How do spider monkeys modify their environment? Are they the gardeners of Mexican forests?

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Progress Report

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My project aims to evaluate the role of Geoffroy's spider monkeys (*Ateles geoffroyi*) in influencing the floristic composition of regenerating forests in different stages of succession in the Yucatan Peninsula, Mexico. I will generate a map of the different forest successional stages and perform drone surveys to calculate spider monkey abundance for each successional stage. Vegetation plots will be created to evaluate the diversity and richness of tree species and to measure the density and diversity of seedlings and juvenile trees. This will allow me to evaluate the influence of spider monkeys on forest regeneration.

Specific Objectives

1) Categorize forest successional stages through satellite imagery and ground-truthing.
2) Determine the presence of spider monkeys in different stages of forest succession.
3) Determine the floristic composition of different forest successional stages and sample seedlings and juvenile individuals of tree species consumed by spider monkeys and relate their density and diversity to spider monkey presence.

1. Categorization of forest successional stages

Starting in June 2021, I began to search for different places to perform spider monkey surveys and to sample seedlings and juvenile trees of importance in the spider monkey diet. My study area is located between the municipalities of Tulum (in the state of Quintana Roo) and Chemax (in the state of Yucatan), covering an area of approximately 1,500 km^2 on both sides of the main road between Tulum and Chemax (Figure 1). This area was selected because it presents the necessary conditions to support populations of spider monkeys, but no information on the presence and abundance of spider monkeys exists outside of the two protected areas that are located there (Tulum National Park and the Flora and Fauna Protected Area of Otoch Ma'ax Yetel Kooh) and from Los Arboles Tulum (a residential development where a long-term project on the behavior and ecology of spider monkeys has been developed for over 5 years). The areas adjacent to these three sites are a mixture of private properties and ejidos (communal land holdings) with no protected status and where different factors are threatening the wildlife found there.

Over the past 6 months I located different sites within the study area that presented the conditions to carry out my study (i.e., they had forests in different stages of succession). Once the site was located, I proceeded to establish contact with the owner (in the case of private lands) or with the commissioner in the case of ejidos. After explaining the methods and the importance of the study to spider monkey conservation, I was able to obtain permission to carry out my study in 25 sites (sample sites) within the study area (Figure 1).

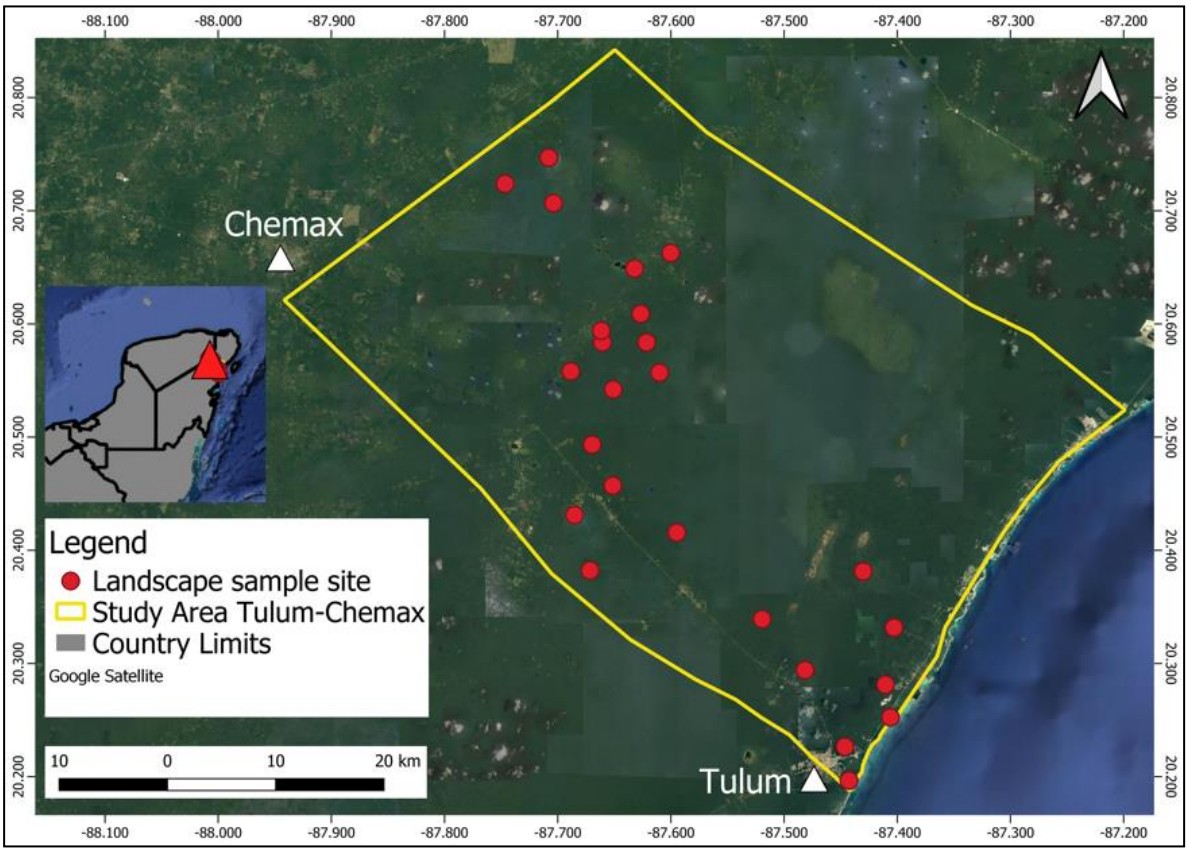

Figure 1. Location of the Tulum-Chemax area and 25 sample sites where I obtained permission from the landowners or ejidatarios to carry out the research.

To determine the different categories of forest cover and anthropogenic land-covers within the study area, I am developing a land-cover map in Google Earth Engine (GEE) using high resolution satellite imagery from the Sentinel-2 Multispectral Instrument (MSI). I classify the land-cover categories within each landscape as follows: 1) water bodies; 2) human infrastructure (i.e., roads, cities); 3) agricultural or cattle ranching areas; 4) early regenerating forests (0-15 years of age); 5) medium regenerating forests (16-30 years); 6) late regenerating forests (31-50 years); and 7) mature forests (> 50 years). The age-based forest successional stage categories are based on categories used in previous studies conducted in the area where vegetation type, land use history and local ecological knowledge were taken into account in the classification (García-Frapolli et al., 2007; Ramos-Fernandez et al., 2013; Ramos-

Fernández & Ayala-Orozco, 2003). To determine the land cover categories mentioned above, I have taken validation points in the field with the help of a GPS device (Garmin GPSMAP 64 model). I visited different sampling sites where, accompanied by local field assistants who have knowledge about the historical use of forests I was able to take multiple validation points for the correct determination of each of the land-cover categories (Figure 2). During the month of December 2021, I will finalize the collection of validation points to generate the land-cover map of the different stages of forest succession.

Figure 2. Photos from the field: A) Don Jose (local field assistant) and I taking a break after an 8 km walk taking validation points for the land-cover map. B) A group of volunteers and park rangers of the Tulum National Park team and I during a walk to collect validation points.

An added bonus during the past 6 months was working with the Tulum National Park team. I was invited to train a group of volunteers in the use and programming of camera traps, establishment of permanent vegetation plots and recognition of tracks of different species of mammals present in the park. I gave presentations and short field exercises (Figure 2).

2. Determine the presence of spider monkeys

Mainly because of their high degree of fission-fusion dynamics (Aureli et al., 2008), searching for spider monkeys using conventional methods such as line transect surveys is difficult (Spaan et al., 2018). The use of new conservation technology that can help improve spider monkey surveys is necessary to obtain better results. Recently, there has been a large spike in the use of novel technology to generate information for primate conservation. For example, the use of remote sensing via drones has been used to determine primate species´ presence (*Ateles geoffroyi*: Kays et al., 2018; Spaan et al., 2019; *Pan sp.*: Bonnin et al., 2018; *Nomascus hainanus*: Zhang et al., 2020; *Brachyteles hypoxanthus*: Melo, 2021). Due to their relatively low cost and ease of use, drones present an important alternative to determining the presence of primate species in poorly studied areas or areas with challenging terrain compared to line or point transects (Spaan et al., in press). Pilot studies have demonstrated the feasibility of using drones to determine spider monkey presence with both visual spectrum red-green-blue (RGB; Spaan et al. in press) and thermal cameras (Spaan et al.,

2019) in the Yucatan Peninsula.

To determine spider monkey presence in regenerating forest in different states of succession, I will perform drone flights with an over-the-counter drone with a visual-spectrum (red-green-blue; RGB) camera. Drones equipped with RGB cameras have been successfully used for the detection of a wide variety of animals species of different sizes and in different habitats: gray seals *(Halichoerus grypus)* in exposed coastal bog (Seymour et al., 2017); elephants (*Loxodonta africana*) in shrub and woody savannah (Vermeulen et al., 2013); straw-necked ibis *(Threskiornis spinicollis)* in flooded wetlands and floodplains (Lyons et al., 2019); golden crown sifakas *(Propithecus tattersalli)* in dry forests (Semel et al., 2020); and spider monkeys *(Ateles geoffroyi)* and howler monkeys *(Aloutta paliatta)* in a semi-deciduous tropical forest (Kays et al., 2018).

I will perform the drone flights during the dry season months (January to June 2022). Previous research in the Yucatan Peninsula has found seasonal differences in both spider monkey behavior and movement patterns (Smith-Aguilar et al., 2016). For instance, during the dry season when food avaibility is lower, individual core areas are larger and individual monkeys are spaced farther apart (Smith-Aguilar et al., 2016). During thse dry season spider monkeys are also forced to use other types of vegetation (i.e., regenerating forests in different stages of sucession) and less-frequented and more distant areas within their home ranges at times when mature forests do not provide sufficient food (Ramos-Fernandez et al., 2013). This, together with the large number of tree species in the Yucatan Peninsula that lose their leaves (Huechacona-Ruiz et al., 2020), indicates that the period with the highest probability of detecting spider monkeys in regenerating forests is the dry season.

During the past 6 months I participated in a training course for the use and programming of drones to perform spider monkey surveys (Figure 3). During this course I learned how to create predetermined routes of the flights to later carry out the surveys of the spider monkeys.

Figure 3. The Mexican drone pilot and I during the training course focused on the handling and programming of drones for the survey of spider monkey populations.

3. Sampling seedlings and juvenile individual of trees in regenerating forest

In order to determine the vegetation structure of each of the stages of forest succession and to sample seedling and juvenile individuals of trees important for the diet of spider monkeys, I worked with a local botanist to learn to correctly determine the species used by spider monkeys. We conducted a survey of trees, seedlings and juveniles (saplings) of 10 species that are important in the spider monkey diet. When the species of interest were located and identified, they were measured and photographed for the development of a personal field guide which I will use in all sampling sites (Figure 4). During the months of January to June 2022, I will sample seedlings and juvenile individuals of trees important for the spider monkeys' diet in the different sampling sites.

Figure 4. A) Measurement and determination of seedlings and juveniles of tree species important in the spider monkey diet. B) Avelino, the local botanist that accompanied me in the field.

Anecdotes from the field

In one of the walks that I made for the collection of the validation points for the land-cover map, we encountered a group of spider monkeys near the lagoon of the community of Campamento Hidalgo. This group is not used to the presence of people so during the whole encounter they vocalized a lot and after a couple of minutes they left. However, I was able to take photos and videos of some of the individuals (Figure 5).

Figure 5. Individual spider monkeys photographed at the encounter

On another field trip I visited one of the interior zones of my study area, approximately 8 km into the forest. After a long hike I was lucky enough to visit one of the least visited lagoons in the area. According to Don Jose (my local guide), this lagoon had not been visited by anyone from his community in over 15 years so when we arrived, we were able to enjoy an incredible place that very few people could reach (Figure 6).

Figure 6. Photograph taken upon arrival at the lagoon.

During the visit to one of my sampling sites I had the possibility to visit a cenote (subterranean or superficial water bodies unique to the Yucatan Peninsula) where I was able

to find one of the most amazing fig trees (*Ficus* spp.) I have ever seen! The roots of this tree reached more than 10 meters from the ground to reach the water at the bottom of the cenote.

Figure 7. An individual Ficus where you can see its roots falling down to reach the water of the cenote.

References

Aureli, F., Schaffner, C. M., Boesch, C., Bearder, S. K., Call, J., Chapman, C. A., Connor, R., Di Fiore, A., Dunbar, R. I. M., Peter Henzi, S., Holekamp, K., Korstjens, A. H., Layton, R., Lee, P., Lehmann, J., Manson, J. H., Ramos-Fernandez, G., Strier, K. B., & Van Schaik, C. P. (2008). Fission-fusion dynamics new research frameworks. *Current Anthropology*, *49*(4), 627–654.

Bonnin, N., Andel, A. C. Van, Kerby, J. T., Piel, A. K., Pintea, L., & Wich, S. A. (2018). Assessment of chimpanzee nest detectability in drone-acquired images. *Drones 2018, Vol. 2, Page 17*, *2*(2), 17.

García-Frapolli, E., Ayala-Orozco, B., Bonilla-Moheno, M., Espadas-Manrique, C., & Ramos-Fernández, G. (2007). Biodiversity conservation, traditional agriculture and ecotourism: Land cover/land use change projections for a natural protected area in the

northeastern Yucatan Peninsula, Mexico. *Landscape and Urban Planning*, *83*(2–3), 137–153.

Huechacona-Ruiz, A. H., Dupuy, J. M., Schwartz, N. B., Powers, J. S., Reyes-García, C., Tun-Dzul, F., & Hernández-Stefanoni, J. L. (2020). mapping tree species deciduousness of tropical dry forests combining reflectance, spectral unmixing, and texture data from high-resolution imagery. *Forests 2020, Vol. 11, Page 1234*, *11*(11), 1234.

Kays, R., Sheppard, J., Mclean, K., Welch, C., Paunescu, C., Wang, V., Kravit, G., & Crofoot, M. (2018). Hot monkey, cold reality: surveying rainforest canopy mammals using drone-mounted thermal infrared sensors. *International Journal of Remote Sensing*, *40*(2), 407–419.

Lyons, M. B., Brandis, K. J., Murray, N. J., Wilshire, J. H., McCann, J. A., Kingsford, R. T., & Callaghan, C. T. (2019). Monitoring large and complex wildlife aggregations with drones. *Methods in Ecology and Evolution*, *10*(7), 1024–1035.

Melo, F. R. de. (2021). Drones for conservation: new techniques to monitor muriquis. *Oryx*, *55*(2), 171–171.

Ramos-Fernández, G., & Ayala-Orozco, B. (2003). population size and habitat use of spider monkeys at Punta Laguna, Mexico. In *Primates in Fragments* (pp. 191–209). Springer US.

Ramos-Fernandez, G., Smith Aguilar, S. E., Schaffner, C. M., Vick, L. G., & Aureli, F. (2013). site fidelity in space use by spider monkeys (*Ateles geoffroyi*) in the Yucatan Peninsula, Mexico. *PLoS ONE*, *8*(5), 62813.

Semel, B. P., Karpanty, S. M., Vololonirina, F. F., & Rakotonanahary, A. N. (2020). eyes in the sky: assessing the feasibility of low-cost, ready-to-use Unmanned Aerial Vehicles to monitor primate populations directly. *Folia Primatologica*, *91*(1), 69–82.

Seymour, A. C., Dale, J., Hammill, M., Halpin, P. N., & Johnston, D. W. (2017). Automated detection and enumeration of marine wildlife using unmanned aircraft systems (UAS) and thermal imagery. *Scientific Reports 2017 7:1*, *7*(1), 1–10.

Smith-Aguilar, S. E., Ramos-Fernández, G., & Getz, W. M. (2016). seasonal changes in socio-spatial structure in a group of free-living spider monkeys (*Ateles geoffroyi*). *PLOS ONE*, *11*(6), e0157228. https://doi.org/10.1371/JOURNAL.PONE.0157228

Spaan, D., Burke, C., McAree, O., Aureli, F., Rangel-Rivera, C. E., Hutschenreiter, A., Longmore, S. N., McWhirter, P. R., & Wich, S. A. (2019). thermal infrared imaging from drones offers a major advance for spider monkey surveys. *Drones 2019, Vol. 3, Page 34*, *3*(2), 34.

Spaan, D., Ramos-Fernández, G., Schaffner, C. M., Pinacho-Guendulain, B., & Aureli, F. (2018). How survey design affects monkey counts: A case study on individually recognized spider monkeys (*Ateles geoffroyi*). *Folia Primatologica*, *88*(5), 409–420.

Vermeulen, C., Lejeune, P., Lisein, J., Sawadogo, P., & Bouché, P. (2013). Unmanned Aerial Survey of Elephants. *PLOS ONE*, *8*(2), e54700.

Zhang, H., Wang, C., Turvey, S. T., Sun, Z., Tan, Z., Yang, Q., Long, W., Wu, X., & Yang, D. (2020). Thermal infrared imaging from drones can detect individuals and nocturnal behavior of the world's rarest primate. *Global Ecology and Conservation*. 23 (9). E01101.