Red mangrove *(Rhizophora mangle)* **along the shore of Río San Pedro**

Biotopo Laguna del Tigre-Río Escondido
Maya Biosphere Reserve (RBM)
Petén, Guatemala
March, 2024

Nicholas Hellmuth, Sergio D'angelo Jerez, Eva López, Neil Morales and Victor Mendoza

FLAAR MESOAMÉRICA
FLAAR

APPRECIATION FOR THE COOPERATION TO EXPLORE RIO SAN PEDRO AND BIOTOPO LAGUNA DEL TIGRE-RIO ESCONDIDO

WE THANK CECON (CENTRE FOR CONSERVATION STUDIES) OF SAN CARLOS UNIVERSITY OF GUATEMALA FOR PROVIDING PERMITS AND TRANSPORTATION FOR THE EXPLORATION OF THE AREA
(March 2023).

- **Biologist Mirtha Cano** - CECON, Coordinator of the Protected Biotope Laguna del Tigre-Rio Escondido.
- **Forest Ranger David Misty -** CECON, Protected Biotope Laguna del Tigre-Río Escondido

APPRECIATION FOR ENCOURAGING OUR 5-YEAR RESEARCH PROJECT ON THE MAYA BIOSPHERE RESERVE (RBM)

INITIATION AND COORDINATION OF THE PROJECT OF COOPERATION FOR 2021-2025 ON THE MAYA BIOSPHERE RESERVE (RBM), PETÉN

- **Licda. Merle Fernandez** - CONAP
- **Marla Mercedes Bolvito Jerónimo** - Unit of National and International Cooperation of the Executive Secretary of CONAP
- **Licda. Ana Luisa De León N.** - Director of Education for Sustainable Development CONAP
- **Lic. Apolinario Córdova** - CONAP, Petén
- **Ing. Jorge Mario Vazquez** - CONAP, Santa Elena, Petén

We acknowledge the contibutions of the Mexican biologists Eva López and Neil Morales as co-authors of this FLAAR report who based such contributions on their valuable research in the Tabasco side of Río San Pedro Mártir.

Photo by: Haniel López,FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

Photo by: Haniel López,FLAAR Mesoamérica.
March 1, 2023. Camera: DJI Mavic 3 Drone.

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Introducción

By Nicholas Hellmuth, Vivian Hurtado and Sergio Jerez (FLAAR Mesoamérica)

After we received a request by CONAP to accomplish a 5-year research project in the RBM area of Guatemala, I began to look at the map of these 21,600 square kilometers to decide where it was most effective to undertake field work. Plus, CONAP asked us to do initial field work in the areas on both sides of Tikal: Parque Nacional Yaxhá, Nakum and Naranjo (PNYNN) to the right, and Cerro Cahui, Bio Itzá to the south and west. Also, Parque Nacional Laguna del Tigre (PNLT) is another important and large area of the RBM, to the west. Within these areas our focus is on segments that have not been documented by biologists or ecologists, or if visited by earlier scientists, not documented with good resolution digital photos. In PNLT's helpful Plan Maestro, and on other reports on this park, there is mention of a remnant of a mangrove swamp along the Río San Pedro, near the border with Tabasco, Mexico.

While doing library research I learned that anyone working in this remote corner of Petén has at least heard that these mangrove trees are present, but there are only a few low-resolution, low-detail snapshots in reports. On the Tabasco (Mexico) side there is better documentation of the area. There are even scholarly videos of the red mangrove tree areas on the Tabasco side of the border with Petén, Guatemala. Therefore, one of our goals was to visit the mangrove area of the Guatemalan (Petén) side and do aerial photography from above and panorama photography from the river. In January, Biologist Mirtha Cano asked if FLAAR could do aerial and panoramic photography of remote areas of the PNLT for her team. She kindly arranged access to a motorboat and "lancheros (motorboat drivers)". We then networked and found an individual who knew where the mangrove trees were. So, the first day upon arrival to Río San Pedro the last week of February 2023, was to explore the Río Escondido area, as requested by Biologist Mirtha Cano, Coordinator of the protected area Biotopo Río Escondido (CECON). During the second day FLAAR covered the cost of the gasoline and oil for the motorboat and we went to find and photograph the mangrove trees.

After we had accomplished the February-March field trip, both biologist Mirtha Cano (CECON) and forest engineer Sergio Balan (CONAP) said they would like to visit and inspect these mangrove trees themselves. So, we drove the 600 km from our office to the town of Naranjo, and went downstream to do additional photography. Plus, both specialists were able to get out of the boat and walk on the shore behind the row of mangrove trees. These trees are only a single line along the river. Behind them there are tasiste palms and *Crescentia cujete*, calabash trees.

Since FLAAR has already published a complete botanical and ethnobotanical review of red mangrove swamps of the Livingston area (coastal and inland from Amatique Bay of the Caribbean) we do not need to repeat the dozens of pages of botanical documentation here. The other FLAAR Report is called **"Edible Plants of Wetlands, Red Mangrove Swamps, *Rhizophora mangle*,"** March 2021. The present FLAAR report of our RBM, Petén project will show where these mangrove trees need urgently to be protected. Plus we will show aerial photos and our photos from the river in front of these mangroves.

Also, Balick, Nee and Atha (2000) provide an excellent list of uses of red mangrove: *Rhizophora mangle* L. as a source of medicine, field, food, dye and more.

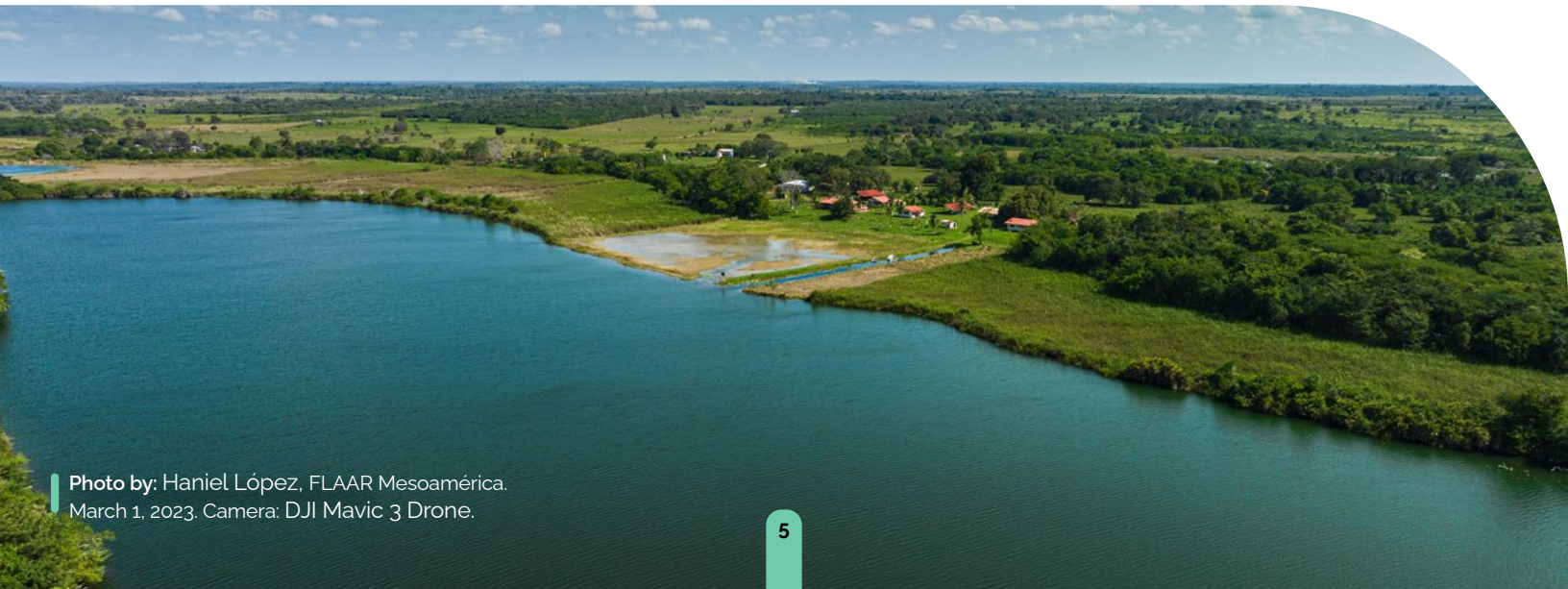


Photo by: Haniel López, FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

How did we decide to undertake photo documentation of these inland mangroves

by Nicholas Hellmuth and Sergio Jerez (FLAAR Mesoamérica)

Photo by: Nicholas Hellmuth, FLAAR Mesoamérica, March 1, 2023

In May of 2022, we learned about the mangrove remnants through the research work of Aburto-Oropeza et al. (2021). This research project was mostly conducted in Mexico, but mentioned the existence of mangrove trees in the Guatemalan side of Río San Pedro. However, some of the most interesting findings were not only on the inland distribution of mangrove trees, but also on their evolutionary history. Aburto-Oropeza et al. (2021) found that these mangroves initially developed in this area because at some point the sea reached a higher level. **Put in other words, a portion of the Yucatan peninsula was fully covered by water, and mangroves could develop well since there was enough brackish water.** Later on, the sea level decreased but the mangrove trees evolved, adapted and remained in the area. The high concentration of calcium in the waters of Río San Pedro has allowed the mangrove population to survive, and now, approximately 120,000 years after the mangroves first developed here, it is still possible to find them (Aburto-Oropeza et al. 2021). So, our team kept in mind the existence of these mangroves.

Aburto-Oropeza and his team reported **the mangroves 170 km inland, in Mexican territory**, but if there were any mangrove trees in Guatemala, which the FLAAR team was to find out, they would definitely constitute the naturally occuring most isolated remnants of mangrove (perhaps anywhere in the world, and for any mangrove species).

Once biologist Mirtha Cano asked us to do documentation on the western area of PNLT, we started exploring the area through satellite imagery. This area covers more than 1500 km2 and by looking at the course of Río San Pedro, we found that most of the surrounding land is already deforested. In fact, there are very few patches of the river's coast that still have vegetation. So basically, the only chance of finding mangrove trees would be by visiting each individual patch by boat.

If there were still any standing mangroves, the risk of them being chopped down for fuel, timber or simply to "clean" the land is alarmingly high.

Before our first expedition to this area, we already knew that one of our first destinations was going to be Río San Pedro, even when we weren't sure if we would be able to find any mangroves. So we asked local people if they knew any mangroves in the vicinity of Naranjo, a village next to Río San Pedro which also happens to be the biggest in this area. Effectively, a local park ranger told us about the presence of mangroves and it was at that point that we decided to explore Río San Pedro, by taking a boat in Naranjo.

We also decided to explore this portion of Río San Pedro to document the ecosystems in the river's basin. While looking at these areas through satellite images, we found what appeared to be cibales, marshes and floodable areas. Moreover, we found extensive areas that seemed to be covered by water lilies. None of these individual ecosystems might have been studied or documented before.

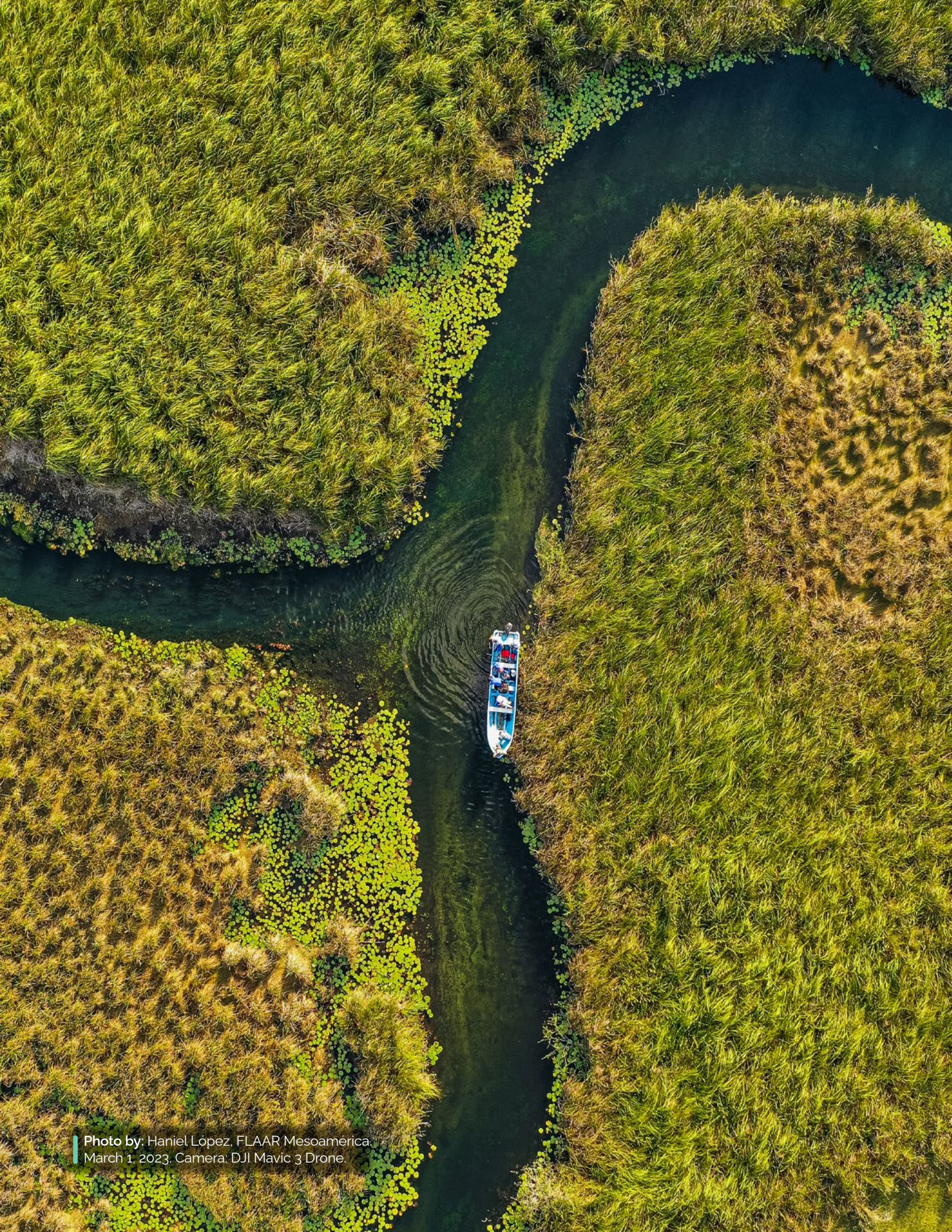


Photo by: Haniel López, FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

Distribution of Mangrove Swamps in Guatemala

By Nicholas Hellmuth (FLAAR Mesoamérica)

Mangrove swamps are common in many parts of the world. Guatemala has mangrove swamps on both the northeastern Caribbean area and the entire southern area (Pacific Coast and inland). For the Izabal area simply drive to the Río Dulce bridge area and there are motor boats that can take you west to Livingston. You will see mangrove swamps along much of this route. There are even more mangrove swamps along the Río Sarstun, on the border between Izabal and Belize. The eastern part of Izabal has multiple species of mangrove trees; Río San Pedro, on the other hand, has only *Rhizophora mangle* L., also known as mangle colorado, mangle rojo, and red mangrove.

Mangroves, especially red mangrove, grow in brackish water, meaning they can grow dozens of miles away from the ocean or sea. Most of the other mangrove species tend to be closer to the Caribbean or Pacific (although it would be best to have a complete research project on these aspects: how far inland can each species survive). Keep in mind that when the Polochic River has less water flowing into Lake Izabal and into El Golfete, a strong tide of the Amatique Bay will allow brackish water to come deep into El Golfete. There used to be even Bull sharks as far inland as El Golfete on Lake Izabal (today, with so many motorboats and yachts, you don't get to see sharks come anywhere near that far nor often; but they did still reach El Golfete several years ago).

Swamps are a significant portion of the landscape of Guatemala in most portions of the lowlands and even in the highlands. I have explored the swamps on the southwest side of Yaxhá in the 1970's, the tinto ecosystems (*Haematoxylum campechianum*, also known as Palo de Campeche) and swamps of Arroyo Pucté (tributary of Río La Pasion, 1970's into 1990's). During the last 10 years I have been learning about the diverse kinds of swamps in the CECON preservation area to the north and northwest of Monterrico and the Chiquimulilla Canal, in the Pacific Coast. Decades before, I explored the swamps of Tabasco, Campeche, and Quintana Roo, Mexico. You can see the remains of mangrove swamps being taken over by expanding villages in Belize and all parts of Mesoamerica. Then, several years ago, I ventured into the mangrove swamps of Manchón Guamuchal, west of Champerico, Guatemala. These ecosystems are under the protection of CONAP. Four species of mangrove can be studied there.

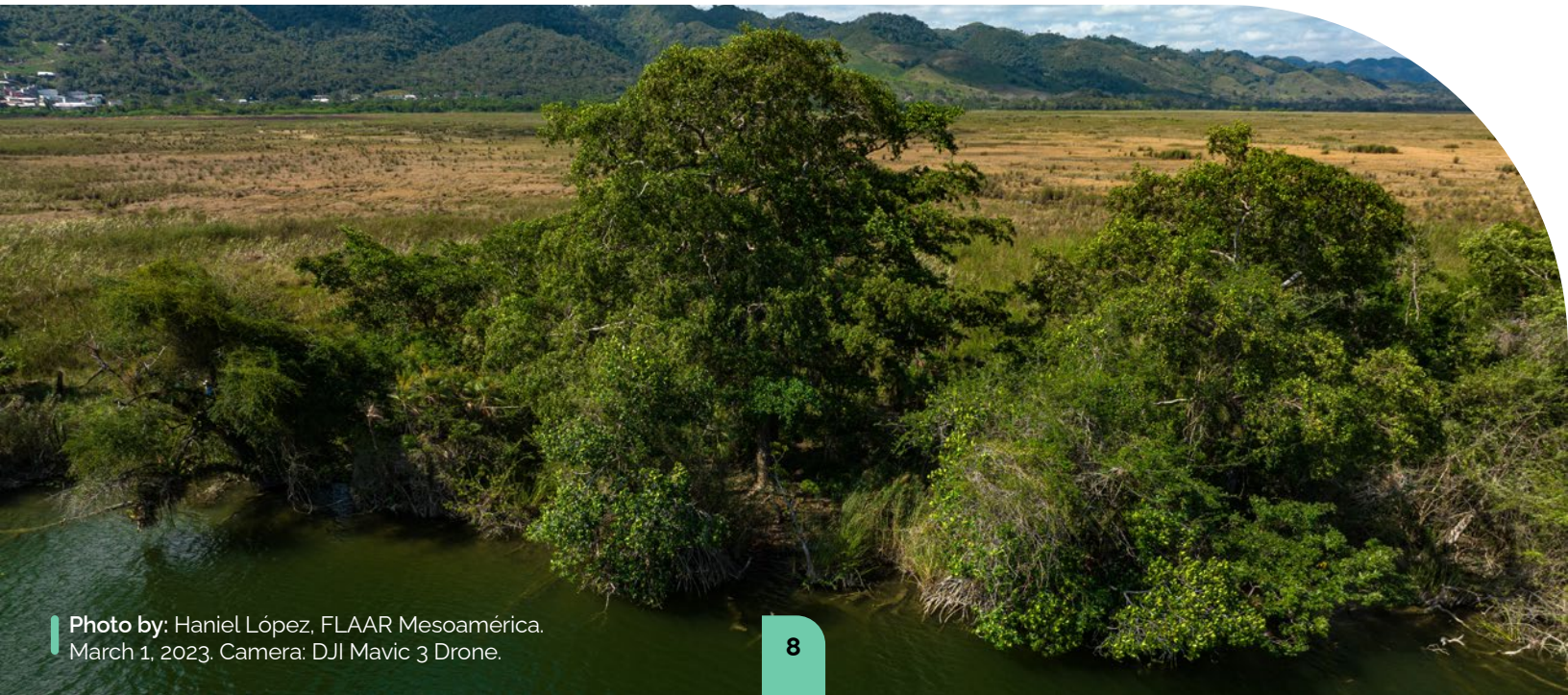


Photo by: Haniel López, FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

Table 1. Mangrove species in Guatemala

Genus species	Name in Spanish	Name in English	Potential use as	Reference and page number: Trees of Guatemala, Parker 2008
Conocarpus erectus L.	Mangle Blanco, mangle Botoncillo	Buttonwood	Bark used for tanning animal skins	Parker 2008: 175
Laguncularia racemosa (L.) Gaertn., Synonym: *Conocarpus racemosa* L.	Mangle chaparro, mangle colorado, mangle blanco	White mangrove	Bark used for tanning animal skins	Parker 2008: 176
Rhizophora mangle L.	Mangle colorado, mangle rojo	Red mangrove	House construction, fences, tanning skins, dye colorants; roots are edible	Parker 2008: 749
Avicennia germinans (L.)	Mangle negro	Black mangrove	Tannin in the bark.	Parker 2008: 942

Trees of Guatemala (Parker 2008: 1,033 pages) is the most complete single book on the trees of Guatemala. So if you find it easier not to have to sort through five or more monographs by Standley, Steyermark and co-workers; you can get it all in Parker's compilation. The difference is that Standley, Steyermark, Williams and their colleagues of the Natural History Museum of Chicago did actual field work, day after day, month after month, year after year out in the field and in herbaria across the Americas. The contribution of Parker is to take all their multiple volumes, plus the work of several other botanists, and copy-and-paste it into one single easy-to-use volume. The downside is that there are no citations whatsoever for each species: the sources are mentioned only for the family, at the end of the chapter on the family. One probable reason for zero citations is because it would make the text so ridiculously large and for all the trees would add so many dozens of pages that the book would be too heavy to carry. But nowadays, with Google, after you know the scientific name, and which one of the Chicago monographs the trees are in, you can find what she copied on the Internet. For Mangrove trees it would be Standley and Williams 1962, Fieldiana: Botany, Vol. 24, Part VII, No. 2, pp. 187-281.

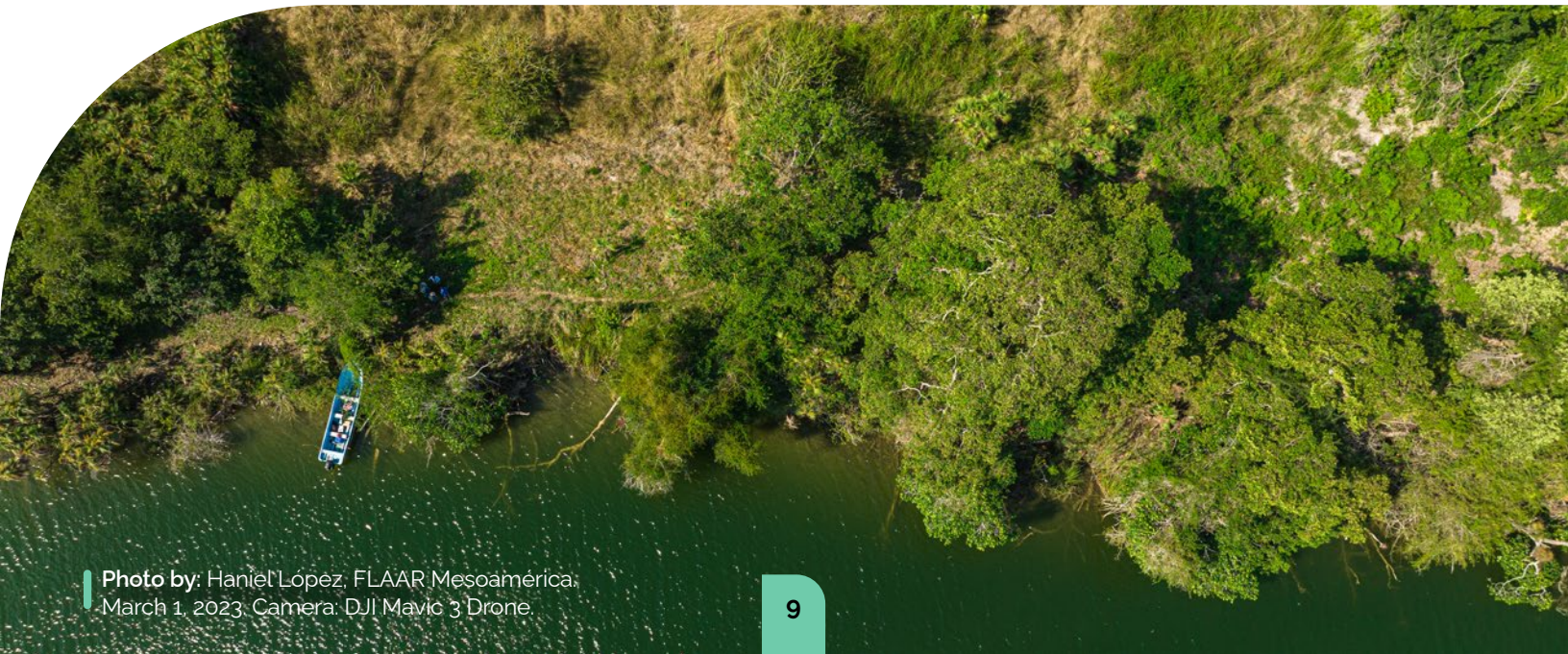
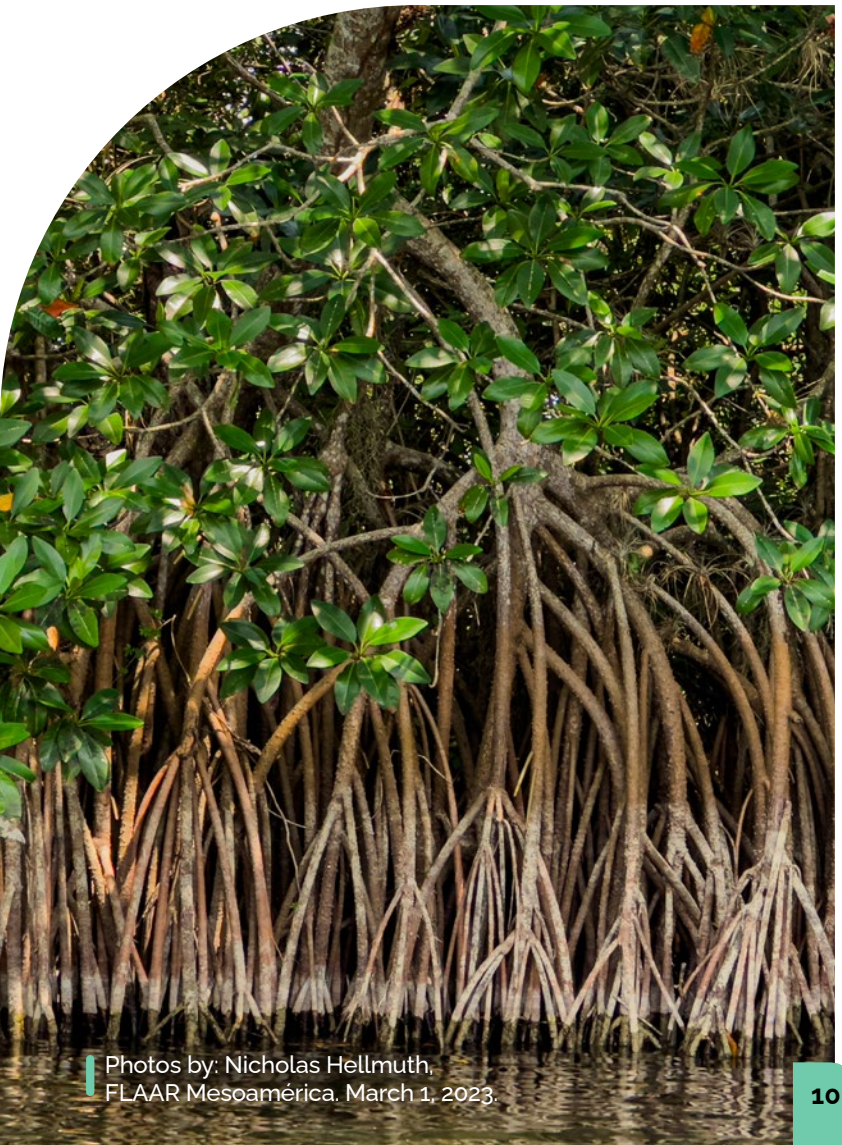


Photo by: Haniel López. FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

Ecology of these millenary mangroves

By Sergio Jerez (FLAAR Mesoamérica)

Mangrove remnants of Río San Pedro are characterized by their singular ecology, evolution and uniqueness. To better document every possible mangrove tree and to analyze the water components that allow their survival are some topics that any student or academic could handle in depth in the future. In fact, our work primarily consisted of doing photography documentation to encourage other capable researchers to better study and protect these mangroves and wetland ecosystems. We also look forward to explore and document these areas to encourage local authorities and park administrators to look after these natural assets of great ecological value.



Photos by: Nicholas Hellmuth, FLAAR Mesoamérica. March 1, 2023.

The value of mangrove ecosystems: the importance of inland mangroves of Río San Pedro Mártir, Tabasco

By Mexican biologists Eva López Dobrusin and Neil Morales Rodríguez

Mangroves are ecosystems usually found in tropical and subtropical coastal areas with a prevalence in salt water areas. Mangroves, however, can also be found in freshwater wetlands, far from the sea. The latter are known as "inland mangroves". One example of these was recorded in 2021 by Aburto-Oropeza and collaborators. They report the presence of solitary individuals and small groups of red mangroves (*Rhizophora mangle*) along the Río San Pedro Mártir (RSPM) in Tabasco, Mexico, over 110 km away from the Gulf of Mexico. This phenomenon came to be over 120,000 years ago during an interglacial period. At the time, global temperature rose, as did the sea levels. As a result, the sea reached the present area of the Cascadas de Reforma in Balancán, Tabasco. Later, the Earth cooled down and the sea level receded to its actual level. Some coastal vegetation was left behind along the RSPM. Such historic events show the mangroves' capacity to adapt and survive to environmental changes.

It also emphasizes the importance of understanding these ecosystems in order to preserve and deal with them in an adequate manner. In May of 2023, Dr. Carlos Manuel Burelo Ramos working with CONANP (Mexico's National Commission of Protected Areas) contributed to convince the government to **create the Natural Protected Area (ANP for its initials in Spanish). By achieving this category, the ANP gained the federal status of Biosphere Reserve. Its official name is Reserva de la Biósfera Wanha', and it is located in the municipalities of Balancán and Tenosique in the state of Tabasco. It has a total surface area of 38,255.76 hectares.**

"The mangrove ecosystems play a ***fundamental role*** in the health and balance of coastal ecosystems."

Some of the most important roles mangroves play include:

To retain, filter, and purify water. Mangroves function as natural filters capturing sediments and retaining pollutants, which helps to protect water quality in the surrounding areas. Such functions are essential for the conservation of the ecosystems they inhabit and the supply of freshwater.

Temperature regulation. Mangrove's shade cools coastal areas. By doing so they stabilize the habitat of aquatic life and the general effects of global warming.

Sediment retention. The tight web of roots created by mangroves retains a large number of sediments. It also helps prevent coastal erosion and protect the surrounding areas from soil loss.

They are a refuge for several species. Mangroves create vital habitats for a wide variety of species. This includes fish, birds, crustaceans, and mammals. Such ecosystems provide refuge, nutrition, and areas for reproduction to a large number of species. These characteristics contribute to the biodiversity and productivity of coastal ecosystems.

To prevent soil loss and deterioration. Mangroves as a whole, and specifically their root structure, help stabilize the coastal soil by preventing erosion and reducing the effect of natural phenomena like storms and hurricanes. This is crucial to protect human communities in vulnerable coastal areas.

Mangrove ecosystems have a vital role in the sustainability and health of coastal ecosystems. They also contribute to the wellbeing of human communities which depend on them. Their conservation and adequate management are essential to their long-term survival which benefits humans and nature.

Biodiversity and important findings of the mangroves of Río San Pedro

By Mexican biologists Eva López Dobrusin and Neil Morales Rodríguez

The most recent document related to the biodiversity of the San Pedro River is titled "Estudio Previo Justificativo del Área Natural Protegida Reserva de la Biosfera Wanha'", which registers the list of flowers cited by Aburto-Oropeza et al. (2021). Some of the information was also retrieved from databases collected online by CONANP (Mexico's National Commission of Natural Protected Areas). The most registered biological groups were vascular plants, birds, fish and fungi.

Biological Group	Total Species	Endemic	Protected by norm*
Fungi	48	0	0
Hepatophyta	1	0	0
Bryophyta	7	0	0
Vascular plants	445	14	16
Helminths	12	0	0
Acanthocephala	1	0	0
Molluscs	16	0	0
Crustaceans	1	0	0
Insects	29	0	1
Fish	49	4	2
Amphibians	12	0	2
Reptiles	26	0	13
Birds	203	0	50
Mammals	42	2	18
Total	**892**	**20**	**102**

***Protected species** by NOM-059-SEMARNAT-2010.

Epiphytes and other species growing among the mangroves and the mangrove trees' roots

By Sergio D'angelo Jerez

(FLAAR Mesoamérica)

Aburto-Oropeza et al. (2021) found other coastal species that are mostly associated with mangroves growing inland in Río San Pedro. Moreover, once the FLAAR expedition team got back to the office and started processing all the photographs taken during the expedition, we were able to identify 7 different species of epiphytes growing in the roots of the mangrove trees that were photographed.

Species:

- *Tillandsia makoyana* (the most abundant and recognizable in our photos)
- *Tillandsia pruinosa*
- *Tillandsia schiedeana*
- *Tillandsia usneoides*
- *Catopsis* sp.
- *Selenicereus* sp.
- *Myrmecophila* sp.

It is also probable that there are two other species of *Tillandsia* which we didn't get to identify, since they were not flowering at the moment the pictures were taken. The following photos show the epiphytes that FLAAR Mesoamerica documented growing on the mangroves.

Photo by: David Arrivillaga, FLAAR Mesoamérica. March 1, 2023. Camera: Sony A1. Lens: 90mm Sony.

1. *Tillandsia pruinosa.*
2. *Catopsis sp.*
3. *Tillandsia makoyana.*
4. *Tillandsia schiedeana.*

Photo by: David Arrivillaga, FLAAR Mesoamérica.
Camera: Sony A1. Lens: 90mm Sony.

1. *Tillandsia pruinosa.* **2.** *Myrmecophila sp.* **3.** *Tillandsia sp.* **4.** *Tillandsia makoyana*.

Photo by: Nicholas Hellmuth, FLAAR Mesoamérica.
Camera: iPhone 14 ProMax.

1. *Tillandsia makoyana.* **2.** *Myrmecophila sp. growing among Selenicereus sp.*

Photo by: David Arrivillaga, FLAAR Mesoamérica.
March 1, 2023. Camera: Sony A1. Lens: 90mm Sony.

1. *Tillandsia sp.*

Photo by: David Arrivillaga, FLAAR Mesoamérica.
March 1, 2023. Camera: Sony A1. Lens: 90mm Sony.

1. *Tillandsia usneoides* and **(2.)** another *Tillandsia* species growing in the shaded background.

Photos by: David Arrivillaga, FLAAR Mesoamérica. March 1, 2023. Camera: Sony A1. Lens: 90mm Sony.

Convergence of epiphytes between the coast and the jungle

By Mexican biologist Neil Morales Rodríguez

In the Mexican region of Río San Pedro, 60 species of epiphytes have been reported (Morales-Rodríguez et al., unpublished). They are associated with the red mangroves and other arborescent species of the zone adjacent to the river. Some of the more remarkable species of epiphytes are: *Asplenium serratum* L. (Aspleniaceae), *Myrmecophila tibicinis* Bateman (Rolfe) (Orchidaceae), *Selenicereus grandiflorus* (L.) Briton & Rose (Cactaceae) and *Tillandsia dasyliriifolia* Baker (Bromeliaceae).

During the investigations at Río San Pedro and one of its associated lagoons, we found great similarity between the Tabascan coastal mangrove and the inland mangrove of El Cacahuate Lagoon; moreover, this epiphyte community of El Cacahuate presents a lesser similarity with the ones of the jungle just a few kilometers away.

This lagoon is located 170 km away from the Gulf of Mexico, but it borders with jungle and the southern mountains of Tenosique which are located 2 km away. Such characteristics could reflect a migration phenomenon. As mangroves extended their territory towards the interior of the continent, their epiphytes colonized the new trees until they reached the zone of the El Cacahuate Lagoon.

Water components and mangrove survival

By Eng. Victor Mendoza (FLAAR Mesoamérica)

Aburto-Oropeza et al. (2021) mention that calcium is the most determinant component for the survival of mangroves in Río San Pedro. Analyzing in depth what other water components influence in the survival of these plant associations is encouraged for other capable researchers.

FLAAR Mesoamérica undertook the analysis of the physical conditions of the water of Río San Pedro, specifically in the area of the mangroves. University Rafael Landivar provided a potentiometer to make such analysis. Measurements were taken of the water's pH, the electric conductivity, and total dissolved solids.

The results of such analysis, were as follows:

pH: 6.90

TSD: 846 ppm

Electrical Conductivity: 1694 uS

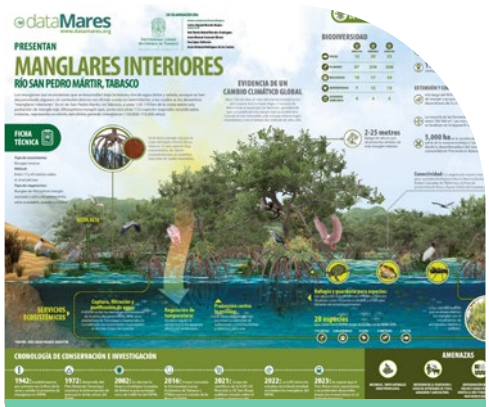
Through these results, we suggest that the water of the Río San Pedro has a relatively neutral pH. Electric conductivity and total dissolved solids are closely related, given that a larger amount of dissolved solids implies a higher electric conductivity. Moreover, theory indicates that a higher amount of salts dissolved in water results in a higher level of electric conductivity. Most of the solids remaining in the water after sand filtration are dissolved ions. This indicates a larger concentration of salts in the water, which implies a higher capacity to transport energy.

Photo by: Haniel López, FLAAR Mesoamérica. March 1, 2023. Camera: DJI Mavic 3 Drone.

Mangroves of Río San Pedro: Previous documentation Analysis, had mangroves been found before in Petén?

Por Nicholas Hellmuth (FLAAR Mesoamérica)

So far, the only photograph I have seen is on page 89 of Bestelmeyer and Alonso 2000. There are several Mexican web site pages that mention these mangrove trees inland in Tabasco:



Inland mangroves in Río San Pedro Mártir, Tabasco (infographic)
–dataMares

Río San Pedro Mártir conserves on its clear waters the dwarf red mangrove.
-Novedades de Tabasco

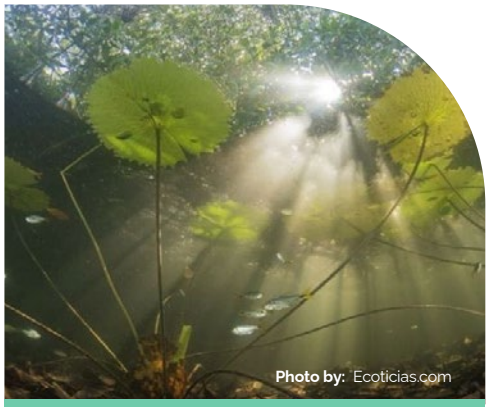


Photo by: Ecoticias.com

What is hidden in the red mangrove swamps of Yucatán?
- Ecoticias.com


Photo by: DA FLAAR Mesoamérica

Mangrove in Río San Pedro, Tenosique, Tabasco.
-Dariana Lemarroy de la Fuente

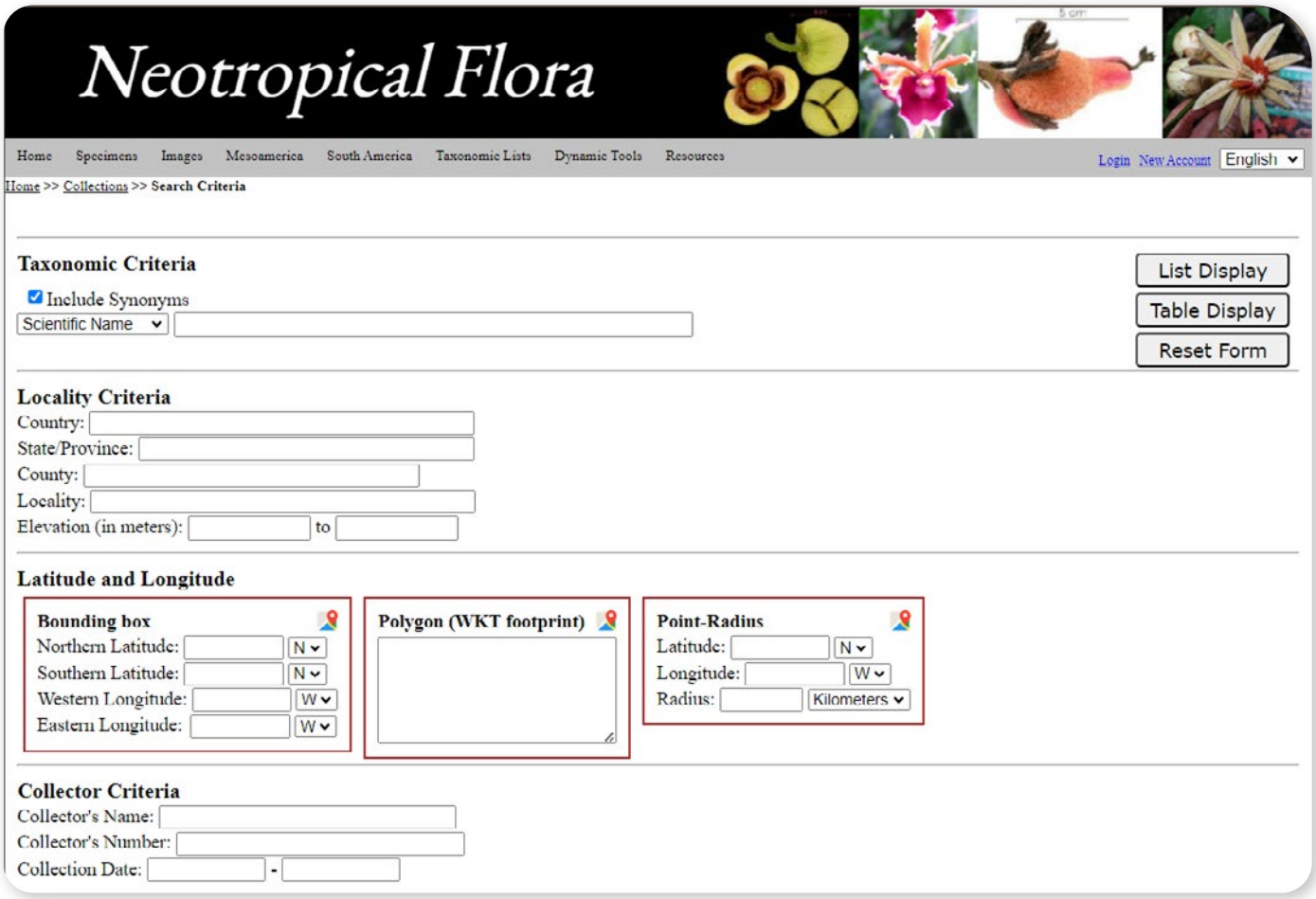
Photo by: Universidad Juárez Autónoma de Tabasco

The discovery of a relict ecosystem from Río San Pedro is presented at FIL UNACH 2022.
-Universidad Juárez Autónoma de Tabasco


Photo by: Thiago Japyassu

Red mangrove in Tabasco; considered a unique environmental treasure in the world. -Radio Fórmula Tabasco

Dozens and dozens more, from Mexico, are on the Internet. Let's hope that capable biologists, ecologists and conservationists from Guatemala can rescue knowledge of these same trees on the Guatemalan side of the Tabasco-Petén area.



Imaged retrieved from: *Neotropical Flora*

This last reference shows zero herbarium specimens for *Rhizophora mangle* outside the coastal areas of Guatemala. All herbaria specimens are from Pacific coastal area swamps or Caribbean coastal area swamps. Zilch for Petén; yet these mangroves are known to botanists and ecologists who focus on wetlands. Lundell did not work in the Petén-Tabasco area of Petén, so has no mention of mangrove trees in his 244 page monograph on "The Vegetation of Petén ".

How to Get to Río San Pedro
adjacent to Naranjo, Petén

By Nicholas Hellmuth (FLAAR Mesoamérica)

Drive about 156 km from Flores-San Benito to El Naranjo. Start with San Benito to La Libertad, then west-northwest to Naranjo. The following image describes the suggested route to drive from San Benito to El Naranjo.

Map with town names in font large enough so you can see the names easily. Background of routes, parks and limits from Caltopo.com with layers from **©OpenStreetMap**. The attributions for each layer of the Caltopo images are included in this report following the reference section.

Rio San Pedro is a true river. La Profundidad and Estrecho are creeks, so in Spanish more correctly named Arroyo La Profundidad and Arroyo Estrecho. But some maps call them all "Río"

Map created by: Sergio Jerez and Andrea Reyes.

This "satellite photo map" is a mosaic of many separate photos joined together. The quality of these photos are significantly better than anything available in Google Earth.

Photographic background from Caltopo.com. The attributions for each layer of the Caltopo images are included in this report following the reference section.

Image created by: Sergio Jerez and Andrea Reyes.

Shows the Tabasco-Petén border at the left and the town of Naranjo at the right. The hills in the lower left corner are in Parque Nacional Sierra de Lacandón; the upper area is Parque Nacional Laguna del Tigre.

Photographic background from Caltopo.com.

Image created by: Sergio Jerez and Andrea Reyes.

Closer view of the area of Río San Pedro that has the dozen remaining mangrove trees. **Photographic background from Caltopo.com.**

Image created by: Sergio Jerez and Andrea Reyes.

Photographic Documentation by FLAAR Mesoamérica

By Nicholas Hellmuth (FLAAR Mesoamérica)

This was the first red mangrove tree area that we found, as we went by boat from Naranjo towards the Petén-Tabasco border. We left the hotel on the shore of the river around 8am. 45 minutes later we arrived at the mouth of the Río Escondido.

Then, at 9:03am we found this first area of several *Rhizophora mangle* trees. After another half hour downstream, we reached the area of more *Rhizophora mangle* trees. When we reached the Guatemalan government office area (on the north of the Río San Pedro) we estimated we were one or two kilometers from the Tabasco border. So, at the government office area we turned around and "photographed our way back", towards Naranjo.

After lunch, we went upstream from Naranjo to the freshwater shellfish "area". It's amazing how many aspects of the far-away Caribbean Sea are in this stretch of the Río San Pedro. So we estimate there is salt in the local minerals. We did not notice any mangrove trees east of Naranjo

Photography by: Nicholas Hellmuth, FLAAR Mesoamérica, March 1, 2023, 9:03 am. Río San Pedro, Petén, Guatemala.
Camera: iPhone 14 Pro Max.

Photography by: Nicholas Hellmuth, FLAAR Mesoamérica, March 1, 2023, 9:34 am. Río San Pedro, Petén, Guatemala.
Camera: iPhone 14 Pro Max

Rio San Pedro, *Rhizophora mangle*, red mangrove trees along the edge of the river.

"We saw only **mangrove trees physically along the shore** of Río San Pedro, none on the inlets."

So far, we haven't been able to find mangrove trees on any waterways parallel to Río San Pedro. Keep in mind that we were only on Río San Pedro. We did not have time or fuel enough on the initial visit to explore the wetlands a dozen meters south and sometimes north of Río San Pedro (most are tributaries).

Plus, we did not take the boat the final 1 to 2 km to the physical border (since we had so many other parts of Río San Pedro and its tributaries to explore). So we do not know how many more mangrove trees are west of the Guatemalan government office area on the north side of the Río San Pedro.

Here at the right is a typical red mangrove tree. They are often entwined with other trees that like to grow along the shore of the Río San Pedro.

Photograph by: Nicholas Hellmuth, FLAAR Mesoamérica, March 1, 2023, 9:35 am. Río San Pedro, Petén, Guatemala.

Camera: iPhone 14 Pro Max.

Photograph by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:44 am. Río San Pedro, Petén, Guatemala.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:55 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

So far the red mangrove trees that we noticed grow physically on the shore of the river. A few meters away from the shore, even if seasonally inundated, we did not notice any mangrove trees. Keep in mind that the grassland area inland is incinerated every year or so by fires, so a tree has to have its roots in water to attempt to survive. In this aerial view there are several clumps of red mangrove trees along the edge and other tree species a few meters behind them.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:45 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

Once you get used to seeing mangrove trees, you can notice their size, shape and color from the air. Lots of vines obscure some areas but enough of the mangrove trees sticks out so you can recognize their leaves.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:45 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:45 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

Again, you see that lots of other **tree species grow** immediately behind the red mangrove trees.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:47 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

The red mangrove trees are not solid; there are lots of other trees and reeds/sedges in between them.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:47 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

Three clumps of **branches of red mangrove** trees stretching out over the water.

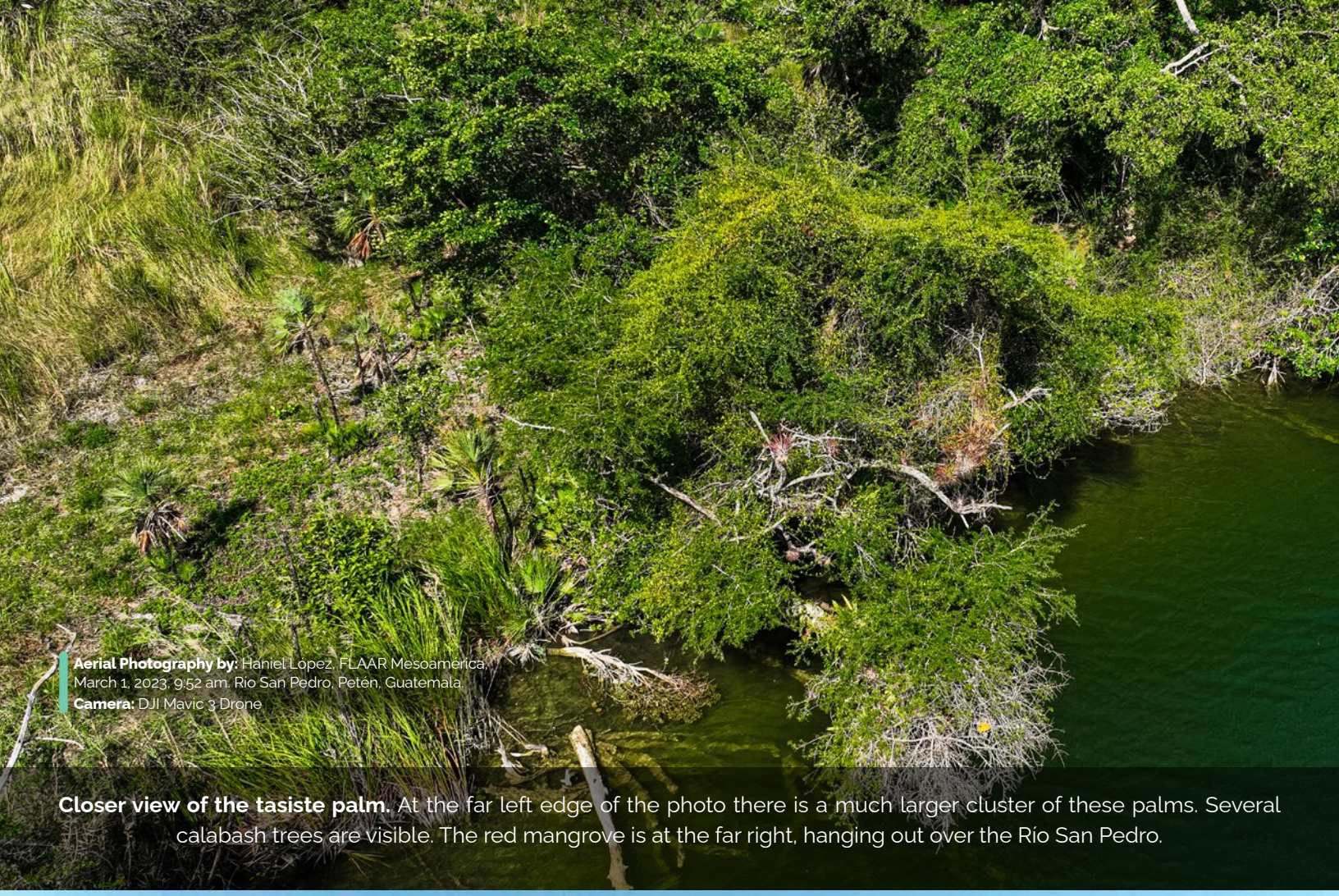
Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:52 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

Tasiste (*Acoelorraphe wrightii*) at left (obviously has been burned recently since the clumps have been reduced). **Then several *Crescentia cujete*, calabash trees.** Then marsh sedges/reeds/grasses. In the upper right middle is the main area of red mangrove; and possibly one more clump further up to the right.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:55 am. Río San Pedro, Petén, Guatemala. **Camera:** DJI Mavic 3 Drone.

Small clumps of tasiste palm in the middle (behind the trees). A few *Crescentia cujete* trees. At least one mangrove area at top right (directly over the edge of the river). **Possibly two more mangrove clumps where branches stick out really far over the river.**

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:55 am. Río San Pedro, Petén, Guatemala. **Camera:** DJI Mavic 3 Drone.



Aerial Photography by: Haniel Lopez, FLAAR Mesoamerica.
March 1, 2023, 9:52 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

Closer view of the tasiste palm. At the far left edge of the photo there is a much larger cluster of these palms. Several calabash trees are visible. The red mangrove is at the far right, hanging out over the Río San Pedro.

Aerial Photography by: Neil Morales.
Tenosique, Tabasco, México.

El Cacahuate Lagoon and southern mountains of Tenosique, Tabasco, Mexico.

Crop by: Nicholas Hellmuth
From aerial Photo by : Haniel López. **Camera:** DJI Mavic 3 Drone

This is a close-up of the complete cluster of tasiste palm, ***Acoelorrhaphe wrightii.***
This is what you see before a fire burns everything down.

Crop by: Nicholas Hellmuth
From aerial Photo by: Haniel López. **Camera:** DJI Mavic 3 Drone

This is a close-up of the ***Crescentia cujete,*** calabash tree, (inland from the *Rhizophora mangle*, red mangrove*).*

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:47 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

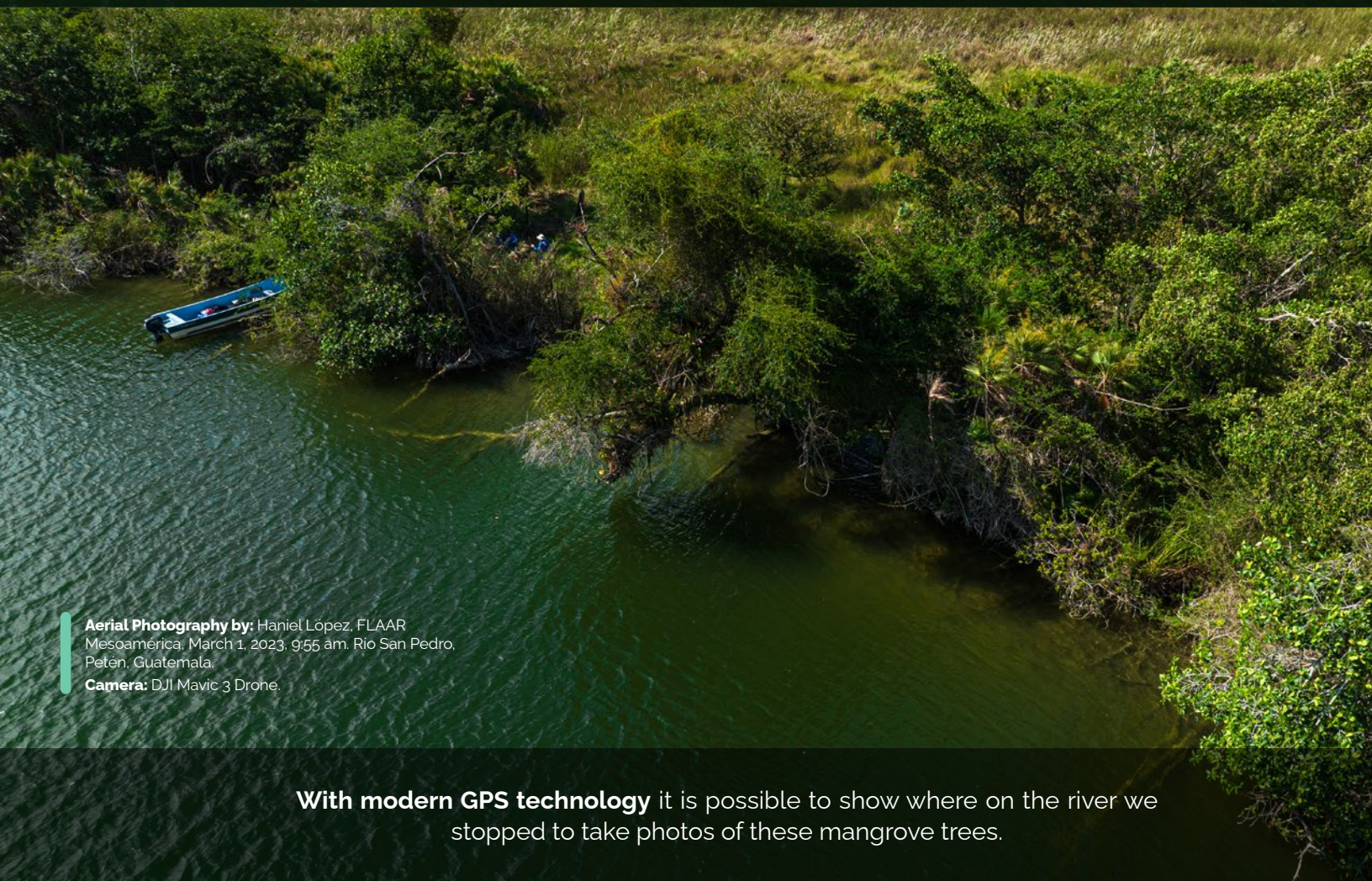
Modern commercial agriculture has cut down most of the original vegetation inland. Behind the trees-along-the-river-edge is a grassland marsh. This is seasonally inundated (so not all kinds of trees would want to grow here).

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:47 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

Marsh inland on the west side of the river. **The Sierra del Lacandón mountain** range is along the horizon. It is probable that none of these marshes have been studied by any ecologist or soil scientist.

Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:55 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone

Red mangrove trees in the middle and far right. **Tasiste palm to the left.**



Aerial Photography by: Haniel López, FLAAR Mesoamérica, March 1, 2023, 9:55 am. Río San Pedro, Petén, Guatemala.
Camera: DJI Mavic 3 Drone.

With modern GPS technology it is possible to show where on the river we stopped to take photos of these mangrove trees.

Are the Sepals of the Red Mangrove in Maya Art?

By Nicholas Hellmuth (FLAAR and FLAAR Mesoamérica)

Many Tepeu 2 ceramic bowls, vases and plates have 4-petalled designs. There are lots of water-related plants either with 4-petals or 4-sepals (or both together) or a 4-leaf pattern. Many years ago I prepared a presentation because I first noticed 4-lobbed motifs in Late Classic Maya art at Tikal in 1965, when I found two bowls with these motifs in the Tomb of the Jade Jaguar (Tikal Bu. 196, Str. 5D-73, facing south side of Temple II).

During many years of field trips to wetlands throughout Guatemala I searched for 4-petalled flowers and found dozens of different species. And, therefore, all the different sizes and shapes of flowers that match the different sizes and shapes of 4-lobbed designs in Late Classic Maya ceramic decoration.

The team at FLAAR and FLAAR Mesoamerica are focused on plants related to wetland ecosystems and iconography of the wetlands' flora and fauna in order to provide material to the many capable iconographers, epigraphers, biologists, and ecologists who are studying wetlands and water in Classic Maya culture. During 2023, water and wetlands was a growing trend. THREE symposia focused 100% on water in the Maya World (the real world and their supernatural worldview):

WATERSCAPES IN MAYA ART, COSMOLOGY, AND ENVIRONMENTT The 2023 Mesoamérica Meetings (at the University of Texas) February 8-11, 2023

Then another complete WATER and WETLANDS symposium:

36 SIMPOSIO DE INVESTIGACIONES ARQUEOLÓGICAS EN GUATEMALA, 17 al 21 JULIO 2023

AGUA DIVINA: SIMBOLISMO, MANEJO Y CONTROL HIDRÁULICO ANCESTRAL

Plus a THIRD symposium on WATER and WETLANDS

Photo by: Nicholas Hellmuth,
FLAAR Mesoamérica, March 1, 2023, 10:20am.
Camera: iPhone 14 Pro Max.

Here you see the sepals remaining from the flower that has long ago started to produce the fruit (the seed pod). *Rhizophora mangle,* red mangrove.

Museo Popol Vuh, Universidad Francisco Marroquín Mid-July 2023.

So here is another potential wetland source for 4-lobbed symbols in Classic Maya art. I had not noticed this in previous decades of field work and library research on 4-petalled flower iconography. We show the flowers of red mangrove trees in our separate FLAAR Report on mangroves of the eastern part of Izabal.

Photograph by: David Arrivillaga, FLAAR Mesoamérica, March 1, 2023. Río San Pedro, Petén, Guatemala.

4-sided designs are very common in Late Classic Maya vases, bowls and occasionally on plates. We all presume these are 4-petalled flowers, but the *Nymphaea ampla* flower has four-sepals (despite having lots of petals, so definitely not "4-petalled").

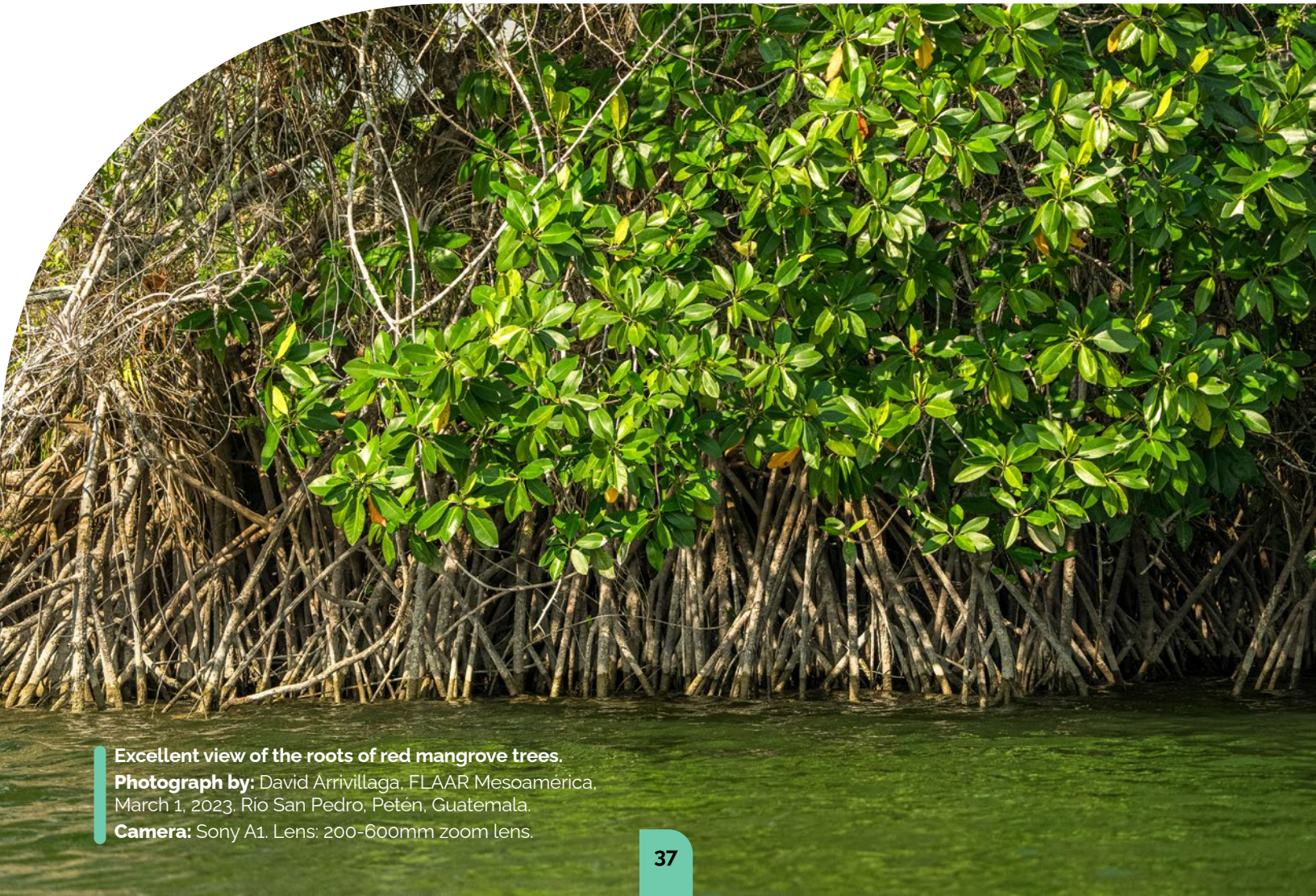
I doubt any iconographer or epigrapher or archaeologist has suggested that red mangrove designs may be an inspiration, especially since no red mangroves grow near Tikal, Yaxhá, Nakum, Naranjo, etc. So, I only mention these 4-sided botanical designs. There are dozens of 4-petalled flowers that are potential models.

Conclusion of the FLAAR Mesoamerica field trip: Red Mangrove Trees of Río San Pedro

There are several red mangrove trees and thousands of mangrove trees of other genera in Guatemala near the Caribbean and along the Pacific Coast.

We found an estimated ten mangrove trees along the Río San Pedro. We did not go the final two kilometers to the physical Tabasco-Petén border, so perhaps there are another dozen in that final stretch. How many thousands are on the Tabasco side is a good research project for capable botanists and ecologists there. But now we have good resolution full-color photos of the presence of *Rhizophora mangle* trees in Petén, Guatemala. This is almost 200 kilometers away from the Caribbean Sea.

These trees have lots of potential uses and surely 2,000 years ago there were thousands of these trees, not just the few we found and potentially few on that final kilometer.



Excellent view of the roots of red mangrove trees.
Photograph by: David Arrivillaga, FLAAR Mesoamérica, March 1, 2023. Río San Pedro, Petén, Guatemala.
Camera: Sony A1. Lens: 200-600mm zoom lens.

Cited References and additional Bibliography

ABURTO-Oropeza, O. BURELO-Ramos, C., EZCURRA, E. EZCURRA, P. HENRIQUEZ, C., VANDERPLANK, S. and **F. ZAPATA**

2021 Relict inland mangrove ecosystem reveals Last Interglacial sea levels. Proceedings of the National Academy of Sciences 2021. Vol. 118, No. 41. https://doi.org/10.1073/pnas.2024518118

This is the ambitious study by Aburto-Oropeza et al. They even found another mangrove species, *Conocarpus erectus,* in the inland mangrove associations from Tabasco, as well as other plant species from coastal mangrove associations.

Aburto-Oropeza et al. (2021) might be the only scientists to have explored these inland mangroves recently.

CABRERA-Cano, E., and **A. SÁNCHEZ-Vázquez**

2000 Rhizophoraceae de la Península de Yucatán (Universidad Autónoma de Yucatán: Sostenibilidad Maya, 2000).

COMISIÓN NACIONAL DE ÁREAS NATURALES PROTEGIDAS

2023 Estudio Previo Justificativo para el establecimiento del Área Natural Protegida Reserva de la Biósfera Wanha'. Tabasco, México. 232 pages, including 4 attachments.

COSTA, M., EZCURRA, E., EZCURRA, P., SALINAS-De-Leon, P., TURNER, B., KUMAGAI, J., LEICHTER, J. and **O. ABURTO-Oropeza**

2022 Sediment depth and accretion shape belowground mangrove carbón stocks across a range of climatic and geologic settings. Limnol Oceanogr, 67: S104-S117. https://doi.org/10.1002/lno.12241

HERNANDEZ, G.

2013 Legislación, cambio de uso de suelo y reforestación en manglares de Cárdenas, Tabasco [Doctoral thesis]. Mexico. Colegio de Postgraduados. 129 pp. http://hdl.handle.net/10521/2356

HERNANDEZ, G., RUIZ, O., SOL, A. and **J. VALDEZ**

2016 Cambios de uso del suelo en manglares de la costa de Tabasco. Revista Mexicana de Ciencias Agrícolas Pub. Esp. No. 14. Pp. 2757-2767.

LARA, A., DAY, J., VILLALOBOS, G., TWILEY, R., GUILLEN, H., and **A. YÁÑEZ-Arancibia**

2005 Structure of a unique inland mangrove forest assemblage in fossil lagoons on the Caribbean Coast of Mexico. Wetlands Ecology and Management, 13.

MARTINEZ-Camilo, R., GALLARDO-Cruz, J., SOLORZANO, J., PERALTA-Carreta, C., JIMENEZ-Lopez, D., CASTILLO-Acosta, O., SANCHEZ-Gonzalez, M. and **J. MEAVE**

2020 An assessment of the spatial variability of tropical swamp forest along a 300 km long transect in the Usumacinta River Basin, Mexico. Forests. 2020; 11(12):1238. https://doi.org/10.3390/f11121238

THOM, B.

1967 Mangrove Ecology and Deltaic Geomorphology: Tabasco, Mexico. Journal of Ecology. Vol. 55, No. 2. Pp. 301–343. https://doi.org/10.2307/2257879

TREJO-Torres, J., DURAN, R. and **I. OLMSTED**

1993 Manglares de la Península de Yucatán. In: Salazar-Vallejo, S. and N.. González (comps.). Biodiversidad Marina y Costera de México. CONABIO and CIQRO. Pp. 660-672.k

ZAPATA, F.

2021 *Rhizophora mangle* from Yucatan. GitHub. https://github.com/zapata-lab/ ms_rhizophora. Deposited 9 June 2021.

Attributions for satellite imagery used in this report

The following attributions correspond to each layer of the Caltopo images that were used as photographic background for the maps in this report.

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Suggested Reading on Red Mangrove Trees of Mesoamérica

Here we just list other suggested publications if you want to learn more about mangroves and the surrounding region of where mangroves were found in the Río San Pedro.

BALICK, Michael J., NEE, Michael H. and **Daniel E. ATHA**
2000 Checklist of the Vascular Plants of Belize: With Common Names and Uses. Memoirs of the New York Botanical Garden Vol. 85. 246 pages.

BALICK, Michael J. and **Rosita ARVIGO**
2015 Messages from the Gods: A Guide to the Useful Plants of Belize. The New York Botanical Garden, Oxford University Press.

BUENO, Joaquín. ALVAREZ, Fernando and **Silvia SANTIAGO (editors)**
2005 Biodiversidad del Estado de Tabasco. CONABIO, UNAM, Mexico. 370 pages.

CHIZMAR, Carla
2009 Plantas Comestibles de Centroamérica. Instituto Nacional de Biodiversidad (INBio) Santo Domingo de Heredia. Costa Rica. 360 pages.

Available online:
www.museocostarica.go.cr/descargas/PlantasComestiblesCA-VE.pdf

ESTRADA Loreto, Feliciana
2010 Indicadores ecológicos de la zona riparia del Río San Pedro, Tabasco, México. MS Thesis, El Colegio de la Frontera Sur. 131 pages.

Available online:
https://ecosur.repositorioinstitucional.mx/jspuibitstream/1017/1656/1/100000050585_documento.pdf

LUNDELL, Cyrus L.
1937 The Vegetation of Peten. Carnegie Institution of Washington, Publ. 478. Washington. 244 pages.

LUNDELL, Cyrus L.
1938 Plants Probably Utilized by the Old Empire Maya of Peten and Adjacent Lowlands. Papers of the Michigan Academy of Sciences, Arts and Letters 24, Part I:37-59.

Mangrove studies in Petén, Guatemala

There are very few publications that mention the presence of mangroves in Río San Pedro, but these are better than nothing.

CASTELLANOS, B. (ed).
2006 Plan Maestro Parque Nacional Laguna del Tigre y Biotopo Laguna del Tigre-Río Escondido. Guatemala. Consejo Nacional de Áreas Protegidas – CONAP. Alianza Kanteel. Wildlife Conservation Society. 24 pages.

The existence and location of mangroves is mentioned in pages 31 and 34.

BESTELMEYER, Brandon T. and **Leeanne E. ALONSO** (editors)
2000 A Biological Assessment of Laguna del Tigre National Park, Petén, Guatemala. RAP Bulletin of Biological Assessment 16, Conservation International, Washington, DC. 221 pages.

Rhizophora mangle is mentioned in pages 15 and 37, as being present and outside of Laguna del Tigre National Park (which increases the risk of these mangroves not being protected).

Web pages specifically on *Rhizophora mangle* inland, Río San Pedro, Tabasco and Petén

- https://agua.org.mx/biblioteca/manglares-interiores-en-el-rio-san-pedro-martir-tabasco-infografia-datamares/

This site includes an infographic published by Mexican authors regarding the mangroves of Río San Pedro.

- https://nubedemonte.com/los-mangles-que-aprendieron-a-vivir-lejos-del-mar/

Beautiful photographs, including one of a dead mangrove tree that was probably burnt with fires produced by local people. It also includes links to other publications and sites related to the mangroves and the Río San Pedro area.

- https://www.inecol.mx/inecol/index.php/es/component/content/article/17-ciencia-hoy/1773-el-manglar-que-el-tiempo-olvido

- https://www.abc.es/ciencia/abci-encuentran-bosque-perdido-atrapado-tiempo-durante-mas-100000-anos-202110060054_noticia.html

- https://botany.one/2021/10/los-mangles-del-deshielo/

- https://www.ngenespanol.com/ecologia/que-pasa-con-los-manglares-de-tabasco/

Videos on *Rhizophora mangle* inland, Río San Pedro, Tabasco and Petén

- https://vimeo.com/493503303

  "Memories of the Future: the modern discovery of a relict ecosystem" – Ben Fiscella. This is the actual documentary that we saw first, when we first learned about the mangroves of Río San Pedro.

- https://www.facebook.com/institutonacionaldebosques/videos/380459584228101

  "Seminario virtual Manglares de Guatemala" – INAB (this virtual seminar facilitated by the Forests' National Institute of Guatemala [INAB] includes a presentation by Carlos Burelo about the mangroves of Río San Pedro).

- https://www.youtube.com/watch?v=yza04MmustI

  "Humedales de San Pedro (Tabasco), Dr. Carlos Burelo" – Comité Mexicano de Manglares A.C.

- https://www.facebook.com/watch/?v=246710320494353

- https://www.youtube.com/watch?v=Cw6T_kn9oh4

  "Un relicto del Edén: la vegetación del río San Pedro Mártir" – Sociedad Botánica de México.

- https://www.facebook.com/JJJimenezChanPresidente/videos/156221169991245/

- https://www.youtube.com/watch?v=FtMKLol95PU

  "Manglar rojo de Balancán, ecosistema único en el mundo" – Azteca Noticias. This is a news report about the mangroves of Río San Pedro, but still shows some captures of the mangroves trees and the ecosystem they live in.

- https://www.facebook.com/institutonacionaldebosques/videos/564941728509954

  "El mangle: un ecosistema único y especial" – INAB (this video is part of a series of presentations that INAB shared to show the importance of the mangrove ecosystem in Guatemala; however, it is interesting that they get to mention the few mangroves in Río San Pedro while indicating where mangroves are distributed in Guatemala).

- https://www.facebook.com/maresmexicanos/videos/397471435088626

- https://www.facebook.com/agecifca.gt/videos/2867685233533849

  "Charla sobre el ecosistema manglar – AGECIFCA Guatemala" (this video as well mentions the few mangroves of Río San Pedro while assessing the distribution of mangrove ecosystems in Guatemala, minute 10:30, and it also states that no assessments have been done there to quantify how much area of mangrove ecosystem there is on Río San Pedro).

Appendix A

FLAAR Mesoamérica fieldnotes of the Rio San Pedro expedition

Mar 01, 2023: Río San Pedro mangroves and Arroyo la Icotea (Jicotea)

Date	Hour	Where	Coordinates	What was photographed
01/03/2023	07:58 am	Field trip beggins		
01/03/2023	08:33 am	Río San Pedro	N 17.266851° O 090.867969°	Kingfisher
01/03/2023	08:45 am	Arrival to Río Escondido and to the mangrove area	N 17.263757° O 090.891828°	Río Escondido
01/03/2023	08:57 am	Río San Pedro	N 17.246519° O 090.916033°	Photographs of a wildfire
01/03/2023	09:03 am	Arrival to Arroyo La Profundida	*	Mangrove
01/03/2023	09:19 am	Río Estrecho	N 17.268456° O 090.966972°	The river narrows
01/03/2023	09:26am	Arrival to the Ceibo Path	N 17.261292° O 090.970889°	Bromeliad growing on a dry tree
01/03/2023	09:35 am	Río San Pedro	*	Red Mangrove Cactus
01/03/2023	09:45 am	Río San Pedro	*	Jicara (*Crescentia cujete*) Tasiste (*Acoelorraphe wrightii*), drone expedition
01/03/2023	10:21 am	Río San Pedro	*	Mangrove flower
01/03/2023	10:42 am	Río San Pedro	N 17.264425° O 090.970920°	Caoba fruits Underwater photographs
01/03/2023	10:58 am	Río San Pedro	N 17.266239° O 090.969873°	Drone documentation Caoba fruits
01/03/2023	11:01 am	Río San Pedro	N 17.267689° O 090.968187°	Tree cactus Waterlilies Pachira aquatica Underwater photographs
01/03/2023	11:32 am	Río San Pedro	*	Red mangrove
01/03/2023	11:47 am	Río San Pedro	N 17.250304° O 090.925243°	Waterlilies
01/03/2023	11:58 am	Río San Pedro	N 17.250557° O 090.925263°	Drone documentation Underwater photographs of waterlilies
01/03/2023	12:24 pm	Río San Pedro	N 17.255269° O 090.895567°	Southern area of the cenote

Date	Hour	Where	Coordinates	What was photographed
01/03/2023	12:41 pm	Rio San Pedro	N 17.266535° O 090.893720°	Drone documentation
01/03/2023	12:54 pm	Rio San Pedro	N 17.271170° O 090.871560°	Drone documentation Waterlilies
01/03/2023	01:10 pm	Rio San Pedro	N 17.261322° O 090.864029°	Drone documentation Waterlilies
01/03/2023	01:33 pm	Rio San Pedro	N 17.260129° O 090.863415°	Tillandsia, Spanish moss

March, 01, 2023: Río San Pedro to East of Naranjo

Date	Hour	Where	Coordinates	What was photographed
01/03/2023	3:48 pm	Río San Pedro	N 17.266309° 090.725896°	
01/03/2023	4:21 pm	Arrollo la Icotea	N 17.236733° O 090.757461°	
01/03/2023	4:29 pm	Arrollo la Icotea	N 17.234810° O 090.754444°	Drone documentation Underwater photographs

Photograph by: David Arrivillaga, FLAAR Mesoamérica, March 1, 2023. Río San Pedro, Petén, Guatemala.
Camera: Sony A1. Lens: 200-600mm zoom lens.

ACKNOWLEDGEMENTS TO FLAAR MESOAMÉRICA

Vivian Hurtado is an environmental engineer and passionate researcher. She is the general coordinator of FLAAR Mesoamerica and is responsible for managing the development of projects.

Jorge Luis Arana is responsible for the financial administration of the institution and supports the supervision of daily activities.

Victor Mendoza is an environmental engineer and director of the research team, in charge of the photographic database and its taxonomic identification.

Sergio Jerez is an agricultural engineering student involved in plant identification and supports research topics.

Mariana Rivas is a biologist and is responsible for editing information for our reports. She also helps with various investigations and data processing for FLAAR projects.

Alejandra Valenzuela is a biology student and part of the research team. He edits reports and supports other activities. He also supports the creation and analysis of web statistics.

Pamela Jerez is a biologist and is mainly in charge of managing FLAAR's social networks, and also supports as a researcher.

Andrea Sánchez is a graphic designer who helps prepare the graphic line of our publications. She is our editorial art director.

Jaqueline González is a graphic designer who diagrams text and photographs to create our reports.

Carlos Marroquín is a graphic designer and designs the publications that are made on social networks, as well as diagramming some of the flora and fauna reports that we generate.

María Alejandra Gutiérrez is an experienced photographer and audiovisual production director. She was also the coordinator of the field trips for the documentation project in Livingston, Izabal.

Edwin Solares He is an environmental engineer, as well as a photographer and videographer during our expeditions. He then edits this content to be used in our different materials.

Pedro Pablo Ranero has a degree in communications and is in charge of editing videos of flora and fauna to create content on our sites.

Milstrid Arana is in charge of editing videos for our social networks.

Paulo Núñez is an engineer and the administrator of our websites. He is the director of the web team and is responsible for the maintenance and programming of the entire FLAAR network of websites.

Juan Carlos Hernández is a graphic designer and part of the web team. He receives the material we produce to place on our sites.

María José García is a graphic designer and part of the web team. She receives the material we produce to place on our sites.

Andrés Fernández is a graphic designer and is in charge of keeping our websites updated and making them more efficient for the user.

Valeria Avilés is a graphic designer and illustrator. She is the director of MayanToons, our children's division and is in charge of coordinating the team's activities, as well as creating illustrations for the different materials we prepare.

Laura Morales is a digital content engineer and is in charge of directing the animation department at MayanToons.

Paula García is a graphic designer and part of our MayanToons Animation team. Her job is to bring our favorite characters to life.

Niza Franco is a graphic designer and part of our MayanToons Animation team. Her job is to bring our favorite characters to life.

Isabel Trejo is a graphic designer and illustrator for MayanToons and social media posts.

Josefina Sequén is an illustrator for MayanToons.

Dafne Ramírez is an illustrator for MayanToons

Karen Arana assists in the planning and management of FLAAR USA and FLAAR Mesoamerica activities.

Byron Pacay is our assistant during field trips.

Norma Cho is our assistant during field trips.

Karla Cho provides general assistance with investigations and office assistance

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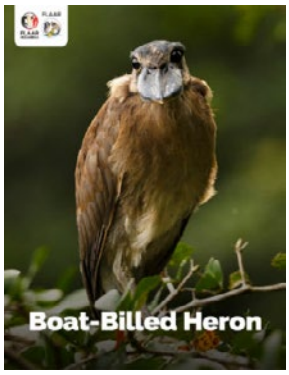

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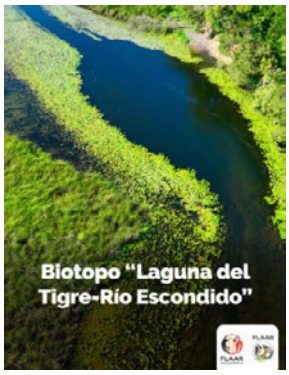

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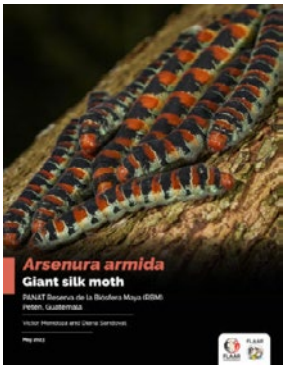

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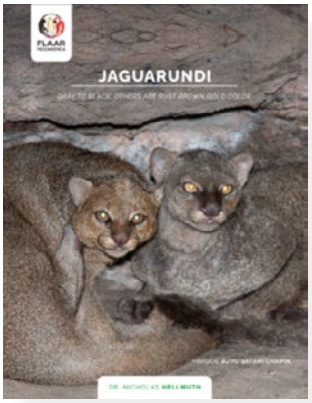

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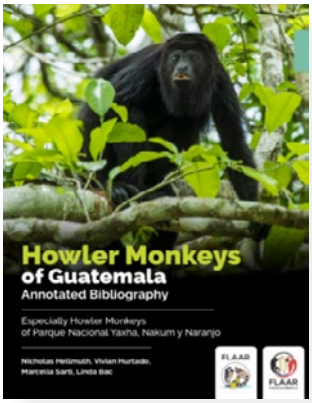

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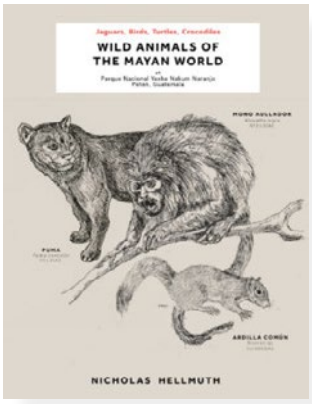

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