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A Preliminary Study for the Future Translocation of a Saimiri sciureus Troop from Sumak Allpa to Yasuní National Park: Assessing the Habitat Use, Population, and Behavior of a Common Squirrel Monkey Troop in Indillama

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A Preliminary Study for the Future Translocation of a Saimiri sciureus Troop from Sumak Allpa to Yasuní National Park:

Assessing the Habitat Use, Population, and Behavior of a Common Squirrel Monkey Troop in Indillama

Saimiri sciureus, Luv Viator, Wikimedia Commons (2007)

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Abstract: Sumak Allpa, an organization specializing in primate rehabilitation, plans to introduce a Common Squirrel Monkey Troop (*Saimiri sciureus*), the Yasuní Troop, to the Indillama region of Yasuní National Park. This study analyzes the habitat use, population, and behavior of the *Saimiri sciureus* troop, referred to as the Indillama Troop, already existing in the region, from April 14th to May 4th, 2019. Focal and scan observation techniques were used to observe the troop's behavior, and EasyTrails on an iPhone 7 was used to record GPS data. EasyTrails was also used to map the trail system in the Indillama region. Thirty 10x30 m transects, 108 10x20m transects, and eight 20x30 meter transects were used to map the distribution of potential food sources and evidence of *Saimiri sciureus* presence. These data were analyzed using ArcGIS Online to establish the current home range of the Indillama Troop in order to figure out the best locations to introduce the Yasuní Troop. Population and behavior data were analyzed using Excel to determine the size of the trop and create an activity budget. The Indillama Troop's home range is 72.3 hectares and to takes up a large portion of Northwest Indillama. The Indillama Troop consists of 29 individuals, 16 adults, 6 subadults, and 7 juveniles, and was found to spend most of its time moving or foraging. Since a large squirrel monkey troop already dominates most territory in Northwest Indillama, the Yasuní Troop should be introduced to the southeastern part of the region.

Resúmen:

Sumak Allpa, una organización que se especializa en la rehabilitación de los primates, quiere introducir una tropa del mono ardilla común, La Tropa Yasuní, a la región Indillama en Parque Nacional Yasuní. Este estudio se analiza el uso de hábitat, la población y el comportamiento de la tropa de *Saimiri sciureus*, La Tropa Indillama, que ya exista en el región, desde April 14th a May 4th, 2019. Las técnicas de observación de "escanear" y "focal" fueron usados para observar el comportamiento de la tropa. Se usaba a EasyTrails, una aplicación de iPhone 7, para grabar los datos de GPS. También se usaba EasyTrails para crear un mapa del sistema de los senderos en el región Indillama. Treinta transectos de 10x30m, 108 transectos de 10x20m, y ocho transectos de 20x30m fueron usados para grabar datos de GPS de fuentes de comida potencial y grabar evidencia de la presencia de *Saimiri sciureus.* Se analizaba los datos con ArcGIS Online para establecer el rango hogar de la Tropa Indillama para averiguar las ubicaciones preferidas en donde se puede introducir la Tropa Yasuní. Los datos de población y comportamiento fueron analizados usando Excel para calcular el tamaño de la tropa y crear un presupuesto de actividades. El rango hogar de la Tropa Indillama es 72.3 hectáreas y toma un gran porción del área noroeste de Indillama. La Tropa Indillama tiene 29 individuos, 16 adultos, 6 subadultos, y 7 juveniles, y estaba moviendose o buscando la comida la mayoría del tiempo. Dado que una tropa bastante grande de monos ardillas ya domina la mayoría del territorio del noroeste de Indillama, debería introducir la tropa Yasuní a las partes surestes del región.

Background

Sumak Allpa and Indillama as a Potential Primate Relocation Site

Sumak Allpa is a foundation dedicated to natural primate rehabilitation, located on an island of the same name in Rio Napo, Orellana, Ecuador. A common squirrel monkey (*Saimiri sciureus*) troop on the island, referred to as the "Yasuní Troop" is ready for translocation to a new habitat in the Indillama region of Yasuní National Park (Riggs, 2016). According to Héctor Vargas, the director of Sumak Allpa and an environmental activist, the Yasuní Troop's move to Indillama would be Sumak Allpa's first successful primate translocation.

In order for the translocation to be successful, Indillama must be assessed as a potential *Saimiri sciureus* habitat. Indillama is the region surrounding the Kichwa community of Indillama, located in the Northwest corner of Yasuní National Park. It borders both the Napo River and the Indillama River. Assessing Indillama as a potential habitat includes establishing the habitat of the squirrel monkey troop that currently lives in Indillama in order to gain a better understanding of where the Yasuní Troop should be released (Vargas, personal communication, 2019).

Figure 1. Indillama region (pink and orange) of Yasuní

Introduction

Background on the Common Squirrel Monkey

Saimiri sciureus is a small primate, also known as a platyrrhine, distributed widely throughout Central America and the Amazon. Their hind legs are covered in short, olive-grey fur, and their faces, chests and bellies have beige fur (Riggs, 2016). Referred to as "mono payaso", or clown monkey, in Spanish, they have distinctive beige facial markings around their eyes and dark gray markings around their mouth. Their ears are prominent, with white tufted fur, and are generally around the same size as their heads, and their tails have a short, black tuft at the end. Sexual dimorphism is subtle: males have bright orange fur on the forelimbs and backs, while females' fur is paler (Riggs 2016).

Unlike other squirrel monkey species, *Saimiri sciureus* tends to live in troops of 15-30 individuals (Boinski 2005). Troops are characterized a linear hierarchy where males are dominant over females. Each troop generally has one to two breeding males, that will gain weight during the wet season in order to become more attractive to females (Boinski et. al. 2005). Breeding usually takes place during the dry season, and females carry their offspring on their backs for their first two to three months of life (Boinski 2002).

Saimiri sciureus are territorial, and troops generally have a well-defined "home range" of territory that is typically 70 hectares (Vargas, personal communication, 2019). They often prefer secondary forest and edge habitats, due to their tendency to have higher insect populations (Boinski et. al. 2005). They utilize understory, lower canopy and main canopy forest strata, and cover a large vertical range (Fleagle et. al. 1981). *Saimiri sciureus* has a tendency to travel where the canopy is the most dense, so as to provide maximum protection from avian predators (Boinski et. al. 2005).

Saimiri sciureus are insectivores and frugivores, and the composition of their diet depends on the season. Some literature suggests that during the dry season (May-September), they are mostly insectivores, while during the rainy season they are mostly frugivores (Lima and Ferrari, 2003, Terborgh 1983, Stone 2006). However, a study found that two troops in the eastern Amazon are predominately frugivorous throughout the year: 72% of their in the rainy season consisted of plants, 92% of which was fruit, to 68% in the dry season. (Pinheiro et. al. 2013). The plant species utilized by *Saimiri sciureus* vary based on the plant composition of the region as well as the season (Lima and Ferrari, 2003, Pinheiro et. al. 2013). In the eastern Amazon, the main plant species are Fabaceae species of the genus Inga and Sapotaceae species (Lima and Ferrari, 2003), as well as *Attalea Maripa* (Stone 2006). A more recent study found that in the eastern Amazon, *Saimiri sciureus* plant diet is mostly made up of *Inga spp.*, *Attalea maripa*, and *Bellucia grossularioides*, with *A. Maripa* dominating in the rainy season and *Inga spp.* in the dry season (Pinheiro et. al. 2013). A study based the Peruvian Amazon found that *Inga spp.* and *Ficus spp.* made up the majority of their diet (Terbourgh, 1983). This diet preference has been confirmed in studies of the Yasuni Troop: 25.71% of the time the troop was observed to be feeding on guaba (Carr, 2015).

Objectives: Habitat Analysis of the Indillama Troop

This project initially aimed to analyze Indillama as a potential habitat for the Yasuní Troop, using potential food sources as indicators of habitat suitability. However, since this study was able to confirm the existence of a *Saimiri sciureus* troop currently residing in Indillama, the objectives changed. The presence of a *Saimiri sciureus* troop in Indillama, which will be referred to as the Indillama Troop, means that releasing the Yasuní Troop into the region will be more difficult, as *Saimiri sciureus* is territorial (Stone 2006).Therefore, understanding the habitat, diet, and population composition of the Indillama Troop is essential to the future relocation of the

Yasuní Troop, as it will help Sumak Allpa determine the best location to release the Yasuní Troop (Hector Vargas, personal communication 2019).

The objectives of this study were the following:

1. Establish Indillama Troop's home range territory through
   a. Mapping the locations where they are observed
   b. Surveying Indillama for indicators of *Saimiri sciureus* habitat and presence (foraged Inga pods, Cecropia trees, etc)
2. Conducting a population analysis of the Indillama Troop
3. Mapping the Trail System in Indillama to assist in future scientific studies of the region

Methodology and Materials

Methodology

The project was divided into three parts: mapping the trail system in Indillama, observing the Indillama Troop, and surveying the trail system for potential indicators of the Indillama Troop's presence. The study was conducted in Indillama, Yasuní National Park, located in the Orellana Province of Ecuador.

Mapping the Indillama Trail System

As the Indillama trail system had never before been mapped using GPS, the first days of the project were dedicated to mapping the trail system. The trail system was mapped using the trail function on EasyTrails app on an iPhone 7. Six trails were mapped: Sendero Ceibo, Sendero Anaconda, Sendero Saino, Sendero Amfibio, Camino Vecinal and Sendero Tapir. Sendero Tapir was excluded from the study area both because it was only 836m long and because accessing it required crossing a swamp that was often flooded. Sendero Ceibo and Sendero Amfibio included parts of Camino Vecinal, but the rest of Camino Vecinal was excluded because it is primarily a community path. Sendero Anaconda connects the beginning and end of Sendero Ceibo so it can be walked as a loop. Overall, the study area was considered to be Sendero Ceibo, Sendero Anaconda, Sendero Saino and Sendero Amfibio, which resulted in 8 km of trails over an area of approximately 100 hectares.

Figure 2. A map detailing the trail system in Indillama. The study area Sendero Amfibio, Sendero Saino, Sendero Ceibo, and Sendero Anaconda.

Observing the Indillama Troop

Throughout the 21 day observation period, 34 observation periods were conducted. Out of these 34 observation periods, 17 were considered "active" observation periods, meaning that the sole goal of the time frame was to locate and observe the Indillama Troop. 17 were considered "passive" observation periods, meaning that the main goal of the time frame was to collect data on habitat indicators. However, if the Indillama Troop was encountered during a passive observation, the current task would be abandoned in order to follow and observe the troop. Observation periods were typically conducted between 7:00 am and 1:00 pm in the morning and then 2:00 pm and 5:30 pm in the evening, but this schedule was often shifted for rain. Once the Indillama Troop's sleeping area was discovered, mornings began at 6:15 am to attempt to observe them leaving this area.

When the Indillama Troop was encountered, the EasyTrails route function was used to map the troop's location throughout the observation period. Once the troop was encountered, they would be followed for as long as possible. In order to locate the troop, a set of distinctive sounds were listened for. A combination of scan and focal observation techniques were used to observe and record the monkeys' behavior (Altman 1971). Monkeys were identified as adults, subadults or juveniles using their relative size: adults are the largest, while juveniles are the

smallest. Gender was identified by using binoculars to observe forearm coloration, with the most bright being classified as males, and less bright being classified as females. Behavior was recorded and identified using the following guide used by Bria Riggs in 2016:

> *Movement*: locomotion that is unable to be put in any other category
> *Play*: interaction with other individuals or objects that is not aggressive
> *Rest*: no motion, usually in close proximity to other individuals
> *Groom*: picking through and brushing other individuals' fur
> *Human*: looking at or interacting with me or other humans
> *Aggression*: specific vocalizations and large movements towards the ground
> *Stress*: specific vocalizations, unusual repetitive activity
> *Eating*: placing food in the mouth
> *Foraging*: examining or manipulating a food item but not placing it in the mouth
> *Association*: physically interacting with other monkey species

During passive observation periods, the distribution of common squirrel monkey troop habitat indicators was mapped. Trail tape and a compass were used to help navigate back to the trail after following the monkeys off trail.

Mapping Indicators of the Indillama Troop's Territory

In order to further establish the Indillama Troop's territory, indicators of *Saimiri sciureus* habitat and presence were used. Indicators of *Saimiri sciureus* presence were defined to be evidence of foraging, which is characterized by partially eaten Inga pods on the ground. When partially eaten Inga pods were encountered, the locations' GPS coordinates would be taken using along with a photo, using EasyTrails. Indicators of *Saimiri sciureus* habitat were defined to be potential food sources, which were *Inga spp., Cecropia spp.,* and *Ficus spp.* At times, other fruiting tree species were mapped and later identified using *Common Trees of Yasuní.* When a potential food source was encountered, GPS coordinates would be taken along with a photo, using EasyTrails.

In order to map habitat indicators, three different transecting methods were utilized. First, the Sendero Ceibo and Sendero Anaconda were transected creating 30 transects, 150 meters apart. Each transect was 30 meters by 10 meters, and was set up across the trail so that it would reach 15 meters into the forest on either side. The transect distances were measured using string: once the transect was set up, the area was walked in order to map indicators of squirrel monkey presence and habitat. Distances between transects were approximated by walking 225 steps between each transect.

Secondly, Sendero Ceibo, Sendero Anaconda, Sendero Amfibio and Sendero Saino were transected by creating 108 ten by twenty meter transects, each 50 meters apart. The transects were measured using string, and set up so that the transect went five meters into the forest on

either side. Only the length was measured with string, and the width was approximated using footsteps and sight. The distance between each transect was approximated by walking 75 steps between each transect. The start and end of each transect, as well as all habitat indicators within the transect, were recorded using EasyTrails.

Thirdly, once the Indillama Troop's habitat was established, 'habitat zone' transects were created in areas were the troop was observed to frequent. Two of these zones were set up off of Sendero Saino, one off of Camino Vecinal, and four off of Sendero Ceibo. One was set up 40 meters off of Sendero Ceibo, reaching a maximum distance of 70 meters off of the trail.These transects were 20 meters by 30 meters, and were measured using string. Each corner of the transect was recorded using EasyTrails, and trail tape was

At the end of the 21 day observation period, geographic data was transferred into ArcGIS Online to be analyzed. In order to determine the Indillama Troop's total territory, three different habitat projections were created. The first habitat projection used only data where the Indillama Troop was observed, the second took into account where the Indillama troop was observed as well as indicators of presence, and the third took into account areas where the troop was observed, presence indicators, and habitat indicators. A buffer of 25 m was created around all habitat routes and a buffer of 50 meters was created around all habitat points to account for the distance the Indillama Troop spread out in the canopy. The identify clusters tool was used to establish areas with many eaten inga pods as indicators of presence. The hot spots tool was used to generate areas of the highest concentration of Inga, Cecropia and Ficus. Summarize within was used to calculate the total projected territory for the Indillama Troop. Population data was transferred into Google Sheets to be analyzed, and from this data the Indillama Troop's gender composition, age composition, and activity budget were determined.

Insects

This project intended to use four Van Sommer Traps to analyze the composition of arboreal insects that *Saimiri sciureus* are known to eat— primarily orthoptera and lepidoptera species. Four Van Sommer Traps were set up on three different occasions, in branches between 2m and 5m above the ground. The intention was to set up all four Van Sommer Traps for atleast 6 hours in each of the 8 Habitat Zones throughout the course of the project. Traps were set up in Zone 1, near Zone 7, and near Zone 6. String was tied to a weighted plastic bag, which was used as a projectile in order to hang the traps as high as possible. Each time the traps were set, they were left open for 6-10 hours. On the first trapping attempt, ants invaded three out of four of the traps, so Shampoo was placed on the strings on future trapping sessions to deter the ants from climbing up the strings. While the Shampoo method seemed to be successful in deterring the ants, these results were eventually discarded, as only one Orthoptera individual was captured. Furthermore, because the Indillama Troop was located, the project shifted to analyzing their behavior, habitat and diet rather than analyzing potential habitat.

Materials
- 20 m of string
- iPhone 7 with EasyTrails
- Botany Field Guide: *Common Trees of Yasuní*
- Binoculars
- Field Notebook
- Compass
- ArcGIS Online

Results

Observing the Indillama Troop

Overall, 34 observation periods were conducted for a total of 121.5 hours of attempted observation time. Out of the 34 observation periods, 55.9% were successful, meaning that *Saimiri sciureus* was encountered during 19 observation periods. 12/17, or 70.6% of active periods were successful, while 7/17, or 41.2% of passive periods were successful. The Indillama Troop was observed 20 times overall. Additionally, the Indillama Troop was observed twice by Lindsey Adler, and once by John Licuy, the guard working at Sacha Runa Lodge in April.

Population Analysis

While *Saimiri sciureus* was encountered during 19 observation periods, it was rare to encounter the entire Indillama Troop. Smaller groups of 1-5 individuals were observed most often, and the largest group encountered was 24 individuals. On two separate occasions, only one individual was encountered, and twice more groups of two individuals were encountered. Each time these groups were encountered, 30 minutes were spent attempting to locate the rest of the Indillama Troop, but this strategy was never successful.

The Indillama Troop was most often observed in the afternoon, especially the later afternoon, between 4-7 PM. However, there wasn't a correlation between group size and time observed: no group size was observed at a particular time more than twice. The average number of individuals seen was 11 individuals.
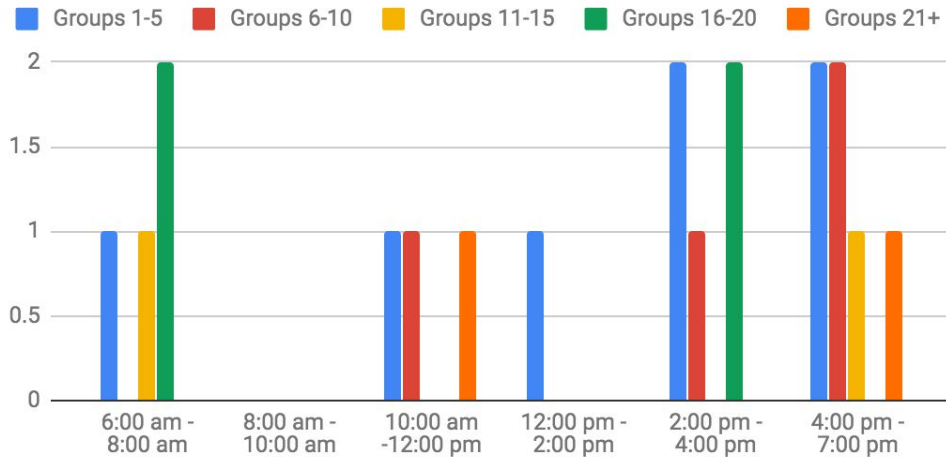
Figure 3. A chart showing how often different sized groups were observed at different times a day. The y-axis represents how many times groups were observed at each time.

In addition to counting the group size, age and gender was determined when possible. As the study went on, it became easier and easier to determine the age of the squirrel monkeys seen. It was most common to see adults, especially in smaller groups. Juveniles were only seen once in a group less than five, and were never seen alone. Additionally, an infant still riding on its mother's back was seen twice, on 4/14 and 4/22. Both times, the mother was traveling towards the front of the group.
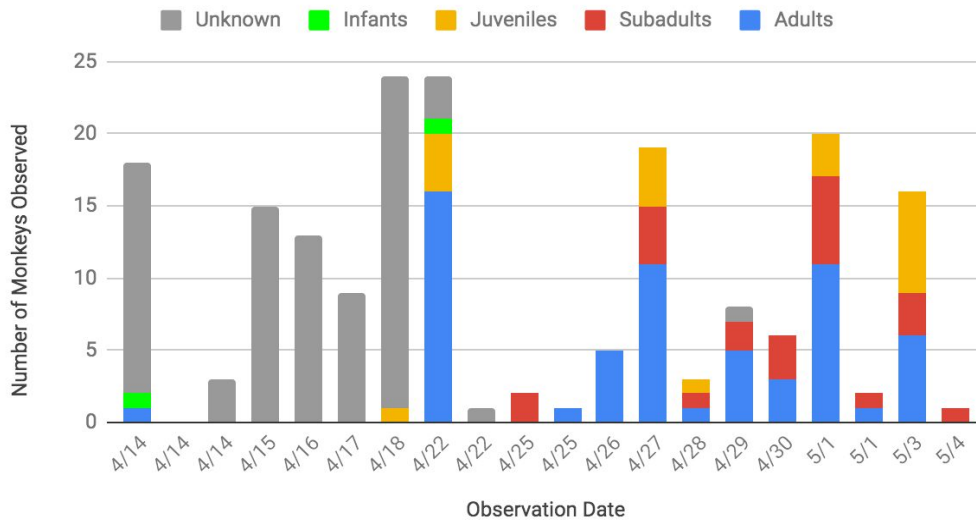
Figure 4. A chart showing the age composition of each group of *Saimiri sciureus* observed by observation date

Before this study, the total population of the Indillama Troop was unknown. While the largest group seen was 24 individuals, by summing the maximum amount of adults, subadults and juveniles seen at once, the study found the total population of the Indillama Troop to be 29 individuals. The troop is made up of 16 adults, 6 subadults, and 7 juveniles, meaning adults are

55%, subadults are 21% , and juveniles are 24% of the total troop. Both age and sex were determined for 23 individuals: the study found at least 13 females and at least 11 males. Females then are at least 44% of the troop, and males at least 37% of the troop.
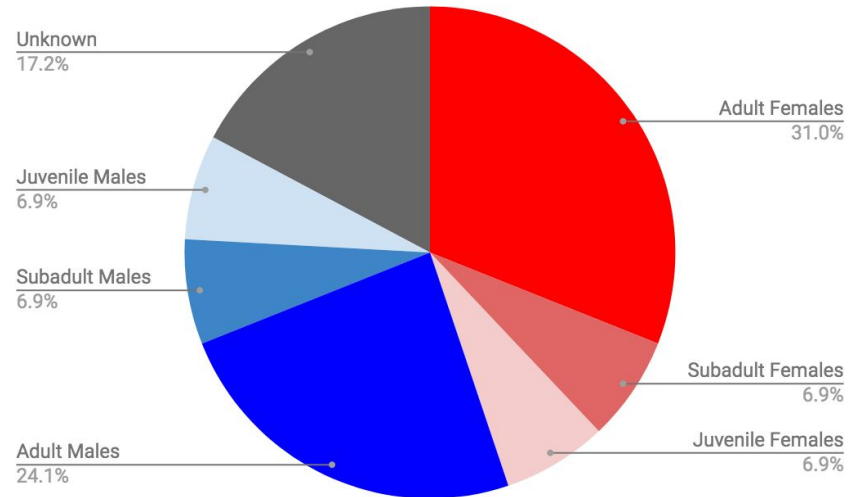

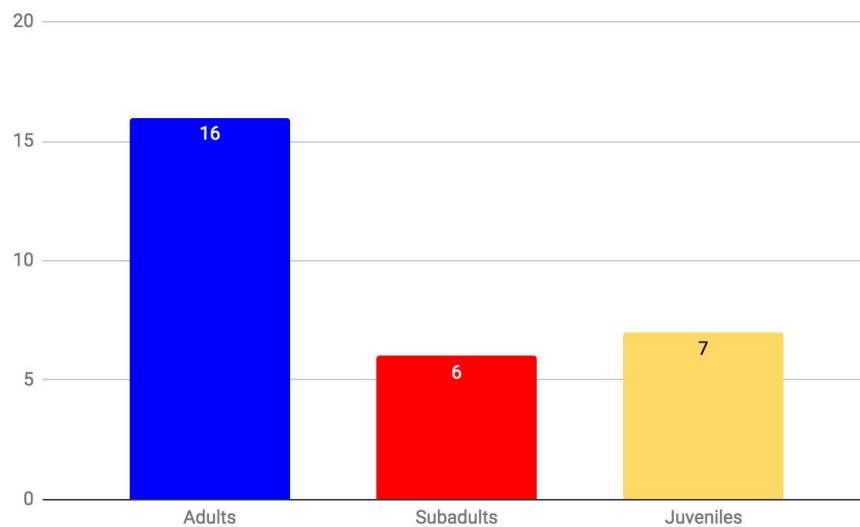**Figure 5.** A chart showing the composition of the Indillama Troop, divided by both age and sex

Figure 6. A chart showing the age composition for the entire Indillama Troop

Behavior and Diet

The Indillama Troop was observed for a total of 5 hours and 9 minutes. The large majority of the troop's behavior was Movement: Movement was observed for 69.8% of the total

time. Aside from Movement, the second most common activity was Foraging, made up 14.8% of the total time. The study categorized the rest of their behavior as Eating, Human, Stress, or Association— no instances of Grooming, Play, Rest or Aggression were recorded. Human
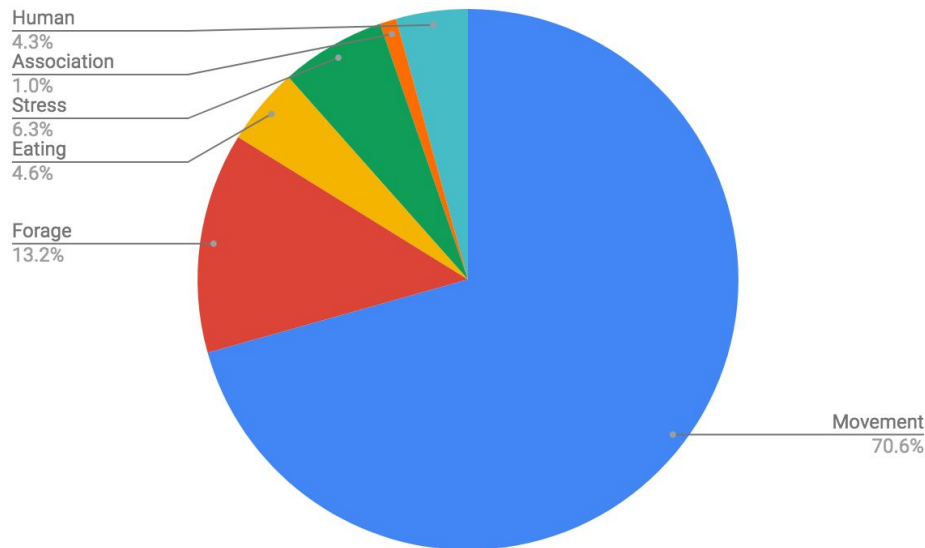

Figure 7. The Indillama Troop's overall behavior for the entire observation period, as percentages of the total observation period

Interaction, Eating, and Association made up event behaviors, and were 9.9% of observed behavior, while state behaviors, Movement, Foraging and Stress, made up 90.1% of observed behavior. Human Interaction occurred in 11/19 observations. A common interaction with Indillama Troop involved them noticing me, looking at me for a few seconds, then making stress calls to the whole group and moving into denser forest away from me. This interaction occurred on 10/19 of interactions with the Indillama Troop.

The Indillama Troop was observed to be Foraging and/or Eating for 54 minutes, or 17.5% of the total observation time. The Indillama Troop foraged *Inga spp* and *Cecropia spp* frequently, and ate these species on four separate occasions. Once, an adult female was eating an orange and green fruit, which was identified as *Sapindaceae melicoccus novogranatensis.* The Indillama Troop never ate insects or other fruit while they were being observed, but on one occasion, an Orthoptera abdomen was found below an adult male.

Association occurred once, between two subadult Saimiri sciureus and four Golden Mantled Tamarins (*Saguinus Tripartitus)*. The two *Saimiri sciureus* were sitting in a tree next to the Golden Mantled Tamarins, who noticed me first and began chirping. The squirrel monkeys then turned, looked at me, and then turned and ran deeper into the forest. The area was surveyed for the rest of the Indillama Troop, but it was not located. Aside from the Tamarins, three other

monkey species were observed in the region: Dusky Titi Monkeys (*callicebus molloch*), Red Howler Monkeys (*Aoulatta seneculos*), and Monk Sakis (*Pithicea monachus*). Golden-Mantled Tamarins, Dusky Titi Monkeys, and Red Howler Monkeys were observed within the Indillama Troop's home range.
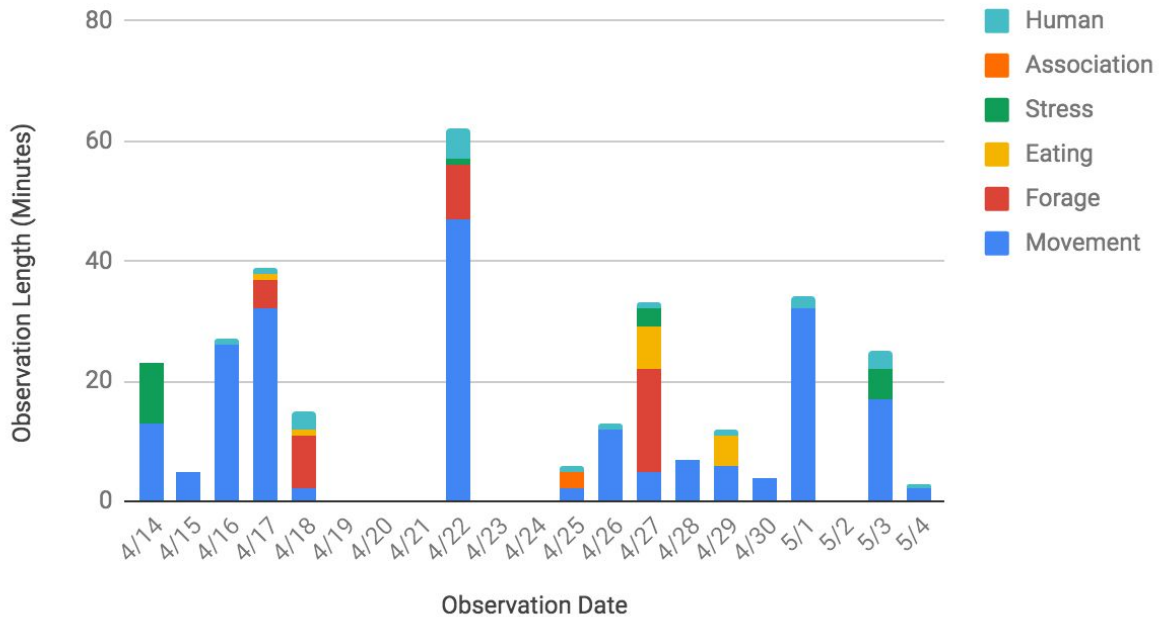

Figure 8. The activity budget for the Indillama Troop, broken down by date observed.

Habitat Analysis

   Establishing the Indillama Troop's Territory Through Direct Observation

   The Indillama Troop was observed along Sendero Ceibo, Sendero Amfibio and Sendero Saino. The Indillama Troop was observed most often along Sendero Ceibo, before the intersection with Sendero Saino. While this study never observed the Indillama Troop along Sendero Anaconda, the group was observed along that trail twice by Lindsey Adler, another student conducting a study in the Indillama region. The study located one of the Indillama Troop's sleeping locations, which is a group of spiky palms located along Sendero Amfibio, bordering the Indillama River. The Indillama Troop was observed entering the sleeping location for the night at 6:10 pm on 4/30/2019, and leaving the sleeping location at 6:45 am on 5/1/2019. In total, the Indillama Troop was directly observed across an area of 20.8 hectares. Territory Projection #1, created by combining the areas where the Indillama Troop was observed, shows that the total area is 42.2 hectares.
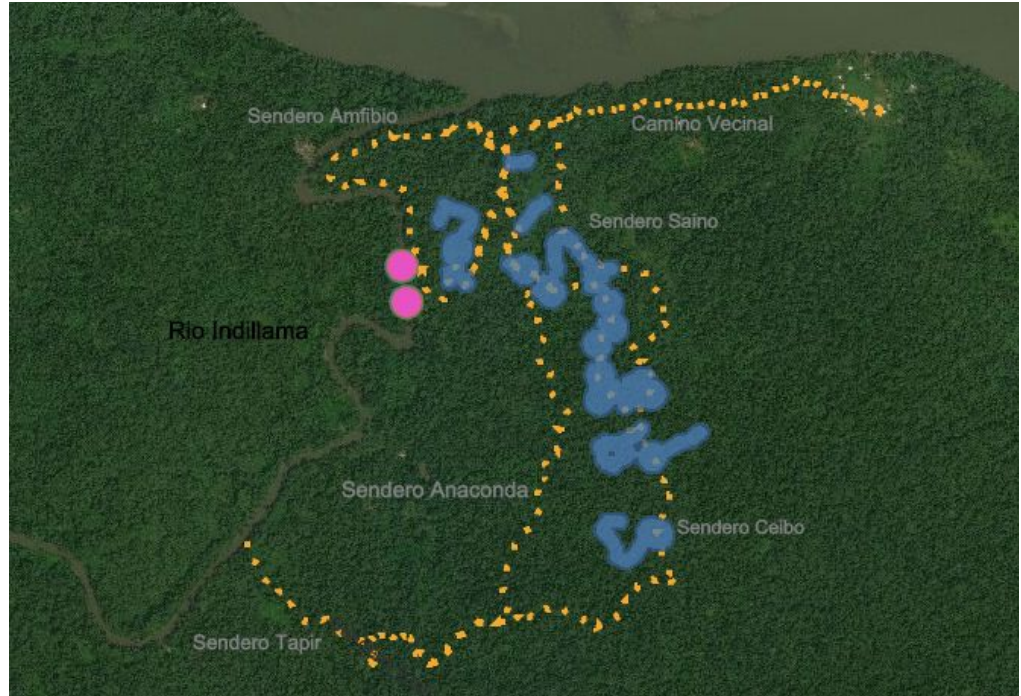
Figure 9. Map showing the Indillama Troop's sleeping spot, and areas where the Indillama Troop was observed

Figure 10. Map showing Territory Projection #1 of the Indillama Troop's territory, given the areas the troop observed. Light green is Territory Projection #1, which is 42.2 hectares

Using Habitat Indicators to Establish Indillama Troop's Territory

The presence of habitat indicators was important to establishing the full territory of the Indillama Troop. Evidence of foraging activity was taken to be the most important indicator of the Indillama Troop's potential territory. 8 instances of evidence of foraging activity were recorded throughout the 21 day observation period. Pods were identified to the species level where possible: pods were identified to be *Inga cordatolata, Inga ruziana, Inga marginata* and *Inga capitata.*

Indillama troop presence indicators, or evidence of Inga forage by monkeys, generally corresponded with places that the Indillama Troop was observed, except for one instance along Camino Vecinal and two instances along Sendero Anaconda. Given that Lindsey observed the Indillama Troop along Sendero Anaconda and that there is significant evidence of the Indillama Troop foraging *Inga spp* in an area along the trail similar close to where the Indillama Troop has been observed before, this area was included as part of the Indillama Troop's habitat. Territory Projection #2 was created considering the area where evidence of foraging was found and the area that the Indillama Troop was directly observed in, and was calculated to be 54.0 hectares.
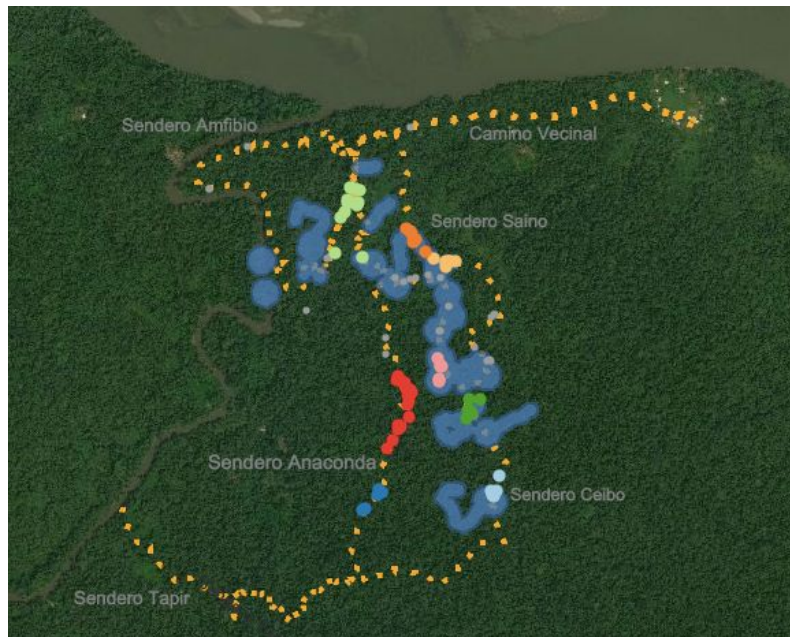

Figure 11. Map showing Indillama Troop presence indicators, or locations where evidence of Inga forage by monkeys was observed (colorful points) and the total observed territory of the Indillama Troop

Figure 12. Territory Projection #2 (light green), taking into account areas where the Indillama Troop was observed and areas where evidence monkeys foraged Inga were observed. It was calculated to be 54.0 hectares.

The study mapped *Saimiri sciureus* habitat indicators, which were *Inga spp., Cecropia spp.,* and *Ficus spp*. Overall, 393 *Inga* individuals, 104 *Cecropia* individuals, and 19 *Ficus* individuals were identified throughout the 21 day observation period. Six species of Inga were identified: *Inga cordatolata, Inga ruziana, Inga marginata, Inga auristellae, Inga leiocalycina, Inga cayennensis* and *Inga capitata* . Two species of cecropia, *Cecropia scalladophylla* and *Cecropia ficofolia*, were identified. Ficus were not able to be identified beyond the genus level in the field because the field guide used did not include Ficus species. All were found throughout the entire study area, but Inga were found to have the widest distribution.

There is high Inga concentration on Sendero Anaconda, Sendero Ceibo and Sendero Saino. There is an especially high concentration zone where Sendero Saino meets Sendero Ceibo. Unsurprisingly, areas of high Inga concentration correspond to areas where Indillama Troop presence indicators were observed. However, there are also several statistically significant hotspots of Inga where significant evidence of foraging was not observed. For Cecropia hotspots, the largest is located between Sendero Anaconda, Sendero Ceibo and Sendero Saino. There are also statistically significant Cecropia hotspots located along Camino Vecinal. Using these hotspots in addition to the area established in Territory Projection #2, Territory Projection #3 was created and calculated to be 73.2 hectares.

Figure 13. Map showing hot spots of Inga distribution

Figure 14. Map showing hot spots of Cecropia distribution

Figure 15. Territory Projection #3 (light pink), created by including habitat presence indicators (inga distribution, cecropia distribution, ficus distribution), Indillama troop presence indicators, and areas where the Indillama Troop was observed. It was calculated to be 73.2 hectares

For each of the 8 habitat zones, *Inga* presence was high. Cecropia was generally present, but in smaller numbers. Ficus was present in some zones, but not all. Other fruiting trees were present, which were identified to be *Fabaceae pseudopiptadeniua suvaolens, byrsonima putumayensis, Sapindaceae melicoccus novogranatensis, Myrtaceae eugeinia florida, lecthidaceae gris neuberthii* (piton), and *violaceae leonia crassa*.

Figure 16. Chart showing the distribution of habitat indicators per zone

Discussion

Throughout the 21 day study period, the Indillama Troop was observed 20 times, with an average length of observation 15 minutes and 30 seconds. Compared to other studies of *Saimiri sciureus*, this observation time is rel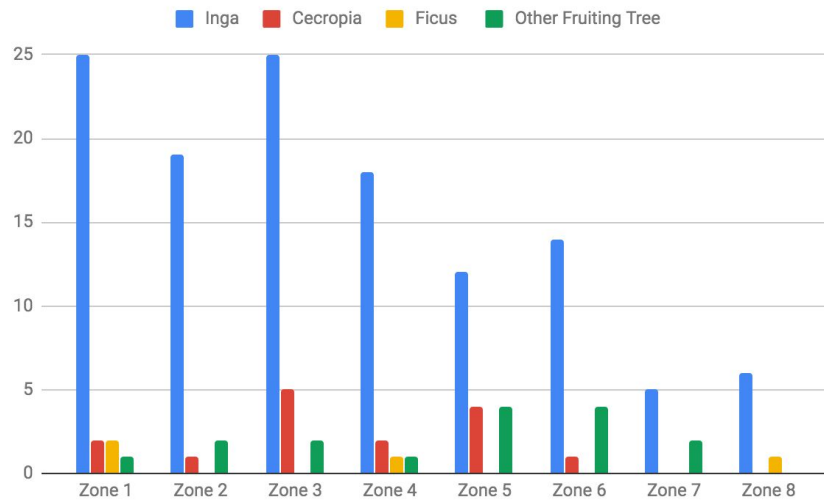atively short (Riggs 2016, Carr 2015). Some reasons for the short observation times were the large presence of thick swamps throughout Indillama that made it challenging to follow the Indillama troop for a large amount of time. Furthermore, Senderos Ceibo, Anaconda and Saino were mainly used during observation periods to attempt to locate *Saimiri sciureus.* However, on Day 18 of the project, the local people of Indillama took me by canoe to see one of the Indillama Troop's sleeping areas, which was along Sendero Amfibio. According to the local people of Indillama, the Indillama Troop is seen frequently nearby this sleeping area, and in a nearby swamp off of Sendero Amfibio. It's likely that the Indillama Troop utilizes more area along Sendero Saino than was recorded.

Population Analysis

The population of the Indillama Troop was found to be 29 individuals, 16 adults, 6 subadults, and 7 juveniles. The infant observed early in the study was excluded from the final population count because on May 3rd, a juvenile that was much smaller than the rest was observed. Since most squirrel monkey infants are born from November-January (Vargas, personal communication 2019), it's likely that throughout the course of this study the infant was beginning to leave its mother's back and travel on its own. Since it is possible that the juvenile observed was actually this infant, the infant was not counted separately in the final population count.

Even though squirrel Monkey troops in general can be as large as 100 individuals, average group size for Saimiri Sciureus is 20-30 individuals (Boinski et. al. 2005). However, previous literature has found that Saimiri sciureus troops in the Amazon can be even larger. One study of squirrel monkeys in the Eastern Amazon observed troops of 32 and 39 individuals (Pinheiro et. al. 2013), while another study in the Amazon observed troops that varied between 18-25 individuals and 24-32 individuals, respectively (Boinski et. al. 2005).

While the Yasuní Troop on Sumak Allpa has kept a rather consistent size for the past three years (Carr 2015, Riggs 2016), it is not uncommon for *Saimiri sciureus* troops to vary in size. It's possible that my counts varied so much in size because I was not able to count every individual present— *Saimiri sciureus* dispersion can be rather large— one study found that the average dispersal density for a *Saimiri sciureus* troop was 23 individuals per .1 hectare. However, it's also possible that the size of the Indillama Troop varied throughout the duration of the study due to the species' tendency to disperse farther than other *Saimiri* species (Boinski et. al. 2005).

Previous studies of squirrel monkey troops on Sumak Allpa have cited that it was rare to see groups of 1-5 individuals (Riggs 2016). However, in this study, groups of 1-5 individuals were most commonly observed throughout the 21 day observation period. Specifically, adult

males were observed by themselves on two separate occasions. For *Saimiri sciureus,* adult males can become solitary or periphery males for up to two years (Boinski et. al. 2005). Furthermore, while females disperse less than males, philopatric behavior is low overall in *Saimiri sciureus*, meaning that it is common to observe smaller groups outside of a cohesive troop (Boinski et. al. 2005).

In terms of population composition, according to Héctor Vargas, the most typical population composition for *Saimiri sciureus* is 20% juveniles, 30% subadults, and the rest adults (Vargas, personal communication, 2019). One study observed troops with 12 adults, 2 subadults, 5 juveniles, and 6 infants, and with 15 adults and subadults and 5 infants (Thoisy 2002). While it is common for adults to make up the majority of a troop, numbers can vary with seasons of reproduction (Thoisy 2002). Additionally, the number of juveniles can be an indicator of how large the troop is: a troop of 25 individuals may have 4 offspring, for example (Vargas, personal communication, 2019). This pattern holds up in the troop composition for other studies of Amazonian squirrel monkey troops— a group of 39 individuals had at least 8 juveniles, and a group of 32 individuals had at least 10 juveniles (Pinheiro et. al., 2013).

Behavior Analysis

This study found that movement took up the large majority of the Indillama Troop's time while they were being observed, which is different from previous studies. A previous study of the Yasuní Troop found that movement consumed 32.32% of the total time (Riggs 2016), while a study of *Saimiri sciureus* in the Eastern Amazon found that movement took up 28.9% of time for both troops (Pinheiro et. al. 2013). In each of those studies, forage was the most commonly observed activity, taking up 47.54% of time in Riggs' study and 48.7% and 49.6% for each troop in Pinheiro et. al.'s study. However, compared to Riggs' and Pinheiro et. al.'s study, this study had significantly less contact hours with the study troop, which may have biased the results.

The Indillama Troop was observed to eat *Inga spp.*, *Cecropia spp.,* and on one occasion a fruit that was identified as *Myrtaceae eugeinia florida*. Even though some studies have found that squirrel monkeys generally prefer Inga in the dry season (Lima and Ferrari, 2003), local sources said that squirrel monkeys tend to feed mostly on Inga in April because that is when it is fruiting. The study took place from late April to early May, which is when the rainy season comes to a close and the dry season begins (Lima and Ferrari, 2003). Because of this, the study was looking to observe whether the Indillama Troop's diet shifted from fruit to insects as the rainy season came to an end (Lima and Ferrari, 2003). However, the Indillama Troop was never observed eating insects, so this shift in diet was not able to be established.

Association was only observed once, with a group of Golden-Mantled Tamarins (*sagunis tripartitus)*. Many *Saimiri sciureus* troops are known to follow Capuchin Monkey Troops, *Cebus albifrons*, and utilize their more disturbance based forage strategy to find more insects (Fleagle et. al. 1981). This instance of association was not observed for the Indillama Troop, and according to local sources, the Capuchin monkeys utilize space deeper into the forest.

Habitat Analysis

This study was successfully able to establish portions of the Indillama Troop's home range. The Western border of their habitat was the Indillama River. The Eastern border was unclear. The troop utilizes habitat at least to Sendero Saino, and likely beyond, but they were never observed to be farther east of Sendero Saino. The southern border of their habitat is just north of the Ceibo tree. The Northern border is most likely Camino Vecinal and the beginning of Sendero Rio— the farthest north point they were observed is where Camino Vecinal intersects with Sendero Ceibo. They were observed frequently in trees directly bordering swampy areas.

In terms of the size of the Indillama Troop's range, they were directly observed in an area covering 42.2 hectares, and their total habitat, taking into account evidence of foraging and potential food source distribution, was calculated to be 72.3 hectares. Approximately 70 hectares is thought to be the average for *Saimiri sciureus* habitat (Vargas, personal communication, 2019, Pinheiro et. al. 2013). However, *Saimiri sciureus* troops home ranges have been observed to be as large as 110 and 123 hectares (Stone 2006). Since *Saimiri sciureus* is known to keep very consistent home ranges, and that all locations *Saimiri sciureus* were observed were within 100m of each other, these 72.3 hectares likely make up the Indillama Troop's home range (Stone 2006).

When introducing the Yasuní Troop to Indillama, it will be important to introduce the troop to an area outside of the Indillama Troop's home range. In areas with more than one squirrel monkey troop, the troops tend to interact very little and develop home ranges that don't overlap (Stone 2006, Pinheiro et. al. 2013). Some of this phenomenon was observed in Indillama— according to local sources, there is another *Saimiri sciureus* troop that lives farther down the Indillama river. This troop was never seen, but on one occasion it was heard (from a canoe) approaching the river, 1.45 km away from where the Indillama Troop was encountered 30 minutes later.

There are three possible locations that the Yasuní Troop could be introduced to Indillama so as not to interfere with the Indillama Troop's home range. The first would be in the region southeast of Sendero Saino, the second in the region south of the Ceibo, and the third south of Sendero Tapir by the Indillama River. Since another squirrel monkey was observed in Location #3, it is likely not the most ideal, but another study would need to be conducted to establish the territory of the other squirrel monkey troop in Indillama. Location #1 and Location #2 are both potential spots to introduce the Yasuní Troop.

Overall, Indillama was found to be a very suitable region for *Saimiri sciureus.* There were 393 Inga trees located throughout the study region, and 104 Cecropia. These results make sense with previous research into Inga distribution in Yasuní: one study found 2258 individuals representing 37 species in a 100 hectare area. The relatively large distribution of Cecropia is likely due to the fact that much of Indillama is secondary forest edge habitat, where Cecropia are common (Valencia et. al. 2004). Furthermore, the Indillama region is a combination of

secondary and primary forest. *Saimiri sciureus* are known to prefer secondary forest and edge habitats because these are areas where insect distribution is highest (Boinski et. al. 2002). The presence of fruit, as well as the combination of secondary and primary forest habitat, makes Indillama very suitable for *Saimiri sciureus*.

Figure 17. Map showing potential locations to introduce the Yasuní Troop (green circles), and the location of the other Squirrel Monkey Troop (white dot)

Potential Sources of Error

      As discussed previously, the Indillama troop was observed for a total of 5 hours and 9 minutes, which is significantly less than other squirrel monkey studies. Human error was likely a factor that impacted the quality of the observations— any time the monkeys noticed me, they would utter distress calls and run deeper into the forest. This is likely part of the reason movement was observed more often in this study than it was in other studies. Additionally, one of my field shirts was red, which I learned part way through the study is very easy for monkeys to detect. This could have had an impact on my results because it may have lead the monkeys to notice me more in earlier observation periods. Furthermore, often I wasn't able to follow the monkeys as fast as necessary, as needed to set trail tape to track my way, and would lose them in the forest. Human error also likely impacted the accuracy of the composition count— since *Saimiri sciureus* prefers dense canopy cover, it is often very challenging to observe the whole group all at once. Human error also could have affected the group size distribution I observed: because I had several observations that were very short, I was only able to count a few individuals, which could have skewed my results.

Another potential source of bias in my results is that the majority of my study was concentrated around Senderos Ceibo, Anaconda, and Siano. Because I spent more time on these trails, I observed the squirrel monkeys the most on these trails, which may have skewed my perception of the Indillama Troop's home territory. My transecting was centered around the trail system, especially Senderos Ceibo and Anaconda— more off trail transects were created off of these trails. This could have skewed my perception of where hot spots of presence and habitat indicators were. Furthermore, identifying trees was often very difficult, as some of the most distinctive parts of Inga are microscopic organisms that are high up in the canopy and couldn't be observed from the ground level. It was also incredibly challenging to identify other species of fruiting trees. It's very possible that I wasn't successfully able to identify every fruiting tree in every transect I created, and also it's possible that I misidentified some species.

Additionally, for my habitat projections, I used evidence of foraging as a significant indicator of the Indillama Troop's territory. While large presence of partially eaten inga pods is usually a good indicator that monkeys were responsible, it doesn't necessarily mean that the squirrel monkeys were the ones who created all of the evidence of foraging. Also, I used tree distribution as a marker of potential habitat, and it is entirely possible that there are areas of high inga density that the squirrel monkeys do not frequent due to low canopy density or any number of reasons. I also wanted to use a spatial analysis tool to create these areas, but due to the limited functionality of ArcGIS Online I had to draw them by hand. This could also give room for potential error because my drawing is not as accurate as that of a mathematical model.

Conclusion

This study was a successful preliminary study of the habitat, composition, diet and behavior of the Indillama Troop. One of their sleeping areas as well as 73.2 hectares of their home territory were established. The troop was found to have 29 individuals total, 16 adults, 6 subadults, and 7 juveniles, and at least 13 females and 10 males. Indillama was found to be a very suitable region for *Saimiri sciureus*, with a strong distribution of fruiting trees that could be potential food sources. While the Indillama Troop was observed to eat Inga and Cecropia, not very many instances of eating were observed. Future studies of the Indillama Troop should focus entirely on following the troop so as to better establish its habitat and diet.

Since the Indillama Troop utilizes a significant part the areas along Sendero Amfibio and the northern parts of Sendero Saino, Sendero Ceibo and Sendero Anaconda as its territory, the Yasuní troop should not be introduced to this specific location. Due to the large presence of potential food sources in Indillama, it still remains a good location to release the Yasuní Troop. However, the best location to introduce the Yasuní Troop is likely outside the trail system that currently exists in Indillama, either east of Sendero Saino or south of Sendero Ceibo. Before the Yasuní Troop can be successfully introduced to Indillama, a habitat analysis should be conducted of the other squirrel monkey troop in the area to figure out that troop's home territory.

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Bibliography

Arellano, P., Tansey, K., Baltzer, H., Tellkamp, M. (2017). Plant Family-Specific Impacts of Petroleum Pollution on Biodiversity and Leaf Chlorophyll Content in the Amazon Rainforest of Ecuador. *PLoS One*, *12(1),* 1932-6203 (Online). doi: 10.1371/journal.pone.0169867.

Boinksi S, Sughrue K, Selvaggi L, Quatrone R, Henry M, Cropp S. (2002). An Expanded Test of the Ecological Model of Primate Social Evolution: Competitive Regimes and Female Bonding in Three Species of Squirrel Monkeys (Saimiri oerstedii, S. boliviensis, and S. sciureus). *Behaviour*, 139(2/3): 227-261.

Boinski, S., Kauffman, L., Ehmke, E., Schet, S., Vreedzaam, A. (2005). Dispersal Patterns among three species of squirrel monkeys (*Saimiri oerstedii, S. bolivienes* and *S. sciureus*): I. Divergent Costs and Benefits. *Behavior, 142(5),* 525-632. Retrieved from: https://www-jstor-org.ezproxy.library.tufts.edu/stable/4536260

Carr, G. (2015). Assessment of a Common Squirrel Monkey Troop in Rehabilitation: A Study of the Territory and Feeding Habits of Saimiri sciureus in Preparation for Translocation from Sumak Allpa to Yasuní National Park. *SIT: Comparative Ecology and Conservation, 2015.*

De Thoisy, B., Louget, O., Bayart, F., Contamin, H. (2002). Behavior of Squirrel Monkeys (*Saimiri sciureus)*. 16 years on an Island in French Guiana. *Neotropical Primates, 10(2),* 73-76. Retrieved from http://static1.1.sqspcdn.com/static/f/1200343/18198183/1337026350417/NP10.2.saimiri. behavior.pdf?token=nYH3o0lkn1Fc2in0OuZ05gZsyU8%3D.

Endara, M. J., & Jaramillo, J. L. (2011). The Influence of Microtopography and Soil Properties on the Distribution of the Speciose Genus of Trees, Inga (Fabaceae: Mimosoideae), in Ecuadorian Amazonia. *Biotropica 43(2)*, 157-164, retreieved from https://www-jstor-org.ezproxy.library.tufts.edu/stable/41057992.

Lima, E. M., Ferrari, S. F. (2003). Diet of a free-ranging group of squirrel monkeys (Saimiri sciureus) in eastern Brazilian Amazonia. *Folia Primatologica, 74(3),* 150-158. Retrieved from https://search-proquest-com.ezproxy.library.tufts.edu/docview/219357377/fulltextPDF/94

F66070815D44C2PQ/1?accountid=14434.

Martin, P. L. & Scholz, I. (2014). Policy Debate: Ecuador's Yasuní-ITT Initiative: What Can We Learn from its Failure? *Revue internacionale de politque de développment,* 5. doi: 10.4000/poldev.1705.

Pinheiro, T., Ferrari, S. F., Lopes, M. A. (2013). Activity budget, diet, and use of space by two groups of squirrel monkeys (Saimiri sciureus) in eastern Amazonia. *Primates, 54(3),* 301-308. doi: https://doi-org.ezproxy.library.tufts.edu/10.1007/s10329-013-0351-9.

Pitman, N. C. A., Terborgh, J., Silman, M., Núñez, P., Neill, D., Cerón, C., Palacios, W. A., Aulestia, M. (2001). Dominance and Distribution of Tree Species in Upper Amazonian Terra Firme Forests. *Ecology,82*(8), 2101-2117. doi:10.2307/2680219

Riggs, B. (2016). Evaluating a Squirrel Monkey Troop in Natural Rehabilitation: An Assessment of Population and Behavior of Saimiri sciureus in Preparation for Relocation from Sumak Allpa to Yasuní National Park. *SIT: Comparative Ecology and Conservation, Fall 2016.*

Stone, A. I. (2007). Responses of squirrel monkeys to seasonal changes in food availability in an eastern Amazon forest. *American Journal of Primatology, 69(2),* 142-157. doi: https://doi-org.ezproxy.library.tufts.edu/10.1002/ajp.20335

Terborgh, J. (1983). *Five New World Primates: A Study in Comparative Ecology.* Princeton, NJ: Princeton University Press.

Villa, G., Bass, M., Garwood, N., Navarette, H. (2016). *Common Trees of Yasuní.* Centro de Publicaciones del PUCE.

Vormisto, J., Svenning, J.C., Hall, P., Balslev, H. (2014). Diversity and dominance in palm (Arecaceae) communities in *terra firme* forests in the Western Amazon basin. *Journal of Ecology, 92(4),* 577-588. doi: https://doi.org/10.1111/j.0022-0477.2004.00904.x.

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