYS.**

**EXPLAIN FUTURE WORK HERE [1 – Explain current primate work, Stephanie, Suzanne]** Currently, graduate students in primatology from U.S. universities are proposing research projects in this same geographic area. Their studies will examine factors influencing spider monkey populations, such as hunting, genetic viability, and use of habitat corridors. Wherever possible, we plan to involve these researchers in this project by sharing data, inviting them to participate in field work, and by requesting that they interact closely with local people. Paso Pacífico will be providing logistical and moral support to foreign researchers in exchange for being able to apply the scientific outputs from their work throughout our conservation planning processes. [Maybe mention that the vegetation work we were supposed to do (see magenta highlighting below) will be done then.

**[2- Related work, eg. What Katie Goodall might do, studying drivers of deforestation?**

Additionally, it is clear that not only are the forest fragments key to persistence of wildlife, but the quality of the matrix of anthropogenic habitat surrounding the forest fragments. Land use patterns in the area are diverse, including pasture, small-scale agricultural production, traditional agroforestry systems, and large-scale hardwood cultivation. The effects of these varied land-use types on wildlife are largely unknown. As part of her long-term research on matrix habitats, Kim Williams-Guillén is planning a research project in the area considering how various kinds of forest transformation affect mammals, such as primates and bats.

[3 – How do results from study influence what Paso Pacifico is currently doing, eg how will be integrated into environmental education, etc.]

**Characterization of Fragment Quality.** To determine the extent to which fragment occupancy by spider monkeys reflects vegetation characteristics, we will collect vegetative data on tree communities in each fragment. Spider monkeys are known to use high canopy, therefore we will only consider trees with a minimum diameter of 20 cm for this characterization. Using the “closest individual” plotless sampling method (Cottam and Curtis 1956) we will measure the diameter, height, canopy width, species, and phenology for the nearest tree at each of the sample points. We will use a grid placed (representing 30m intervals) over each forest fragment map, and then randomly place sample points across the grid, with sample points within a total of 20% or more of the total fragment area. We will also measure forest cover at the sample point using a spherical densitometer. All trees identified in the plots will later be categorized according to their potential use by spider monkeys as identified by previous literature, local accounts and according life history and structural properties of the trees themselves.

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**TABLE 1.** Characteristics of primate survey routes; all routes were covered a total of six times between May and July 2007.

<b>Survey Route</b>	<b>Total Length (m)</b>	<b>Length in Forest (m)</b>	<b># Forest Fragments on Route</b>	<b>Total Fragment Area (ha)</b>
Soto/Estrada	4157	2759	1	29.0
Soto arriba/Duarte	2605	2009	2	50.5
El Príncipe	3076	1624	1	38.0
Guadalupe (La Palmera)	5050	3164	1	136.2
Guadalupe (Rogelio)	4951	1788	1	24.9
Marín/Nacsie	8753	4039	4	34.3
<b>Total</b>	<b>28,592 m</b>	<b>15,383 m</b>	<b>10 fragments</b>	<b>312.9 ha</b>

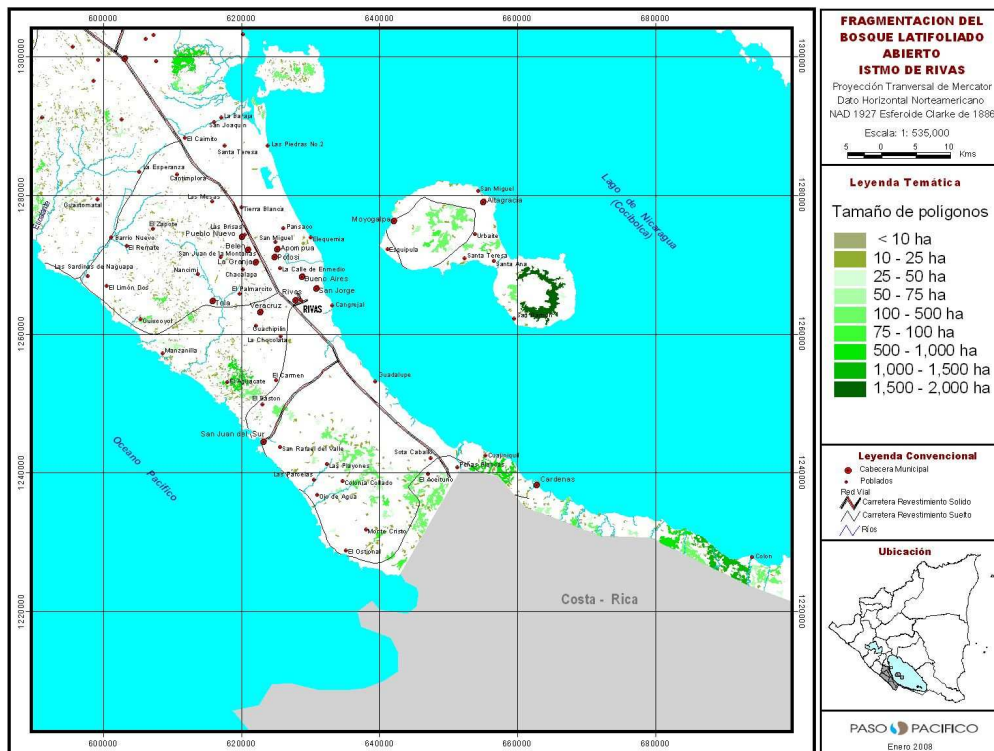
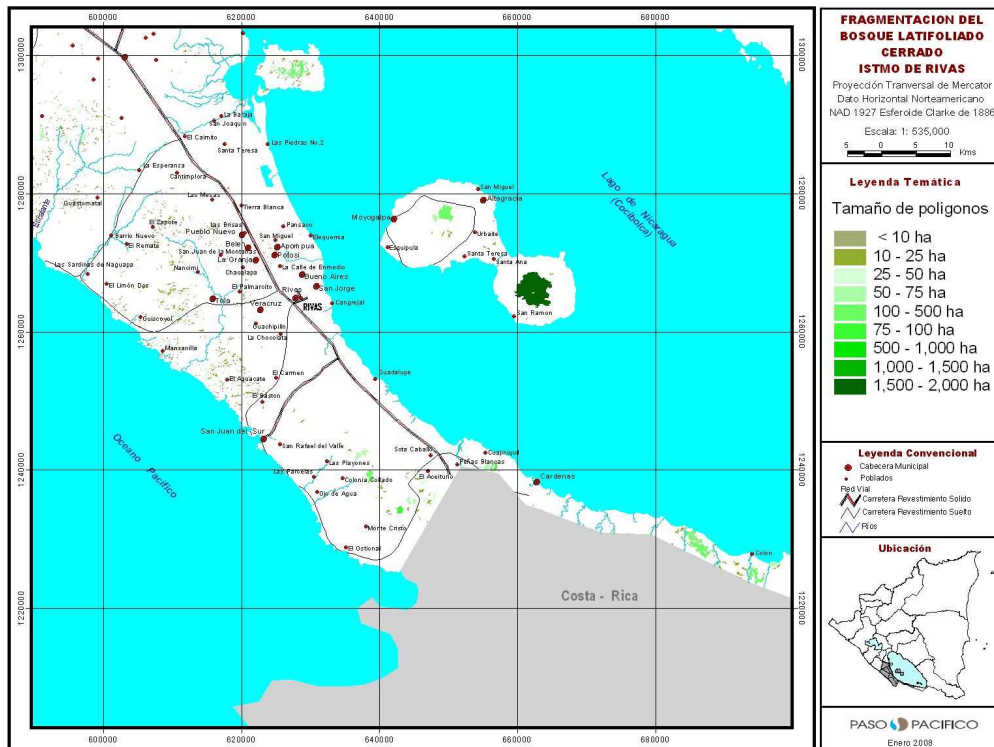
**TABLE 2.** Minimum and maximum group sizes and total number of observed individuals along survey routes, May – July 2007.

Survey Route	<u>HOWLER MONKEYS</u>		<u>CAPUCHINS</u>		<u>SPIDER MONKEYS</u>	
	Max Group Size	Total Observed	Max Group Size	Total Observed	Max Group Size	Total Observed
Soto/Estrada	--	--	--	--	8	8
Salto arriba/ Duarte	14	30	--	--	--	--
El Príncipe	13	22	19	35	5	7
Guadalupe (Las Palmeras)	16	16	3	5	9	9
Guadalupe (Rogelio)	9	10	12	12	--	--
Nacsi/Marín	11	18	--	--	8	8
<b>TOTAL</b>	<b>63</b>	<b>96</b>	<b>34</b>	<b>52</b>	<b>30</b>	<b>32</b>

**TABLE 3.** Structure of howler, capuchin, and spider monkey groups observed along survey routes in study area, May-July 2007.

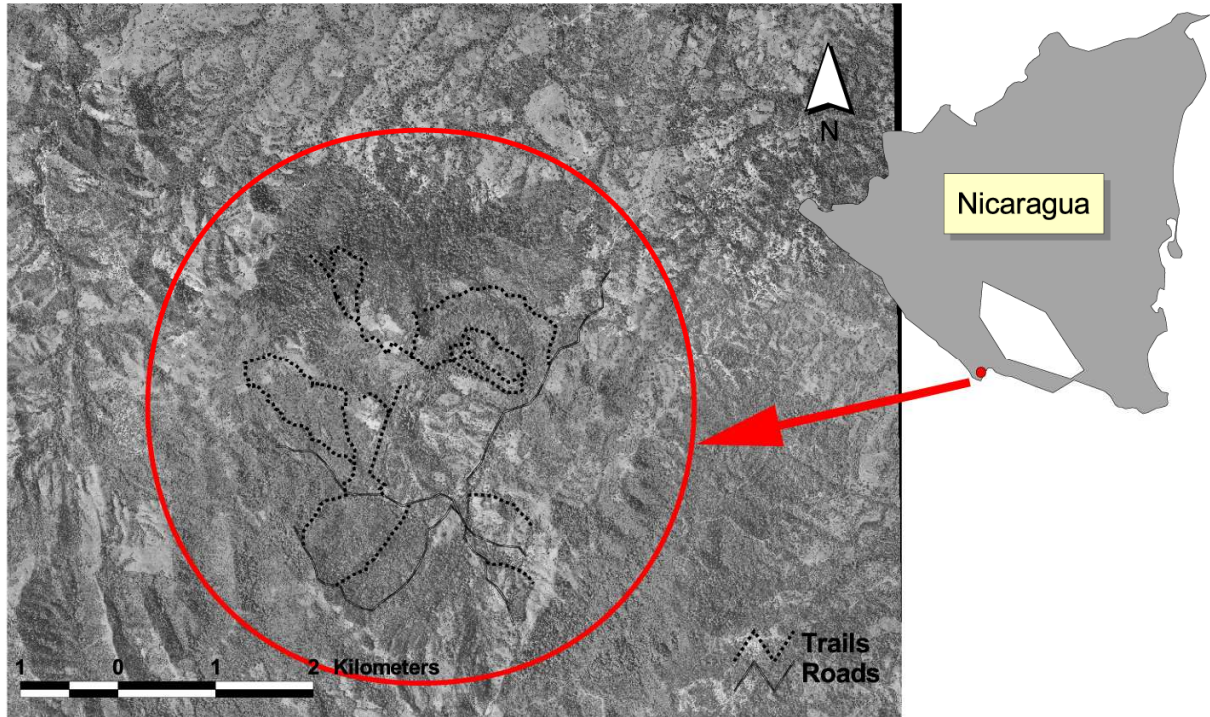
Species	Groups Observed	Average Number (min-max)				
		Adult Males	Adult Females	Juveniles	Infants	Total Group
Howlers	12	1.8 (0-4)	5.6 (0-12)	0.2 (0-2)	0.3 (0-1)	8.0 (1-16)
Capuchins	5	2.4 (1-4)	6.4 (1-12)	0.2 (0-1)	1.4 (0-7)	10.4 (2-19)
Spiders	5	1.8 (1-3)	4.2 (1-6)	-- --	0.4 (0-1)	6.4 (2-9)

FIGURE 1. Locations of (a) closed and (b) open canopy broadleaf forest in southwestern Nicaragua.





**FIGURE 2.** Location of core study area in southwestern Nicaragua, superimposed on an orthophotomap of the area (map dates from 2004; darker areas indicate arboreal vegetation).



**FIGURE 3.** Locations of forest fragments and primate survey routes in core study area, superimposed on an orthophotomap (darker areas indicate arboreal cover). Red X's on the map indicate areas which we confirmed have been deforested since the aerial photographs were taken in the early 2000's; red ?'s indicate areas where we were unable to confirm the current extent of forest fragments.

