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# Characteristics of Geoffroy's tamarin (*Saguinus geoffroyi*) population, demographics, and territory sizes in urban park habitat (Parque Natural Metropolitano, Panama City, Panama)

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Characteristics of Geoffroy's tamarin (*Saguinus geoffroyi*) population,  
demographics, and territory sizes in urban park habitat (Parque Natural  
Metropolitano, Panama City, Panama)

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Fall 2015

## Abstract

Metropolitan parks are an important refuge for wildlife in developed areas. In the tropics, land conversion threatens rainforest habitat that holds some of the highest levels of biodiversity in the world. This study aims to investigate the characteristics of Geoffroy's tamarin (*Saguinus geoffroyi*) population, demographics, and territory size in a highly urbanized forest habitat (Parque Natural Metropolitano (PNM), Panama City, Republic of Panamá). Studies of animal response to modified habitats are important as development continues worldwide. *S. geoffroyi* is an ideal species to study for this purpose due to the species' tolerance to habitat disturbance. This particular park is of interest because it is part of a biological corridor that spans more than 26,000 hectares. Over the course of 12 days, the park was surveyed from its trails and auditory was used luring twice. Graphics were created of the 16 detection events and data concerning group sizes, demographics, location, and direction of movement were used to establish groups sighted. This study found a preference for the area of the park including trails Cieneguita and Mono Tití. Observations and personal communications from Park guards indicate that this is likely due to distribution of fruiting trees in that area at this time. Additionally, observations of *S. geoffroyi* responses to auditory luring in this study indicate the potential for this method to be used to determine sex of individuals. Restrictions of transect surveying to established trails made it impossible to determine territory sizes or group sizes and demographics with certainty in this study. Additional studies of the Park's connectivity, territory sizes, food sources, and population are suggested to better understand the impacts of forest habitat in an urban area on Geoffroy's tamarins.

## **Acknowledgements**

The success of this project and growth I have experienced through its completion could not have been accomplished without the knowledge, support, and guidance of many people.

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## Introduction

Metropolitan parks are an important refuge for wildlife in developed areas. In the tropics, land conversion threatens rainforest habitat (Rompré 2008) that holds some of the highest levels of biodiversity in the world (Condit et al. 2001). This study aims to investigate the impacts of forested park habitat in a highly urbanized area on the population, demographics, and territory size of Geoffroy's tamarins (*Saguinus geoffroyi*) in Parque Natural Metropolitano (PNM), Panama City. Studies of animal response to modified habitats are of importance as development continues worldwide. *S. geoffroyi* is an ideal species to study for this purpose due to the species' tolerance to habitat disturbance (Moynihan, 1970, Díaz-Muñoz 2010).

### Species information

*Saguinus geoffroyi* is a small, social, New World primate commonly known as Geoffroy's Tamarin, Rufous-Naped Tamarin, and in Panama, Mono Titi. The species prefers secondary forest and is well adapted to living in altered habitats (Moynihan, 1970, Díaz-Muñoz 2010). Though previously accepted as a subspecies of *Saguinus Oedipus (geoffroyi)* (Hershkovitz, 1977), the separation the Geoffroy's Tamarin (*S. geoffroyi*) and the Cotton-top Tamarin (*S. oedipus*) into distinct species has been widely accepted as a result of additional dental morphology studies, and considerations of fur color and ear size (Skinner 1986, Moore & Cheverud 1992, Rylands 1993, Defler 2004). Due to this relatively recent separation, there is limited peer-reviewed research available about *S. geoffroyi* specifically. The Geoffroy's tamarin (*S. geoffroyi*) does not exhibit physical sexual dimorphism visible from a distance, with all adult individuals weighing about 486-507g and having a body length of 225-240mm. The species' nonprehensile tails range in length from about 314mm to 386mm (Defler 2004).

The preferred habitat of *S. geoffroyi* is secondary forest and forest edge (Dawson 1979, Defler 2004). The proximity of trees and distance between the canopy and the ground are important factors impacting the species' use of an area (Madden et al. 2010). They are omnivorous, with as much as half of their diet coming from fruit, about a third coming from insects or other animal prey, and plant exudate, flowers, buds, and other plant material accounting for their remaining consumption (Hladick and Hladick 1969, Garber 1980). The species' diet changes seasonally and depending on availability. Tamarin groups typically begin to stir and begin foraging 15 – 45min after sunrise and locate a sleeping tree 30 – 60min prior to sunset each day. In the morning, after several hours of foraging, individuals begin moving to the shade to rest until early afternoon (Neyman 1978, Dawson 1979). Groups of *S. geoffroyi* generally have one dominant reproductive female and are able to carry twins, with larger tamarin groups providing more food and carrying to young (Price 1992).

Male and female tamarins have been shown to emigrate to neighboring groups equally and relatively often from established groups (Dawson 1977, Neyman 1978, Savage 1996). Female tamarins actively defend their breeding position when fertile (Dawson 1979, Savage 1996). Tamarin groups define and defend home range territories through scent marking, physical means, and vocalizations (Neyman 1978, Savage 1996, Defler 2004). Reported group sizes of tamarins usually ranges from 5-7 individuals, although some studies have reported group sizes of anywhere from 2-15 individuals (Dawson 1977 & 1979, Lindsay 1980, Savage 1996). There is also a wide range in

territory sizes, which change with the season and habitat quality (Dawson 1976). Known territory sizes can range from 7.8-10ha (Neyman 1978, Garber 1980) to 26-43ha (Dawson 1979).

The IUCN reports *S. geoffroyi* as a species of Least Concern (LC), although also reports that numbers are declining (IUCN 2008). The species is well adapted in diet, size, and social structure to living in fragmented areas; however, basic requirements such as sufficient food sources and sufficiently close canopy cover are necessary to ensure individual's movements between areas and groups are possible. Additionally, Diaz-Muñoz (2010) found that tamarins are more likely to forage and socialize in forest habitats than other habitats like gallery, backyard, pasture, or urban settings.

### **Park habitat**

Parque Natural Metropolitano de Panamá (PNM) is one of 37 protected areas within the range of *S. geoffroyi* in Panama (IUCN 2008). In its 233 hectare area, the park is primarily secondary growth tropical dry forest. Along with nearby parks including Soberania National Park and Camino de Cruces National Park, the PNM is part of the Biological Corridor on the east side of the Panama Canal which amounts to more than 26,000 hectares of protected areas along the eastern canal bank (ANAM 2014).

The park is an area recognized as a Key Biodiversity Area (KBA) and as an Area of Importance to Birds (IBA) (ANAM 2014); however, to date, there has been no study of *S. geoffroyi* populations in PNM. Additionally, there are limited studies on the impacts of modified habitats on the species (Díaz-Muñoz 2010). Studies of other Central American primates have noted influences of fragment size, connectivity, and proximity to anthropogenic activity on population sizes and activity (*Alouatta pigra*: Gilberto 2011, *Alouatta palliata*: Mandujano and Escobedo-Morales 2008, *Cebus capucinus*, *Alouatta palliata*, and *Ateles geoffroyi*: Sorenson 2000).

### **Current Study**

This study investigates the impacts of restrictive, forested habitat in an urban area on *Saguinus geoffroyi* population demographics and territory size (Parque Natural Metropolitano, Ciudad de Panamá). I attempt to shed light on the differences in troop size, overall population, and geographic territory size between urbanized forest environment (Parque Natural Metropolitano, Ciudad de Panamá) and wild populations of *S. geoffroyi*. This species is known for its adaptability and use of secondary and peripheral forest. As development across Panama continues, this study aims to further understand how this species responds to restricted forest habitat. I hypothesize that troop size, overall population, and geographic territory size of *Saguinus geoffroyi* in forested urban park habitat with a restrictive boundary (Parque Natural Metropolitano, Panama City, Republic of Panama), will be smaller than those of wild types with less restrictive boundaries.

### **Research Question**

What are the population demographics, troop size, and geographic territory size of Geoffroy's tamarin (*Saguinus geoffroyi*) living in a protected forested park in an urbanized area?

## Methods

Due to their social nature, auditory lure methods have been successful in attracting tamarins for population census and distribution studies. Savage et al. (2010) surveyed populations using traditional transect methods and territorial tamarin call playbacks. This technique is ideal for small primates which, when unhabituated to humans, are known to flee without a sound. In their trials with tracked and habituated groups, tamarins moved toward the sound of the recording. In trials with wild, unhabituated groups, Savage et al. (2010) were able to anticipate the same response. Peres (1999) further developed standardized methods for performing transect surveys of primates in tropical forests. Standardized methods include specifics for cutting trails, carrying out surveys from 6:30-10:30 AM, briefly stopping to reduce background noise, and recording important information when individuals are detected (group size, spread, location along transect, detection cue, among other things). This information, along with detection angle and distance, is presented well in maps (Jablonski et al. 2010).

## Study site

The area of study was Parque Natural Metropolitano de Panamá, Panama City, Panama.

## Trail mapping

All established park paths were mapped and measured using Garmin GPSMAP 64s system, Garmin Base Camp, and Google Earth. Settings used are listed in Table 1.

**Table 1 Garmin GPSMAP 64s Settings**

<b>System</b>	
<b>Satellite System</b>	GPS+GLONASS
<b>WAAS/EGNOS</b>	ON
<b>Language</b>	English
<b>Interface</b>	Garmin Serial
<b>AA Battery Type</b>	Traditional NiMH
<b>Units</b>	
<b>Distance and Speed</b>	Metric
<b>Elevation (Vertical Speed)</b>	Meters (m/hr)
<b>Depth</b>	Meters
<b>Temperature</b>	Celsius
<b>Pressure</b>	Millibars
<b>Position Format</b>	
<b>Position Format</b>	UTM UPS
<b>Map Datum</b>	WGS 84
<b>Map Spheroid</b>	WGS 84
<b>Tracks</b>	
<b>Track Log</b>	Record, Show On Map
<b>Record Method</b>	Time
<b>Recording Interval</b>	00:00:08



### Transect setup

Transect width was determined using path length and my visual detection range (Savage et al. 2010). My ability to detect *Saguinus geoffroyi* from the paths influenced the amount of The Park monitored. To provide an accurate estimate of the amount of The Park monitored, distances of initial detection from each detection event were averaged to estimate my visual detection range.

The canopy density was determined using a densiometer at each waypoint. Estimations of canopy cover were made in each cardinal direction from the same point and those four measures were averaged for each waypoint.

### Detection Events

A combination of modified transects and a lure method (Savage et al. 2010) were used to observe *S. geoffroyi* within the park. Two of the four transects were walked once per day. Due to the single loop formed by two of the transects, the same two transects were always walked together. The two transects observed each day was alternated and the transect that was walked first was alternated; however, transects were always walked in the same direction.

Monitoring of the first transect began between 7:00 and 7:30 AM. The length of the transect was walked slowly, while scanning the surrounding canopy, and briefly pausing every 20 steps for visual and auditory signs of *S. geoffroyi*. Once a detection event occurred, a waypoint was marked immediately utilizing Garmin GPSMAP 64s, the angle (using a baseplate compass) and distance of the animal from the initial detection waypoint (using a laser range finder), then start time was recorded. Then number of *S. geoffroyi*, their relative age (infant, juvenile, adult) based on size and tail length, and behavioral notes were recorded. Finally, precipitation and wind were recorded. If during observation, *S. geoffroyi* exit in another direction or location, exit direction and location, and time were recorded as well.

For each detection event, a standardized naming technique (Table 2) was utilized. Detection waypoints were labeled “TITI#” where “#” represents the detection event number. If during observation, the animals moved from the initial detection site, additional waypoints were made to reflect their movement pattern. This was represented by adding “.#” to the name of that detection event for each additional waypoint created. In the event the animals exited from view in a different location or angle than initially detected, a waypoint was made to describe their exit. The name of exit waypoints were the same as the detection waypoint name and include “E” at the end.

**Table 2 Detection waypoint naming scheme**

<b>Full detection waypoint naming example:</b>	
<b>TITI1</b>	An individual has been detected, this is the first detection event
<b>TITI1.1</b>	Individual has moved 15m along trail,

	within sight of observer from initial detection point
<b>TITI1.2</b>	Individual has moved another 10m along trail, within sight observer from initial detection point
<b>TITI1E</b>	Individual has exited from view away from path

On the ninth and twelfth day of sampling, an auditory lure method (Savage 2010) was used to attract *S. geoffroyi* to the transect. The recording used includes 60s of *S. geoffroyi* long call vocalization, followed by 30s of silence and was played continuously until individuals were detected. Groups within 150-200m have been shown to respond to this technique by approaching the sound and responding with territorial calls (Savage 2010). Once individuals had been detected, the same methods as used for observational detection method were used.

In the field, waypoints were marked using Garmin GPSMAP 64s. All other data was recorded using pen and notebook on pre-prepared data sheets. Data was analyzed in Garmin Base Camp/Google Earth and Excel. Following the observational period, densiometer readings were taken at each detection event waypoint.

The mapping of the modified transects and detection events provide a visual representation of *Saguinus geoffroyi* distribution in the park. Information about troop size, demographics, and any distinguishing individual's characteristics was compiled to determine whether individual detection events were of the same groups. A correlation was performed between canopy cover and distances of initial detection. Averages and standard deviations of data (time spent on trails and length of detection events) were calculated.

### Population estimation

The size of the park's *Saguinus geoffroyi* population, N, was estimated using

$$N = \frac{nsA}{a}$$

where n is the number of groups observed, s is the average number of individuals in each group, A is the total park's area, and a is the area surveyed. The total park area was determined using Google Earth's images. The area surveyed was calculated by averaging the initial distance of detection and adding that distance as a buffer on either side of the trail. The number of groups and individuals observed were established using detection location, group size and demographics, detection time, and exit direction of groups.

## Results

### Survey area

The average distance of initial detection was 29m (Table 3). To calculate total area visibly surveyed, a 29m buffer was mapped along all transects. The total area surveyed was 25.38 hectares and the total park area was measured as 280 hectares. The percentage of the total park surveyed was 9.1% (Figure 1).



**Figure 1 All park map including delineated visible detection area (29m either side of transects)**

### **Detection Events**

In total there were 16 detection events over the course of this study. During the 12 day data collection period, there were 15 detection events and 1 detection event was recorded during a preparatory survey of the study site using the same methodology (Table 3). Each set of trails (Momotides/Caobos and Mono Titi/Cieneguita) was surveyed 6 days (Figure 1). The mean time of survey for Momotides/Caobos was  $1.78 \pm 0.28$  hours per day. The mean time of survey for Mono Titi/Cieneguita was  $2.86 \pm 0.29$  hours per day. Surveying of Mono Titi/Cieneguita took significantly longer than surveying Momotides/Caobos ( $t = 6.47$ ,  $d.f. = 15$ ,  $p = 0.000036$ ) The mean length of detection events was  $17.33 \pm 14.18$  minutes (Table 3).

Detection events occurred only on Mono Tití, Cieneguita, and Caobos. The greatest number of detection events occurred on Cieneguita and Mono Titi and only one detection event occurred on Caobos (Table 3). No detection events occurred on Momotides. The average distance of initial detection was  $29 \pm 13.97$ m (Table 3).

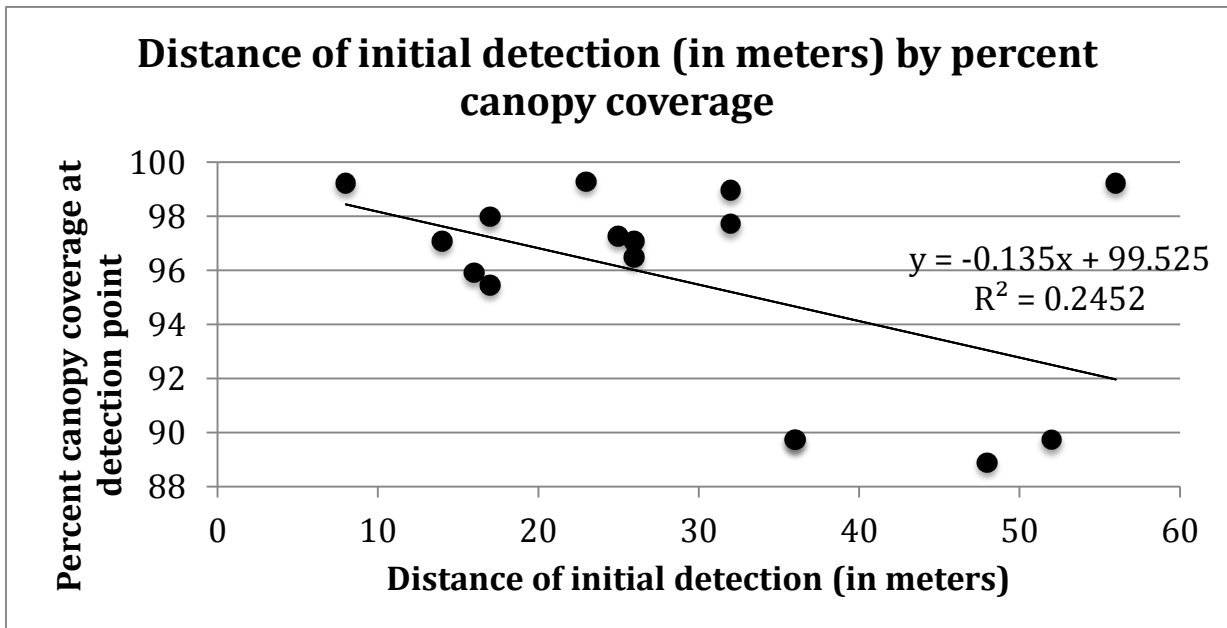


**Figure 2 Map of all paths ("Momo," "Caobos," "Cien," and "Mono Titi")**

Date	Name	Start Time	End Time	Length (minutes)	Trail	Coordinates	Distance (meters)
13-Oct-15	TITI1	3:50		Unknown	Mono Titi	0659960-0994628	25
10-Nov-15	TITI2	7:42	7:51	9	Mono Titi	0660060-0994345	16
10-Nov-15	TITI3	8:30	8:42	12	Cien	0659507-0994381	36
12-Nov-15	TITI4	9:20	10:05	45	Cien	0659934-0993965	26
13-Nov-15	TITI5	8:04	8:13	9	Mono Titi	0659948-0994622	14
13-Nov-15	TITI6	8:22	8:28	6	Mono Titi	0659883-0994714	32
13-Nov-15	TITI7	8:45	8:50	5	Mono Titi	0659802-0994678	26
13-Nov-15	TITI8	9:50	10:13	23	Mono Titi	0659978-0994172	23
17-Nov-15	TITI9	7:52	8:38	46	Mono Titi	0660077-0994271	48
20-Nov-15	TITI10	7:38	8:04	26	Cien	0659736-0994196	32
20-Nov-15	TITI11	8:20	8:21	1	Cien	0659499-0994365	52
20-Nov-15	TITI12	8:22	8:45	23	Cien	0659501-0994386	36
20-Nov-15	TITI13	9:58	10:18	20	Cien	0659973-0994100	8
23-Nov-15	TITI14	8:18	8:42	24	Cien	0659777-0994166	17
23-Nov-15	TITI15	8:57	9:07	10	Cien	0659418-0994460	17
23-Nov-15	TITI16	10:20	10:21	1	Caobos	0659810-0993711	56

**Table 3 Detection event data (times, transect name, coordinates, distance of initial detection)**

A marginally significant negative correlation was found between canopy cover at location of initial detection and distance of initial detection ( $r = -0.4951$ ,  $d.f. = 15$ ,  $p = 0.05124$ ) (Figure 3). When one outlying point (TITI16) was removed, there was a significant negative correlation between canopy cover and distance of initial detection ( $r = -0.7542$ ,  $d.f. = 14$ ,  $p = 0.0012$ ). The average canopy coverage at initial points of detection was  $95.61 \pm 3.81$  percent. A combination of visual and auditory detection cues were used to alert observers to the presence of *Saguinus geoffroyi*.



**Figure 3 Graph of correlation between distance of initial detection and percent canopy coverage for each detection event**

**Groups detected**

Over the course of 16 detection events, the number of individuals observed totaled 71; however, after consolidating detection events into inferred 8 groups, the estimated number of individuals observed was 38 (Table 4). Information from all detection events including number of individuals per group, demographics, location, time of detection and exit direction, groups detected were sorted to establish which detection events over the course of the study period may have been of the same group (Figure 3).

*Group A*

Detection events TITI1, TITI2, and TITI5 were consolidated into Group A based on detection location, exit direction of TITI2, the presence of 1 juvenile in TITI1 and TITI2 and the unknown age of all individuals in TITI5.

*Group B*

Detection events TITI4, TITI13, and TITI16 were considered Group B for the same reasons as Group A.

### *Group C*

Group C was determined to include TITI15 and TITI11 due to location of detection as well as direction of movement of the single individual in TITI11. The initial distance of detection of TITI11 was 52m and visibility was poor, though it was noted that there might have been more individuals present that were not confirmed by sight.

### *Group D and Group E*

Groups D and E were determined to include only one observation event (TITI6 and TITI respectively) due to their detection locations, times of detection, the exit directions of previous detection events the day they were detected.

### *Group F*

Group F was determined to include TITI8, TITI10, and TITI14 due to group size, detection location, and exit locations.

### *Group G*

Group G was also determined to include only one detection event (TITI 9), because of its location, number of individuals, and lack of exit direction.

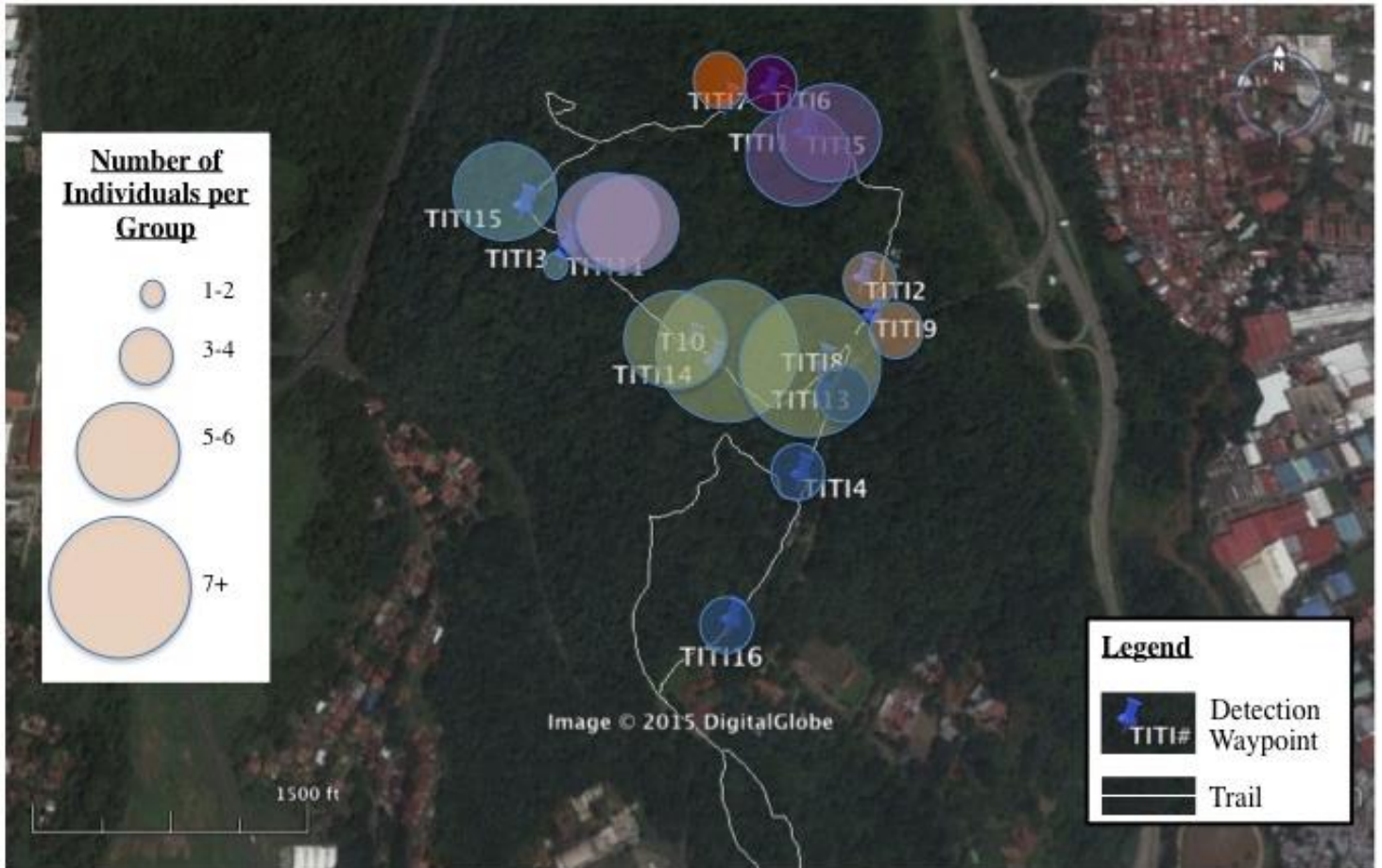
### *Group H*

The individuals observed in detection events TITI3 and TITI12 were eating in the same tree and the groups included the same total number of individuals.

**Table 4 Detection event group demographics and group designation**

Date	Name	Group Size	Adult	Juvenile	Unknown	Group Letter
13-Oct-15	TITI1	5	3	1	1	A (dark pink)
10-Nov-15	TITI2	4	3	1	0	A (dark pink)
13-Nov-15	TITI5	6	0	0	6	A (dark pink)
12-Nov-15	TITI4	3	2	1	0	B(blue)
20-Nov-15	TITI13	3	2	0	1	B(blue)
23-Nov-15	TITI16	3	2	1	0	B(blue)
20-Nov-15	TITI11	1	1	0	0	C(dark green)
23-Nov-15	TITI15	5	3	1	1	C(dark green)
13-Nov-15	TITI6	3	2	1	0	D(magenta)
13-Nov-15	TITI7	3	3	0	0	E (orange)
13-Nov-15	TITI8	9	6	1	2	F(light green)
20-Nov-15	TITI10	5	2	1	2	F(light green)
23-Nov-15	TITI14	7	5	1	1	F(light green)
17-Nov-15	TITI9	4	3	1	0	G(orange)
10-Nov-15	TITI3	5	4	0	1	H(light pink)
20-Nov-15	TITI12	5	2	1	2	H(light pink)





**Figure 4 Map of all detection waypoints and group dot density map**

#### **Population estimation**

Estimates of the park's *Saguinus geoffroyi* population were determined using the 8 groups and 31 individuals established. The resulting estimate was 419 individuals within the entire park, which when divided into the average group size (4.75), indicate the possibility for 88 groups within the park.

#### **Reactions to auditory lure**

On the 9th and 12th days of data collection, an auditory lure was used. On the 9th day, the lure was used on Momotides/Caobos and resulted in no detections; however, both observers confirmed hearing *Saguinus geoffroyi* long calling at approximately 8:50 AM on Momotides. On the 12th day, the lure was used on Mono Titi/Cieneguita and resulted in 2 detection events. The playback was initiated approximately 15 minutes into the first trail of the day, Cieneguita and played continuously until the end of the Mono Titi trail. The first group encountered approached the sound, long calling frequently but not continuously. I used the playback until all individuals had stopped moving. Three individuals moved lower to the ground and the rest remained spread out above in the canopy. After about 10 minutes, the lower individuals began to move back up into the trees and away. Then, I began to walk away, turning the call back on about 3 meters from the previous detection site. The 5 individuals, including one juvenile, from the group of 7

followed me, long calling. Individuals moved lower to the ground, approximately 3 meters away from where I stood holding the speaker and 2 or 3 meters off of the ground. For the majority of the observation period a half-meter or more separated the individuals, but 2 individuals moved close together at least twice. They were closer than before, and I was able to observe that individuals alternated long calling. The 5 individuals formed somewhat of a semi-circle surrounding me. At least two individuals defecated in the last 15 minutes of observation. About 10 minutes after I stopped the recording the second time, the individuals began to move back up into the trees. This detection event lasted approximately 24 minutes. I walked away about 15m down the trail before starting the recording again.

Then about 15 minutes after leaving the first group, I encountered a second group. This group consisted of 5 individuals, including at least one juvenile. This group also came close to the ground, long calling. The first 3 individuals came quickly and the remaining 2 individuals were a bit slower. They also formed a kind of semi-circle, although not all individuals were as close to the ground as the previous group. They remained in place long calling for about 10 minutes. When they began to move away, I exited, again walking about 15 meters before starting the auditory lure again. This detection event lasted approximately 10 minutes.

### **Road crossing**

On the fourth day of data collection, four individuals from a group of 9 individuals (TITI8) were observed crossing over the road (Avenida Juan Pablo II) using connected tree branches leaning over the road. They crossed from near the conjunction of the trails Cieneguita and El Roble to an area unsurveyed by this study, but still within the limits of the park.

### **Discussion**

The results of this study indicate the presence of multiple *Saguinus geoffroyi* groups resident to the park, a population preference for the main area of the park, the effectiveness of auditory luring in a forested park in a highly urbanized area, and confirm the connectivity of the park over Avenida Juan Pablo II in at least one location.

### **Detection events**

Detection events revealed multiple sightings of several of the same groups, utilizing the same areas. Though park guards reported seeing groups on all trails (Park guard, *personal communication*), detection events occurred only on Mono Titi, Cieneguita, and once on the very end of Caobos, near the road. It is apparent that the groups have a preference for the larger, more northern areas surveyed. The size and location of the Momotides area could have been a factor in determining the species' avoidance of the area during the time of survey; however, the most likely reason is that there are not sufficient fruiting feeding trees in the area. During the morning, *S. geoffroyi* leave their sleeping trees and begin foraging (Peres 1999). If there are not sufficient in season feeding trees in this area, it would be expected that no detection events would occur there during the morning.



One assumption of this study was that all individuals along the transects within the visible detection area would be detected. This is not likely justified considering the negative correlation between canopy cover and distance of first detection and low number of detections over 36 meters. Only 18.75% of detection events were over 36m away. There was notable variability in visibility along the transects. Some areas were so densely vegetated that it was not likely possible to see past 3m off of the trail (ex. middle of Caobos), while other areas were so open that branches could be seen rustling more than 50m away (ex. end of Caobos).

### **Population information**

The population information collected in this study fell within the range of group sizes and juveniles published in previous studies. Compared to data of wild populations provided by Diaz-Munoz (2010) and Savage et. al (1996) of *S. geoffroyi* and *S. oedipus* respectively indicated similar, but insignificantly higher average group sizes than groups of this study ( $F(2, 28) = 1.13, p = 0.33$ ). A more definitive comparison of average group sizes could be produced if more of the park is surveyed or when more scientific literature becomes available regarding groups of *S. geoffroyi* in the wild. Group sizes collected in this study were assumed to be representative of the total group, but throughout the data collection period it became apparent that the spread of groups could be large. This meant that during detection events in which the entire group did not pass through a visible opening or remain in a clearly visible area, group sizes could easily be miscounted.

The population estimate calculated using established group sizes and numbers of individuals was 419 individuals within the park. This number seems far from realistic for several reasons. Most importantly, it assumes that all areas of the park are equally likely to be used by the species, which is not the case. The groups showed a clear preference for the area of Cieneguita and Mono Titi, which could have had to do with food availability, distance from the road, or other unmeasured factors. Additionally, there is no way to know whether groups detected in the park were permanent residents or transient groups. The study period was so short that at least 3 groups were seen only once. Finally, the irregular shape and uneven park coverage the transects provided have likely biased this estimate to be rather high. The formula used accounts for the proportion of the area surveyed over the total area of the park, and only 9.1% of the park was surveyed. I believe this calculation resulted in a higher population estimate than is realistic; however, do to time constraints more precision was not afforded to determining visible detection ranges.

Defler (2004) published a range of *S. geoffroyi* territory sizes and population densities. When considering the total park area is 280ha, and that published territory sizes for the species range from 9.4 ha, to 26 ha and 43 ha, a more reasonable population estimate can be presumed between 29 groups (9.4 ha territory divided into 280 ha park size) and 11 groups (26 ha territory divided into 280 ha park size). These estimates would result in 138 individuals and 52 individual in the park total.

### **Auditory lure**

The auditory lure was successful in attracting *S. geoffroyi* and was notably agitating to the groups, although its use did not produce the highest daily rate of detection of the study. It may be that the timing of movement of groups for the particular day I

used the lure meant that they were not close enough to hear the audio or could not reach me before I exited their area. It is also possible that the quality of the recording used was poor and that a more clear, uninterrupted recording would produce better results.

One notable observation is that during the first detection event using the auditory lure (TITI14), I began to walk away playing the audio and was followed by all but 2 individuals from the group I had been observing. Behavioral sexual dimorphism has been described in this species, with females tending to exhibit longer latency in response to unfamiliar intruders and males tending to be more aggressive (French and Snowden, 1981). Considering groups of *S. geoffroyi* tend to have 1 or 2 females per troop, it could be inferred that those individuals that did not follow were the group's females.

### **Limitations**

Limitations in methodology have undoubtedly influenced data collection. Using data from each detection event including, number of individuals per group, demographics, location, time of detection and exit direction, groups detected were sorted to establish which detection events over the course of the study period may have been of the same group. Assumptions of this method include that at each detection event I saw all individuals within the group. With this in mind, I elected to use the largest possible group size available to calculate population estimates.

Due to the restrictiveness of the transect lengths and shapes, it was not possible to calculate territory sizes. Additionally, data regarding food consumption by the groups was not collected because of time and feasibility, but is likely an important factor in determining group location. It has been published that seasonal changes in food availability influence territory locations and sizes, so data collected in this study must be considered as representative only for this time of year (November).

### **Personal communications**

Advice and knowledge provided by the park guards was invaluable during this study. The movements, feeding locations, and other important information about the *S. geoffroyi* population are relatively well known and followed regularly by the park staff. Although only one detection event included individuals crossing a road, it is well known amongst park staff that groups cross the road frequently, sometimes multiple times in a day (Park guard, *personal communication*). The staff was an excellent resource. On one occasion (TITI2) a group was detected and pointed out on the trail by a park guard before I arrived and I was warned of its presence when I reached that point in the transect. Additionally, seasonal food sources, including fruit at the top of the lookout and near the park center were pointed out as favorites of *S. geoffroyi* groups when ripe, although no detection events occurred near those areas.

### **Conclusion**

In conclusion, data collected in this study indicated several resident groups of *Saguinus geoffroyi* within Parque Natural Metropolitano and confirmed the connectivity of the park for the species over Avenida Juan Pablo II, which bisects the park. The average group size, 4.75 individuals, was smaller than average numbers reported in other studies, 6.17 individuals, but could not be established as significant. There is a lack of

available data about specific group sizes in wild populations from published literature, making comparisons insignificant. Additionally, it is likely that due to the spread of groups, not all individuals were counted in every detection event.

Due to the shape and length of the transects, I do not believe population estimates calculated from the methodology of Savage et. al (2010) to be representative of the area's true capacity. I think a much lower estimate would be appropriate. This methodology also did not lend itself well to estimating territory sizes because groups could not be followed past the trails edge and a mere 9.1% of the park was estimated to have been surveyed.

The modifications made to previously successful methodologies made this study feasible for the short time period available. The study provided a brief snapshot of the groups utilizing the trail areas and showed that the species has a clear preference for the trails Cieneguita and Mono Titi. The data collected in this study may act as a reference for future tamarin population studies within park settings, which would be particularly useful for Parque Natural Metropolitano considering the influence of human activity to the area and the connectivity of its location.

### **Future research**

This study attempted to adapt previously established methods to a level feasible to accomplish in a very short study period. Some modifications appeared to work well. For example, Peres (1999) suggests beginning transects at 6:30-6:45AM, but beginning transects at 7:00-7:30AM due to safety concerns as only 3 of 16 detection events occurred before 8:00 AM. Additionally, some studies include marking individuals; however, I believe that a longer-term study with more transects following a uniform pattern could use the same methods of group estimation as this study effectively. It would also be useful to include transect surveying in the afternoon from about 2:00-6:00 PM the second most active time period of the day (Peres 1999). Data collected in this additional time could provide useful information for determining territory size.

Due to the short period of time available for this study, I used established trails as modified transects. Ideally, future studies should attempt to more closely follow the general guidelines presented by Peres (1999) in terms of transect length and arrangement. Surveying the entire park, even if it means creating transects, would allow for a more complete understanding of the *S. Geoffroyi* population residing there. To best understand territory sizes, it would make sense to capture and mark at least some individuals within each group (Diaz-Munoz 2010).

The auditory lure method was useful for this study. Despite the significant noise pollution impacting the area during morning traffic, the responses from the two groups encountered were strong. As mentioned previously, response to auditory lure (following or not) could indicate sex of individuals. Additional studies of responses to auditory lures between the sexes could establish this as a potential technique for determining group demographics, while avoiding the need to capture individuals.

Additionally, future studies would do well to consider the knowledge of park guards and staff. Guards could collect data from the watch station between the paths Cieneguita and Mono Titi, could help establish a map of utilized food trees, and could provide knowledge about the daily movement patterns of groups. Utilizing their intimate knowledge of the area and the species in these ways would be wise.

Ideally, more information would be collected about the connectivity of the park to Camino de Cruces and Soberania. Only one crossing event was observed during the study period and this event occurred in an area where crossing is readily observed by park staff. Knowledge of *S. geoffroyi* crossing roads on other sides of the park would be useful to determine actual connectivity to the rest of the “biological corridor.” This information is essential as the utility of parks as a conservation strategy is studied.

## References

- Anderson, Rowcliffe, & Cowlishaw. (2007). Does the matrix matter? A forest primate in a complex agricultural landscape. *Biological Conservation*, 135(2), 212-222.
- Arroyo-Rodríguez, & Mandujano. (2006). Forest fragmentation modifies habitat quality for *Alouatta palliata*. *International Journal of Primatology*, 27(4), 1079-1096.
- Condit, R., Robinson, W. D., Ibáñez, R., Aguilar, S., Sanjur, A., Martínez, R., . . . others. (2001). The status of the Panama Canal watershed and its biodiversity at the beginning of the 21st. *BioScience*, 51(5), 389–398.
- Dawson, G. A. (1977). Composition and stability of social groups of the tamarin, *Saguinus oedipus geoffroyi*. *Panama: Ecological and Behavioural Implications*. in: DG Kleiman (Ed.). *The Biology and Conservation of the Callitrichidae*. Smithsonian Institution Press, Washington, DC, 23–37.
- Dawson, G. A. (1979). The use of time and space by the Panamanian tamarin, *Saguinus oedipus*. *Folia Primatologica*, 31(4), 253–284.
- Defler, T. R. (2004). *Primates of Colombia conservation international tropical field guide series* Bogota.
- Diaz-Munoz, S. L. (2010). Behavior, ecology and genetics of geoffroy's tamarin (*Saguinus geoffroyi*). *UC Berkeley: Integrative Biology*.
- Garber. (1980). Locomotor behavior and feeding ecology of the Panamanian tamarin (*Saguinus oedipus geoffroyi*, Callitrichidae, primates). *International Journal of Primatology*, 1(2), 185-201.
- Gogarten, Bonnell, Brown, Campenni, Wasserman, & Chapman. (2014). Increasing group size alters behavior of a folivorous primate. *International Journal of Primatology*, 35(2), 590-608.
- Hershkovitz, Philip. *Living new world monkeys (Platyrrhini)*. University of Chicago Press, 1977.

- Hladik, A., & Hladik, C. M. (1969). Report on tropical vegetation and primates in the forests of Barro Colorado (Panama). *Terre Et La Vie*, 23, 25-117.
- Jablonski, McNulty, & Schlesinger. (2010). A digital spot-mapping method for avian field studies. *The Wilson Journal of Ornithology*, 122(4), 772-776. ]
- Lian Pin Koh, & Navjot S. Sodhi. (2004). Importance of reserves, fragments, and parks for butterfly conservation in a tropical urban landscape *Ecological Applications*, 14(6), 1695-1708.
- Lindsay, N. B. (1980). A report on the field study of geoffroy's Tamarin—Saguinus oedipus geoffroyi.. *Dodo: Journal of the Jersey Wildlife Preservation Trust*, 17, 27-51.
- Łopucki, Mróz, Berliński, & Burzych. (2013). Effects of urbanization on small-mammal communities and the population structure of synurbic species: An example of a medium-sized city. *Canadian Journal of Zoology*, 91(8), 554-561.
- Madden, Garber, Madden, & Snyder. (2010). Rain-forest canopy-connectivity and habitat selection by a small neotropical primate, geoffroy's tamarin (saguinus geoffroyi). *Journal of Tropical Ecology*, 26(06), 637-644.
- Mandujano, S., & Escobedo-Morales, L. A. (2008). Population viability analysis of howler monkeys (*alouatta palliata mexicana*) in a highly fragmented landscape in los tuxtlas, mexico. *Tropical Conservation Science*, 1(1), 43-48.
- Miller, L., Savage, A., & Giraldo, H. (2004). Quantifying remaining forested habitat within the historic distribution of the cotton-top tamarin (*saguinus oedipus*) in colombia: Implications for long-term conservation. *American Journal of Primatology*, 64(4), 451-457.
- Moore, A. J., & Cheverud, J. M. (1992). Systematics of the *saguinus oedipus* group of the bare-face tamarins: Evidence from facial morphology. *American Journal of Physical Anthropology*, 89(1), 73–84.
- Moynihan, M. (1970). *Some behavior patterns of platyrrhine monkeys. 2. Saguinus geoffroyi and some other tamarins*. Smithsonian Institution Press.
- Neyman, P. F. (1978). Aspects of the ecology and social organization of free-ranging cotton-top tamarins (*saguinus oedipus*) and the conservation status of the species. *The Biology and Conservation of the Callitrichidae*, 39–71.
- Peres, C. A. (1999). General guidelines for standardizing line-transect surveys of tropical forest primates. *Neotropical Primates*, 7(1), 11–16.
- ANAM. Pinzón, Z., Flores, E., Luque, D., Tejada, I., Montero, A., Vega, A., . . . Abre, F.

- (2014). *Quinto informe nacional de biodiversidad de panamá ante el convenio sobre diversidad biológica*. Autoridad Nacional del Ambiente (ANAM).
- Pozo-Montuy, Serio-Silva, & Bonilla-Sánchez. (2011). Influence of the landscape matrix on the abundance of arboreal primates in fragmented landscapes. *Primates*, 52(2), 139-147.
- Price, E. C. (1992). The benefits of helpers: Effects of group and litter size on infant care in tamarins (*saguinus oedipus*). *American Journal of Primatology*, 26(3), 179–190.
- Rompré, Robinson, & Desrochers. (2008). Causes of habitat loss in a neotropical landscape: The panama canal corridor. *Landscape and Urban Planning*, 87(2), 129-139.
- Rylands, A. B. (1993). *Marmosets and tamarins: Systematics, behavior, and ecology* Oxford: Oxford University Press.
- Savage, A., Giraldo, L. H., Soto, L. H., & Snowdon, C. T. (1996). Demography, group composition, and dispersal in wild cotton-top tamarin (*saguinus oedipus*) groups. *American Journal of Primatology*, 38(1), 85-100.
- Savage, Thomas, Leighty, Soto, & Medina. (2010). Novel survey method finds dramatic decline of wild cotton-top tamarin population. *Nature Communications*, 1(3), 1-7.
- Skinner, C. A. (1986). A life history study of the geoffroy's tamarin, *saguinus goeffroyi*: With emphasis on male-female relationships in captive animals. *Dissertation Kent State University*.
- Sorensen, & Fedigan. (2000). Distribution of three monkey species along a gradient of regenerating tropical dry forest. *Biological Conservation*, 92(2), 227-240.
- Withey, J. C. (2013). Within-territory use of different land cover types by tropical forest in a fragmented landscape. *Biological Conservation*, 167, 40.